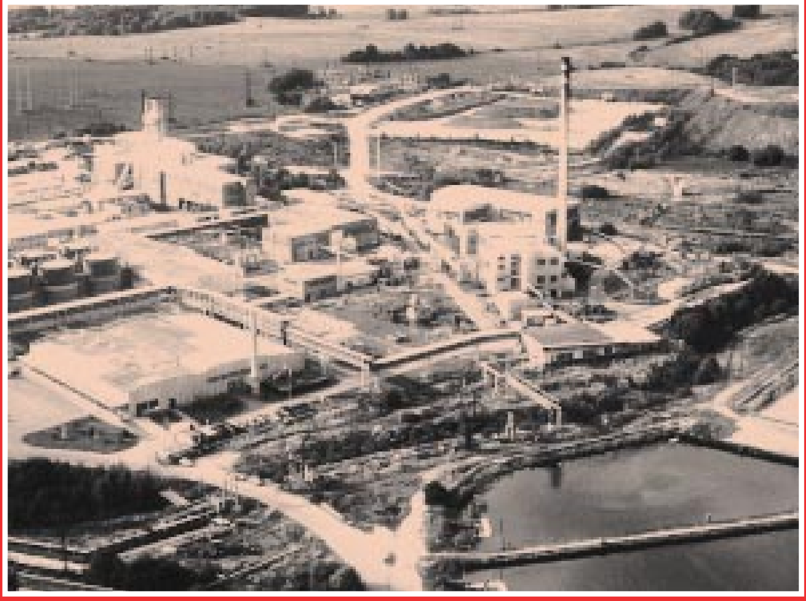
URANIUM

1997
RESOURCES, PRODUCTION AND DEMAND



A JOINT REPORT BY THE
OECD NUCLEAR ENERGY AGENCY
AND THE
INTERNATIONAL ATOMIC ENERGY AGENCY

OECD
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PARIS

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

– to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
– to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
– to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of all OECD Member countries, except New Zealand and Poland. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

– *encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
– *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
– *developing exchanges of scientific and technical information particularly through participation in common services;*
– *setting up international research and development programmes and joint undertakings.*

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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URANIUM 1997
RESSOURCES, PRODUCTION ET DEMANDE – ÉDITION 1998

Photo Credit: The Hamr production centre, Czeck Republic – courtesy of Diamo s.p.

PREFACE

Since the mid-1960s, with the co-operation of their Member countries and states, the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) have jointly prepared periodical updates on world uranium resources, production and demand. These updates have been published by the OECD/NEA in what is commonly known as the "Red Book". This seventeenth edition of the Red Book replaces the 1995 edition and reflects current information on 1 January 1997.

Since 1973 the Red Book has been produced once every two years. It presents a comprehensive assessment of the uranium supply and demand situation at present and periodically up to the year 2015. The basis for the assessment consists of estimates of uranium resources in several categories of assurance of existence and economic attractiveness, and projections of production capability, installed nuclear capacity, and related uranium requirements. Annual statistical data are included on exploration expenditures, uranium production, employment and uranium stocks. In addition to the global analysis, detailed national reports are provided concerning uranium resources, exploration, production activities and relevant uranium policies.

This publication has been prepared on the basis of data obtained through questionnaires sent by the NEA to its Member countries and by the IAEA to its participating Member states which are not OECD Member countries. Although some countries prepared comprehensive national reports which are presented essentially in their original form in Part III, a number of these reports were prepared by each agency based on the responses to the questionnaire and/or on some other official responses. Preparation of the remaining sections of the report was divided equally between the two agencies under the general guidance of the NEA-IAEA Uranium Group.

Parts I and II (Uranium Supply and Uranium Demand) were drafted by separate working parties composed of members of the NEA-IAEA Uranium Group and chaired by the Vice-Chairmen of the Group (see Annex 1).

It also reviews the uranium supply situation throughout the world by evaluating and compiling data on uranium resources, past and present production, and plans for future production. The data, provided by 59 countries, are then compared with possible future reactor-related uranium requirements. Recent levels of exploration for uranium are also reported and analysed. This edition of the Red Book contains for the second time resource estimates at a production cost level of $40/kg of uranium or less.

Information on short-term uranium demand has been provided by national authorities up to the year 2015. Longer-term projections of uranium demand, based on expert opinion rather than on information submitted by national authorities, are qualitatively discussed in the report.

The opinions expressed in Parts I and II do not necessarily reflect the position of Member countries or international organisations. This report is published on the responsibility of the Secretary-General of the OECD.

ACKNOWLEDGMENT

The OECD Nuclear Energy Agency (NEA), Paris, and the International Atomic Energy Agency (IAEA), Vienna, would like to acknowledge the co-operation of those organisations (see Annex 2), which replied to the questionnaire submitted to them.

Following an agreement between the NEA and the IAEA, the NEA Uranium Group was reconstituted as the Joint NEA-IAEA Uranium Group during 1996. This provides the opportunity of full participation by representatives of all Member countries of the two organisations with an interest in uranium related activities. It has resulted in increased participation of IAEA Member states in preparation of this Red Book.

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EXECUTIVE SUMMARY

This report, Uranium 1997 – Resources, Production and Demand, presents results of the 1997 review of world uranium supply and demand based on official reports from 59 countries including information from all uranium producing countries. It provides a statistical profile of the uranium related activities as of 1 January 1997. It contains data on uranium exploration activities, resources and production, updating the 1995 edition of the Red Book. Significant new information is provided for uranium producing countries including plans for production expansion in Australia, Canada, Kazakhstan, Mongolia, the Russian Federation, USA and Uzbekistan. This report also provides projections of nuclear generating capacity and reactor related uranium requirements through 2015 for all countries with existing, planned or potential nuclear programmes.

World Uranium Market

Following a decade and a half of falling market prices and contracting activities, decreasing supply availability combined with growing demand for new uranium purchases resulted in a recovery in uranium prices from October 1994 through mid-1996. By August 1996 the unrestricted price had increased by 116 per cent to $39.65/kgU ($15.25/lb U_3O_8), while the restricted price had climbed 75 per cent to $42.38/kgU ($16.30/lb U_3O_8). After September 1996, however, the trend of rising prices reversed, and unrestricted and restricted uranium prices fell sharply to about $23.92/kgU ($9.20/lb U_3O_8) and $26.52/kgU ($10.20/lb U_3O_8), respectively by 31 August 1997.

The increase in uranium prices observed from October 1994 to mid-1996 was taken by some commentators to indicate the beginning of a recovery period for the uranium market. However, the return to falling spot prices in mid-1996 indicated that the over-supply situation still dominated the market through mid-1997.

While the world uranium industry has shown signs of change and renewal in the last few years, the events characterising the uranium market illustrate the persistent uncertainty faced by all uranium producers and consumers. With world nuclear capacity expanding and uranium production satisfying less than 65 per cent of demand since 1990, uranium stockpiles have continually been depleted at a high rate (i.e. up to 28 200 tU/year). The uncertainty related to the remaining levels of world uranium stockpiles and to the amount of surplus defence material that will be entering the market make it difficult to determine when a closer balance between uranium supply and demand will be reached, and what will be the price equilibrium that develops between the new supplies and uranium buyers.

Known Conventional Resources (RAR and EAR-I)

As of 1 January 1997, Known Conventional Resources (RAR and EAR-I) recoverable at costs of ≤$130/kgU amount to about 4 299 000 tU. Compared to the last edition of the Red Book (1995), the total increased by about 448 000 tU or by 12 per cent. The increase is partly due to the inclusion of resources previously in the “Other Known Resources” category (e.g. the Russian Federation, Uzbekistan and India) and partly from reassessment of resources made in several countries.

As of 1 January 1997, total resources in the RAR category recoverable at $80/kgU or less are 2 340 000 tU, or about 10 per cent more than in 1995. In the EAR-I category, 745 000 tU are estimated in the cost category of ≤$80/kgU, or 17 per cent more than in 1995. Increases have been reported in both categories producible at $80/kgU or less by Canada (61 000 and 69 000 tU) and South Africa (14 000 and 10 000 tU). New information was contributed by the Russian Federation (145 000 and 36 500 tU) and Uzbekistan (66 000 and 39 000 tU).

In the RAR category, about 757 990 tU are reported by 11 countries as producible at ≤$40/kgU. This is about 30 per cent of the RAR cost category ≤$80/kgU. In the category EAR-I, about 300 110 tU are reported in the cost range of ≤$40/kgU, which is about 36 per cent of the EAR-I cost category of ≤$80/kgU.

RAR, recoverable at costs of ≤$130/kgU, increased to 3 349 900 tU, or by about 213 000 tU (7 per cent) over 1995. The EAR-I category recoverable at ≤$130/kgU increased to 1 079 000 tU, or about 179 000 tU (20 per cent) more than in 1995.

Uranium Exploration

After more than 10 years of decreasing exploration activities, there was an increase of exploration expenditures in 18 of the 26 reporting countries. Another 24 countries reported that no uranium exploration took place in 1995 and 1996. The amount of exploration activities are still quite low compared with the early 1980s.

In 1995, a total of 26 countries reported exploration expenditures of US$ 83.6 million, an increase of 12 per cent over 1994 (US$ 74.7 million). In 1996, 24 countries reported exploration expenditures totalling about US$ 85.9 million. For comparison, in 1986, about US$ 180 million were spent in 37 countries, not including expenditures in former non-WOCA (World Outside Centrally Planned Economic Areas) countries. Currently most exploration activities (accounting for 83 per cent of expenditures) are taking place in Australia, Canada, Egypt, India, the Russian Federation, USA and Uzbekistan, and to a lesser extent in France, Gabon, Mongolia and Romania.

Exploration efforts of Canadian, French, German, Japanese, Korean and US companies, in countries outside their national boundaries, declined from US$ 48.8 million in 1994 to US$ 21.5 million in 1996. This primarily resulted from declining overseas exploration expenditures by France.

Uranium Production

World uranium production increased 5 per cent to about 33 200 tU in 1995 and about 9 per cent to 36 200 tU in 1996. After falling over 36 per cent from 1990, uranium production reached a low of 31 611 tU in 1994. The changes in the level of production are unevenly distributed geographically. In the former WOCA countries, annual increases of more than 12 per cent occurred, while production in the rest of the world decreased by about 18 per cent from 1994 to 1996. Taking into account announced plans for 1997, and estimates made for non-reporting countries, the world production may increase to the range of 38 000 to 39 000 tU, or more in 1997.

In 1996, twenty-three countries produced uranium, including Germany which recovered uranium in association with its industry closure programme. The ten major producers (Australia, Canada, Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, Ukraine, USA and Uzbekistan) contributed about 90 per cent of the output. Total production from China, India and Pakistan is estimated to account for about 2-3 per cent of the output. The production came from about 63 mining centres, with concentrates produced at about 44 processing plants (mills).

Employment associated with uranium production, reported by 21 countries, not including India, Mongolia, Pakistan and South Africa, fell from 59 071 to 52 363 person years from 1994 to 1996, a decrease of 11 per cent.

Conventional mining and milling remained the dominant technology for producing uranium by contributing nearly 80 per cent of the world output over the period 1994 to 1996. Underground mining continues to contribute slightly more than open pit mining. The share produced by ISL technology has remained nearly constant at around 14 per cent of the production. Other methods (phosphate by-product, heap and in-place leaching) contribute to about 7 per cent of the total. In this estimate, all South African and Olympic Dam (Australia) production is classified with the conventional technology.

Projected Production Capabilities

A projection of world uranium production capability through 2015 is provided in this report based on plans of 25 producing and/or potentially producing countries. Two projections are given: Existing and Committed production centres, and Planned and Prospective facilities. Both projections are made using RAR and EAR-I resources recoverable at costs of US$ 80/KgU or less, and which are tributary to the production centres.

In 1997, the annual production capability of Existing and Committed production centres is about 42 900 tU. By 1998, the capability of Existing and Committed centres increases to about 45 600 tU. By 2000, the capability from Existing and Committed centres will decrease slightly to 45 200 tU per year. The closure of existing mines (because of resource depletion) results in the Existing and Committed capability falling sharply to 33 400 tU by 2005. The Existing and Committed capability then continues to fall slowly to about 32 100 tU in 2015.

The uranium production industry will undergo considerable change over the 1997 to 2005 period. In 1996, with plant capacity utilisation at about 85 per cent, Existing and Committed capability (42 500 tU) was about 70 per cent of 1996 requirements. This relationship is expected to remain about the same through 2000. With expected facility closures after 2000, Existing and Committed capability equals less than 50 per cent of projected requirements by 2005. By 2015 only about 40 to 50 per cent of requirements will be met by Existing and Committed capability.

By 2000, Planned and Prospective centres are projected to add about 14 600 tU for a total Existing, Committed, Planned and Prospective capability of about 59 800 tU. By 2005 Planned and Prospective production is projected to comprise about 28 300 tU of capability. Putting this total capability into service by 2005 would make available 61 600 tU per year, equivalent to about 90 per cent of annual requirements. Planned and Prospective capability is then projected to continue increasing to about 33 100 tU in 2010. Total Existing, Committed, Planned and Prospective capability would then be about 66 200 tU, equivalent to 86 to 93 per cent of requirements.

Planned and Prospective capability will then decline to about 28 600 tU by 2015, while total Existing, Committed, Planned and Prospective capability is projected to be about 60 700 tU. This is between 73 and 97 per cent of projected requirements.

Development of the projected capability described above would leave unfilled requirements of about 5 000 tU in 2000, 5 000 to 8 000 tU in 2005, 5 000 to 11 000 tU in 2010, and 2 000 to 22 000 tU in 2015. The unfilled requirements could be met by alternative sources of supply including civilian inventories, LEU blended from HEU, sales from government stockpiles and reprocessed material.

Uranium Inventories

Based on a survey of world utilities and other holders (i.e. government, producer and others) of inventory, the Uranium Institute estimated the world inventory was 160 000 tU at year end 1995. The inventories held by China and the Russian Federation are not known.

The history of uranium supply and demand has been dominated by an imbalance between production and consumption. For many years production exceeded reactor requirements and other uses, resulting in the accumulation of large stockpiles in the world.

Since 1990 world uranium production has been below uranium requirements which has substantially reduced inventories. The difference between world production and reactor requirements increased from 11 000 tU in 1991 to about 28 000 tU in 1995. It was about 24 300 tU in 1996. By 1 January 1997 the cumulative difference over the period was about 136 000 tU. Much of this shortfall has been met by the world-wide drawdown of inventory. A small portion was being met from reprocessing of discharged fuel and the sale of LEU blended from Russian HEU.

Currently there are no indications that this condition of a large difference between production and requirements has significantly changed. It is expected that 1997 requirements could exceed production by more than 20 000 tU. The development of planned projects discussed in this report could substantially reduce the imbalance in future years.

Other Supply Sources

In 1996, more definitive plans and schedules for disposing of Russian Government surplus HEU and US Government surplus HEU, natural uranium, and LEU were announced. Under current schedules, around 180 800 tU (470 million pounds U_3O_8) and 100 million separative work units (SWU) of enrichment are expected to be displaced by the commercialisation of US and Russian Government surplus inventories over the next 15 to 20 years. Over 11 500 tU (30 million pounds U_3O_8) and 6 million SWU from these sources could enter the market annually within the next 5 years. The blending down of 500 tonnes of Russian surplus HEU will contribute the largest share; it is equivalent to about 153 000 tU (398 million pounds U_3O_8) and 92 million SWU. The United States Enrichment Corporation (USEC) Privatisation Act established a quota for the sale to the United States end users of uranium derived from Russian HEU: from 769 tU (2 million pounds U_3O_8) in 1998, to 5 000 tU (13 million pounds U_3O_8) in 2004, reaching 7 692 tU (20 million pounds U_3O_8) by 2009. The HEU-derived material represents 4 per cent of US reactor requirements in 1998, increasing to 33 per cent by 2004, and reaching more than 50 per cent in 2009. This is equivalent to between 1 and 11 per cent of the annual world requirements over the period.

Recycling of recovered plutonium in Mixed Oxide (MOX) fuel (and to a lesser extent reprocessed uranium) is being utilised in the civilian fuel cycles of some countries. This technology improves the overall efficiency of the fuel cycle but will not dramatically alter world uranium demand in the short term, as the quantities involved are rather small. In 1996 about 1 200 tU (natural equivalent) of MOX, and 500 tU reprocessed uranium were burned in utility reactors in the European Union. At present no other countries are using significant amounts of MOX. The use of MOX could increase to 3 000 tU (natural equivalent) by 2010.

The US Government is investigating ways of disposing of its declared 38.2 t of excess plutonium inventory. One proposed option is to burn the plutonium as MOX fuel in civilian reactors at the rate of 2.25 t Pu per year, or at about 380 tU natural equivalent uranium over the 2005 to 2022 period. A similar programme may be developed to dispose of excess plutonium held by the Russian Federation.

Radiation Safety and Environmental Aspects

The section on radiation safety and environmental aspects of uranium mining and production has been included for the second time in this publication to inform readers about the relevance of environmental protection. This aspect is becoming more important due to two developments: first, the increasing number of production facilities which have recently been taken out of operation, and second, the increasing requirement for environmental clearance approvals for new projects. In addition, environmental aspects need to be considered for production sites which were abandoned at a time when legal provisions for proper decommissioning and rehabilitation had not been established. Many of these sites were abandoned without taking safety or reclamation and restoration measures into consideration. Important environmental activities are reported by several countries including Australia, Canada, Czech Republic, France, Germany, Kazakhstan, Namibia, South Africa, USA and Uzbekistan. Environmental activities related to new projects are becoming increasingly important with the large amount of new production capability required over the next 10 years and beyond.

Uranium Demand

World annual requirements of nuclear power plants in 1996 were estimated at about 60 488 tonnes natural uranium equivalent. An increase of about 3 300 tU to 63 757 tU was expected for 1997. Reactor-related requirements over the short term are determined mainly by the installed nuclear capacity, or more specifically, by nuclear generation. By the beginning of 1997, there were 442 nuclear power units operating in the world with a total net capacity of 353 GWe connected to the grid. A total of 36 new reactors are under construction with a capacity of about 28 GWe. In recent years, however, the growth in nuclear power has slowed considerably. Only about 13 GWe of new installed capacity has been added since the last Red Book study two years ago.

Improvements and modifications to nuclear reactor technology may also affect requirements; however, these factors are not likely to have a major impact before 2015. Fuel utilisation in thermal reactors can primarily be improved by: optimising in-core management, lowering the tails assay in the depleted stream of enrichment plants, and recycling plutonium. Higher availability factor and reactor power levels increase uranium requirements of existing plants, while higher burnup reduces requirements.

Uranium Demand Projections

The world nuclear capacity is expected to grow from 353 GWe in 1996 to levels ranging between 395 GWe and 501 GWe by the year 2015. This represents a 12 to 42 per cent increase from

1996 capacity, or an annual growth rate ranging from 0.6 to 1.9 per cent for the forecasting period. While the high projections indicate steady growth in nuclear capacity through the year 2015, the low projections show a steady increase up to 427 GWe by 2010, followed by a reduction to 395 GWe in 2015.

World reactor-related uranium requirements are projected to increase from 60 488 tU in 1996 to between 62 500 tU and 82 800 tU by the year 2015. This corresponds to annual growth rates of 0.2 to 1.7 per cent. The cumulative requirements over the period 1997 to 2015 range from 1 262 000 tU to 1 366 000 tU.

Uncertainties in the projections arise from different assumptions about construction schedules of nuclear power plants, cancellations, new orders, and the potential for reactor life extension. Changes in national economic and regulatory policies and in the structure of the electricity supply industry may also have an increasing impact on nuclear plant lifetimes with a corresponding impact on uranium requirements.

Supply-Demand Relationships

The 1996 world uranium production (36 195 tU) provided only about 60 per cent of the world reactor requirements (60 488 tU). In OECD countries the 1996 production (21 183 tU) satisfied only 42 per cent of the demand (50 372 tU). The remaining material to fuel reactors came primarily from stockpiles. Small amounts came from the sale of Low Enriched Uranium (LEU) from Highly Enriched Uranium (HEU). An additional 1 700 tU (natural equivalent) was from MOX fuel (1 200 tU) and reprocessed uranium (500 tU).

Uranium demand over the short-term is fundamentally determined by nuclear capacity. Although there are uncertainties related to potential changes in world nuclear capacity, short-term uranium requirements are fairly predictable. Most of nuclear capacity is already in operation; there is only a limited degree of uncertainty regarding construction lead times and in the implementation of plans for new units in some countries. Operational factors such as load factors, plutonium recycle/MOX fuel, and burnup may also affect requirements; however, these factors are not likely to have a major impact. Another potential source of uncertainty is the possibility of early retirement of nuclear reactors. The potential for reductions of nuclear capacity exists in a few countries that have some relatively inefficient old nuclear units and where restructuring of the electricity supply industry may have an impact on nuclear plant lifetimes. Nevertheless, it is expected that the projected number of additions of nuclear plants world-wide would be sufficient to offset potential early plant retirements.

There is a higher level of uncertainty in the supply side of the uranium market over the next two decades. The uncertainty is primarily related to the large changes expected to take place regarding sources of reactor fuel. When will these changes occur and what will be the relative importance of each of the supply sources? Could periods of disequilibrium occur as the large changes take place?

For several years requirements have been met by production, supplemented by uranium from stockpiles. Since 1991 drawdown of stockpiles has supplied between 20 per cent and 50 per cent of the reactor requirements not met by production. Other sources including MOX fuel, reprocessed uranium, LEU from HEU and sales of US Government stockpiles have met a few per cent of demand in the last few years. It now appears that excess stockpiles are nearing exhaustion; however, the amount of Russian stockpile material is unknown.

It is therefore necessary that a new equilibrium be established between supply and demand. Over the next few years the supply from inventory is expected to decrease, while the relative contribution from both production and other alternative supplies will increase. The largest alternative supply is expected to be LEU blended from 500 t of Russian HEU purchased by the US. Additional amounts will be made available from surplus HEU, natural uranium and LEU. Small amounts of demand are expected to be met by MOX and reprocessed uranium. An additional small contribution could come from burning of weapons plutonium held by both the US and the Russian Federation sometime after 2005.

Mine production is expected to continue to be the supply source satisfying the largest share of requirements. In the longer term, it is expected that reactor-related uranium requirements and production will achieve a closer balance. A more balanced market between production and demand may be achieved when stockpiles of excess materials have been drawn down and once a considerable amount of converted weapons material has entered the market.

Concerns about longer term security of supply of fossil fuels and the heightened awareness that nuclear power plants are environmentally clean with respect to acid rain and greenhouse gas emissions might contribute to even higher than projected growth in uranium demand over the long-term. In particular, the increasing importance of the debate on greenhouse gases and global warming could increase public acceptance of nuclear power as a valid alternative within the framework of long-term sustainable development.

DEFINITIONS AND TERMINOLOGY

Only minor changes have been made to the NEA/IAEA resource terminology and definitions since the modifications that were introduced in the December 1983 edition of the Red Book. An exception was the introduction in the 1993 edition of the Red Book of a new lower-cost category, i.e., resources recoverable at $40/kgU or less. This category was introduced to reflect a more relevant cost range to current uranium market prices.

RESOURCE ESTIMATES

Resource estimates are divided into separate categories reflecting different levels of confidence in the quantities reported. The resources are further separated into categories based on the cost of production. *All resource estimates are expressed in terms of metric tons (t) of recoverable uranium (U) rather than uranium oxide (U_3O_8).* Estimates refer to quantities of uranium recoverable from mineable ore, unless otherwise noted (see d).

a) Definitions of Resource Categories

Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of deposit characteristics. Reasonably Assured Resources have a high assurance of existence.

Estimated Additional Resources – Category I (EAR-I) refers to uranium in addition to RAR that is inferred to occur, mostly on the basis of direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data, including measurements of the deposits, and knowledge of the deposits' characteristics are considered to be inadequate to classify the resource as RAR. Estimates of tonnage, grade and cost of further delineation and recovery are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR.

Estimated Additional Resources – Category II (EAR-II) refers to uranium in addition to EAR-I that is expected to occur in deposits for which the evidence is mainly indirect and which are believed to exist in well-defined geological trends or areas of mineralization with known deposits. Estimates of tonnage, grade and cost of discovery, delineation and recovery are based primarily on knowledge of deposit characteristics in known deposits within the respective trends or areas and on such sampling, geological, geophysical or geochemical evidence as may be available. Less reliance can be placed on the estimates in this category than on those for EAR-I.

Figure 1. **Approximative Correlations Of Terms Used In Major Resources Classification Systems**

	← Known Resources →			← Undiscovered Resources →		
NEA/IAEA	Reasonably Assured		Estimated Additional I	Estimated Additional II	Speculative	
Australia	Reasonably Assured		Estimated Additional I	Undiscovered		
Canada (NRCan)	Measured	Indicated	Inferred	Prognosticated	Speculative	
France	Reserves I	Reserves II	Perspective I	Perspective II		
Germany	Proven	Probable	Possible	Prognosticated	Speculative	
United States (DOE)	Reasonably Assured		Estimated Additional		Speculative	
Russian Federation, Kazakhstan, Ukraine, Uzbekistan	A + B	C 1	C 2	P1	P2	P3

The terms illustrated are not strictly comparable as the criteria used in the various systems are not identical. "Grey zones" in correlation are therefore unavoidable, particularly as the resources become less assured. Nonetheless, the chart presents a reasonable approximation of the comparability of terms.

Speculative Resources (SR) refers to uranium, in addition to Estimated Additional Resources – Category II, that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. The location of deposits envisaged in this category could generally be specified only as being somewhere within a given region or geological trend. As the term implies, the existence and size of such resources are speculative.

The correlation between the resource categories defined above and those used in resource classification systems is shown in Figure 1.

b) Cost Categories

The cost categories used in this report are the same specified in the 1995 edition of the Red Book. The categories are defined as: $40/kgU or less; $80/kgU or less; $130/kgU or less; and $260/kgU or less. In this edition, the current year costs are expressed in terms of 1st January 1997 US$.

NOTE: It is not intended that the cost categories should follow fluctuations in market conditions.

To convert from costs expressed in $/lb U_3O_8 to $/kgU, a factor of 2.6 has been used (e.g., $40/kgU = $15.38/lb U_3O_8, $80/kgU = $30.77/lb U_3O_8, $130/kgU = $50/lb U_3O_8).

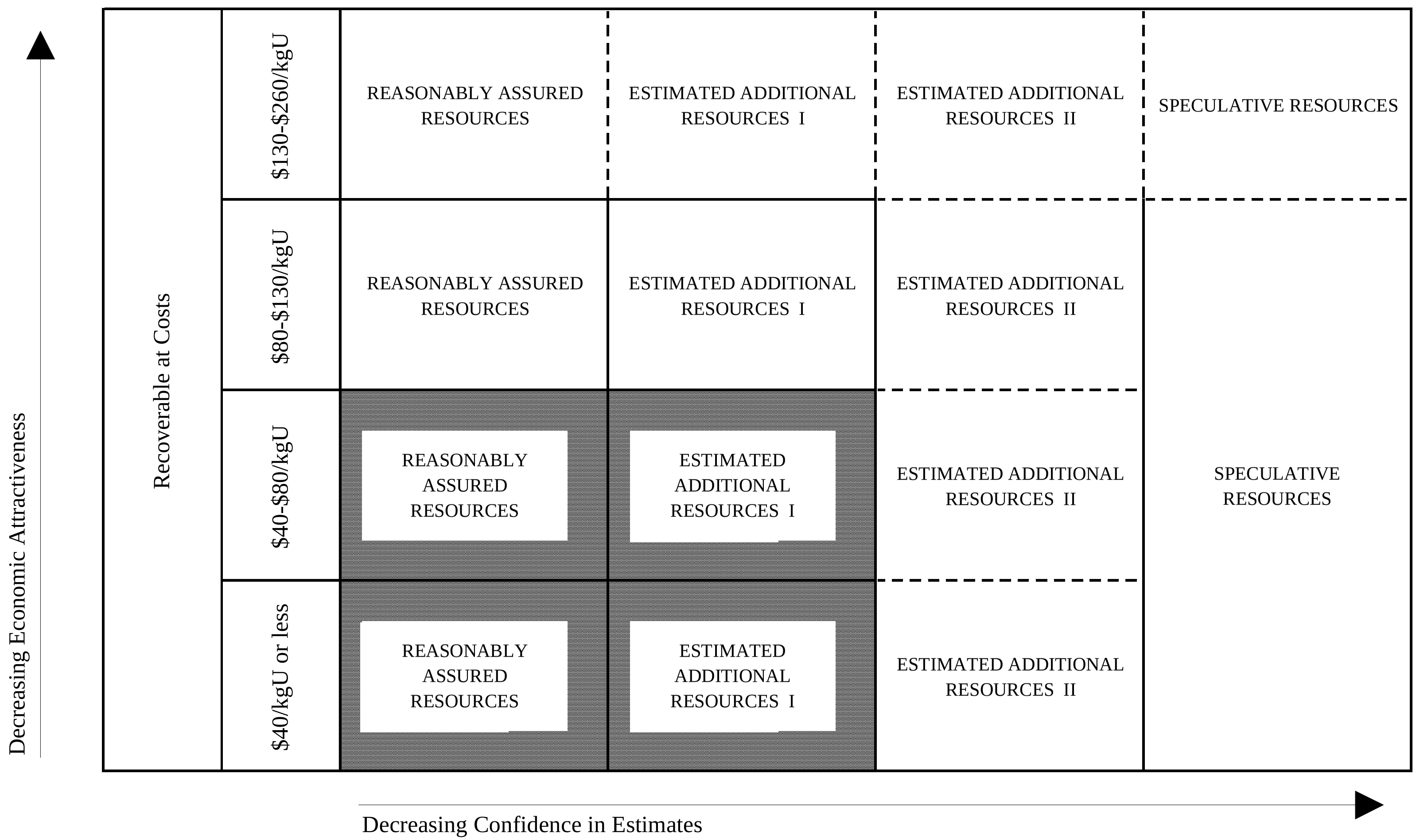
Conversion from other currencies into US$ should be done using the exchange rates of 1st January 1997. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant.

When estimating the cost of production for assigning resources within these cost categories, account has been taken of the following costs:

- the direct costs of mining, transporting and processing the uranium ore;
- the costs of associated environmental and waste management during and after mining;
- the costs of maintaining non-operating production units where applicable;
- in the case of ongoing projects, those capital costs which remain unamortized;
- the capital cost of providing new production units where applicable, including the cost of financing;
- indirect costs such as office overheads, taxes and royalties where applicable;
- future exploration and development costs wherever required for further ore delineation to the stage where it is ready to be mined.

Sunk costs were not normally taken into consideration.

Figure 2. **NEA/IAEA Classification Scheme For Uranium Resources**



c) Relationship between resource categories

Figure 2 illustrates the inter-relationship between the different resource categories. The horizontal axis expresses the level of assurance about the actual existence of given tonnages based on varying degrees of geologic knowledge while the vertical axis expresses the economic feasibility of exploitation by the division into cost categories.

The dashed lines between RAR, EAR-I, EAR-II and SR in the highest cost category indicate that the distinctions of level of confidence are not always clear. The shaded area indicates that known resources (i.e., RAR plus EAR-I) recoverable at costs of $80 kgU or less are distinctly important because they support most of the world's EXISTING and COMMITTED production centres. RAR at prevailing market prices are commonly defined as “Reserves”.

Because resources in the EAR-II and SR categories are undiscovered, the information on them is such that it is not always possible to divide them into different cost categories and this is indicated by the horizontal dashed lines between the different cost categories.

d) Recoverable Resources

Resource estimates are expressed in terms of recoverable tonnes of uranium, i.e. quantities of uranium recoverable from mineable ore, as opposed to quantities contained in mineable ore, or quantities in-situ. Therefore both expected mining and ore processing losses have been deducted in most cases. Deviations from this practice are indicated in the tables. In-situ resources are recoverable resources in the ground not taking into account mining and milling losses.

e) Types of Resources

To obtain a better understanding of the uranium resource situation, reference is made to different geologic types of deposits containing the resources and a distinction is drawn between conventional and unconventional resources, as follows:

i) Geologic types of uranium deposits

The major uranium resources of the world can be assigned on the basis of their geological setting to the following 15 ore types:

1. Unconformity-related deposits;
2. Sandstone deposits;
3. Quartz-pebble conglomerate deposits;
4. Vein deposits;
5. Breccia complex deposits;
6. Intrusive deposits;
7. Phosphorite deposits;
8. Collapse breccia pipe deposits;
9. Volcanic deposits;
10. Surficial deposits;
11. Metasomatite deposits;
12. Metamorphic deposits;

13. Lignite;
14. Black shale deposits;
15. Other types of deposits.

(See Annex 3 for a more detailed discussion of deposit types.)

ii) Conventional and unconventional resources

Conventional resources are those that have an established history of production where uranium is either a primary product, co-product or an important by-product (e.g., gold). The first six geological ore types listed above, together with selected types from categories seven, eight, nine and eleven, are considered to be conventional resources. Very low grade resources, which are not now economic or from which uranium is only recoverable as a minor by-product are considered unconventional resources (e.g., phosphates, monazite, coal, lignites, black shales).

PRODUCTION TERMINOLOGY[1]

a) Production Centres

A PRODUCTION CENTRE, as referred to in this report, is a production unit consisting of one or more ore processing plants, one or more associated mines and the resources that are tributary to them. For the purpose of describing production centres, they have been divided into four classes, as follows:

i) EXISTING production centres are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.

ii) COMMITTED production centres are those that are either under construction or are firmly committed for construction.

iii) PLANNED production centres are those for which feasibility studies are either completed or under way, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.

iv) PROSPECTIVE production centres are those that could be supported by tributary RAR and EAR-I, i.e., “known resources”, but for which construction plans have not yet been made.

b) Production Capacity and Capability

PRODUCTION CAPACITY denotes the nominal level of output, based on the design of the plant and facilities over an extended period, under normal commercial operating practice.

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(1) Manual on the Projection of Uranium Production Capability, General Guidelines, Technical Report Series No. 238, IAEA, Vienna, Austria, 1984.

PRODUCTION CAPABILITY refers to an estimate of the level of production that could be practically and realistically achieved under favourable circumstances from the plant and facilities at any of the types of production centres described above, given the nature of the resources tributary to them.

Projections of production capability are supported only by RAR and/or EAR-I. One projection is presented based on those resources recoverable at costs up to $80/kgU.

DEMAND TERMINOLOGY

REACTOR-RELATED REQUIREMENTS refer to uranium acquisitions *not* consumption.

UNITS

Metric units are used in all tabulations and statements. Resources and production quantities are expressed in terms of metric tons (t) contained uranium (U) rather than uranium oxide (U_3O_8).

1 short ton U_3O_8 = 0.769 tU $1/lb U_3O_8 = $2.6/kgU

Exploration expenditures are reported in US dollars. Conversions from other currencies have been done using exchange rates for June of the year in which the expenditures were incurred.

GEOLOGICAL TERMS

a) Uranium occurrence

A naturally occurring anomalous concentration of uranium.

b) Uranium deposit

A mass of naturally occurring mineral material from which uranium could be exploited at present or in the future.

I. URANIUM SUPPLY

This chapter summarises the current status of uranium resources, exploration and production in the world. In addition, production capabilities in reporting countries for the period ending in the year 2015 are presented and discussed. The last section of the chapter describes relevant aspects of radiation safety and environmental protection in uranium mining and milling.

A. URANIUM RESOURCES

Known Conventional Resources

Known Conventional Resources consist of Reasonably Assured Resources (RAR) and Estimated Additional Resources Category I (EAR-I) recoverable at a cost of $130/kgU or less (≤$130/kgU).

Tables 1 and 2, which include RAR and EAR-I estimates respectively, are subdivided into two parts. Tables 1a and 2a list resource estimates made within the last five years, Tables 1b and 2b include resource estimates assessed prior to that period. Some countries report in situ resource estimates that are not adjusted to account for mining and milling losses. These estimates are not fully consistent with NEA/IAEA standard terminology and therefore, the in situ estimates in these tables are identified.

As of 1 January 1997, Known Conventional Resources (RAR and EAR-I) recoverable at costs of ≤$130/kgU amount to about 4 299 000 tU (see Tables 1 and 2). Compared to the last edition of the Red Book (1995), the total increased by about 448 000 tU. The increase is partly due to the inclusion of resources previously included in the "Other Known Resources" category (e.g. the Russian Federation, Uzbekistan, India) and partly from reassessments of resources made in several countries.

In addition China reports known resources of more than 64 000 tU, with no cost range assigned.

As of 1 January 1997, known resources recoverable at costs of $80/kgU or less (≤$80/kgU) are 3 085 000 tU, or about 324 000 tU more than in 1995. The increase is due to reclassification of several "Other Known Resources" into the RAR and EAR-I categories and the reassessment of resources in several countries.

In both cost ranges, resources of the Russian Federation and of Uzbekistan are, for the first time, reported separately as RAR and EAR-I. A major revision was made by Canada, increasing the RAR and EAR-I at a cost of ≤$80/kgU, to 430 000 tU, compared to 300 000 tU in 1995; and removing all of the RAR and EAR-I in the $80–130/kgU cost range. South Africa reports increased known resources.

Table 1a. **Reasonably Assured Resources (in 1 000 tU, as of 1.1.1997)**
Assessment made within last 5 years

COUNTRY	Cost Ranges				
	≤ $40/kgU	$40-80/kgU	≤ $80/kgU	$80-130/kgU	≤ $130/kgU
Argentina	NA	NA	4.62	4.22	8.84
Australia	NA	NA	622.00	93.00	715.00
Bulgaria (a) **	2.22	5.61	7.83	0	7.83
Canada	conf.	conf.	331.00	0	331.00
Czech Republic (b)	0	6.63	6.63	23.59	30.22
Finland (a)	0	0	0	1.50	1.50
France	NA	NA	13.46	8.90	22.36
Gabon	6.03	–	6.03	0	6.03
Germany	0	0	0	3.00	3.00
Greece *	1.00	–	1.00	–	1.00
Hungary (a)	0	0.37	0.37	0	0.37
India (a)	NA	NA	NA	NA	52.08
Indonesia (a) *	0	0	0	6.27	6.27
Kazakhstan (a)	323.34	115.88	439.22	162.04	601.26
Mongolia (a) **	10.60	51.00	61.60	0	61.60
Namibia	74.09	82.04	156.12	31.23	187.36
Niger	41.80	28.16	69.96	0	69.96
Peru (a)	–	–	1.79	0	1.79
Portugal	NA	NA	7.30	1.60	8.90
Romania	–	–	–	–	6.90
Russian Federation (a)	66.10	78.90	145.00	–	145.00
Slovenia	0	2.20	2.20	0	2.20
South Africa	110.50	107.80	218.30	51.50	269.80
Spain	NA	NA	4.65	7.51	12.16
Ukraine (a)	0	45.60	45.60	38.40	84.00
United States	NA	NA	110.00	251.00	361.00
Uzbekistan	66.21	0	66.21	17.49	83.70
Zimbabwe (a) *	NA	NA	1.80	NA	1.80
Sub total 1a (c)	> 701.89	> 524.19	2 322.70	701.25	3 082.93

Table 1b. **Assessment not made within last 5 years or not reported for 1997**

Algeria (a) *	–	–	26.00	0	26.00
Brazil (a)	56.10	105.90	162.00	0	162.00
Central African Republic*	–	–	8.00	8.00	16.00
Denmark *	0	0	0	27.00	27.00
Italy *	–	–	4.80	0	4.80
Japan	–	–	–	6.60	6.60
Mexico (a) *	–	–	0	1.70	1.70
Somalia (a) *	–	–	0	6.60	6.60
Sweden	0	0	0	4.00	4.00
Turkey (a)	–	–	9.13	0	9.13
Vietnam	NA	NA	NA	1.34	1.34
Zaire (a) *	–	–	1.80	0	1.80
Sub total 1b (c)	56.10	105.90	211.73	55.24	266.97
Total (c)	**> 757.99**	**> 630.09**	**2 534.43**	**756.49**	**3 349.90**
Total adjusted (d)	**> 666.00**	**> 555.00**	**2 340.00**	**718.00**	**3 220.00**

– No resources reported. NA = Data not available. conf. = Confidential.
(a) In situ resources. (b) Mineable resources.
(c) Subtotal and totals related to cost ranges ≤$40/kgU and $40–80/kgU are higher than reported in the tables because certain countries do not report resource estimates, mainly for reasons of confidentiality.
(d) Adjusted to account for estimated mining and milling losses, not incorporated in certain estimates.
* Data from previous Red Book. ** Data from previous Red Book, depleted by past production.

Table 2a. **Estimated Additional Resources – Category I (in 1 000 tU, as of 1.1.1997)**
Assessment made within last 5 years

COUNTRY	Cost Ranges				
	≤ $40/kgU	$40-80/kgU	≤ $80/kgU	$80-130/kgU	≤ $130/kgU
Argentina	NA	NA	0.90	2.21	3.11
Australia	NA	NA	136.00	44.00	180.00
Bulgaria (a) *	2.20	6.20	8.40	0	8.40
Canada	conf.	conf.	99.00	0	99.00
Czech Republic (b)	0	1.18	1.18	17.78	18.96
France	NA	NA	1.21	0.19	1.40
Gabon	1.00	0	1.00	–	1.00
Germany	0	0	0	4.00	4.00
Greece *	–	–	6.00	0	6.00
Hungary (a)	0	0	0	15.41	15.41
India (a)	NA	NA	NA	NA	24.25
Indonesia (a) *	–	–	–	1.67	1.67
Kazakhstan (a)	113.20	82.70	195.90	63.40	259.30
Mongolia (a) *	11.00	10.00	21.00	0	21.00
Namibia (a)	70.55	20.27	90.82	16.70	107.52
Niger	1.20	0	1.20	0	1.20
Peru (a)	–	–	1.86	0	1.86
Portugal (a)	–	–	1.45	0	1.45
Romania	–	–	–	–	8.95
Russian Federation (a)	17.20	19.30	36.50	–	36.50
Slovenia	–	–	5.00	5.00	10.00
South Africa	44.40	21.70	66.10	21.70	87.80
Spain	NA	NA	NA	NA	8.19
Ukraine (a)	0.00	17.00	17.00	30.00	47.00
Uzbekistan	39.36	0.00	39.36	7.14	46.50
Sub total 2a (c)	**> 300.11**	**> 178.35**	**729.88**	**229.20**	**1 000.47**

Table 2b. **Assessment not made within last 5 years or not reported for 1997**

Algeria (a) *	–	–	0.70	1.00	1.70
Brazil (a)	NA	NA	100.20	0	100.20
Denmark *	–	–	0	16.00	16.00
Italy *	–	–	0	1.30	1.30
Mexico (a) *	–	–	0	0.70	0.70
Somalia (a) *	–	–	0	3.40	3.40
Sweden	0	0	0	6.00	6.00
Vietnam	NA	NA	0.49	6.25	6.74
Zaire (a) *	–	–	1.70	0	1.70
Sub total 2b (c)			103.09	34.65	137.74
Total (c)	**> 300.11**	**> 178.35**	**832.97**	**263.85**	**1 138.21**
Total adjusted (d)	**> 257.00**	**> 158.00**	**745.00**	**244.00**	**1 079.00**

– No resources reported. NA = Data not available. conf. = Confidential.

(a) In situ resources.

(b) Mineable resources.

(c) Subtotal and totals related to cost ranges ≤$40/kgU and $40–80/kgU are higher than reported in the tables because certain countries do not report resource estimates, mainly for reasons of confidentiality.

(d) Adjusted to account for estimated mining and milling losses, not incorporated in certain estimates.

* Data from previous Red Book.

Figure 3. **Distribution of Reasonably Assured Resources (RAR) Among Countries with Major Resources**

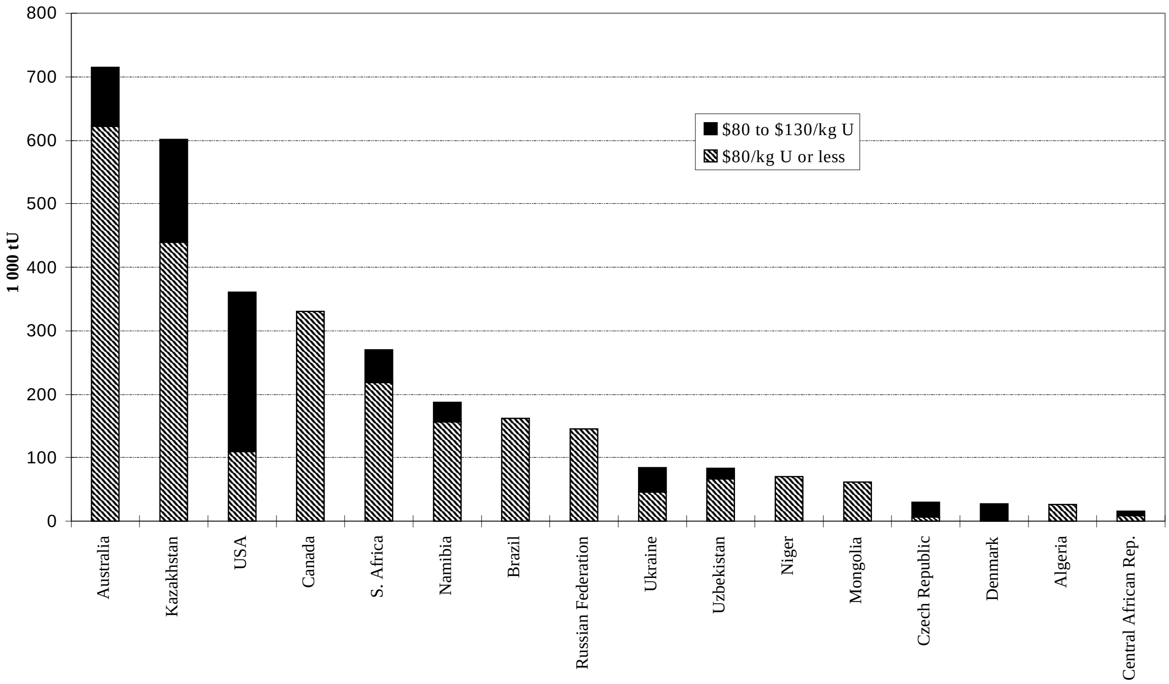
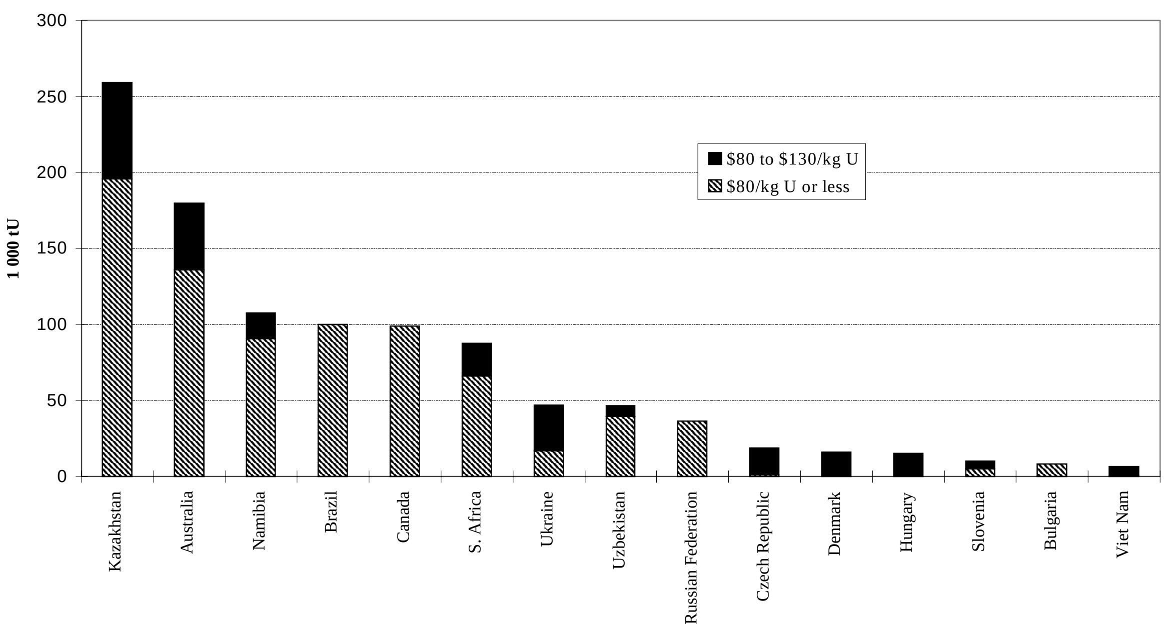


Figure 4. Distribution of Estimated Additional Resources Category I (EAR-I) Among Countries with Major Resources



Introduction of the cost range of $40/kgU or less

In the 1995 edition of the Red Book, data for **Known Resources** in the cost category of $40/kgU or less (≤$40/kgU) were reported for the first time by a few countries. Most of these were reported as in situ resources. For the 1997 edition of the Red Book, a number of countries continue to report that they do not estimate resources recoverable at ≤$40/kgU or are unable to report them due to confidentiality. Other countries report there are no existing resources recoverable at costs ≤$40/kgU.

Reported **Known Resources** as of 1 January 1997 in the cost category of ≤$40/kgU are 1 058 100 tU, of which 672 500 tU are in situ resources. This compares to a total of 866 000 tU reported in 1995, of which about 587 000 tU were in situ resources. The increase is mainly due to resources reported for the first time by the Russian Federation and Uzbekistan.

In addition Known Resources in the cost range of $40–80/kgU have been reported as 808 440 tU of which 558 700 are in situ resources, compared to 723 000 tU in 1995. The increase is due to resources reported by the Russian Federation and Uzbekistan, partly balanced by a decrease in Brazil.

Distribution of Known Resources Categories and Cost Ranges

In the RAR category recoverable at costs of ≤$130/kgU, the world total increased by about 213 000 tU (7 per cent) over 1995. The total of 3 349 900 tU includes about 1 171 000 tU reported as in situ resources; therefore, it was adjusted to about 3 220 000 tU, by taking mining and milling losses into account. This is about 269 000 tU more than in 1995. The increase is due to new resource information for India, the Russian Federation and Uzbekistan formerly reported as “Other Known Resources”.

In the EAR-I category recoverable at costs of ≤$130/kgU, about 1 138 210 tU have been estimated, of which about 632 000 tU are in situ resources; therefore, the total was adjusted to 1 079 000 tU, or about 179 000 tU more than 1995. The increase is due to new resource data made available by India, the Russian Federation and Uzbekistan.

In the RAR category, about 2 534 430 tU are reported in the cost range of ≤$80/kgU, of which about 900 000 tU are reported as in situ resources. The total, adjusted for mining and milling losses, is 2 340 000 tU, which is 216 000 tU (10 per cent) more than in 1995. In the EAR-I category, about 832 970 tU are estimated in the cost range ≤$80/kgU, of which about 476 000 tU are in situ resources. The total, adjusted as above, amounts to 745 000 tU, which is 108 000 tU (17 per cent) more than in 1995. In both categories increases have been reported by Canada (61 000 and 69 000 tU) and South Africa (14 000 and 10 000 tU). New information was contributed by Uzbekistan (66 210 and 39 360 tU) and the Russian Federation (145 000 and 36 500 tU).

In the RAR category, about 757 990 tU are reported by 11 countries in the cost range of ≤$40/kgU. This is about 23 per cent of the RAR cost category of ≤$130/kgU, or 30 per cent of the RAR cost category ≤$80/kgU. In the category EAR-I, about 300 110 tU are estimated in the cost range of ≤$40/kgU, which is about 26 per cent of the EAR-I cost category of ≤$130/kgU, or about 36 per cent of the EAR-I cost category of ≤$80/kgU. As in the other cost ranges, the total of the RAR was adjusted to 666 000 tU and of EAR-I to 257 000 tU for resources at ≤$40/kgU, to take mining and milling losses into account.

Figures 3 and 4 show the distribution of RAR and EAR-I among countries with major resources. Major changes reported in the individual categories and cost ranges, may be summarised:

Australia reports 622 000 tU in the RAR cost category of ≤$80/kgU, which is 11 000 tU less than in 1995. In the cost range of $80/kgU to $130/kgU, Australia's RAR is 93 000 tU, or 16 000 tU more than in 1995. Australia's EAR-I category at costs of ≤$80/kgU decreased by about 18 000 tU. Changes are due to reassessments and decreases resulting from production in 1995 and 1996. Australia has the highest quantity of RAR in the world in both the ≤$80/kgU and the ≤$130/kgU cost categories. **Kazakhstan**'s RAR in the cost range of ≤$130/kgU estimated as 601 260 tU (439 220 tU in the cost category of ≤$80/kgU) as in situ resources, rank second in the world. **Canada** revised its RAR to 331 000 tU in the cost category of ≤$80/kgU. It eliminated all RAR in the category $80-130/kgU due to the closure of the mines in the Elliot Lake district. Compared to 1995, Canada's RAR increased by 61 000 tU, taking recent developments in Saskatchewan into account. Similarly EAR-I recoverable at ≤$80/kgU increased to 99 000 tU, versus 30 000 tU in 1995. Minor changes in RAR are reported for the **USA, Namibia and South Africa**. **Niger's** RAR at ≤$80/kgU increased by 12 500 tU to about 70 000 tU. However all of the $80–130/kgU has been eliminated.

For the RAR and EAR-I recoverable at ≤$40/kgU, a total of 1 058 100 tU are reported by 11 countries. The first ranking **Kazakhstan**, reports 323 340 tU in the RAR category and 113 200 tU in the EAR-I category. Both are reported as in situ. Kazakhstan reports that nearly all of these resources can be recovered using in situ leach mining technology. Therefore, no adjustments are made to account for mining losses. **South Africa's** recoverable RAR ≤$40/kgU are estimated at 110 500 tU. The EAR-I equal 44 400 tU. **Namibia** reports recoverable RAR at ≤$40/kgU of 74 090 tU and EAR-I of 70 550 tU, in situ. In **Niger** about 41 800 tU recoverable RAR have been reported. **Uzbekistan's** RAR ≤$40/kgU are 66 210 tU and EAR-I ≤$40/kgU are 39 360 tU. This is the first report by Uzbekistan for resources in all categories. Also, for the first time, the **Russian Federation** has reported resource figures separately as RAR and EAR-I, both as in situ resources.

Other countries have reported minor changes mainly due to reassessments and/or production losses.

Availability of Resources

In order to estimate the availability of resources for production, countries were requested to report the percentage of RAR plus EAR-I recoverable at ≤$40/kgU, and at ≤$80/kgU, that are also tributary to Existing and Committed production centres. For reasons of confidentiality, only nine countries submitted information on resource availability. These countries reported more than 300 000 tU recoverable at ≤$40/kgU, and more than 900 000 tU recoverable at ≤$80/kgU, as tributary to existing and committed production centres.

Other Known Resources

In previous editions of the Red Book a category of **Other Known Resources** was included to accommodate reported resource data that were not strictly consistent with the standard NEA/IAEA terminology. The table has been eliminated in this edition. In most cases data submitted (excluding China and India) for this edition are consistent with NEA/IAEA terminology and are included in

Tables 1, 2 and 3. Known resources for China are discussed in the country report and in a paper presented at the 1997 Forum on Uranium Resources Development.[1]

Undiscovered Conventional Resources

Undiscovered Conventional Resources include Estimated Additional Resources – Category II (EAR-II) and Speculative Resources (SR). EAR-II refers to uranium that is expected to occur in well defined geological trends of known ore deposits or mineralised areas with known deposits. SR refers to uranium that is thought to exist in geologically favourable yet unexplored areas. Therefore EAR-II are assigned with a higher degree of confidence than are SR. Both categories of undiscovered conventional resources are reported together in Table 3. A number of countries did not report undiscovered conventional resources for the 1997 Red Book. Other countries report that they do not undertake a systematic evaluation of undiscovered conventional resources.

Only a few countries have re-estimated EAR-II for this report. New estimates are reported by Gabon, Kazakhstan, Russian Federation, South Africa, Ukraine and Uzbekistan (see Table 3). Other countries have made minor changes. Gabon's EAR-II decreased to less than 2 000 tU. Kazakhstan reports EAR-II of 200 000 tU in the cost range of ≤$40/kgU, and 90 000 tU in the cost range of $40/kgU– $80/kgU. It should be noted that the USA does not separate EAR-I and EAR-II. For the purpose of this report, all the EAR reported by the USA are classified under EAR-II. The Russian Federation reports revised EAR-II of 56 300 tU in the ≤$80/kgU class, and 104 500 tU in the ≤$130/kgU category. Uzbekistan reports EAR-II of 52 510 tU in the cost range of ≤$40 and 72 570 tU at ≤130/kgU.

From data reported in the EAR II category, about 2.3 million tU are estimated at ≤$130/kgU, about 1.5 million tU at ≤$80/kgU, and about 285 000 tU at ≤$40/kgU.

In the category of Speculative Resources only a few revisions of data are reported. Gabon did not report SR for 1997. For the first time, Iran reported 25 000 tU recoverable at <$100/kgU. The Russian Federation also reports for the first time SR of 550 000 tU in the ≤$130/kgU class, and 450 000 tU in the unassigned class, for a total of 1 000 000 tU. Uzbekistan reports about 100 000 tU.

Information regarding SR is incomplete on a worldwide scale. The estimated total for reporting countries at ≤$130/kgU amounts to about 4.5 million tU. About 5.7 million tU of SR are reported with no recovery costs estimated.

Unconventional Resources and Other Materials

In this report no specific chapter is provided for Unconventional Resources as only a few countries reported relevant information.

Table 3. Undiscovered Resources (in 1 000 tU, as of 1.1.1997)*

COUNTRY	Estimated Additional Resources Category II			Speculative Resources		
	Cost Ranges			Cost Ranges		
	≤$40/kgU	≤$80/kgU	≤$130/kgU	≤$130/kgU	Cost Range Unassigned	TOTAL
Argentina	NA	0	1.10	NA	NA	NA
Brazil	0	120.00	120.00	0	500.00	500.00
Bulgaria (a)	2.24	2.24	2.24	16.00	–	16.00
Canada	conf.	(b) 50.00	(b) 150.00	700.00	–	700.00
China (a)	NA	NA	NA	–	1 770.00	1 770.00
Chile	–	–	NA	–	–	4.00
Colombia (a)	–	–	11.00	217.00	–	217.00
Czech Republic	0	5.48	8.48	0	179.00	179.00
Denmark	–	–	–	50.00	10.00	60.00
Egypt	–	–	–	-	15.00	15.00
Gabon	1.61	1.61	1.61	0	0	0
Germany	0	0	0	0	61.50	61.50
Greece (a)	0	6.00	6.00	0	0	0
Hungary	0	0	15.48	0	0	0
India	NA	NA	14.73	NA	NA	17.00
Iran (e)	NA	NA	NA	25.00	0	25.00
Italy (a)	–	–	–	–	10.00	10.00
Kazakhstan	200.00	290.00	310.00	500.00	0	500.00
Mexico (a)	–	–	2.70	–	10.00	10.00
Mongolia	0	0	0	1 390.00	–	1 390.00
Peru	–	6.61	20.00	20.00	6.00	26.00
Portugal (a)	–	1.50	1.50	1.50	NA	1.50
Romania	–	–	1.97	–	–	3.00
Russian Federation	–	56.30	104.50	550.00	450.00	1 000.00
Slovenia	–	–	1.06	–	–	–
South Africa	28.74	34.90	113.00	NA	1 113.50	1 113.50
Ukraine	NA	NA	10.00	NA	231.00	231.00
United States (c)	NA	839.00	1 270.00	858.00	482.00	1 340.00
Uzbekistan (d)	52.51	52.51	72.57	–	101.60	101.60
Venezuela (a)	–	–	–	–	–	163.00
Vietnam	NA	NA	5.70	100.00	130.00	230.00
Zambia	0	0	22.00	0	0	0
Zimbabwe (a)	0	0	0	25.00	0	25.00

* Undiscovered resources are generally reported as in situ resources.
– No resources reported. NA = Data not available. conf. = Confidential.
(a) Data from previous Red Book.
(b) Mineable resources.
(c) USA does not separate EAR as EAR-I and EAR-II.
(d) EAR-II and Speculative Resources are expressed as recoverable.
(e) Reported as recoverable at <$100/kgU.

B. URANIUM EXPLORATION

Fifty countries submitted information on domestic uranium exploration. Of these, twenty-four indicated that no uranium exploration took place in 1995 and 1996, while twenty-six countries reported exploration activities.

As in previous years the exploration efforts are unevenly distributed geographically, depending on the specific uranium requirements of individual countries, as well as the reasonable likelihood for the discovery of economically attractive deposits.

After more than ten years of constantly decreasing exploration activities, in 1995 and 1996 an increase of activities is reported in a few countries. This contrasts with the continuing decrease reported in other countries. The total exploration activities are still quite low compared with the beginning of the 1980s. This is demonstrated by the amount of drilling (numbers of holes and metres drilled), as well as by the exploration expenditure expressed in local currencies.[1]

For 1995, a total of 26 countries reported exploration expenditures of US$ 83.6 million, which is nearly 12 per cent higher than in 1994 (US$ 74.7 million). For 1996, 24 countries reported exploration expenditures totalling about US$ 85.9 million compared to 29 countries in 1992 totalling about US$ 118.7 million (Table 4). For comparison, in 1986 about US$ 180 million were spent, not including expenditure in non-WOCA countries.

Currently most exploration activities are taking place in Canada, Australia, USA, the Russian Federation and to a lesser extent, Mongolia and Uzbekistan. Uranium exploration in the Russian Federation was reported in the range of US$ 4.0 to 5.6 million between 1994 and 1996. Malaysia and Thailand, with small exploration projects, increased their expenditures slightly in 1995, but discontinued these activities in 1996. Indonesia reported continuing work with a moderate budget. China reports increased uranium demand, and that exploration is continuing in support of the nation's self supply policy. However, details are not reported. Egypt maintained exploration at the same level in 1994 and 1995 of about US$ 3.2 million and then increased it by 100 per cent in 1996. Exploration expenditures were made in France, Romania, Gabon and Niger, but they are for the most part connected with delineation of already discovered deposits, rather than investigating new areas. A large increase of exploration expenditures is reported in India. Namibia reported expenditures in 1995 related to re-appraisal of the country's resources. However in 1996, no exploration took place. Spain stopped its exploration after 1994. Exploration continues on a reduced level in Kazakhstan, and the Czech Republic.

The continuing low level of uranium exploration is caused by several factors. The unstable uranium market conditions in recent years are the principal cause. The relatively low level of recent market prices, together with the contradictory price trends, and political uncertainty regarding the

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(1) Since 1994, uranium exploration expenditures in this report include the cost of feasibility studies but exclude costs associated with preparing for the production phase of mining.

Table 4. **Industry and Government Uranium Exploration (Domestic) in Countries Listed**

(US$ 1 000 in year of expenditure)

COUNTRY	Pre-1990	1990	1991	1992	1993	1994	1995	1996	1997 (Expected)
Argentina	44 304	340	588	1 330	1 242	700	950	700	1 100
Australia	400 820	11 835	10 803	10 273	5 790	4 904	5 942	11 842	NA
Bangladesh	453	NA	NA	NA	NA	NA	NA	NA	NA
Belgium	1 685	0	0	0	0	0	0	0	0
Bolivia	9 368	–	NA	NA	NA	NA	NA	NA	NA
Botswana	640	–	NA	NA	NA	NA	NA	NA	NA
Brazil	189 920	0	0	0	0	0	0	0	0
Bulgaria	NA	NA	NA	NA	NA	NA	0	0	0
Canada	865 857	39 381	39 252	38 417	31 825	26 087	32 353	28 467	NA
Central African Rep.	20 000	–	–	–	–	NA	NA	NA	NA
Chile	7 809	82	99	117	115	94	218	143	156
Colombia	23 935	–	–	–	–	0	0	0	0
Costa Rica	361	–	–	–	–	–	–	–	–
Cuba	NA	NA	NA	236	230	228	142	86	50
Czechoslovakia	302 990	7 370	1 540	660	xxxx	xxxx	xxxx	xxxx	xxxx
Czech Republic	xxxx	xxxx	xxxx	xxxx	579	468	282	201	245
Denmark	4 350	–	–	–	–	0	0	0	0
Ecuador	2 055	NA	NA	NA	NA	NA	NA	NA	NA
Egypt	20 541	4 373	3 614	4 505	6 647	3 245	3 264	6 528	NA
Finland	14 777	0	0	0	0	0	0	0	0
France	805 755	32 472	23 725	14 984	9 963	6 217	2 882	1 152	1 105
Gabon	85 261	NA	NA	2 011	1 839	1 050	939	1 338	343
Germany	117 965	26 800	0	0	0	0	0	0	0
Ghana	90	NA	NA	NA	NA	NA	NA	NA	NA
Greece	14 815	658	395	389	403	154	148	273	290
Guatemala	610	–	–	–	–	NA	NA	NA	NA
Hungary	3 700	0	0	0	0	0	0	0	0
India	150 107	15 420	13 230	9 010	9 519	9 363	9 536	7 394	8 048
Indonesia	8 844	368	886	1 230	1 523	648	574	643	540
Ireland	6 800	–	–	–	–	0	0	0	0
Italy	75 060	–	–	–	–	NA	NA	NA	NA
Jamaica	30	–	–	–	–	NA	NA	NA	NA
Japan	8 640	0	0	0	0	0	0	0	0
Jordan	283	108	42	36	13	10	30	100	100
Kazakhstan	xxxx	xxxx	xxxx	2 500	2 525	1 290	113	242	276
Korea, Republic of	4 607	38	25	NA	NA	0	0	0	0
Lesotho	21	NA	NA	NA	NA	NA	NA	NA	NA
Lithuania	0	0	0	0	0	0	0	0	0
Madagascar	5 243	NA	NA	NA	NA	NA	NA	NA	NA

Table 4. **Industry and Government Uranium Exploration (Domestic) in Countries Listed (contd.)**

(US$ 1 000 in year of expenditure)

COUNTRY	Pre-1990	1990	1991	1992	1993	1994	1995	1996	1997 (Expected)
Malaysia	8 032	246	281	310	368	399	163	239	NA
Mali	51 637	–	–	–	–	NA	NA	NA	NA
Mexico	24 910	0	0	0	0	0	0	0	0
Mongolia	NA	NA	NA	48	60	700	1 650	2 560	3 135
Morocco	2 752	–	–	–	–	NA	NA	NA	NA
Namibia	15 522	NA	NA	364	0	0	2 044	0	0
Netherlands	0	0	0	0	0	0	0	0	0
Niger	196 340	1 432	1 128	1 343	440	1 481	1 665	427	1 653
Nigeria	6 950	NA	NA	NA	NA	NA	NA	NA	NA
Norway	3 180	–	–	–	–	0	0	0	0
Paraguay	25 510	NA	NA	NA	NA	NA	NA	NA	NA
Peru	4 092	60	36	9	0	4	0	0	0
Philippines	3 347	10	10	10	10	30	30	30	50
Portugal	15 577	736	289	277	135	106	130	119	NA
Romania	NA	NA	NA	NA	NA	2 998	2 448	1 861	2 423
Russian Federation	xxxx	xxxx	xxxx	9 710	2 828	4 197	5 581	4 271	11 307
Slovak Republic	xxxx	xxxx	xxxx	xxxx	0	0	0	0	0
Slovenia	xxxx	xxxx	0	NA	0	0	0	0	0
Somalia	1 000	–	–	–	–	NA	NA	NA	NA
South Africa	108 993	NA	NA	NA	NA	NA	NA	NA	NA
Spain	125 786	2 485	3 552	4 119	2 872	891	0	0	0
Sri Lanka	33	–	–	–	–	NA	NA	NA	NA
Sweden	46 870	0	0	0	0	0	0	0	0
Switzerland	3 868	–	–	–	–	0	0	0	0
Syria	800	89	179	0	0	NA	NA	NA	NA
Thailand	10 359	63	63	63	138	116	119	0	0
Turkey	20 504	77	–	–	–	0	0	0	0
Ukraine	xxxx	xxxx	xxxx	NA	NA	NA	NA	NA	NA
United Kingdom	2 600	–	–	–	–	0	0	0	0
United States	2 590 900	19 200	19 700	16 000	12 000	4 329	6 009	10 054	NA
Uruguay	231	NA	NA	NA	NA	NA	NA	NA	NA
USSR	NA	187 520	60 000	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Uzbekistan	xxxx	xxxx	xxxx	NA	NA	472	6 197	7 026	8 671
Viet Nam	–	462	353	252	324	137	161	209	226
Yugoslavia	970	36	NA	NA	NA	NA	NA	NA	NA
Zambia	81	32	57	21	NA	4 380	NA	NA	NA
Zimbabwe	5 139	719	526	518	0	0	0	0	0
TOTAL (a)	**6 473 679**	**352 412**	**180 373**	**118 742**	**91 388**	**74 697**	**83 570**	**85 908**	

(a) Of available data only.
– No expenditures reported.
NA Data not available.
xxxx National entity not in existence or politically redefined.

market introduction of government stockpile and weapons derived material all contribute to make planning difficult. The urgency for increased exploration is also reduced by the relative abundance of known resources.

Exploration efforts by Canadian, French, German, Japanese, Korean and US companies continue in countries outside their national boundaries (Table 5). However, the amount of exploration abroad declined from US$ 48.8 million in 1994 to US$ 21.5 million in 1996 (Figure 5). The decrease resulted from the large decline in overseas expenditures by France which fell from US$ 31.0 million in 1994 to US$ 6.8 million in 1996.

Table 5. **Non-Domestic Uranium Exploration Expenditures (Abroad) by Countries Listed (US$ 1 000 in year of expenditure)**

COUNTRY	Pre-1990	1990	1991	1992	1993	1994	1995	1996	1997 (Expected)
Belgium	4 500	0	0	0	0	0	0	0	0
Canada	–	–	–	–	–	1 449	1 471	3 650	4 044
France	565 863	5 726	11 076	19 438	32 619	30 959	10 245	6 808	11 619
Germany (FRG)	372 800	6 766	4 853	2 898	3 107	2 646	2 951	3 111	4 358
Italy	NA	NA	200	–	–	–	–	–	–
Japan	307 791	10 990	11 210	12 010	11 620	12 923	14 771	7 533	4 801
Korea, Rep. of	21 317	158	177	260	225	175	178	373	895
Spain	20 400	0	0	0	0	0	0	0	0
Switzerland	26 906	600	540	482	502	627	0	0	0
United Kingdom	50 009	8 300	1 900	899	155	0	0	0	0
United States	228 770	0	0	0	0	W	NA	NA	NA
TOTAL	**1 598 356**	**32 540**	**29 956**	**35 987**	**48 228**	**48 779**	**29 616**	**21 474**	**25 718**

– No expenditures reported.
NA Data not available.
W Withheld to avoid disclosure of company specific data.

Current Activities and Recent Developments

Current exploration efforts are mainly concentrated on targets with potential for low production costs such as high grade unconformity related deposits (e.g. Canada, Australia) and sandstone-hosted deposits amenable to ISL mining.

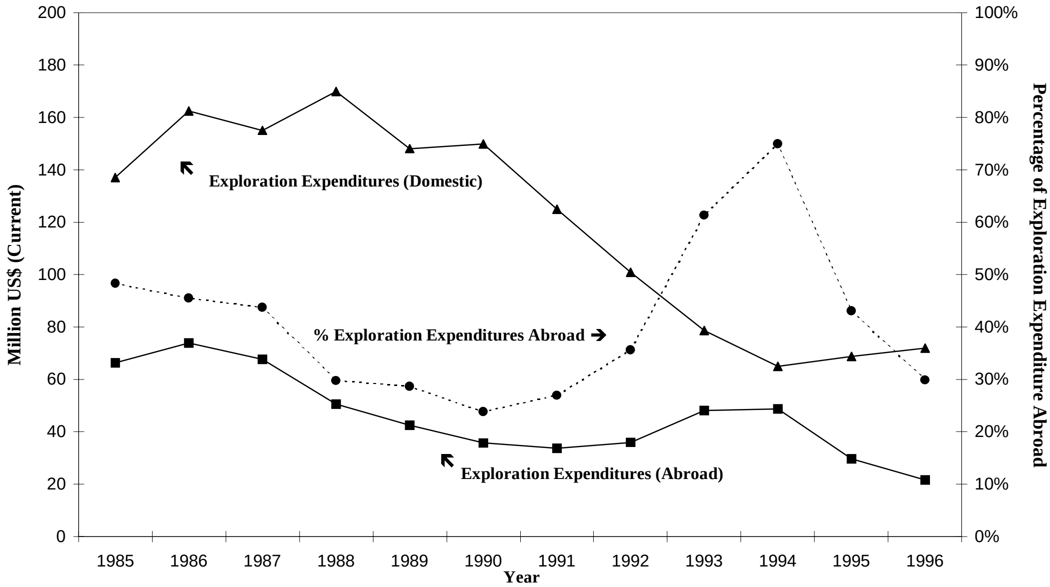
In **North America** exploration activities occurred in Canada and USA. In **Canada** exploration work is concentrated on targets favourable for unconformity-related high grade deposits, mostly in the Athabasca Basin. Expenditures in 1995 increased slightly (C$ 44 million) from those of 1994 (C$ 36 million). In 1996 about C$ 39 million was spent, of which about half was for “grass-roots” exploration. Much of the expenditure is attributed to advanced underground exploration and deposit appraisal at such projects as McArthur River and Cigar Lake, as well as to “care and maintenance” activities at projects awaiting production approvals. Detailed exploration was also carried out in the Kiggavik area and in the extreme western and north-eastern part of the Thelon Basin in the Northwest Territories. Some geological research and grass-roots exploration is carried out in the western part of the Athabasca Basin, in Alberta and in the Great Bear Magmatic zone (Northwest Territories). Grassroots exploration expenditures in Saskatchewan have increased to C$ 17 million in 1996 compared to C$ 12.5 million in 1995 and C$ 11 million in 1994. Overall, the amount of drilling was about 75 000 metres in 1995 and 79 000 metres in 1996. The number of active companies declined from 20 in 1994 to 15 in 1995 and to about a dozen in 1996. However, the number of active exploration projects in 1996 was 38, compared to 27 in 1994. In the **USA** uranium exploration expenditures, which had declined to an all time low level of US$ 4.3 million in 1994, increased to US$ 6.0 million in 1995 and US$ 10.1 million in 1996. The share of surface drilling expenditures increased from about 30 to 70 per cent, due in part to the increasing costs of drilling, but also to an increase in the amount of surface drilling: 200 000 metres in 1994, 411 000 metres in 1995, and 915 000 metes in 1996. Exploration activities continued in Wyoming and to a lesser degree in Arizona, Colorado, Nebraska and Texas. Most of the effort was focused on sandstone-type deposits.

In **Central and South America** exploration continued in **Argentina** on the Cerro Solo sandstone deposit, located in Patagonia, and on the Las Termas occurrence. The later consists of vein-type mineralization in metamorphic rocks in the vicinity of a granitic intrusion. Surface drilling of 16 300 metres during 1995–1996 resulted in an increase of the resources. About 4 500 metres of drilling is planned in 1997. Studies of other geological units in Argentina have been carried out to estimate their undiscovered potential for uranium. No exploration activities occurred in **Brazil**. However, a feasibility study was conducted on the Lagoa Real deposit in 1995/96. Exploration in **Chile** focused on the Coast Range area, where uranium is associated with Rare Earth occurrences.

In **Western Europe and Scandinavia** exploration continued to decline. In **France** exploration activities decreased in the period 1994 to 1996, from about FF 35 million to FF 6 million. Most of the work was concentrated in Le Bernardan mine area in the northern part of the Massif Central. During the period, drilling declined from about 83 400 metres to 24 400 metres annually. COGEMA has continued major exploration work in foreign countries through its subsidiaries, concentrating efforts in Canada and to a lesser extend in Australia, USA, Niger and Gabon. Nevertheless the expenditures abroad decreased from about FF 174 million in 1994 to FF 35 million in 1996. In **Germany** no exploration has been carried out. German mining companies continued exploration abroad, mainly in Canada. Related expenditures were DM 4.0 million in 1994, DM 4.1 million in 1995 and DM 4. million in 1996. **Spain** carried out a 100 000 metre per year development drilling programme strictly related to the Fe deposit in the Salamanca Province. This programme concluded at the end of 1996.

In **Central and Eastern Europe** exploration activities are declining. In **The Czech Republic** exploration expenditures decreased from Kc 13.0 million in 1994 to Kc 7.4 million in 1995 and Kc 5.50 million in 1996. In 1995 and 1996 no field work was carried out. The activities were focused on developing an exploration database by compiling and processing of previously collected data. This work continued in 1997. The **Russian Federation** reports the State Concern “Geologorazvedka” is conducting exploration with expenditures increasing from Roubles 7.57 billion in 1994 to Roubles 21.4 billion in 1996. Expenditures are focusing on valley-type sandstone deposits amenable to ISL mining. The Russian Federation is planning to increase exploration expenditures to more than Roubles 62.3 billion in 1997. **Romania** continues exploration in existing deposits by spending 4.7 to 5.4 billion Lei, respectively in 1995 and 1996. **Turkey** is carrying out a limited exploration programme in sedimentary rocks in north-western Anatolia. An airborne survey is expected to be completed in 1997. In **Ukraine**, the State Geological Enterprise Kirovgeology carried out exploration activities including geological, geophysical and geochemical mapping, as well as extensive drilling. The work focused on the southern part of Ukraine. In this area the crystalline shield is covered by sedimentary rocks.

Figure 5. **Trend in Uranium Exploration Expenditures for Selected Countries (Excluding China, Cuba, NIS and Eastern Europe)**



Note: The USA did not report expenditures abroad in 1994, 1995 and 1996.

In **Africa, Egypt** carried out exploration activities in three areas of the Eastern Desert. It has been spending between EGP 11 million and EGP 22 million annually. In **Gabon** COMUF continues exploration, spending between FCFA 591 million to FCFA 696 million. The expenditure is mainly for drilling around the Okelobondo deposit and in the Lekedi South area. **Namibia** reports that currently there is only one exploration project being carried out by industry. The results and the expenditure related to this work are confidential. In 1995, through the SYSMIN Fund of the European Union N$ 7.7 million were spent conducting a high resolution radiometric and magnetic airborne survey over most of Central Western Namibia. In **Niger** uranium exploration by two mining companies continued at the same level in 1994 and 1995 (respectively FF 8.34 million and FF 8.14 million). This expenditure decreased sharply to FF 2.22 million in 1996. This activity focused mainly on surface drilling to confirm the definition of the uranium deposits. **Zambia** indicated a decline in uranium exploration. It reported no exploration expenditure after 1994. No exploration was done in **Zimbabwe** since 1992.

Uranium exploration in the **Middle East, Central and South Asia** is still active in some countries. **India** has a substantial exploration programme, spending annually between Rupee 251 million and Rupee 298 million in 1994 to 1996. Presently, activities are focused on Cretaceous sandstones in the Meghalaya area where the Domiasiat deposit was found; and in Andrah Pradesh, where an unconformity related deposit was discovered in the Cuddapah Basin near the Lambapur area. Other activities are concentrated in Madhya Pradesh, Uttar Pradesh, Bihar, Orissa and Rajasthan. **Jordan** has continued reconnaissance activities to discover uranium occurrences. Expenditures of 1995 and 1996 are in the range of US$ 30 000 to US$ 100 000. For several years **Kazakhstan** has substantially decreased its exploration efforts. For the next few years it will rely on its already discovered large resources. In 1995–1996 the main activities were carried out by Stepgeologiya in the northern part of the country. The target is unconformity-related deposits. In **Uzbekistan**, the exploration for uranium is conducted by Navoi Mining and Metallurgical Complex (NMMC) and by Kyzyltepageologia, the State geological enterprise. Drilling activities decreased because of complex geological conditions, but exploration expenditures continued to increase from about Soum 17.9 million in 1994 to Soum 25.4 million in 1996. **Malaysia** continued its exploration of granites located on the Peninsula using geochemical surveys and ground follow-up of airborne spectrometry. Expenditures decreased from RM 1 080 000 in 1994 to RM 400 000 in 1995 and RM 598 000 in 1996.

In **South East Asia**, exploration continued at a low level. **Indonesia** reports that exploration expenditures by its Nuclear Minerals Development Centre were US$ 573 800 in 1995 increasing to US$ 643 400 in 1996. Work continued with limited drilling and mapping, with emphasis on the Kalimantan area. In 1995–1996 the **Philippine** Nuclear Research Institute continued reconnaissance exploration and a semi-detailed geochemical programme in the northern part of the Palawan Island. Annual expenses were US$ 30 000. Two favourable areas with uranium occurrences related to granites and metamorphic rocks were identified. After **Viet Nam** completed the evaluation of the Nong Son sandstone basin in previous years, exploration is now focused on the Tabhing and An Diem areas. Expenditures increased slightly from US$ 136 000 in 1994 to US$ 161 000 in 1995 and US$ 209 000 in 1996.

In the **Pacific** area exploration activities increased. After declining to an historic low level in 1994, exploration expenditures in **Australia** increased from A$ 6.67 million in 1994 to A$ 8.26 million in 1995 and A$ 14.92 million in 1996. In the same period surface drilling increased from 12 375 metres to 19 293 metres. This increase is due partly to the abolition of the former government "three mines policy" and partly in response to the perception of an improved uranium market. In 1996, 13 exploration projects were active compared to 17 in 1995, and 8 in 1994. Exploration was focused mainly on three areas: Paterson Province (Western Australia), Arnhem Land (Northern Territory), and in the Westmoreland area (Queensland). In the Paterson province unconformity-related mineralization similar to those of the Kintyre orebody are expected to occur. In Arnhem Land exploration work continued for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie sandstones. In Queensland, the exploration for sandstone type deposits continued in the McArthur Basin sediments.

In **East Asia**, where substantial nuclear development is expected to occur in the next ten years, exploration for uranium continues. **China** concentrated its exploration efforts on sandstone-hosted deposits amenable to ISL in the Yili basin, Xingiang Autonomous Region and the Erlian basin, Inner Mongolian Autonomous Region. In southern China the exploration for granitic- and volcanic-hosted deposits was reduced. **Japan** has no domestic exploration programme. However, PNC is active in foreign countries, mainly in Canada and Australia but also in China and Zimbabwe. In 1995 and 1996 expenditures abroad were Yen 1 226 million and 806 million respectively. In the Rep. of **Korea** no domestic uranium exploration is carried out. However, Korean companies are engaged in joint ventures in Canada (Cigar Lake, Dawn Lake, Baker Lake) and USA (Crow Butte). Expenditures were US$ 175 000 in 1994, US$ 178 000 in 1995 and US$ 373 000 in 1996. **Mongolia** opened uranium mining activities to joint ventures with foreign mining companies. Exploration is carried out by three companies: "Uran", a Mongolian state owned company, "Gurvansaikhan", a joint Mongolian-Russian-American venture and "Koge-Gobi", a joint Mongolian-French venture. These companies are conducting exploration in different parts of the Mongolian territory. Exploration expenditures show an increase from US$ 700 000 in 1994, to US$ 1.65 million in 1995, and to 2.56 million in 1996. Most of this expenditure is from industry.

C. URANIUM PRODUCTION

After reaching a low of 31 611 tU in 1994, world uranium production increased to about 33 154 tU in 1995 and about 36 195 tU in 1996 (Table 6, Figures 6 and 7). These world values include estimates of production for China, India and Pakistan. The production came from an estimated 63 mines and 44 processing plants (mills). This included the Stanleigh mine and mill, Ontario, Canada, which was permanently closed in 1996. The changes in the level of production are unevenly distributed. In the former WOCA, annual increases of more than 12 per cent occurred while the rest of the world decreased by about 18 per cent over the two years.

Present Status of Uranium Production

The small increase of world uranium production in 1995 and 1996, following more than 10 years of decreases, results primarily from increases in Australia, Canada, the Russian Federation and the USA. Improved market conditions in 1996 help account for this evolution. The increases more than offset the continuing decreases in some countries including France, Hungary, South Africa, Kazakhstan, and Uzbekistan. In the OECD the increase from 1995 to 1996 is more than 13 per cent**,** coming from Australia (+1 263 tU), Canada (+1 233 tU), and USA (+107 tU). France was the OECD Member country with the largest decline (-86 tU). During this period both the world installed nuclear power capacity and uranium requirements have increased. In 1996 the production level is about 60 per cent of world uranium requirements compared to 54 per cent in 1995. The remaining material to fuel reactors not covered by production came primarily from stockpiles.

In **North America** production increased by 10.5 per cent from 1995 to 1996. The region contributed nearly 40 per cent of the 1996 total. **Canada** remained the world's leading producer. Its 1996 production was about 12 per cent higher (11 706 tU) compared to 1995. Canadian exports increased about 35 per cent compared with 1995. The Stanleigh Mine (the last mine in Ontario) closed in 1996. This production loss is largely offset by a large increase in production from Saskatchewan mines. This increase came from the Cluff Lake mill operating on a full capacity basis instead of the previous alternate weekly basis; and from the Cameco/Uranerz Rabbit Lake plant which now mills ore from the Eagle Point and the Collins Bay D and Collins Bay A zones. Cameco and Uranerz also operate Canada's largest producer, Key Lake, with a 1996 output of 5 429 tU. Employment in the Canadian production centres declined from 1 350 to 1 155 persons. Canadian production in 1996 was owned 52 per cent by private domestic companies, 27 per cent by private foreign companies, 5 per cent by domestic government and 16 per cent by foreign government organisations. In the **USA** the 1996 production, which increased 5 per cent compared with 1995, originates from: 5 in situ leaching, 2 phosphate by-product plants and one conventional mill. The mill operated in the USA from 1995 to the beginning of 1996 to process ore stockpiled prior to 1993. A total of 689 persons were employed in uranium production in 1996. An additional 429 persons worked in reclamation activities. In 1996, US production was owned 49 per cent by domestic private companies, 36 per cent by foreign government organisations and 16 per cent by foreign private companies.

The **Central and South America** production which came only from **Argentina** (as Brazil placed its production on standby in 1996), represented less than 0.1 per cent of the world output in 1996. There was a large decrease in production (85 per cent) because the Brazilian Poços de Caldas

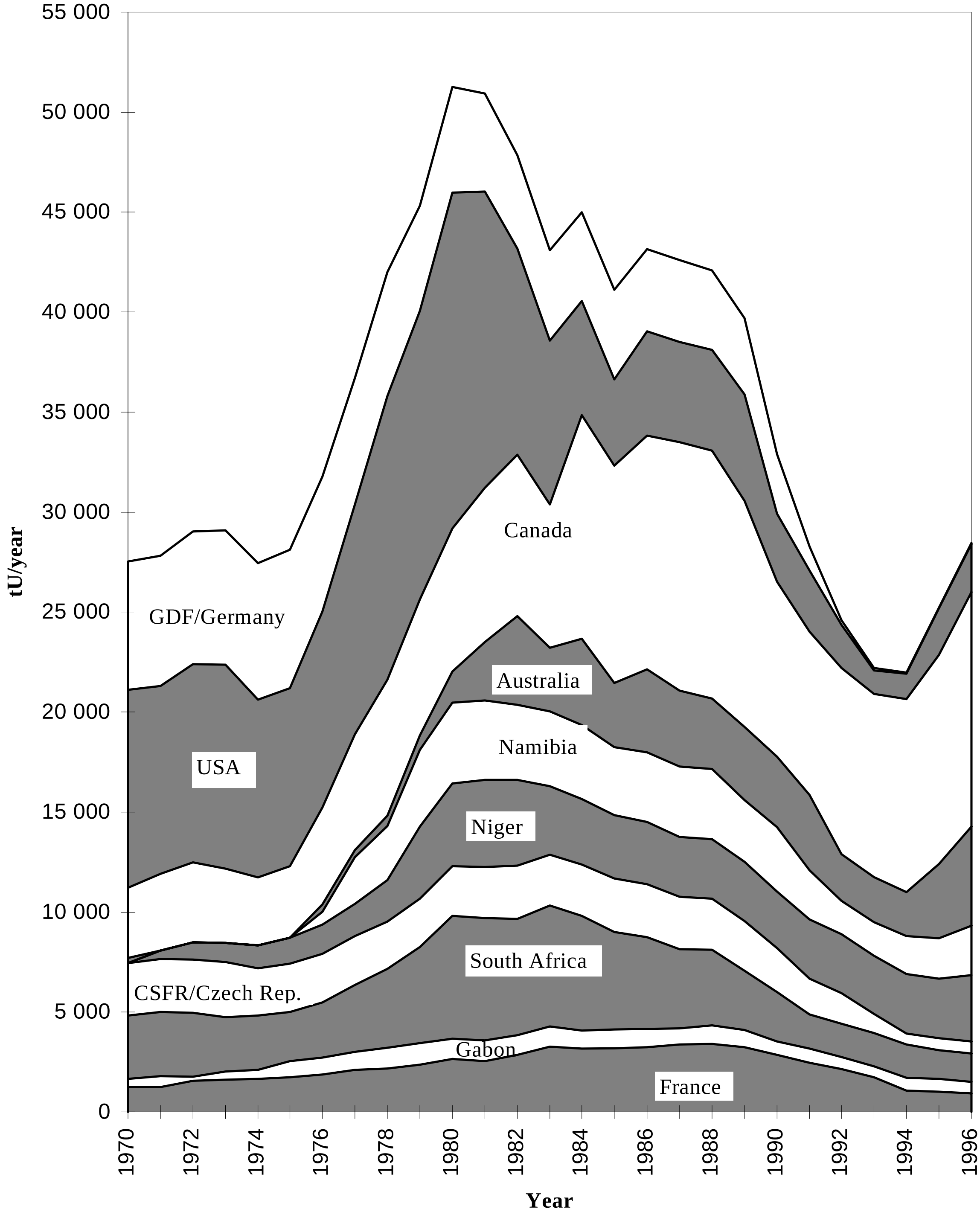
Table 6. **Historical Uranium Production**
(in metric tons U)

COUNTRY	Pre-1990	1990	1991	1992	1993	1994	1995	1996	Total to 1996	Expected 1997
Argentina	2 033	9	18	123	126	80	65	28	2 482	40
Australia	44 503	3 530	3 776	2 334	2 256	2 208	3 712	4 975	67 294	NA
Belgium (a)	377	39	38	36	34	40	25	28	617	27
Brazil	789	5	0	0	24	106	106	0	1 030	0
Bulgaria	15 755	405	240	150	100	70	0	0	16 720	0
Canada (b)	231 506	8 729	8 160	9 297	9 155	9 647	10 473	11 706	298 673	NA
China(c)	NA	800	800	955	780	480	500	560	NA	600
CSFR	96 786	2 142	1 778	1 539	xxxx	xxxx	xxxx	xxxx	102 245	xxxx
Czech Republic	xxxx	xxxx	xxxx	xxxx	950	541	600	604	2 695	609
Estonia	65	0	0	0	0	0	0	0	65	0
Finland	30	0	0	0	0	0	0	0	30	0
France	60 707	2 841	2 477	2 149	1 730	1 053	1 016	930	72 903	761
Gabon	20 299	709	678	589	556	650	652	568	24 701	587
Germany	699	2 972	1 207	232	116	47	35	39	5 347	30
German Democratic Rep.	213 380	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	213 380	0
Hungary	15 439	524	415	430	380	413	210	200	18 011	200
India	5 200 (c)	230 (c)	200 (c)	150	148	155	155 (c)	250 (c)	6 488	250 (c)
Japan	87	0	0	0	0	0	0	0	87	0
Kazakhstan (e)	xxxx	xxxx	xxxx	2 802	2 700	2 240	1 630	1 210	82 582	1 500
Mexico	49	0	0	0	0	0	0	0	49	0
Mongolia	94	89	101	105	54	72	20	0	535	0
Namibia	45 679	3 211	2 450	1 660	1 679	1 895	2 016	2 447	61 037	3 000
Niger	47 809	2 839	2 963	2 965	2 914	2 975	2 974	3 321	68 760	3 400
Pakistan(c)	570	30	30	23	23	23	23	23	745	23
Portugal	3 400	111	28	28	32	24	18	15	3 656	17
Romania	16 360	210	160	120	120 (c)	120	120	105	17 315	106
Russian Federation (f)	xxxx	xxxx	xxxx	2 640 (d)	2 697	2 541	2 160	2 605	103 983	2 800 (c)
Slovenia	xxxx	xxxx	0	2	0	0	0	0	2	0
South Africa	137 568	2 460	1 712	1 669	1 699	1 671	1 421	1 436	149 636	1 450
Spain	3 176	213	196	187	184	256	255	255	4 722	255
Sweden	200	0	0	0	0	0	0	0	200	0
Ukraine	xxxx	xxxx	xxxx	1 000	1 000	1 000	1 000	1 000	5 000	1 000
United States	330 640	3 420	3 060	2 170	1 180	1 289	2 324	2 431	346 514	NA
USSR	NA	14 000 (c)	13 500	xxxx	xxxx	xxxx	xxxx	xxxx	NA	xxxx
Uzbekistan (g)	xxxx	xxxx	xxxx	2 680 (d)	2 600 (d)	2 015	1 644	1 459	86 422	2 050
Yugoslavia	327	53	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	380	xxxx
Zaire	25 600 (c)	0	0	0	0	0	0	0	25 600	0
OECD TOTAL	904 193	22 379	19 357	16 863	16 017	15 518	18 668	21 183	1 034 178	****
WORLD TOTAL	****	**49 571**	**43 987**	**36 035**	**33 237**	**31 611**	**33 154**	**36 195**	****	****

NA Data not available.
xxxx National entity not in existence or politically redefined.
**** No estimate due to insufficient information.

(a) Uranium is produced locally as a byproduct from imported phosphates.
(b) Primary output. An additional 73tU, 31tU, 50tU, 44tU, 40tU, 30tU, 53tU, 55tU and 48tU were recovered at Elliot Lake from Cameco's refinery/conversion facility by-products, respectively in 1988, 1989, 1990, 1991,1992, 1993, 1994, 1995 and 1996.
(c) Secretariat estimate.
(d) Uranium Institute.
(e) Kazakhstan pre-1992: 72 000 tU.
(f) Russian Federation pre-1993: 93 980 tU.
(g) Uzbekistan pre-1994: 82 763 tU.

Figure 6. **Historical Uranium Production for Selected Countries**



Note: Graphical data is stacked.

mine was on standby in 1996. **Brazil**'s production could increase in the near future if, as planned, the Lagoa Real mill comes into operation in 1998. In Argentina employment decreased from 180 in 1994 to 100 in 1996. During the same period, employment in Brazil followed the same trend, decreasing from 408 to 305 persons. In both countries the production is owned by domestic government organisations.

In the **Western Europe and Scandinavia** region, production decreased by 6.1 per cent from 1995 to 1996 (to about 1 267 tU), mainly because of the decline in **France**. The production of this area, which is only 3.5 per cent of the world production, represents only 6.5 per cent of the area requirements. The French production decrease is expected to continue in 1997 because of the closure of the Lodève mine. French production is owned 89 per cent by domestic government organisations and 11 per cent by domestic private companies. Employment was reduced to 441 persons in 1996, down from 496 persons in 1994. The production in other countries remained almost stable. In **Belgium** uranium production as by-product from imported phosphate was reduced to a range of 25 tU to 28 tU annually. This material is owned by a private company. The workforce for uranium extraction is 5 persons. In **Germany** the output of uranium from the decommissioning of the underground leaching operation at Königstein was 35 and 39 tU, respectively in 1995 and 1996, compared with 47 tU in 1994. Employees in Germany are all engaged in reclamation and rehabilitation. Their number continues to be reduced. There were 4 200 persons in 1996 compared to 4 400 in 1995 and 4 613 in 1994. These activities are carried out by Wismut, a privately organised, government owned company. In **Spain** the conventional and heap leaching operation at the Fe plant is continuing. Employment declined slightly to 178 persons in 1996, down from 185 in 1994. Production is owned 100 per cent by the company ENUSA (60 per cent National Industrial Institute, 40 per cent Energy and Technology Centre). In **Portugal** uranium production was 18 tU in 1995 and 15 tU in 1996.

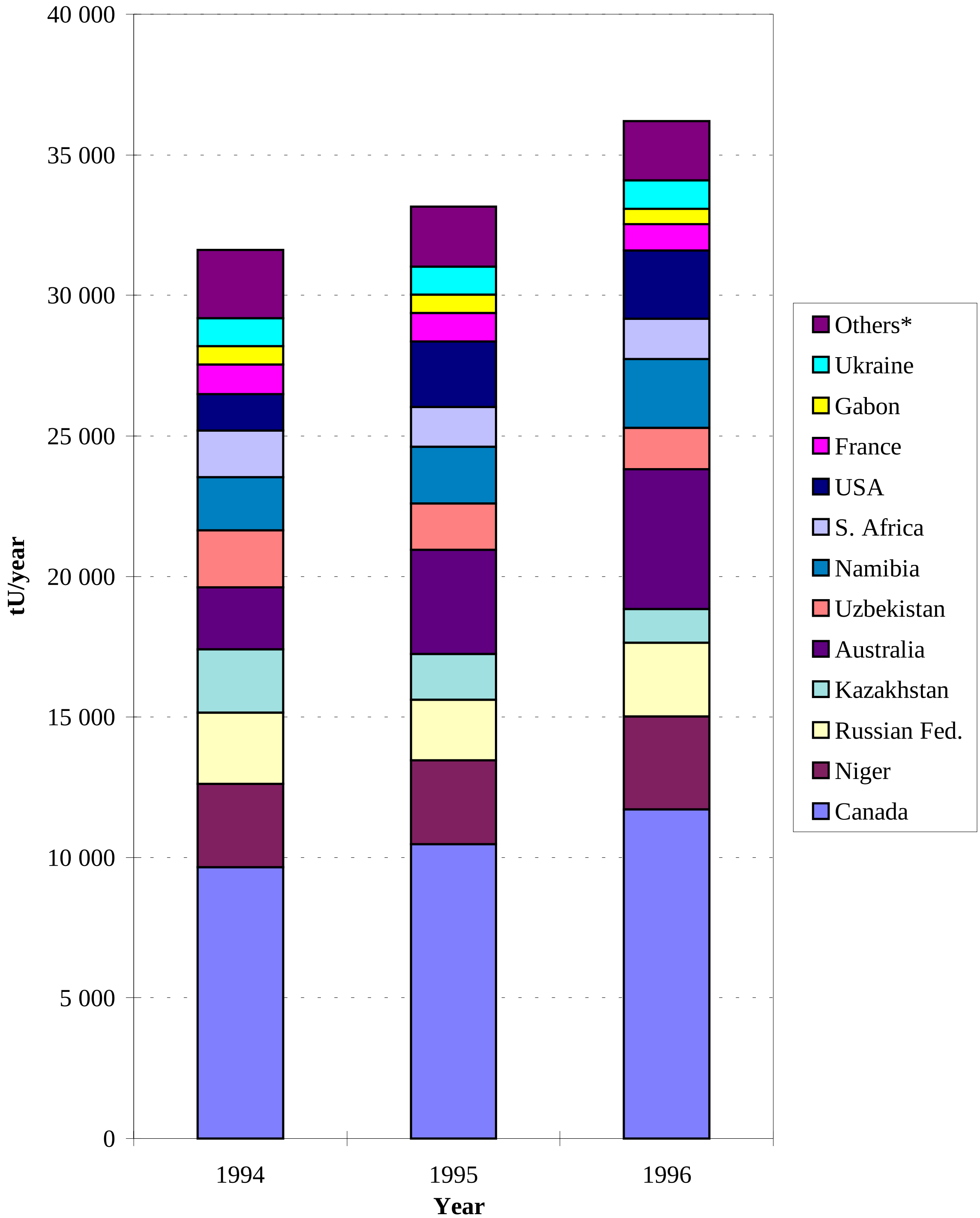
Production in the **Central and Eastern Europe** area increased by 10 per cent, from 4 125 tU in 1995 to 4 553 tU in 1996. The shutdown of production in **Bulgaria** is now complete as mandated by government decision. The environmental cleanup and restoration programme is continuing. The **Czech Republic** production of 600 tU in 1995 and 1996 came both from the Rozna underground mine and from the Stráz ISL mine. In 1996 the groundwater restoration phase was started at Stráz. Employment was reduced from 5 400 persons in 1994 to 3 600 persons in 1996. The production is carried out by the government owned DIAMO enterprise. Production in **Hungary** production continued to decrease from 400 tU in 1994 to 200 tU in 1995 and 1996. The Government plans to close the Mecsek mine and mill by the end of 1997. Employment was reduced from 1 766 persons in 1994 to 1 144 persons in 1996. Mecsekuran Ltd, which operates the only uranium production centre in Hungary, is a domestic private enterprise. Production in **Romania** was 120 tU in 1995 and 105 tU in 1996 coming from 3 underground mines. Production in the **Russian Federation** increased by 21 per cent from 2 160 tU in 1995 to 2 605 tU in 1996. This production came primarily from underground mines located near Krasnokamensk. About 22 per cent was from heap and stope leaching, while a few per cent were from an open pit that is being phased out. Production is projected to be 2 800 tU in 1997. Employment is decreasing with a change from 14 400 person-years in 1994 to 14 000 in 1995, followed by an additional decrease to 13 000 in 1996. **Ukraine** reports production of 1 000 tU in 1996. The mines (underground mining) and mill production centres are in a reconstruction phase. The nominal production capacity of the mill is 1 000 tU and could, if needed, be doubled in the future.

The **African** countries, **Gabon**, **Namibia**, **Niger** and **South Africa** contributed about 22 per cent of the total 1996 world production. This area increased its production to 7 772 tU, up about

10 per cent from 1995. The 1996 production in **Gabon** (568 tU) decreased by 13 per cent compared with 1995. COMUF, the operator of the mines and mill, is owned 25 per cent by the Gabonese government, 7 per cent by private domestic organisations and 68 per cent by foreign government interests. The processing centre of Mounana, received the ore mainly from the underground mine of Okelobondo. After 1997, the Mikouloungou open pit will be in operation. The employment which was almost stable since 1994 will decrease in 1997. The depletion of the orebodies is expected in 1999 and Gabon's uranium production will end. **Namibia**'s Rössing mine had the largest production increase in the region (from 2 016 tU in 1995 to 2 447 tU in 1996, with 3 000 tU expected in 1997). Employment was relatively stable over recent years at about 1 200 persons. The mine is operated by Rössing Uranium Ltd which is owned 60.8 per cent by RTZ, 3.4 per cent by the Namibian government, 10 per cent by Industrial Development Corp. SA and 25.8 per cent by other public and private foreign interests. **Niger** is the largest African uranium producer in 1996, with 3 321 tU and ranked third after Canada and Australia. From 1992 until 1995 production remained at the same level (2 975 tU). It was increased to 3 321 tU in 1996. The two centres, Arlit and Akouta each contributed about one-third and two-thirds respectively to the production. To make Niger's uranium sector more competitive, a restructuring programme has been progressively implemented since 1990. The result is a continuous decrease of employment levels (from 3 173 persons in 1990 to 2 104 persons in 1994). While the production increased in 1996, employment continued to decrease to 2 077 persons. Niger's production is owned 33.1 per cent by domestic government organisations, 22.8 per cent by foreign private companies and 44.1 per cent by foreign government interests. **South Africa**'s 1996 production was 1 436 tU, almost unchanged from 1995. All production is as by-product from gold and copper mining. NUFCOR, the marketing organisation of the Chamber of Mines, receives yellow cake slurry from the four uranium mills attached to underground gold mines at Vaals Reef (2 mills), Hartebeestfontein (1 mill), and Western Areas (1 mill) for purification, drying and packaging. The remaining production is from the multi-mineral Palabora deposit.

The **Middle East, Central and South Asia** area had a large decrease (14.8 per cent) in production. This was due to reductions in Kazakhstan and Uzbekistan, two major producing countries which formerly belonged to USSR. **Kazakhstan**'s 1994 output of 2 240 tU declined to 1 630 tU in 1995 and fell further to 1 210 tU in 1996. The total production capacity is 4 000 tU per year. In 1995, the Tselinny Production Centre which processed the ore from underground mining in the Kokchetau area of northern Kazakhstan was mothballed, pending a decision concerning operation by a foreign partner. Three ISL facilities were in operation in 1995, in the south-central part of the country and two new ones began operation in 1996. With these new ISL operations, production will be increased with a planned 1997 production of 1 500 tU. In 1994, 70 per cent of the production came from ISL and 30 per cent from underground. In 1995, ISL output represented 90 per cent of the production and this increased to 100 per cent in 1996. All production is owned by the National Joint Stock Company KATEP. Employment was reduced from 8 050 persons in 1994, to 6 850 in 1995, and to 6 000 persons in 1996. A similar trend in production took place in **Uzbekistan**. The output was reduced from 2 015 tU in 1994, to 1 644 tU in 1995 and to 1 459 tU in 1996. The decline was due to cutbacks of conventional mining (closure of underground and open pit mines), whereas ISL production remained at a constant level. In 1994 the Uchkuduk open pit and the Sugraly underground mine and in situ leaching facility were closed. The 1997 production is expected to increase above 2 000 tU using only ISL method technology. Employment increased from 6 788 persons in 1994 to 8 200 in 1996. The production is owned by the Navoi Mining and Metallurgical Complex (NMMC). No detailed information is available on **India**'s and **Pakistan**'s production which were estimated to be 250 tU and 23 tU, respectively in 1996. Part of Pakistan's production is obtained using alkaline ISL technology.

Figure 7. Recent World Uranium Production



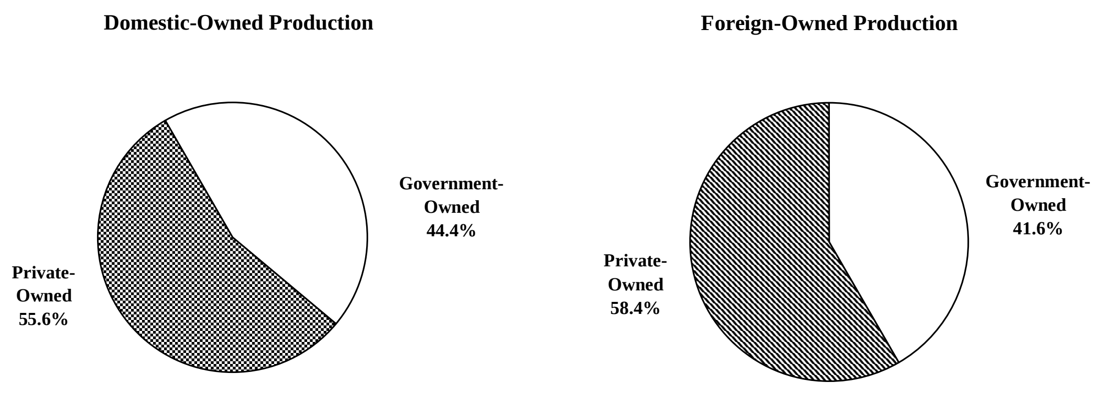
* "Others" includes the remaining producers. Values for China, India and Pakistan in "Others" are estimated.

In the **Pacific** area, the only producing country is **Australia**. It increased its 1996 production by 34 per cent to 4 975 tU. Production originates from the open pit Ranger mine of Energy Resources of Australia (ERA) (3 509 tU), and from the underground Cu-Au-Ag-U Olympic Dam mine (1 466 tU) of Western Mining Corporation. The increase is mainly due to the resumption of year round milling of Ranger mine ores in 1996. It is also due to an increase of capacity at Olympic Dam. Australian production is expected to increase again in the next few years with the expansion of the mill capacities at both Ranger (to process Jabiluka orebody) and Olympic Dam. The Beverly ISL project in South Australia could start production by 2000 but a decision on the Kintyre project has been delayed. Employment in uranium production increased slightly from 412 to 464 persons over the period 1994 to 1996. Australia's production is owned 82 per cent by domestic private companies, 14 per cent by foreign private companies and 4 per cent by foreign government organisations.

In **East Asia**, uranium mines exist in Mongolia and in China. Until 1995, **Mongolia** produced from the Mardai deposit. The ore was processed in the Russian Krasnokamensk mill. This processing agreement with the Russian Federation was terminated in 1995 and the Mardai mine stopped its production. **China**'s total production is not reported. The production is estimated to be about 500 to 600 tU/year. Three of five mills in operation are reported to have produced 260 tU in 1996.

Figure 8 and Table 7 show the ownership in 1996 of the world's uranium production, which took place in 23 countries. Compared to 1994 some changes can be observed. In 1996 about 36.9 per cent of the world production was owned by private domestic companies, 29.5 per cent by domestic government organisations, 19.6 per cent by foreign private companies, and 14.0 per cent was owned by foreign government organisations. For comparison in 1994, 36.1 per cent of the world production was owned by private domestic companies, 34.9 per cent by domestic government organisations, 20.8 per cent by foreign private organisations, and 8.2 per cent by foreign government organisations. The changes are mainly due to a re-assessment of the ownership in some countries and from new information provided for this report.

Figure 8. **Ownership of World Uranium Production**



The changes of employment levels from 1994 to 1996 in the existing production centres in 21 countries (excluding India, Mongolia, Pakistan and South Africa, which did not report) are shown in Table 8. For these countries (excluding Germany and Slovenia), accounting for 95 per cent of world production in 1996, the employment fell from 59 071 to 52 363 from 1994 to 1996, a decrease of 11 per cent. In Germany and Slovenia all activities are related to industry closure, reclamation and restoration.

Future Production Possibilities

An increase of the world's uranium production is expected in 1997. Taking announced plans for 1997, together with estimates for non-reporting countries (including Australia, Canada and the United States where increases are expected), the world production may increase to the range of 38 000 to 39 000 tU, or more. Estimates indicate that production in the OECD area will probably increase again, continuing the trend observed since 1993. In the non-OECD area a stabilisation can be expected.

The projections of production capability discussed in this section are based on officially reported planned and prospective projects. They may not include projects in the early phase of planning and/or projects that are otherwise not officially reported. **North America** is an area where future production increases are very likely to occur. In **Canada** several new mining projects have been reviewed under the Environmental Assessment and Review Process, giving approval to most of them. The projects will extend the lifetime of existing production centres, e.g. the extension of the Cluff Lake Dominique-Janine orebody, Eagle Point/Collins Bay A + D expansion and the McArthur River project whose ore will be processed in the Key Lake plant. The McClean Lake production centre had been scheduled for production in mid-1997 but start-up has been delayed until 1998. If approved, ore from the Cigar Lake and Midwest projects will be milled at McClean Lake after 2000. For Kiggavik in the Northwest Territories, a less advanced project, the feasibility study is ongoing and the project is unlikely to enter into production before 2005. If the additional projects become operational as planned, Canadian annual uranium production capacity could reach 15 000 tU. In the **USA,** uranium annual production could be increased by about 1 500 or 1 600 tU if planned new ISL projects come on stream and/or current ISL operations increase their production level.

In **Central and South America**, the very low production level of about 50 tU/year is expected to continue until Brazil resumes its production at the new Lagoa Real project, scheduled to start-up in 1998.

In **Western Europe**, no new production projects are envisaged for the near future. The present level of about 1 200 tU/year will probably be reduced slightly in the coming years, with the closure of the French Lodève production centre. Recovery of uranium in association with reclamation in **Germany** will be in the same range as 1996. Uranium production in **Spain** and **Portugal** is expected to remain at the same level as in recent years.

In **Central and Eastern Europe**, future production is expected to increase based primarily on plans from the Russian Federation. The **Czech Republic** has announced plans to maintain the current level of 600 tU. Mine production in **Hungary** was planned to cease in 1997 and the Mecsek underground mine was then to be closed. **Romania** could possibly increase its production to about 170 tU/year to meet domestic demand. The **Russian Federation** is planning to expand its production in the near term. In the longer term it plans to develop 3 new large ISL facilities to provide an additional 6 000 tU/year of annual capacity by 2010. It is expected that **Ukraine** will maintain its current production level of the estimated 1 000 tU/y until it upgrades its mill capacity.

Table 7. **Ownership of Uranium Production based on 1996 output**

COUNTRY	Domestic Mining Companies				Foreign Mining Companies				TOTAL
	Government-owned		Private-owned		Government-owned		Private-owned		
	tU/year	%	tU/year	%	tU/year	%	tU/year	%	
Argentina	28	100	0	0	0	0	0	0	28
Australia	0	0	4 094	82	183	4	698	14	4 975
Belgium	0	0	28	100	0	0	0	0	28
Canada	629	5	6 017	52	1 926	16	3 134	26	11 706
China*	560	100	0	0	0	0	0	0	560
Czech Republic	604	100	0	0	0	0	0	0	604
France	830	89	100	11	0	0	0	0	930
Gabon	142	25	40	7	386	68	0	0	568
Germany	39	100	0	0	0	0	0	0	39
Hungary	0	0	200	100	0	0	0	0	200
India*	250	100	0	0	0	0	0	0	250
Kazakhstan	1 210	100	0	0	0	0	0	0	1 210
Namibia	83	3	0	0	235	10	2 129	87	2 447
Niger	1 099	33	0	0	1 465	44	757	23	3 321
Pakistan*	23	100	0	0	0	0	0	0	23
Portugal	0	0	15	100	0	0	0	0	15
Romania	105	100	0	0	0	0	0	0	105
Russian Federation	2 605	100	0	0	0	0	0	0	2 605
South Africa	0	0	1 436	100	0	0	0	0	1 436
Spain	0	0	255	100	0	0	0	0	255
Ukraine	1 000	100	0	0	0	0	0	0	1 000
United States	0	0	1 180	48. 5	865	35. 6	386	15. 9	2 431
Uzbekistan	1 459	100	0	0	0	0	0	0	1 459
TOTAL	**10 666**	**29.5**	**13 365**	**36.9**	**5 060**	**14.0**	**7 104**	**19.6**	**36 195**

* Secretariat estimate.

Table 8. **Employment in Existing Production Centres of Countries Listed (in Persons-Years)**

COUNTRY	1990	1991	1992	1993	1994	1995	1996	Expected 1997
Argentina	340	250	220	220	180	120	100	80
Australia	1 183 (a)	1 189 (a)	376 (a)	405 (a)	412	413	464	494
Belgium	5	5	5	5	5	5	5	5
Brazil	521	463	430	410	408	390	305	305
Bulgaria	NA	NA	13 000	8 000	NA	NA	NA	NA
Canada (b)	2 495	2 195	1 310	1 320	1 370	1 350	1 155	1 200
China	10 000	9 500	9 500	9 300	9 100	8 000	8 500	8 500
Czechoslovakia/CSFR	12 100	9 300	6 600	xxxx	xxxx	xxxx	xxxx	xxxx
Czech Republic	xxxx	xxxx	xxxx	5 900	5 400	4 500	3 600	3 000
France	2 276	1 773	1 368	824	496	468	441	NA
Gabon	NA	NA	207	193	263	276	259	150
Germany	15 710 (c)	7 488 (d)	6 093 (d)	4 895 (d)	4 613 (d)	4 400 (d)	4 200 (d)	4 000 (d)
Hungary	4 798	2 240	1 855	1 755	1 766	1 250	1 144	1 100
India	NA	NA	3 780	3 898	NA	NA	NA	NA
Kazakhstan	xxxx	xxxx	11 800	10 550	8 050	6 850	6 000	5 350
Namibia	NA	NA	1 266	1 240	1 246	1 246	1 189	1 300
Niger	3 173	2 562	2 340	2 118	2 104	2 109	2 077	2 001
Portugal	231	217	94	52	46	52	56	NA
Romania	xxxx	xxxx	xxxx	xxxx	6 500	6 000	5 000	4 550
Russian Federation	xxxx	xxxx	xxxx	15 900	14 400	14 000	13 000	NA
Slovenia (d)	xxxx	200	150	145	145	140	115	105
Spain	309	240	232	186	185	183	178	176
United States	1 335	1 016	682	380	452 (e)	535 (e)	689 (e)	NA
Uzbekistan	NA	NA	NA	NA	6 688	7 378	8 201	8 200
Yugoslavia	440	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
TOTAL	********	********	********	********	**63 829**	**59 665**	**56 678**	********

NA Data not available.
xxxx National entity not in existence or politically redefined.
**** No estimate due to insufficient information.
(a) Olympic Dam does not differentiate between copper, uranium, silver and gold production. Employment has been estimated for uranium related activities.
(b) Data as of end of year, for mine site employment only.
(c) Data includes former GDR.
(d) Employment related to decommissioning and rehabilitation.
(e) Does not include 491 persons-years in 1993, 528 persons-years in 1994, 573 persons-years in 1995 and 429 persons-years in 1996 for employment in reclamation work relating to exploration, mining, milling, and processing.

In **Africa**, **Namibia** could increase production should market conditions warrant. Full capacity of 4 000 tU/year could be reached within a short period. As **South African** production originates as by-product of gold (and copper), a large increase of uranium production is not likely to occur except in association with favourable market conditions for both uranium and for gold. No new projects are envisaged in **Niger**. However the country has the necessary resources to maintain its current production levels through 2015. In **Gabon** all production is expected to stop in 1999, unless new mines are successfully opened.

In Middle East, Central and South Asia, India and **Pakistan** are expected to maintain their production at levels equal to their domestic demand. The capacity in India is 230 tU/year. After undergoing reductions in recent years production in **Kazakhstan** and **Uzbekistan** is planned to increase to 1 500 tU and 2 050 tU, respectively, in 1997. These countries are planning to further increase production in the future in response to anticipated improving market conditions.

In the **Pacific Area**, the production of **Australia** increased to about 5 000 tU annually, and could increase again in the near future. ERA has government approval to extend the Ranger mill capacity to 5 100 tU/year. The company is permitted to mine the Ranger-3 orebody and has made a proposal to develop the nearby Jabiluka deposit. The planned expansion of Olympic Dam to reach 3 900 tU/y in the year 2001 has been accelerated and will be completed in 1999. The retraction of the Australian "three mines policy" in March 1996 has made it possible for the development of new production centres. Canning Resources has delayed the decision to mine the Kintyre orebodies located in Western Australia. Heathgate Ltd., a US private company, is studying the possibility of mining the Beverly orebody in South Australia using in situ leaching methods. In addition, in 1996 COGEMA started a new feasibility study of the Koongarra deposit.

In **East Asia**, **China** indicates it will continue to produce for its domestic consumption, as well as to meet existing export contracts.

Production Techniques

Uranium is produced using both conventional mining and ore processing (milling) and unconventional production techniques. Unconventional techniques include in situ leaching (ISL) technology, phosphate by-product recovery and heap leaching. (In this report the recovery of uranium in association with gold and copper production is included with conventional production.)

Conventional production involves ore extraction by open pit and underground mining. ISL mining uses either acid or alkaline solutions to extract the uranium. The solutions are injected into, and recovered from, the orebearing zone through wells constructed from the surface. ISL technology is only being used to extract uranium from suitable sandstone-type deposits. In this report, "Other" technology includes production by phosphate by-product, heap and in-place (in-stope) leaching. In-place leaching involves leaching of broken ore without removing it from an underground mine, while heap leaching is done once the ore is extracted from a conventional mine, and moved to the leaching facility located on the surface.

The distribution of production for the four technology types or material sources for 1994 to 1996 is shown in Table 9.

Table 9. **Percentage Distribution of World Production by Material Source**

MATERIAL SOURCE	1994	1995	1996
Open pit	38%	37%	39%
Underground	41%	43%	40%
ISL	14%	14%	13%
Other*	7%	6%	8%

* Phosphate by-product, heap and in-place leaching and mine water recovery.

As shown, conventional mining and milling has remained the dominant technology for producing uranium. Conventional mining contributed nearly 80 per cent of the uranium production in 1994 to 1996. Underground mining continues to contribute slightly more than open pit mining. The share produced by ISL technology has remained nearly constant at about 14 per cent of the total world production. Other methods (phosphate by-product, heap and in-place leaching) are responsible for about 6 to 8 per cent of the total.

On a worldwide scale recovery of by-product uranium during phosphate processing is of minor importance. As of 1 January 1997, only 3 phosphate by-product plants, with a total aggregate production capability of about 495 tU/annum, were reported to be in operation. This included two plants in the USA and one in Belgium, with respectively, 450 and 45 tU annual capability. This aggregate capability is equivalent to about 1.4 per cent of 1996 production. Most of the remaining production in the "Other" class was by heap and in-place leaching.

The changes in the sources of production in the 1994 to 1996 period have tended to offset each other. For example, while production using ISL declined in the CIS and Eastern Europe, in the USA production from ISL technology has increased. The estimated amount of US ISL production increased by about 85 per cent from about 900 tU, or 20 per cent of world ISL production in 1994, to nearly 1 675 tU (estimated) in 1996. US ISL production made up an estimated 35 per cent of world ISL production in 1996. Because US producers use only alkaline leach technology, the relative proportion of uranium produced using alkaline solutions has increased significantly, while the amount of uranium produced using acid leaching has declined.

It is expected that the use of conventional production technology will increase, with particular emphasis on underground mining. Existing projects are expected to operate at or near capacity, or to undergo expansion. ISL technology could maintain its relative share if planned, new projects are brought into production.

The prevailing low market prices of recent years have, in most cases, meant that only those deposits amenable to competitive low cost production are being operated and/or developed for future production. Low-cost uranium production from new projects is expected to be primarily from high-grade unconformity-type deposits and sandstone-type deposits amenable to ISL mining technology. Australia and Canada are the only countries with known unconformity-type resources. In Canada, six projects designed to exploit this type of deposit are in various stages of the planning, environmental review and development process, or are in production.

Five of the six new Canadian projects (e.g., Cigar Lake, Eagle Point-Collins Bay, McArthur River, Midwest and McClean Lake) currently employ or will employ underground mining technology to produce ore. With the exception of Cluff Lake, these are the first mines in Canada to exploit high-grade unconformity-type deposits using underground mining technology.

After the change of government policy in March 1996 the development of new uranium projects in Australia is likely to occur within a few years. Three new unconformity-type deposits may be developed in the next future, Jabiluka is the only one to be mined underground. The two others (Ranger-3 and Kintyre) will be mined by open pit. It is also reported that the Beverley deposit in South Australia may be mined using acid ISL technology. This would be the first commercial scale acid leach ISL uranium project in the western world.

Countries using ISL technology include: China, The Czech Republic, Kazakhstan, USA and Uzbekistan. Both Pakistan and Portugal also operate small ISL projects. New projects are planned in Australia, Mongolia and the Russian Federation, while there are plans to expand ISL production in Kazakhstan, USA and Uzbekistan. Bulgaria closed its ISL mines in 1994.

There are at present no known plans for expanding phosphate by-product production. Recovery of uranium by heap leaching is used in China, Portugal, the Russian Federation and Spain. In-stope (in-place) leaching is used in China and the Russian Federation. It is expected that the production in the "Other" category will not increase as fast as Conventional and ISL production, as no plans for new, large projects of these types have been reported.

Projected Production Capabilities

To assist in developing a projection of future uranium availability, member countries were asked to provide projections of their production capability through 2015. The first projection is based on Existing and Committed production centres, and the second includes Planned and Prospective production centres. While a few countries (Brazil, Gabon, Kazakhstan, Mongolia, Niger, South Africa and Uzbekistan) reported their production capability based on ≤$40/kgU RAR and EAR-I, several countries did not report their capabilities at this cost range. Both projections in this report are therefore made using RAR and EAR-I resources which are recoverable at costs of $80/kgU or less, and which are tributary to the production centres.

A total of 18 countries reported projected production capabilities from resources recoverable at costs up to $80/kgU. Uranium producing countries not reporting projected capabilities include: China, India, Pakistan, Romania and Ukraine. These countries have indicated their intent to meet their domestic reactor requirements. For this projection these countries are included with a capability that is equal to the low projection of reactor requirements from Table 12. There is no assurance however that all of these countries have RAR and EAR-1 resources to meet their requirements through 2015.

Table 10 shows the projections for Existing and Committed production centres (A-columns) and for Existing, Committed, Planned and Prospective production centres (B-columns) through 2015 for all uranium producing countries.

In 1997, the production capability of Existing and Committed production centres, reported by selected countries, is about 42 900 tU per year. For comparison, the 1996 uranium production for these selected countries was 36 195 tU, or about 84 per cent of capacity.

By 1998, the production capability increases to about 45 600 tU. Planned and Prospective centres could add another 3 000 tU (7 per cent), giving a total capacity of about 48 500 tU. By 2000, production from Existing and Committed centres is expected to decrease slightly to 45 200 tU per year. About 37 per cent, or 16 600 tU of this capacity is located in two countries – Canada (19 per cent) and Australia (18 per cent). An additional 53 per cent of the total is located in Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, the USA and Uzbekistan. Planned and Prospective centres are expected to add about 14 600 tU for a total of about 59 800 tU.

Closure of existing mines, because of resource depletion, will then cause Existing and Committed capability to fall sharply (26 per cent) to 33 400 tU by 2005. The Existing and Committed capability will then continue to fall slowly to about 32 100 tU in 2015.

Table 10. **World Uranium Production Capability to 2015**

(in tU/year, from resources recoverable at costs up to $80/kgU)

COUNTRY	1997		1998		2000		2005		2010		2015	
	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II	A-II	B-II
Argentina	120	120	120	120	120	120	NA	NA	NA	NA	NA	NA
Australia	5 000	5 000	5 500	5 500	8 100	10 800	8 100	10 800	8 100	10 800	8 100	10 800
Belgium (a) (b)	45	45	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Brazil (c)	0	0	0	300	500	500	0	1 360	0	1 360	0	1 360
Canada	12 950	12 950	14 250	16 250	8 500	17 900	0	13 500	0	13 500	0	11 200
China (b) (f)	740	740	740	840	740	1 040	740	1 040	740	2 400	740	3 200
Czech Republic	680	680	680	680	680	680	110	110	60	60	50	50
France	760	760	500	500	0	0	0	0	0	0	0	0
Gabon (c)	587	587	540	540	540	540	0	0	0	0	0	0
Hungary	0	200	0	30	0	0	0	0	0	0	0	0
India (a) (b) (f)	220	220	220	220	220	246	220	286	220	391	220	508
Kazakhstan (c)	1 500	1 500	1 600	1 600	2 000	2 000	2 800	3 000	3 800	4 000	4 800	5 000
Mongolia (c)	150	150	150	250	150	500	150	1 100	150 (b)	1 100 (b)	150 (b)	1 100 (b)
Namibia	3 000	3 000	3 000	3 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000 (b)	4 000 (b)
Niger (c)	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800
Pakistan (b) (f)	30	30	30	30	30	65	30	65	30	65	30	50
Portugal	50	50	50	200	50	200	50	200	50	200	50 (b)	200 (b)
Romania (a) (b) (f)	300	300	300	300	300	300	300	300	300	400	300	500
Russian Fed. (h)	3 500	3 500	3 500	3 500	3 500	3 500	3 500	6 000	3 500	10 000	3 500	10 000
South Africa (c) (d) (g)	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900	1 900
Spain	255	255	255	255	255	255	NA	NA	NA	NA	NA	NA
Ukraine (b) (f)	1 000	1 000	1 000	1 000	1 000	1 000	1 000	2 000	1 000	2 790	1 000	2 790
United States	4 230	4 230	4 932	5 220	5 816	7 489	3 662	8 835	2 354	6 335	462	1 231
Uzbekistan (c)	2 050	2 050	2 500	2 500	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000
Zimbabwe (e)	0	0	0	0	0	0	0	350	0	50	0	0
TOTAL	**42 867**	**43 067**	**45 567**	**48 535**	**45 201**	**59 835**	**33 362**	**61 646**	**33 004**	**66 151**	**32 102**	**60 689**

A-II Production Capability of Existing and Committed Centres supported by RAR and EAR-I recoverable resources.

B-II Production Capability of Existing, Committed, Planned and Prospective Centres supported by RAR and EAR-I recoverable resources.

NA Data not available.

(a) From resources recoverable at costs of $130/kgU or less.

(b) Secretariat estimate.

(c) From resources recoverable at costs of $40/kgU or less.

(d) OECD/NEA-IAEA, "Uranium 1993 - Resources, Production and Demand", OECD, Paris, 1994.

(e) OECD/NEA-IAEA, "Uranium 1991 - Resources, Production and Demand", OECD, Paris, 1992.

(f) Projections for China, India, Pakistan, Romania and Ukraine are based on the countries' stated plans to produce to meet domestic requirements. China also plans to meet existing export contracts.

(g) South Africa reports uranium production could decrease to 1 000 tU/year around 2 000 if market prices do not increase.

(h) The Russian Federation reports current capability of 3 500 tU, with planned expansion to 10 000 tU/year by 2010. Capability for other years are Secretariat estimates.

The uranium production industry will undergo considerable change over the 1997 to 2005 period. In 1996, with plant capacity utilisation at about 85 per cent, Existing and Committed capability was 42 500 tU, or about 70 per cent of the 1996 requirements. This capability will remain at 70 per cent of projected requirements through 2000. However, with the expected facility closures after 2000, Existing and Projected capability will be less than 50 per cent of projected requirements by 2005. Furthermore, the continuous decrease of Existing and Committed capability through 2015 will meet only between 40 and 50 per cent of the uranium requirements projected for that year.

Planned and Prospective production is projected to add about 28 300 tU of capability by 2005. Putting this into service would make available a total of 61 600 tU per year, or about 90 per cent of the annual requirements in 2005. Planned and Prospective capability is projected to increase to about 33 100 tU in 2010. Total Existing, Committed, Planned and Prospective Capability would then be about 66 200 tU, or about 86 to 93 per cent of requirements.

Planned and Prospective Capability will then decline to about 28 600 tU by 2015. Total Existing, Committed, Planned and Prospective Capability is projected to be about 60 700 tU in 2015. This is between 73 and 97 per cent of projected requirements.

The development of the total capability described in this report (including planned and prospective) would leave unfilled requirements of about 5 000 tU in 2000, 5 000 to 8 000 tU in 2005, 5 000 to 11 000 tU in 2010, and 2 000 to 22 000 tU in 2015. Additional supplies will be necessary to fill the production shortfall indicated by these projections. Significant additional material is likely to come from alternative supplies including fuel reprocessing, excess inventory drawdown and low enriched uranium (HEU) obtained from the blending of highly enriched uranium (HEU) from warheads and government stockpiles. It is probable that LEU from HEU weapons material will be the second largest supply source. In the long term, however, the largest contributor will be the development of new uranium mines and mills.

D. RADIATION SAFETY AND ENVIRONMENTAL ASPECTS

The section on radiation safety and environmental aspects of uranium mining and production has been introduced for the second time in this publication to inform readers about the relevance of environmental protection due to increasing environmental awareness related to these activities. This section provides an indication of the increasing level of activities related to the protection of the environment by uranium mining companies. It also provides an insight to the potential impact of radiation safety and environmental protection considerations on existing uranium production facilities, future capabilities and on the schedule and design of new production facilities. This aspect is becoming more important due to two developments : first, the increasing number of production facilities which have been taken out of operation recently, and second, the increasing requirement for environmental clearance approvals. In addition, environmental aspects need to be considered for production sites which were abandoned at a time when legal provisions for proper decommissioning and rehabilitation were not sufficient. Many of these sites were abandoned without taking into consideration any safety, restoration or reclamation measures. The following is an overview of major past and ongoing environmental issues related to uranium mining and production. A more comprehensive report on Environmental Issues in Uranium Mining and Milling is to be published in

1998 by the OECD/NEA and the IAEA on the basis of detailed information provided by IAEA and NEA country members.

North America. In **Canada**, the six new uranium mining projects in Saskatchewan have been, or are being, reviewed by an independent panel according to the Federal Environmental Assessment and Review Process Guidelines Order. In 1995, the environmental impact statements for the Cigar Lake and McArthur projects and the revised Midwest joint venture project were submitted for review. Public hearings for Cigar Lake and McArthur River began in September 1996. In August 1996 Cogema Resources Inc., the operator of the previously accepted McClean Lake project, informed the Joint Federal-Provincial Environmental Assessment Panel that it would change its tailing disposal plan for the JEB pit; this pit will also accept tailing from the Cigar Lake and Midwest projects. The Panel determined the need for more information about the technical practices to be used to store the tailings of the projects. Subsequently, the Panel reviewed this additional information during supplementary hearings which were necessary before submitting its recommendations to the governments. The review of the McArthur River project was completed at the end of 1996 and the Panel reported to the governments in late February 1997. The Panel recommended that the project be permitted to proceed subject to a number of conditions, and in May 1997, both governments agreed to permit the project to proceed subject to licensing approvals. Concerning the decommissioning of Elliot Lake uranium tailings, the Environmental Assessment Panel submitted in June 1996 its recommendations to the Minister of the Environment which are in agreement with the proposals of Rio Algom and Denison. The federal response, released in April 1997, approved most of the Panel's recommendations.

In the **USA**, out of 26 conventional mills licensed for commercial operation, only one was operational during 1995. Five mills are on standby, the rest are under various stages of decommissioning. According to a 1992 law, the Department of Energy (DOE) has the responsibility of reimbursing licensees of active uranium and thorium processing sites for remedial action costs attributable to by-product material (mill tailings) generated by uranium and thorium concentrate sales to the United States Government. DOE is mandated to reimburse up to US$ 5.50 per dry short ton of Federal-related tailings. Total reimbursement which was previously limited to US$ 270 million was increased to US$ 350 million in 1996, and maximum reimbursement to a single licensee increased to US$ 65 million from US$ 40 million. The report *Decommissioning of US Uranium Production Facilities*, (DOE-ERA-0592, Feb. 1995), examines 25 conventional and 17 non-conventional sites in the USA. Average costs for decommissioning of mills are US$ 14.1 million, over half of it for tailings reclamation. The average for non-conventional facilities is US$ 7 million, about 40 per cent for groundwater restoration. These costs which affect the cost for uranium production are normally amortizedd over the life of the operation and are added to the sales price of the concentrate.

Central and South America. In **Argentina**, the decommissioning of the Malargüe mill has begun, the CNEA will spend about US$ 12 million for starting restoration of the site. Activities and studies are now focused on the area of Los Gigantes mining centre. In **Brazil**, the Poços de Caldas mine and mill facility which is now closed is monitored and controlled by the national mining company. In a radius of 20 km around the complex, all necessary data are collected in regular intervals. The decommissioning of the mine will begin in 1998.

Western Europe and Scandinavia. In **Finland**, the former small uranium mine of Paukkajanvaara, closed in 1962, was monitored since 1974 and finally covered with soil in 1993. In **France**, all excavations of material containing potentially harmful radioactive substances are strongly regulated by existing laws which have become even more strict in the last few years. The regulations require decommissioning and rehabilitation of closed mining and milling facilities as well as waste dumps and tailing facilities so that the release of potentially harmful substances is reduced to a minimum and the standards are met. The decommissioning and rehabilitation of Vendée mining sites are completed and the sites are under monitoring. The decommissioning of the Bessines mining site is in progress. Since the termination of commercial uranium production in **Germany** in 1990, substantial programmes for the decommissioning of mines, mills and adjacent facilities have been carried out. The huge amount of open space created by open pit and underground mining and the large volumes of waste rock and tailing dumps require large financial investment by the government. Annually between DM 700 and 800 million are spent. The total expenditures are expected to amount to DM 13 billion and would provide for decommissioning and total rehabilitation activities over a 15-year period. In **Spain**, the decommissioning of La Haba production centre, Badajoz province, was completed in 1997. A five-year supervision programme is established in order to verify the fulfilment of the criteria imposed to the operator by the Spanish Nuclear Safety Council. In the Fe mine area, Salamanca, decommissioning projects for the old Elefante treatment plant and for old heap leaching operation has been presented and are pending authorisation by the Spanish Nuclear Safety Council. A plan to restore 22 old uranium mines located in the Andalucía and Castilla regions and, for the most part, in the Extremadura autonomous region, has been presented. For its concern, the Extremadura Autonomous Government approved the project in March 1997 and the work is now in progress in this region. In **Sweden**, the Ranstad mine was restored in the early 1990s using state-of-the-art technology. The open pit has been transformed into a lake and the tailings area has been covered with a multi-layer protection cover to prevent acid water generation. The area is continuously monitored. In **Portugal**, ENU has been monitoring several environmental parameters such as air quality, mining effluents (underground mine and surface drainage waters) and collecting data samples on soil, sediments and vegetation for further analysis in the decommissioning mines of Urgeiriça, Castelejo and Cunha Baixa.

Central and Eastern Europe. The **Czech Republic** is conducting an inventory of environmental burden from abandoned uranium production facilities. This will include Jachymov and Horni Slavkov where mining took place in the 1940s and 1950s. A substantial programme of environmental protection is being conducted by DIAMO for active mining sites and recently closed facilities. This programme includes the monitoring of release of emissions into the atmosphere and hydrosphere as well as the assessment of the impact of soil contamination. Major activities are related to landscape modifications due to uranium mining: backfill of underground mines and open pits, reclamation and recultivation of dumps, remediation of tailings impoundment, and mainly the remediation of the Straz ISL fields and associated Cenomanian and Turonian aquifers. This operation started in October 1996. Monitoring and control of the released mine water are in operation at most of the previous mining sites. In **Hungary,** MECSEKURAN Ltd. prepared a plan for the decommissioning of the uranium industry in the Mecsek area in 1996. This includes methodology and schedules for the closure of uranium mines and mill and the environmental measures to be taken in order to restore and rehabilitate the area. After the closure of the Zirovski vrh production facility in **Slovenia**, measures for environmental protection have been initiated. This includes activities for the geomechanical stability of the mine, protection of surface and groundwater, remediation of the mill and actions for other utilisation, rehabilitation of waste dumps and tailing ponds and the protection of the environment against radioactive contamination (e.g. radon exhalation). Until present, no decommissioning of uranium production facilities has been carried out in **Ukraine**; however, the Ukrainian government has now implemented a State programme for radiation protection improvement of these facilities. The programme covers all environmental issues in uranium mining and milling of Ukraine. The potential hazard of waste rock and low-grade ore which are stored near the mines is recognised as well as the need to manage tailings.

Africa. In **Gabon** a study is being carried out with the objective of restoring the mining sites near Mounana and to manage the mill tailing for the long term, following the end of mining activities. In **Namibia**, the application for a mining license requires that an environmental assessment study be carried out. Any damage of the environment due to mining should be prevented. Mining companies are obliged to rehabilitate the land after mining. Rössing Uranium Mines has adopted the existing international standards for uranium mining. At present a review is being carried out to develop site-specific, risk-based environmental objectives and thresholds. For the Rössing mine, located in the Namib desert, the principal environmental consideration is water management. The system used by the mine is aimed at reducing water consumption and minimising ground water contamination. A new tailings deposition method reduces the loss of water by evaporation. Acid mine drainage is reduced by neutralisation. The International Commission on Radiological Protection's Publication 60 of 1990 (ICRP 60) recommendation and the "As Low As Reasonably Achievable" ALARA principle are applied to reduce radiological exposure. In **South Africa**, the Council for Nuclear Safety is the regulatory body responsible for environmental legislation related to uranium production. Issues related to gold/uranium mining on the Witwatersrand include dust pollution, surface and groundwater contamination and residual radioactivity. The strict environmental legislation requires that former mine land and areas of uranium plants be surveyed and decontaminated before re-use.

Middle East, Central and South Asia. In **Kazakhstan**, rollfront uranium deposits are accompanied by radioactive contamination of the water-bearing horizons which can reach a length of 150 km and a width of 15 to 20 km. These areas must be excluded from water use supplies. Uranium production of the past 40 years resulted in an accumulation of about 200 million tonnes of low-level waste dumps and mill tailings. The potential threat for the environment is realised and programmes for environmental restoration are in the planning stage. Potential problems are created by radioactive waste of abandoned sites where no reclamation was done due to the absence of a responsible organisation authority. In **Uzbekistan** the occurrences of rollfronts uranium in the aquifers induce a very high content of uranium and of several other metals in underground waters even in areas where mining activities do not exist. On the surface the main troubles related to uranium production are radioactive dust and radon spreading into the environment. Measurements are being taken to avoid these problems, to isolate the waste and to treat the waste water.

Pacific Area. In **Australia**, the government, which controls the uranium mining in the Northern Territory, is responsible for regulation of mining activities and supervision of environmental programmes in the Alligator Rivers Region (ARR) where the Ranger mine and the old Nabarlek mine are located. Nabarlek mine ceased production in 1988 and the rehabilitation was completed in 1995. The site is under environmental monitoring. The Office of Supervising Scientist (OSS) which oversees uranium mining in the ARR has consistently attested to the high level of environmental protection achieved in the ARR, noting that uranium mining has had a negligible impact on the surrounding environment. Concerning the ERA proposal to develop the Jabiluka deposit, a final Environmental Impact Statement was submitted in May 1997. In 1996, Western Mining Corp., which operates the Olympic Dam Mine, submitted a proposal to expand the production of the mine to 200 000 tonnes per year of copper and 4 600 tonnes per year of U_3O_8 (3 900 tU) from 150 000 tonnes per year of copper with 3 700 tonnes per year U_3O_8. (3 140 tU). An environmental assessment of the proposed expansion is being conducted by both governments (Commonwealth and South Australia State) and an EIS was released by WMC for public comment in May 1997. Moreover the proposals to develop new uranium mines in South Australia at Beverley and in Western Australia at Kintyre will be submitted to Commonwealth/State EIS processes.

East Asia. China has been decommissioning 6 uranium mines and 3 mills since 1986. Most of the decommissioning processes are still underway, mainly for the treatment of waste ore and tailings. In 1993, the government published technical regulations for the environmental management and decommissioning of uranium mining and milling facilities.

REFERENCE

1. Chen, Zhaobao, *The Current Status of Uranium Resources Development in China and its Future*, presented at the Forum on Uranium Resources Development, and organised by the Power Reactor and Nuclear Fuel Development Corporation and Japan Atomic Industrial Forum, Inc., 10 March 1997, Tokyo, Japan.

II. URANIUM DEMAND

This chapter summarises the current status and projected growth in world nuclear generating capacity and commercial reactor-related uranium requirements. Relationships between uranium supply and demand are analysed and important developments related to the world uranium market are described. Particular attention is given to two issues that are significantly affecting the uranium supply market. These issues are the disposition of surplus defence material by the Russian Federation and the United States and the restrictions on the sale of NIS produced uranium in the United States and in the European Union. The last section of the chapter explores the potential impact of recent developments on the long-term perspective.

A. CURRENT NUCLEAR GENERATING CAPACITY PROGRAMMES AND COMMERCIAL REACTOR-RELATED URANIUM REQUIREMENTS(1)

World (353 GWe net). World nuclear electricity generation has roughly doubled over the last decade, and the cumulative nuclear electricity generation now exceeds 29 600 TWh. Nuclear power plants supply about 6 per cent of the world's total energy consumption and some 17 per cent of the world’s electricity. By the beginning of 1997, there were 442 nuclear power units operating in the world with a total net capacity of 353 GWe (net gigawatts electric) connected to the grid (see Table 11 and Figures 9 and 10). A total of 36 new reactors are under construction with a capacity of about 28 GWe. In recent years, however, the growth in nuclear power has slowed considerably. Only about 13 GWe of new installed capacity has been added since the last Red Book study two years ago. Pressurised Water Reactors have by far the largest share of installed capacity, with more than twice as many reactors in operation than the next nearest competitor, Boiling Water Reactors.

In 1995, four new reactors totalling 3.3 GWe were connected to the grid and no new reactors started construction. In the same year, construction of three reactors in Romania was indefinitely deferred. In 1996, five new reactors totalling 5.7 GWe were connected to the grid in France, Japan, Romania and the US, and construction of three reactors with a capacity of 2 GWe started in China and Japan. In the same year, one reactor in Ukraine suspended construction. In 1997, five additional reactors (5 82 GWe) are expected to achieve grid connection.

World annual uranium requirements in 1996 were estimated at about 60 488 tonnes natural uranium equivalent (see Table 12 and Figure 11). An increase of about 3 300 tU was expected for 1997.

(1) Some of the statistical data provided in the following sections are from: IAEA, *Nuclear Power Reactors in the World*, Reference Data Series No. 2, April 1997, IAEA, Vienna, Austria.

Table 11. **Installed Nuclear Generating Capacity(*) to 2015**
(MWe net)

COUNTRY	1996	1997	2000	2005 Low	2005 High	2010 Low	2010 High	2015 Low	2015 High
Argentina	940	940	940	600 a)	1 627 a)	1 292 a)	1 292 a)	1 292 a)	1 292 a)
Armenia	376 c)	376 a)	376 a)	0 a)	376 a)	0 a)	376 a)	0 a)	376 a)
Belarus	0	0 a)	0 a)	0 a)	0 a)	0 a)	600 a)	0 a)	600 a)
Belgium	5 693	5 713	5 713	5 713	5 713	5 713	5 713	5 713	5 713
Brazil	626	626	1 871	1 871	1 871	3 110	3 110	1 871 a)	3 110 a)
Bulgaria	3 538 c)	3 538 a)	2 722 a)	2 314 a)	3 675 a)	1 906 a)	3 812 a)	1 906 a)	3 812 a)
Canada	16 000	16 000	16 000	16 000	16 000	15 000	15 000	13 000	13 000
China (d)	2 100	2 100	3 300	7 000	9 000	17 000	21 000	22 000	27 000
Croatia	0	0 a)	0 a)	0 a)	0 a)	0 a)	600 a)	0 a)	600 a)
Cuba	0	0 a)	0 a)	0 a)	408 a)	0 a)	408 a)	0 a)	408 a)
Czech Rep.	1 632	1 632	2 604	3 516	3 516	3 516	3 516	3 516	3 516
Egypt	0	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	1 200 a)
Finland	2 310	2 310	2 650	2 650	2 650	2 650	2 650	2 650	2 650
France	60 000	63 000	64 400	64 400	64 400	64 400	64 400	64 400	64 400
Germany	22 400	22 400	22 400	22 000	22 000	21 400 a)	21 400 a)	20 200 a)	23 600 a)
Hungary	1 760	1 760	1 760	1 760 a)	1 760 a)	1 729 a)	2 329 a)	1 299 a)	2 929 a)
India	1 695 c)	1 695 a)	1 897 a)	2 203 a)	2 953 a)	3 013 a)	5 463 a)	3 913 a)	6 813 a)
Indonesia	0	0 a)	0 a)	0 a)	0 a)	0 a)	1 500 a)	0 a)	4 200 a)
Iran	0	0 a)	0 a)	950 a)	950 a)	950 a)	2 150 a)	950 a)	2 150 a)
Japan	42 712	45 248	45 600	54 138 a)	54 384 a)	70 500	70 500	70 500 a)	78 925 a)
Kazakhstan	70	70	70	2 070	2 070	6 870	6 870	6 870 a)	6 870 a)
Korea, DPR	0	0 a)	0 a)	0 a)	950 a)	1 900 a)	1 900 a)	1 900 a)	1 900 a)
Korea, Rep.	9 600	10 300	13 700	18 700	18 700	26 300	26 300	26 300 a)	30 714 a)
Lithuania	2 760	2 760	2 760	2 760 a)	2 760 a)	2 760 a)	2 760 a)	1 185 a)	2 760 a)
Mexico	1 308	1 308	1 370	1 370	1 370	1 370	2 370	1 370	3 370
Morocco	0	0	0	0	0	0	0	0	600 a)
Netherlands	507	449	449	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)
Pakistan	125 c)	125 a)	425 a)	425 a)	725 a)	425 a)	725 a)	300 a)	2 600 a)
Philippines	0	0	0	0	0	0 a)	1 800 a)	0 a)	1 800 a)
Poland	0	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	1 200 a)
Romania	650	650	650	1 950	1 950	2 560	3 250	3 250	3 250
Russia	19 843	19 843	22 668 a)	21 676 a)	23 226 a)	23 326 a)	26 226 a)	22 443 a)	26 143 a)
Slovak Rep.	1 588	1 588	2 364	1 592	3 140	1 592	3 140	1 592	2 368
Slovenia	632 c)	632 a)	632 a)	632 a)	632 a)	632 a)	632 a)	632 a)	632 a)
South Africa	1 842	1 842	1 842	1 842	1 842	1 842	1 842	1 842	1 842
Spain	7 130	7 320	7 580	7 715	7 715	7 765	7 765	7 765	7 765
Sweden	10 000	10 000	9 400	8 800	8 800	8 800 a)	9 440 a)	6 918 a)	9 440 a)
Switzerland	3 055	3 117	3 179	3 179	3 179	3 179	3 179	3 179	3 179
Thailand	0	0 a)	0 a)	0 a)	0 a)	0 a)	1 000 a)	0 a)	2 000 a)
Turkey	0	0	0	1 000	1 000	2 000	2 000	2 000 a)	3 400 a)
Ukraine	13 880	13 880	15 880	15 880	15 880	15 880	15 880	15 880 a)	18 161 a)
United Kingdom	12 800 b)	12 800 b)	12 100 b)	9 300 b)	9 300 b)	7 000 b)	7 000 b)	7 000 a)	9 785 a)
United States	100 600	100 600	100 500	100 500	100 500	93 500	100 500	63 700	100 500
Viet Nam	0	0	0	0	0	0	1 000 a)	0	2 000 a)
OECD TOTAL	297 507	303 957	309 405	320 741	320 987	334 822	344 062	299 510	362 886
WORLD TOTAL	**353 056**	**359 506**	**372 686**	**391 890**	**402 406**	**427 264**	**461 282**	**394 720**	**500 957**

(*) Capacity installed at end of year.
(a) IAEA Secretariat estimate.
(b) OECD/NEA, *Nuclear Energy Data 1997,* Paris, 1997.
(c) IAEA, *Nuclear Power Reactors in the World*, RDS No.2, Vienna, 1997.
(d) The following data for Chinese Taipei are included in the World Total but not in the totals for China: 4 884 MWe until 2000, 7 384 MWe until 2015 for low case, and 7384, 9884 and 12 384 for high case until 2005, 2010 and 2015, respectively.

Figure 9. **World Nuclear Electricity Generating Capacity: 353 GWe**
(1 January 1997)

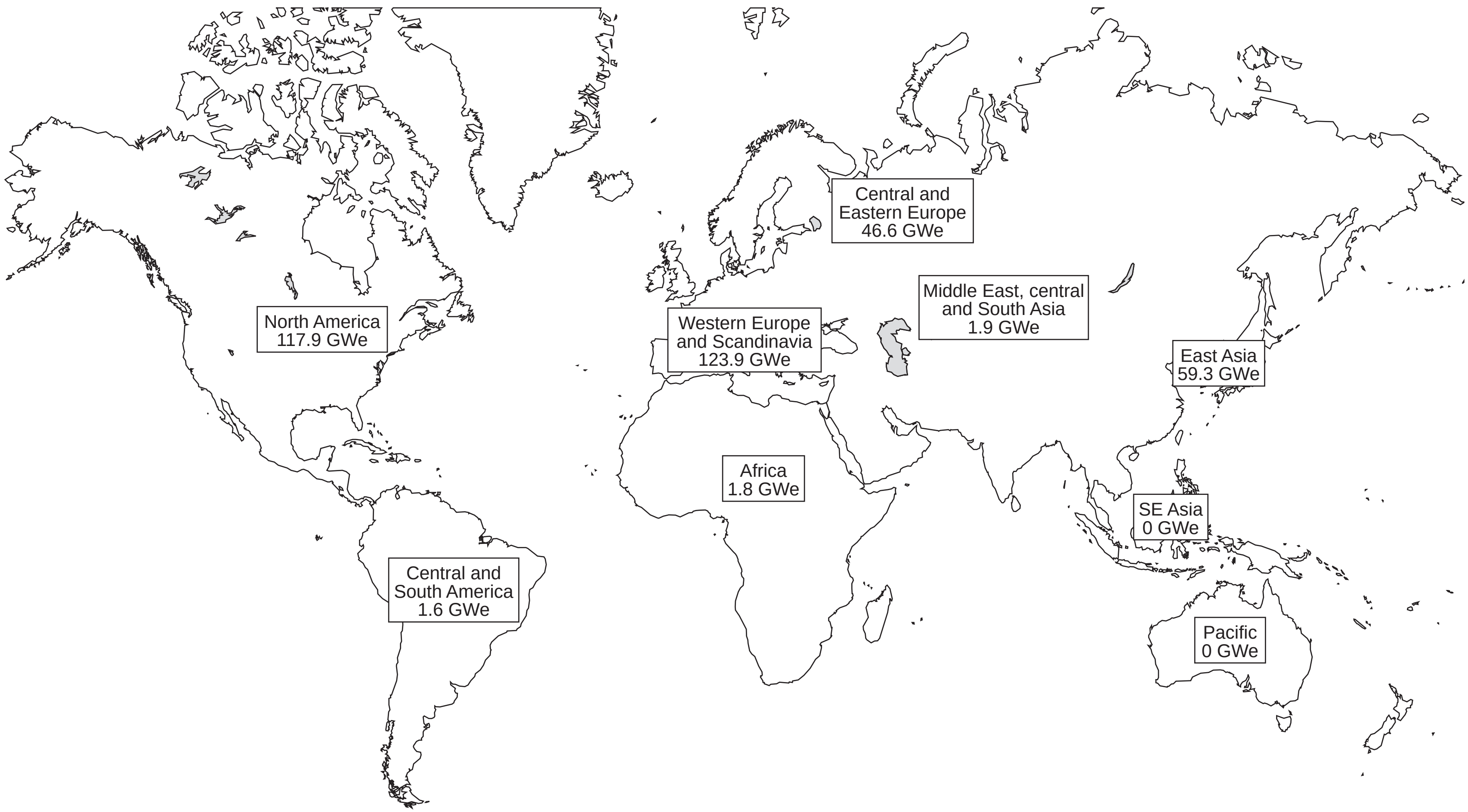


Figure 10. **World Installed Nuclear Capacity: 353 GWe (As of 1 January 1997)**

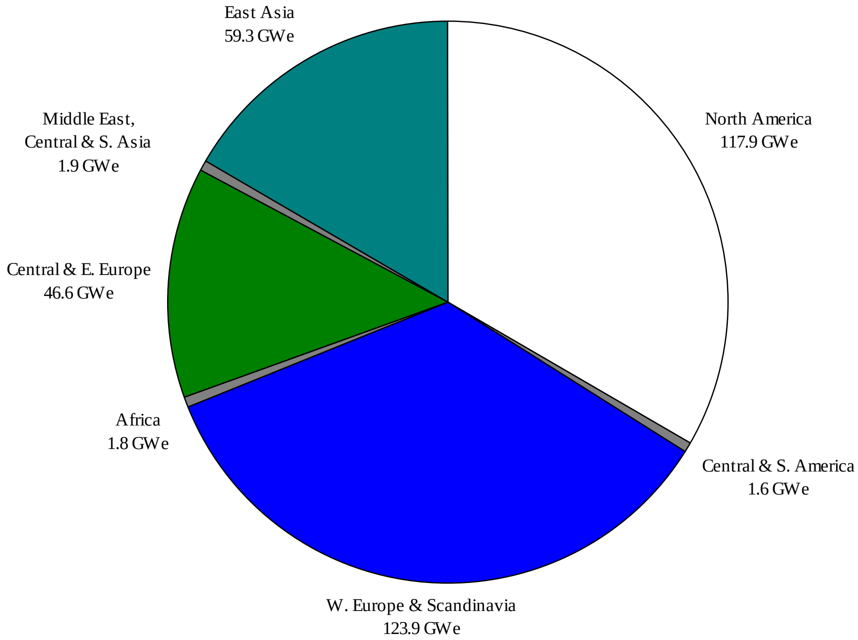


Figure 11. **World Uranium Requirements: 60 488 tU (As of 1 January 1997)**

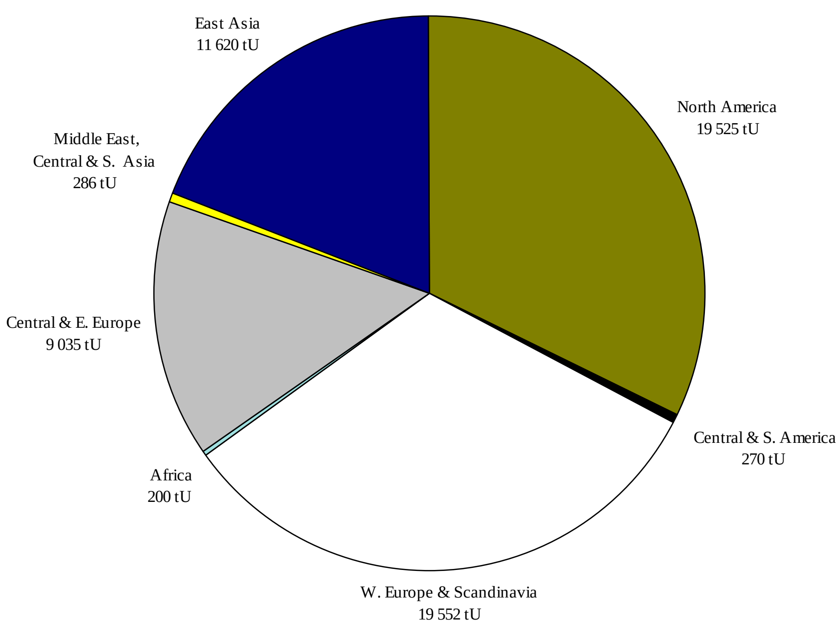


Table 12. **Annual Reactor-Related Uranium Requirements to 2015**
(Tonnes U)

COUNTRY	1996	1997	2000	2005 Low	2005 High	2010 Low	2010 High	2015 Low	2015 High
Argentina	150	150	150	96 a)	260 a)	206 a)	206 a)	206 a)	206 a)
Armenia	89 a)	89 a)	89 a)	0 a)	89 a)	0 a)	89 a)	0 a)	89 a)
Belarus	0	0 a)	0 a)	0 a)	0 a)	0 a)	93 a)	0 a)	93 a)
Belgium	1 050	1 050	1 050	1 050	1 050	1 050	1 050	1 050	1 050
Brazil	120	120	680	370	370	620	620	620 a)	620 a)
Bulgaria	844 a)	844 a)	649 a)	522 a)	876 a)	454 a)	909 a)	454 a)	3 812 a)
Canada	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800	1 800
China (c)	300	300	600	900	1 500	2 400	3 000	3 200	4 000
Croatia	0	0 a)	0 a)	0 a)	0 a)	0 a)	93 a)	0 a)	93 a)
Cuba	0	0 a)	0 a)	0 a)	90 a)	0 a)	90 a)	0 a)	90 a)
Czech Rep.	370	370	525	700	700	700	700	700	700
Egypt	0	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	200 a)
Finland	495	496	557	548	548	545	545	545	545
France	8 900	8 600	8 600	8 500	8 500	8 500	8 500	8 500	8 500
Germany	3 200	2 900	3 000	2 500	2 500	2 432 a)	2 432 a)	2 295 a)	2 682 a)
Hungary	415	415	420	420 a)	420 a)	413 a)	556 a)	310 a)	699 a)
India	220 a)	220 a)	246 a)	286 a)	383 a)	391 a)	709 a)	508 a)	884 a)
Indonesia	0	0 a)	0 a)	0 a)	0 a)	0 a)	248 a)	0 a)	693 a)
Iran	0	0 a)	0 a)	141 a)	141 a)	141 a)	318 a)	141 a)	318 a)
Japan	8 700	7 500	9 700	11 800	11 800	13 000	13 000	14 000	14 000
Kazakhstan	50	50	50	450	450	1 050	1 050	1 050 a)	1 050 a)
Korea, DPR	0	0 a)	0 a)	0 a)	157 a)	314 a)	314 a)	314 a)	314 a)
Korea, Rep.	1 810	2 760	2 890	3 010	3 010	4 290	4 290	4 290 a)	5 010 a)
Lithuania	385	415	425	425 a)	425 a)	425 a)	425 a)	182 a)	425 a)
Mexico	325	170	257	215	215	253	582	216	749
Morocco	0	0	0	0	0	0	0	0	100 a)
Netherlands	93	74	84	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)
Pakistan	16 a)	16 a)	65 a)	65 a)	115 a)	65 a)	115 a)	50 a)	442 a)
Philippines	0	0	0	0	0	0 a)	309 a)	0 a)	309 a)
Poland	0	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	0 a)	200 a)
Romania	100	100	100	300	300	400	500	500	500
Russia	3 800	3 800	4 341 a)	4 151 a)	4 448 a)	4 467 a)	5 022 a)	4 298 a)	5 006 a)
Slovak Rep.	440	770	495	330	660	330	660	330	495
Slovenia	102 a)	102 a)	102 a)	102 a)	102 a)	102 a)	102 a)	102 a)	102 a)
South Africa	200	200	200	200	200	200	200	200	200
Spain	1 155	1 075	1 240	1 470	1 470	1 470	1 470	1 470	1 470
Sweden	1 500	1 500	1 500	1 400	1 400	1 400 a)	1 500 a)	1 038 a)	1 500 a)
Switzerland	537	499	479	470	470	470	470	581	581
Thailand	0	0 a)	0 a)	0 a)	0 a)	0 a)	170 a)	0 a)	340 a)
Turkey	0	0	0	210	210	420	420	420 a)	714 a)
Ukraine	2 490	2 640	2 820	2 890	2 890	2 790	2 790	2 790 a)	3 191 a)
United Kingdom	2 622 (b)	2 622 (b)	2 500 (b)	1 764 (b)	1 764 (b)	1 262 (b)	1 262 (b)	1 262 a)	1 764 a)
United States	17 400	21 300	18 100	19 100	19 500	18 000	19 400	8 500	15 800
Viet Nam	0	0	0	0	0	0	210 a)	0	420 a)
OECD TOTAL	50 372	53 131	52 702	54 957	55 357	56 005	57 977	46 977	57 564
WORLD TOTAL	**60 488**	**63 757**	**64 524**	**66 805**	**69 433**	**70 980**	**77 049**	**62 542**	**82 796**

(a) Secretariat estimate.
(b) OECD/NEA, *Nuclear Energy Data 1997*, Paris, 1997.
(c) The following data for Chinese Taipei are included in the World Total but not in the totals for China: 810 tU/year until 2000, 620 tU/year until 2015 for low case, and 620, 830 and 1 040 tU/year for high case until 2005, 2010 and 2015, respectively.

While the world's nuclear capacity and uranium requirements have steadily increased each year, the growth rates within various regions of the world vary considerably.

OECD (297.5 GWe on 1 January 1997). The countries constituting the OECD hold more than 80 per cent of the world's nuclear capacity. The installed nuclear generating capacity in the OECD countries grew from 283.2 GWe to about 297.5 GWe over the period from 1994 to 1996. The increase of about 14.3 GWe represents a 2.5 per cent annual growth rate since the 1995 Red Book. A total of 14 additional reactors are under construction. The OECD reactor-related uranium requirements for 1996 were 50 372 tU/year, and they are expected to increase by about 5.5 per cent in 1997 to about 53 146 tU/year.

North America[(2)] 117.9 GWe on 1 January 1997). The **United States** added the Watts Bar-1 (1 170 MWe) in 1996, bringing the nation's installed capacity to 101 GWe. Annual reactor-related uranium requirements for North America were about 19 525 tonnes in 1996 and were expected to increase to 23 270 tU in 1997.

Central and South America (1.6 GWe on 1 January 1997). By the beginning of 1997, there were three nuclear units operating in two countries of this region – Argentina and Brazil. There are two units under construction, one in **Argentina** (0.7 GWe) and one in **Brazil** (1.2 GWe). In **Cuba**, the construction of two units, WWER-440 type, was suspended in 1994 due to financial constraints and to restricted technical assistance from the Russian Federation. However, in 1995 the Russian Federation announced its intention to resume assistance and a feasibility study has been undertaken for the completion of the first unit. Reactor-related uranium requirements for Central and South America totalled 270 tU in 1996 and are expected to remain at the same level in 1997.

Western Europe and Scandinavia (123.9 GWe on 1 January 1997). **France**, **Belgium** and **Sweden** continue to produce more than 50 per cent of their electricity from nuclear reactors. In 1996, their nuclear shares were 77 per cent, 57 per cent and 52 per cent, respectively. Three new reactors totalling 4 355 MWe are under construction in this region, all of them in **France**. Also in France, the Chooz-B1 (1 455 MWe) reactor was connected in 1996. One reactor in **Germany**, the Wuergassen (640 MWe), was retired in 1995. Although there have been reactor performance upgrades in several Western European and Scandinavian countries, the installed nuclear capacity has remained essentially constant over the last two-year period in **Belgium**, **Finland**, the **Netherlands**, **Spain** and **Sweden**. The reactor-related uranium requirements for this area in 1996 amounted to about 19 552 tU and were expected to decrease to about 18 831 tU in 1997.

Central and Eastern Europe (46.6 GWe on 1 January 1997). The very large nuclear power programmes under development in the region were slowed down significantly by financial and political difficulties that arose from the transition process to market economies. Since 1994 only two units were connected to the grid in this region. The Ukrainian Zaporozhe-6 (950 MWe) was connected in 1995 and **Romania** connected its first nuclear reactor, Cernavoda-1 (650 Mwe) in 1996. The **Russian Federation** and **Ukraine** have by far the largest installed nuclear capacities in the region at 19.8 GWe and 13.9 GWe, respectively. **Lithuania** led the world in 1996 in terms of its 83 per cent nuclear share of electricity generation. Most of the reactors in operation in the region are of Soviet design RBMK and VVER types. However, **Slovenia** operates a Western-supplied 650 MWe PWR and Romania operates a PHWR (CANDU) reactor and has 4 reactors of the same

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(2) The North American region includes the United States, Canada and Mexico. The geographical grouping of countries in this report is listed in Annex 7.

type under construction. However, construction on three of these reactors has been indefinitely deferred. In **Armenia** one of the two VVER/440-230, closed following an earthquake in 1989, restarted in 1995. In **Ukraine**, Rovno-4 is scheduled for connection to the grid in 1997. In the **Czech Republic** Temelin 1 is expected to go on line in April 1999, followed by Unit 2 in the second half of 2000. Eighteen reactors are under construction in the region (two in the Czech Republic, four in Romania, four in the Russian Federation, four in the Slovak Republic and four in Ukraine) representing a total capacity of 13.1 GWe. The 1996 reactor-related uranium requirements for Central and Eastern Europe were 9 035 tU and are expected to reach 9 545 tU in 1997.

Africa (1.8 GWe on 1 January 1997). Nuclear capacity has remained constant in Africa since the last Red Book. The region's only two reactors are located in **South Africa**. Annual reactor-related uranium requirements were about 200 tU/year in 1996 and are expected to remain the same in 1997.

Middle East, Central and South Asia (1.9 GWe on 1 January 1997). India, Kazakhstan and Pakistan are the only three countries with nuclear reactors in this region. In **India**, ten commercial reactors are presently operating with a total capacity of 1.7 GWe. Four PHWR units, with a total capacity of 808 MWe, are under construction in India and are expected to be connected to the grid before the end of the century. **Kazakhstan** operates a 70 MWe, FBR unit. **Pakistan** currently operates the Karachi (125 MWe) CANDU type reactor. A 300 MWe PWR unit imported from China is under construction in Pakistan and is expected to be connected to the grid by 1999. Reactor-related uranium requirements for the Middle East, Central and South Asia region are about 286 tU per year and are expected to remain at the same level through 1997. There are seven nuclear reactors under construction in this region including four in **India**, two in **Iran** and one in **Pakistan**. These reactors could provide about 3.5 GWe of additional nuclear capacity for the region.

East Asia (59.3 GWe on 1 January 1997). East Asia is currently the region with the highest rate of nuclear growth in the world. **Japan's** nuclear programme continues to increase rapidly, having added about 4.3 GWe between 1995 and 1996. The Japanese Government and industry are maintaining a strong focus on the development of an indigenous fuel cycle industry. **China** and the **Republic of Korea** also have noteworthy nuclear construction programmes underway. The **Republic of Korea** currently has 7 units (6.1 GWe) under construction and expects to add another 11 GWe of nuclear capacity (10 reactors) over the next 13 years. **China** continues construction on its own two units totalling 1.2 GWe at Qinshan and one imported PWR unit (900 MWe) at Lingao, while at the same time it has entered the market as a new reactor supplier. Several additional units are expected to be brought on line by 2005. The 1996 reactor-related uranium requirements for the East Asia region were 11 620 tU; and for 1997, they are expected to decrease slightly to 11 370 tU.

South East Asia (0 GWe). This region has no current nuclear capacity. However, **Indonesia** and **Thailand** are considering the construction of nuclear reactors to satisfy increasing electricity demand expected in the next century. The future operability of the only nuclear unit in the **Philippines**, the PNPP-1 620 MWe reactor, remains uncertain at present. Continuing legal disputes with the manufacturer are blocking decisions on either completing the unit or converting it to a fossil fuel fired plant.

Pacific (0 GWe on 1 January 1997). This region has no current nuclear capacity. **Australia** has only one small research reactor. Australian Government policy prohibits development of further stages of the nuclear fuel cycle at present, thus domestic demand for uranium is not anticipated over the short term. The Government of **New Zealand** has similarly instituted a policy prohibiting the development of nuclear power.

Figure 12. **Projected Installed Nuclear Generating Capacity to 2015 Low and High Projections**

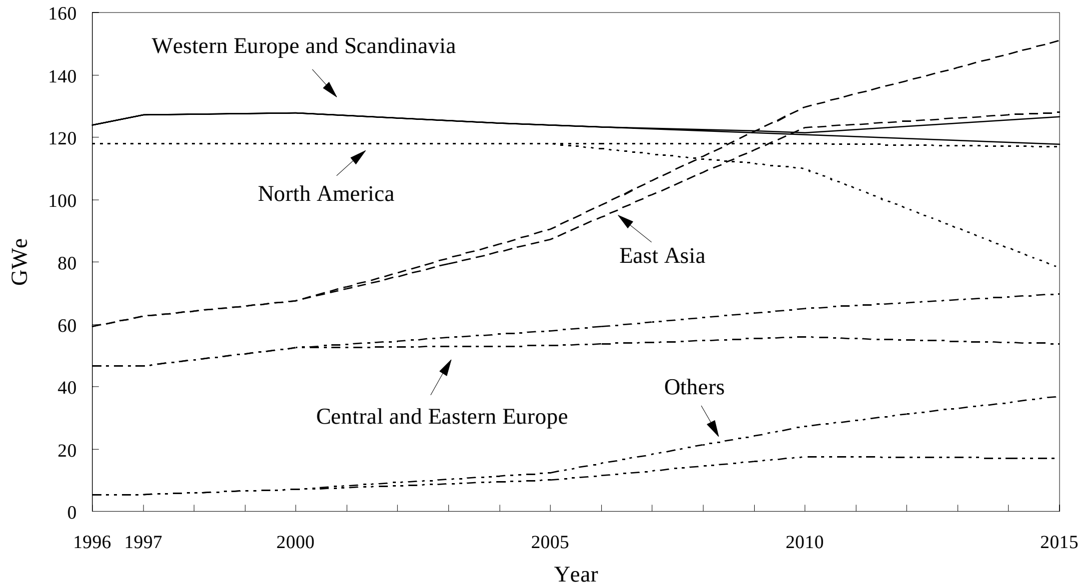
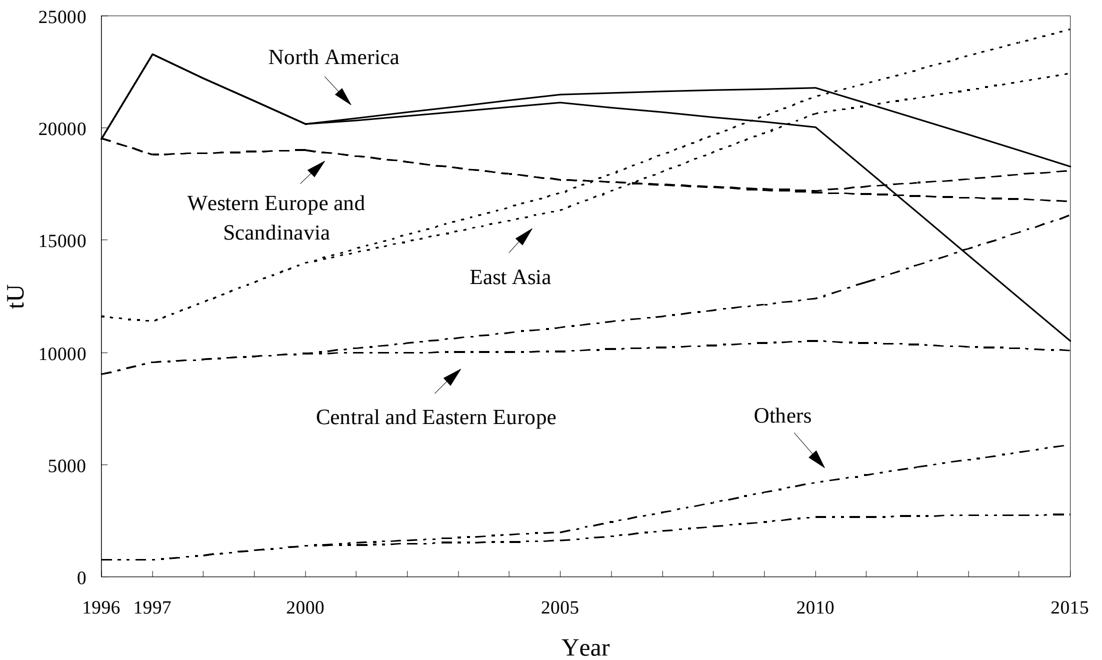


Figure 13. **Annual Reactor Uranium Requirements to 2015 Low and High Projections**



B. PROJECTED NUCLEAR POWER GROWTH AND RELATED URANIUM REQUIREMENTS

Projections of nuclear capacity and reactor-related uranium requirements are based on official responses from Member countries and States to questionnaires circulated by the Secretariat. However, for countries that did not provide this information, projections from the IAEA Secretariat are used. Because of the uncertainty in nuclear programmes in the years 2005, 2010 and 2015, high and low values are given unless a single projection was provided in the official response.

The world nuclear capacity is expected to grow from 353 GWe in 1996 to levels that will range between 395 GWe and 501 GWe by the year 2015. This represents a 12 to 42 per cent increase from current capacity or an annual growth rate ranging from 0.6 to 1.9 per cent for the forecasting period. Although the high world projections show steady growth in nuclear capacity through the year 2015, the low projections show a steady increase up to 427 GWe by the year 2010 followed by a reduction to 395 GWe in 2015.

The growth in nuclear capacity will vary considerably from region to region (Figure 12). Table 11 summarises the projected installed net nuclear electricity generating capacity on a country by country basis. The **East Asia** region will experience the largest increase in nuclear capacity. By the year 2015, this region will have incorporated between 69 GWe and 92 GWe of new capacity. **Central and Eastern Europe** will follow with 7 GWe to 23 GWe of new capacity by 2015. Other regions experiencing some growth include **Middle East, Central and South Asia**, **Central and South America**, **South East Asia** and **Africa**. By contrast, **North America** and the **Western Europe and Scandinavia** region will experience a net reduction in available nuclear capacity by the year 2015. For these regions the projected number of additional nuclear units will not be sufficient to offset the expected retirement of older reactors. In **North America** the capacity will remain constant at about 118 GWe through 2005 and then a decrease of 1 to 40 GWe will occur by 2015. In **Western Europe** nuclear capacity will reach its highest level at about 128 GWe around the turn of the century and then plant retirements will bring down the available capacity to a range estimated between 118 GWe and 126 GWe in 2015.

World reactor-related uranium requirements are expected to rise from 60 488 tU in 1996 to values ranging between 62 542 tU and 82 796 tU by the year 2015 (see Table 12 and Fig. 19). This corresponds to annual growth rates ranging from 0.2 to 1.7 per cent. The cumulative uranium requirements over the period 1997 to 2015 range from 1 262 000 tU to 1 366 000 tU. This corresponds to a variation of ± 4 per cent around the average cumulative requirements for the high and low projections.

As in the case of world nuclear capacity, the uranium requirements will vary considerably from region to region (see Figure 13). In contrast to the rest of the world, **North America** and the **Western Europe and Scandinavia** region will experience declines in uranium requirements through the year 2015. The increase in uranium requirements will be largest in the **East Asia** region where expected accelerated nuclear capacity expansion will entail almost doubling the 1996 uranium needs by the year 2010.

Variation in uranium demand may arise due to changes in the performance of nuclear power plants and fuel cycle facilities even when the installed base capacity remains the same. In recent years there has been a trend toward higher nuclear plant energy availability factors and capacity factors worldwide. The average energy availability factors for reactors worldwide have been generally increasing since the end of the 1970s. In 1996 the average energy availability factor was at the very high level of 77.4 per cent. This followed a steadily increasing trend since 1989 when the factor was 70.1 per cent.[(3)] Energy availability factor improvements directly affect uranium requirements. Tails assay variations also affect natural uranium requirements.

In the fuel cycle itself, recycling of recovered plutonium in MOX fuel (and to a lesser extent reprocessed uranium) is being done in some countries. This situation improves the overall efficiency of the fuel cycle but will not dramatically alter world uranium demand in the short term because the quantities involved are rather small. MOX fuel is projected to contribute 2 500, 4 000 and 4 000 tU (natural equivalent), respectively in the years 2000, 2005 and 2010.[1] The fuel supply from reprocessing is based on projections by the IAEA of MOX fuel fabrication capacities. The Euratom Supply Agency reported that the use of MOX fuel and reprocessed uranium in 1996 in the European Union was estimated to be equivalent to 1 200 tU and 500 tU, respectively.[2] Countries of the European Union have the only reactors at present making use of MOX fuel.

Reactor-related requirements over the short term are fundamentally determined by the installed nuclear capacity, or more specifically kilowatt-hours of operation. As noted, the majority of the anticipated capacity is already operating, thus short-term requirements are fairly predictable.

The largest uncertainties arise in the different assumptions about schedules for the construction of nuclear power plants, cancellations, new orders for reactors, and to what degree the operating life of existing plants can be extended. Construction time spans are currently averaging about 138 months worldwide as measured from first concrete pouring to grid connection. Construction starts have averaged about 8 reactors per year over the last decade but only 2.2 reactors per year between 1991 and 1996. About 71 nuclear units have been permanently retired worldwide. Because of the variety of designs and the fact that some of these units were built as experimental or prototype reactors, the average lives experienced by these reactors do not provide suitable indication of life expectancy for nuclear reactors presently in operation. On the other hand, there is great uncertainty with respect to the life extension process of nuclear reactors.

Programmes are under way in many countries to remove obstacles to new construction. A number of factors, however, still impede the installation of new nuclear generating capacity, including:

- continuing low (or declining) fossil fuel prices;
- the lack of sufficient financial resources in developing countries;
- problems with public acceptance which result in governmental deferral or postponement of new projects in some countries of Western Europe; and
- a weakening of investor confidence due to uncertainties in the return on investment.

(3) This factor, based on all reactors with capacity greater than 100 MW(e) and with more than one year of commercial operation, is from the IAEA's 1997 PRIS database.

Given the current nuclear share of total electricity generation in many countries, a complete phase-out would appear to be a very unlikely outcome. While nuclear plant owners are extending or are currently exploring mechanisms to extend the lives of their facilities, changes in national economic and regulatory policies and in the structure of the electricity supply industry may have an increasing impact on nuclear plant lifetimes with a corresponding impact on uranium requirements.

In summary, a moderate growth in nuclear capacity and generation is expected from now until 2015 with a corresponding increase in reactor-related uranium requirements. Annual reactor-related requirements by 2015 are estimated to reach between 62 500 tU and 82 800 tU. However, the impending factors mentioned above may result in lower reactor requirements in 2015.

C. URANIUM SUPPLY AND DEMAND RELATIONSHIPS

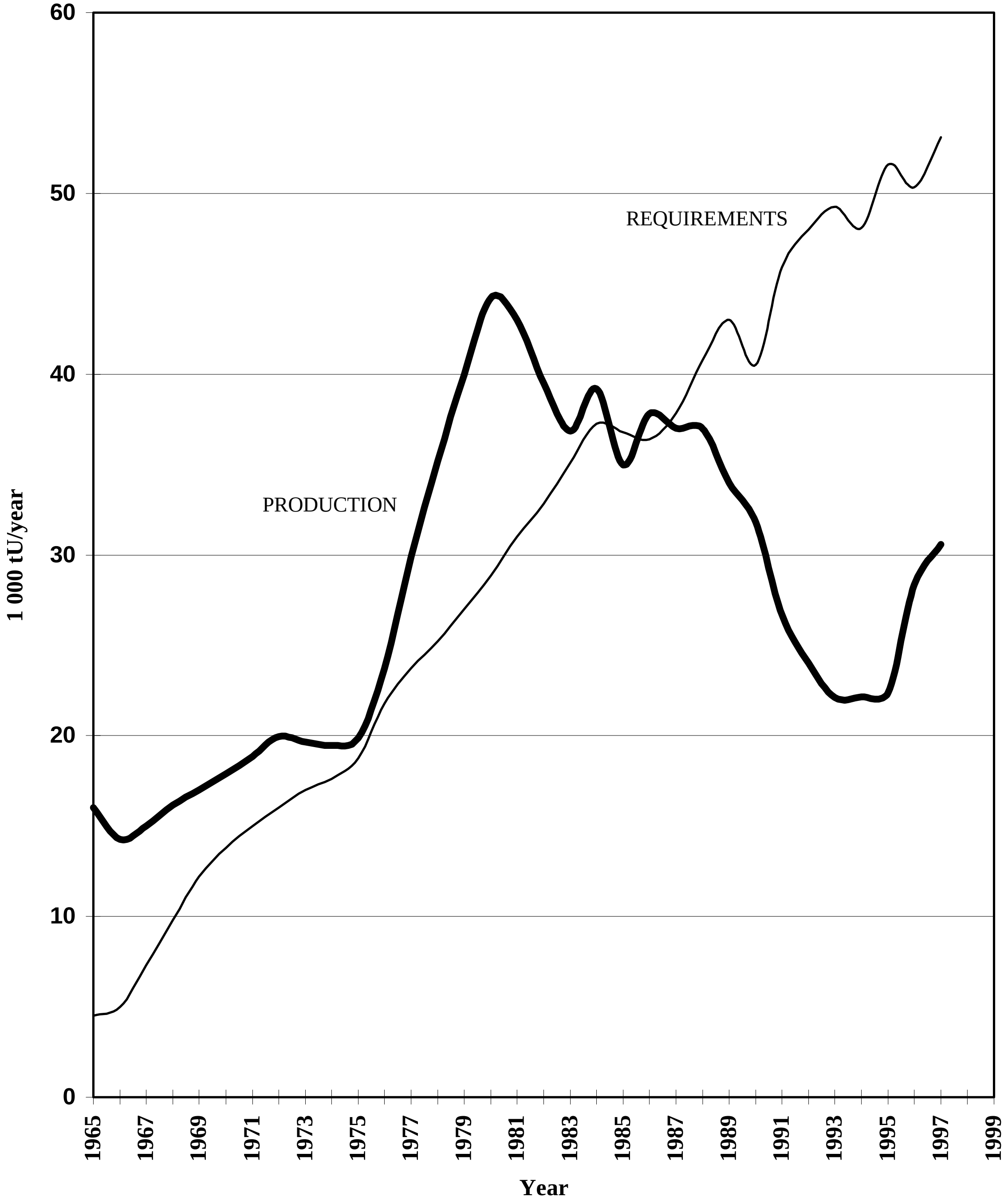
The world uranium market has experienced dramatic changes in this decade due to important trends observed in nuclear power generation and political and economic developments in uranium producing and consuming regions of the world. In particular, several events that took place since publication of the last Red Book appear to mark the development of the realities of the next decade or more.

Since the beginning of commercial exploitation of nuclear power in the early sixties and up to the mid-eighties, the uranium market, in world regions excluding Eastern Europe, the Former Soviet Union and Cuba, was characterised by an over supply situation (see Figure 14). Over supply was mainly the consequence of a lower than expected nuclear electricity generation growth rate. Although limited information is available, it also appears that production substantially exceeded reactor requirements in Eastern Europe and the Former Soviet Union starting at about the same time and extending to 1994. The political and economic reorganisation of this region in the early nineties resulted in major steps toward development of an integrated world uranium market. A consequence of the decrease in political tensions between the East and West has been greater availability of uranium supplies from the Former Soviet Union and the successor republics of Kazakhstan, the Russian Federation, Ukraine and Uzbekistan. It initially appeared that producers in Eastern Europe would also contribute to the world market. However, industry closures and cutbacks have resulted in the region becoming a net importer of uranium.

In addition to the civilian inventories, the perception that large amounts of uranium involved in military applications from both the USA and the Russian Federation will become available for commercial applications has influenced the market. Highly Enriched Uranium (HEU), plutonium, and natural uranium held in various forms by the military sector could total several years' supply of natural uranium equivalent for commercial applications. While the rate at which this material may enter the civilian market is still uncertain, some of the laws, plans and contractual arrangements that will affect the delivery are discussed in a following section of this report: "Disposition of Surplus Defence Material."

The incorporation of uranium requirements and production from Eastern Europe and the Former Soviet Union into an overall world total resulted in an over-production situation lasting until 1990 (see Figure 15); however, the excess supply has had consequences in the uranium market lasting

Figure 14. **Historical Uranium Production and Requirements in Selected Countries ***



* Excludes the following countries because detailed information is not available: Bulgaria, China, Cuba, Czech Republic (and preceding states), GDR, Hungary, Kazakhstan, Mongolia, Romania, Russian Federation, Slovenia, Tajikistan, Ukraine, USSR, Uzbekistan, and Yugoslavia.

1997 production values are estimated.

beyond 1990. Between 1990 and 1994 there were severe reductions in many sectors of the world uranium industry including exploration, production, production capability and market prices. Despite the continuous growth in world uranium requirements, production continued to contract during this period. Uranium market prices declined throughout the first three quarters of 1994. The unrestricted annual average NUEXCO spot price of $18.33/kgU ($7.05/lb U3O8) experienced in 1994 was the lowest since 1974. This situation led to drawdowns from excess supply of over 21 000 tU to 26 000 tU annually. In 1994 world uranium production provided only 55 per cent of the world reactor requirements.

This decreasing supply availability combined with growing demand for new uranium purchases resulted in a recovery in uranium prices from October 1994 through mid-1996. By August 1996 the unrestricted price had increased to $39.65/kgU ($15.25/lb U_3O_8) while the restricted price had climbed to $42.38/kgU ($16.30/lb U_3O_8). This corresponds to a 116 per cent increase of the unrestricted price and a 75 per cent increase of the restricted price in less than two years. In addition, production in 1995 and 1996 expanded by 4.9 and 8.7 per cent respectively, while several important producing companies announced plans for the expansion of existing production centres and the development of new projects. Since September 1996, however, the trend of rising prices has reversed and prices for unrestricted and restricted uranium have fallen sharply to about $23.92/kgU ($9.20/lb U_3O_8) and $26.52/kgU ($10.20/lb U_3O_8), respectively by 31 August 1997.

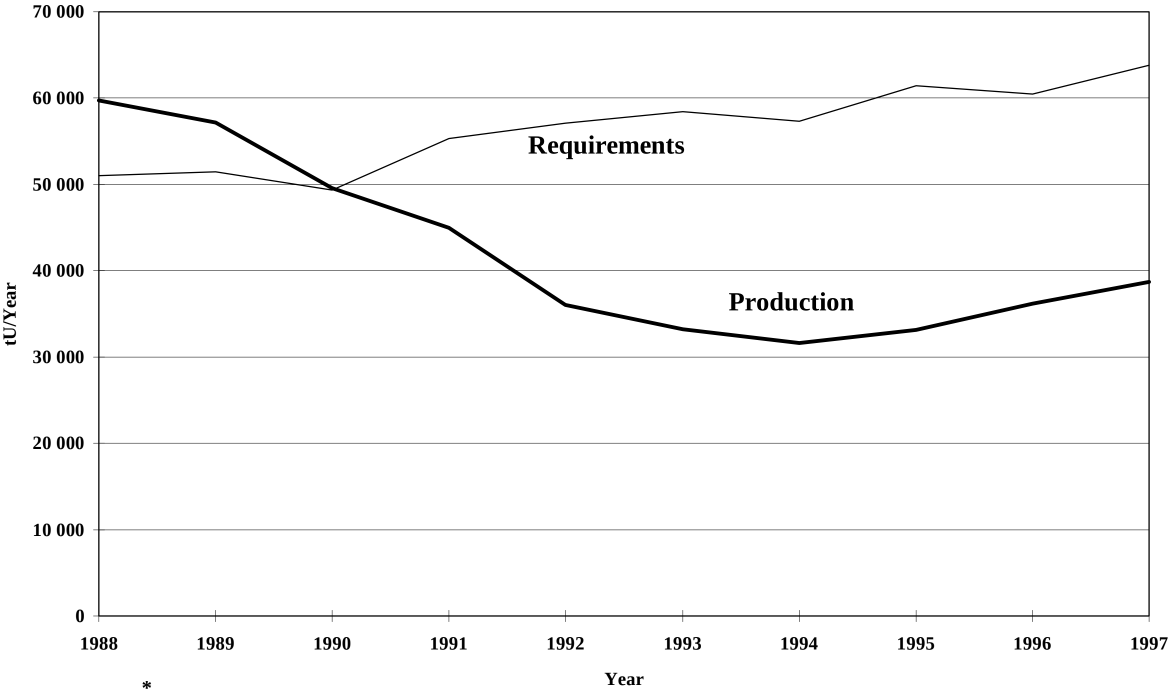
In 1996, twenty-three nations produced uranium, of which the major ten (Australia, Canada, Kazakhstan, Namibia, Niger, the Russian Federation, South Africa, Ukraine, USA and Uzbekistan) produced about 90 per cent of the output. In comparison thirty nations currently consume uranium in commercial reactors. Figure 16 indicates the uneven distribution between countries producing uranium and those with uranium requirements. In 1996 world uranium production (36 195 tU) provided only about 60 per cent (see Figure 15) of the world reactor requirements (60 488 tU) and in OECD countries (see Figure 17) the 1996 production (21 183 tU) could only satisfy 42 per cent of the demand (50 372 tU). The world imbalance between production and requirements was about 136 000 tU from 1991 to 1996. The remaining material to fuel reactors not covered by production came primarily from stockpiles. Small amounts also came from reprocessing of discharged fuel and LEU derived from HEU weapon material. It is projected that the shortfall will be more than 20 000 tU in 1997.

The events that characterised the uranium market in the last several years illustrate the persistent uncertainty faced by uranium producers and consumers worldwide. Some of the uncertainty is the result of political decisions that are, in part, defining the fundamental nature of the future uranium market. The political decisions include the conversion of HEU from warheads to Low Enriched Uranium (LEU) for use as civilian fuel, sale of the US government stockpile material and the changing restrictions imposed by both the USA and the European Community on the sale of uranium produced in the New Independent States (NIS).

Evolution of Uranium Supply and Demand in the Former Soviet Union and Eastern Europe

The nuclear programmes in countries located in the territory of the Former Soviet Union and Eastern Europe have undergone great changes in the last few years. Information, not previously available about uranium markets in this region, has captured the attention of many experts around the world. While there are still unanswered questions about some aspects of the nuclear activities in this region, including existing uranium inventories in the Russian Federation, new information continues

Figure 15. **World Uranium Production and Requirements***

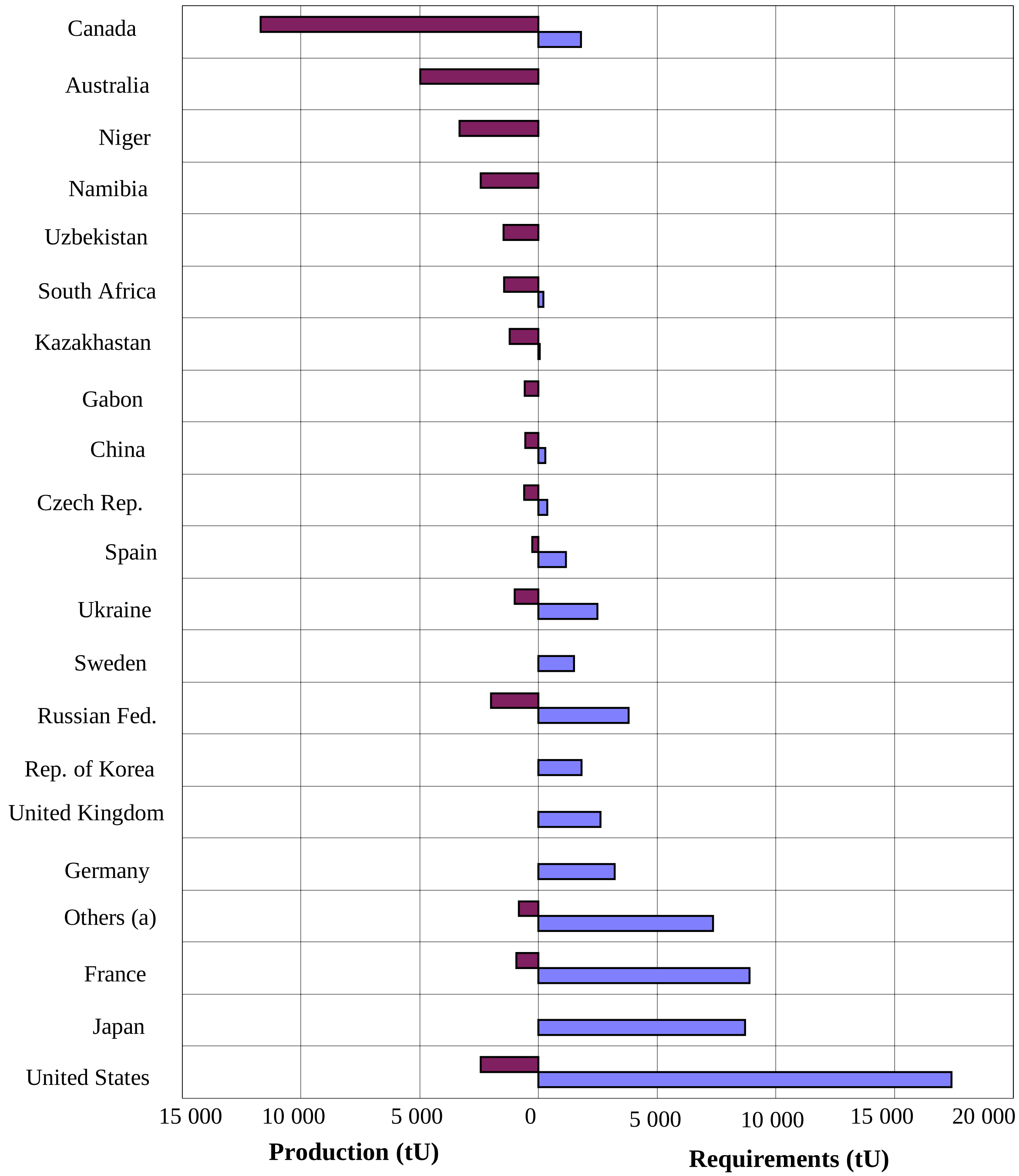


* 1997 production values are estimated.

to be released. The total production of Eastern Europe, Kazakhstan, the Russian Federation and Uzbekistan has been reported. Uranium production for Ukraine between 1992 -1996 has been reported but earlier data is still lacking. However, the more complete information that is available allows a better understanding of the evolution of the uranium supply and demand in these countries. In addition to meeting its domestic reactor requirements of 3 600 tU in 1996, the Russian Federation was a major supplier of uranium to the world market. The material sold is produced at its one operating mine/mill centre, as well as supplied from its stockpile. The Russian Federation provides about 2 200 tU/year in fabricated fuel, to several utilities in Eastern Europe operating Russian designed reactors. It also sells both low enriched and natural uranium concentrate to countries of the European Union (EU), as well as the USA and other countries. In 1996 deliveries to US utilities from the Russian Federation comprised 2 090 tU; while deliveries from Kazakhstan, Ukraine, and Uzbekistan totalled 2 287 tU [3]. In 1996 total acquisitions of natural uranium from the Commonwealth of Independent States (CIS) producers by EU utilities were 6 800 tU.[4]

In 1988 the Former Soviet Union and Eastern Europe region (which included the German Democratic Republic) produced about 23 000 tU, or nearly 40 per cent of world production. This represented nearly 260 per cent of reactor requirements in these countries. By the time of the dissolution of the Soviet Union and the Council for Mutual Economic Assistance (CMEA) in 1991, production in this country group had fallen to about 16 100 tU/year. This was still 168 per cent of reactor requirements. The break down of historic trading patterns and the termination of uranium purchase agreements by the Russian Federation in 1992 resulted in an abrupt production decline to about 11 500 tU. Production continued to decline through 1996 to about 7 183 tU, or 20 per cent of world production. Since 1994 production in the CIS and Eastern Europe have been below regional reactor requirements, estimated in 1996 at 9 580 tU. The cumulative excess production over reactor requirements for the period 1988 to 1994 was estimated to be about 53 000 tU.

Figure 16. **Estimated 1996 Uranium Production and Reactor-Related Requirements.**



(a) "Others" producers include: *Argentina, Belgium, Hungary, India, Pakistan, Portugal, Romania.*

"Others" consummers include: *Argentina, Armenia, Belgium, Brazil, Bulgaria, Finland, Hungary, India, Lithuania, Mexico, the Netherlands, Pakistan, Romania, Slovak Republic, Switzerland.*

Falling demand, recognition of high production costs and associated environmental liabilities resulted in the closure of numerous production facilities over the 1988 to 1996 period. This includes closure of the entire uranium production industries of Bulgaria (1994) and Slovenia (1992), as well as the former German Democratic Republic's WISMUT (1990). Production in the former Czechoslovakia, now in the Czech Republic, and in Hungary, Ukraine and Romania has been significantly reduced. The uranium industries of these countries are producing to meet domestic requirements only. The government of Hungary has decided to stop uranium production in 1997.

All conventional uranium mining has been stopped in Uzbekistan, while all existing and planned production facilities will use ISL mining technology. In Kazakhstan the use of conventional uranium mining and by-product production from phosphatic fish bone deposits have been stopped. Efforts to restart production from conventional mining has not been successful. Kazakhstan is now producing only by ISL technology. Uranium production in the Russian Federation is from the conventional Priargunsky Mining and Chemical Complex near Krasnokamensk, Siberia. Activities in support of developing future ISL facilities for uranium is in progress in other areas of the Russian Federation.

There are some indications that the trend of declining uranium production in the CIS may be halted, and that production may increase. In 1996 the Russian Federation reversed its trend of declining production. Production was 2 605 tU, up 21 per cent from 1995 (2 160 tU). Kazakhstan and Uzbekistan both report plans to increase production over the next few years.

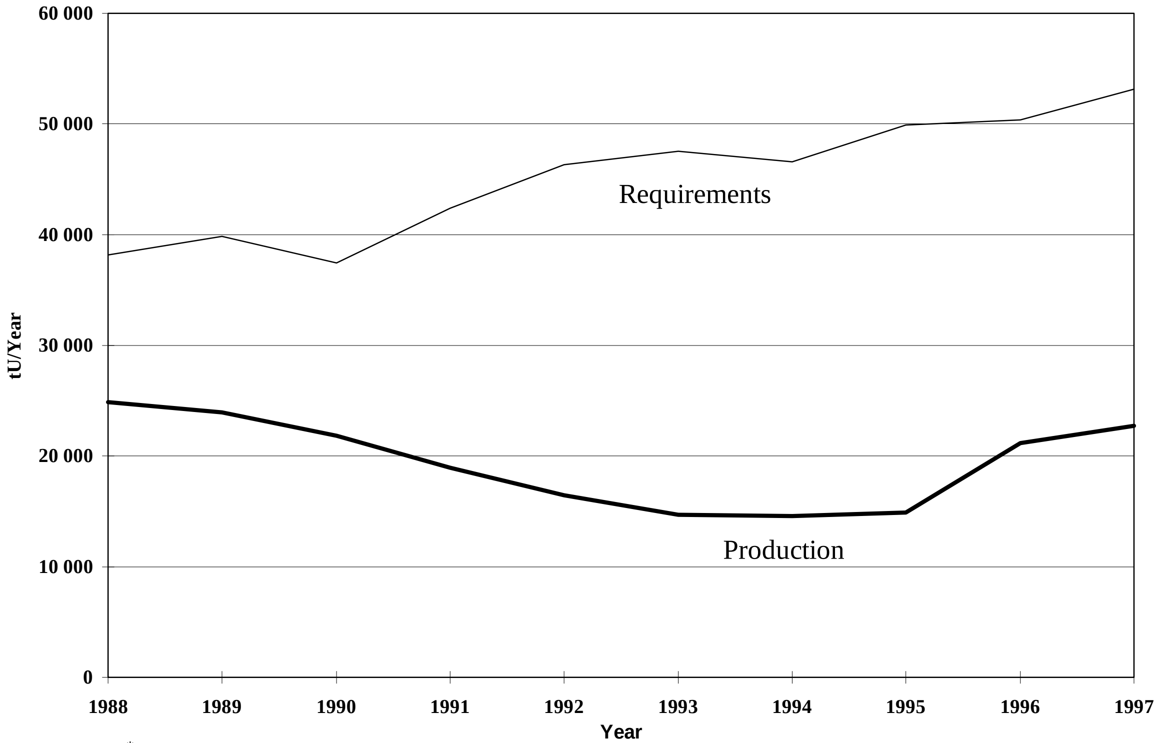
No country in this group, other than the Russian Federation, is thought to have a significant inventory of natural or low enriched uranium. The uranium stockpile of the Russian Federation is believed to be large, but is not known.

The Market Structure

There are six major sources of fissile material which may enter the market. These are described in the following sections and summarised in the table below:

SOURCE	MARKET IMPACT
• Fresh mine production	Essential in short, medium and long term
• Civilian stockpiles of natural and enriched uranium	Important in the short term
• Reprocessed Uranium and Plutonium	Regional importance in the short term May be important in the long term
• Military stocks of Highly Enriched Uranium	May be important in the short and medium term
• Military stocks of Plutonium	Little or no importance in the short term Minor importance in the medium term
• Re-enrichment of depleted uranium	May be important in the short and long term

Figure 17. **OECD Uranium Production and Requirements***



* 1997 production values are estimated.

Today, the market structure is characterised by:

1. increased availability of non-traditional supplies;
2. increased utilisation of fissile material stocks and inventories;
3. increasing recycling activities;
4. restricted trading activities in some regions; and
5. decreased spot market activities following several years of increasing activities.

1. Availability of Non-Traditional Supplies

Kazakhstan, the Russian Federation and Uzbekistan have emerged as potentially significant suppliers of uranium in the world market. However, supply activities from these countries have been affected by decreasing production, by concerns related to the long-term reliability and by restrictions imposed by some Western countries on the purchase of these supplies. In addition, the uranium supply capability of other Eastern European countries is very limited because of facility closures and environmental concerns. Another non-traditional supplier of uranium is China. In 1997, it was reported that China has been exporting uranium to the USA, France, Germany, Belgium, Finland, Japan, India and other countries since the 1980s. Annual exports have reached over 1 000 tU including the enriched uranium with equivalent amounts of natural uranium. Currently, China has several medium- and long-term uranium export contracts.[5]

2. *Utilisation of Fissile Material Stockpiles*

A major source of supply comes from the drawdown of accumulated stockpiles. The civilian inventories include strategic stocks, pipeline inventory and excess stocks available on the market. Few countries have provided detailed information on the size of the uranium stockpiles that are held by producers, consumers or governments so that the data presented in this report describe only a portion of the total picture. Utilities are believed to hold the majority of commercial stocks. Many utilities either hold or have policies that call for the carrying of the equivalent of one to four years of natural uranium requirements.

An estimate of civilian inventories based on a survey of world utilities, and other holders of inventory was published by the Uranium Institute in 1996.[6] It placed the total inventory including utility, government, producer and others at about 160 000 tU at year-end 1995. This estimate includes strategic stocks held by utilities for reasons of security of supply. It does not include pipeline material estimated as one year forward reactor requirements, nor does it include the Russian Federation natural uranium inventories. This estimate of the world civilian uranium inventory is greater than was generally accepted before the release of the 1996 Uranium Institute report. This civilian inventory is equivalent to about 2.5 years of world requirements.[7] The inventory of enriched uranium product and natural uranium held by the Russian Federation has not been officially reported. The Russian Federation stockpile was estimated to be 75 000 tU as of 1 January 1995.[8] Also, it has been estimated that the depletion in 1995 and 1996 left a stockpile of about 49 000 tU as of 1 January 1997.[9]

As shown in Figure 15, following a year of near equilibrium in 1990, world uranium requirements have exceeded world production starting in 1991. During the 1990-1994 period the annual world uranium production fell 36 per cent from about 49 600 tU to about 31 600 tU. This rapidly decreasing production occurred during a period when world requirements increased by 16 per cent from 49 294 tU in 1990 to 56 920 tU in 1994. Although world production increased in 1995 and 1996, uranium requirements in 1996 (60 488 tU) are still about 67 per cent higher than world production in the same year (36 195 tU).

The resulting difference between production and requirements was about 11 000 tU in 1991 and then nearly doubled to about 21 500 tU in 1993. It further expanded to about 28 000 tU in 1995 and was about 24 300 tU in 1996. The cumulative impact of the difference between uranium production and requirements is substantial. By 1 January 1997 the world had experienced a cumulative difference or inventory drawdown of almost 136 000 tU. Currently there are no indications that this condition of a large difference between production and requirements has significantly changed. The development of planned projects discussed in this report could substantially reduce the imbalance.

The rapid inventory drawdown characterising the world uranium market indicates a potential for inventory exhaustion sometime in the future. Although a few countries have started projects to increase their uranium production capability, it would be difficult to quickly increase production to fill the supply gap if the available inventory is exhausted in a short time. The lead time for developing new uranium production facilities is several years. Developing new uranium projects has become more difficult because of increasingly demanding radiation safety and environmental regulations as well as the additional time required to meet licensing, permitting and environmental review procedures. The production data in this report, which includes Existing, Committed, Planned and Prospective production capacity (see Table 10 and Figure 19), indicate insufficient production capability in the world to meet present and future world uranium requirements. Any extended production shortfall in the absence of excess inventory could destabilise the market thereby increasing upward pressure on uranium prices.

Another potential source of uranium supply is expected to come from military stockpiles. This material could help to meet market demand once excess inventories are exhausted. Significant amounts of uranium from the conversion of nuclear weapons material are expected to enter the civilian market after 2000 as the result of purchase agreements between the USA and the Russian Federation.

Disposition of Surplus Defence Material

Uranium[10]

In 1996, more definitive plans and schedules for disposing of Russian Federation Government surplus HEU and US Government surplus HEU, natural uranium, and LEU were announced. Under current schedules, around 180 800 tU (470 million pounds of U_3O_8) and 100 million separative work units (SWU) of enrichment are expected to be displaced by the commercialisation of US and Russian Federation Government surplus inventories over the next 15 to 20 years. Over 11 500 tU (30 million pounds U_3O_8) and 6 million SWU from these sources could enter the market annually within the next 5 years. The blending down of 500 tonnes of Russian Federation surplus HEU will contribute the largest share; it is equivalent to about 153 000 tU (398 million pounds U_3O_8) and 92 million SWU. The United States Enrichment Corporation (USEC) Privatisation Act established a quota for the sale to the United States end users of uranium derived from Russian Federation HEU: from 769 tU (2 million pounds U_3O_8) in 1998, to 5 000 tU (13 million pounds U_3O_8) in 2004, reaching 7 692 tU (20 million pounds U_3O_8) by 2009. The HEU-derived material represents 4 per cent of US reactor requirements in 1998, increasing to 33 per cent by 2004, and reaching more than 50 per cent in 2009.

As US Executive Agent, the USEC continued its purchases of LEU from the Russian Federation pursuant to "The Agreement between the Government of the United States and the Government of the Russian Federation Concerning the Disposition of Highly Enriched Uranium Extracted from Nuclear Weapons" (Russian Federation HEU Agreement). However, the quantity of LEU purchased through 31 December 1996, was less than anticipated because the Russian Federation blended down 18 tonnes of HEU, rather than the 30 tonnes that had been specified in the original Russian Federation HEU Agreement. In November 1996, USEC and Techsnabexport (TENEX), the Russian Federation Executive Agent, amended the original Russian Federation HEU Agreement to provide for prices and quantities over a 5-year period. Under the amended agreement, the Russian Federation would blend down HEU to LEU under the following schedule: (1) 18 tonnes in 1997, (2) 24 tonnes in 1998, and (3) 30 tonnes in 1999 through 2001. (Note: 10 t HEU is equivalent to 3 060 tU natural.) The 5-year contract eliminated considerable uncertainty regarding the availability of uranium from Russian HEU. Previously, USEC and TENEX had to negotiate the details of the contract every year. Adding to the uncertainty, the Russian Federation had indicated the possibility of not meeting the levels of output scheduled for the future.

Under the amended Russian Federation HEU agreement, USEC will pay only for the enrichment content of the LEU. The USEC Privatisation Act authorises that the natural uranium feed component of LEU purchased under the Russian Federation HEU Agreement and delivered after 31 December 1996, be returned to the Russian Federation Executive. USEC accomplishes this by substituting the Russian Federation LEU for the uranium that was delivered by the utilities for enrichment. Prior to 1 January 1997, however, USEC paid the Russian Federation Executive Agent for the natural uranium component. This material, equivalent to approximately 5 385 tU (14 million pounds of U_3O_8), was transferred by USEC without cost to the US Department of Energy (DOE) in December 1996. DOE is authorised to sell this uranium by the following means: (1) to the Russian Federation Executive Agent for use in matched sales to US end-users; (2) any time for foreign end use, or (3) to US end-users after 2001. In December 1996, DOE reached an agreement to sell up to 2 692 tU (7 million pounds of U_3O_8) to Global Nuclear Services and Supply Company for the purpose of filling contracts involving matched sales. In August 1997, CAMECO, COGEMA and NUKEM reported that they had signed an agreement in principle to purchase a majority of the natural uranium feed resulting from the dilution of the Russian HEU.

In July 1996, DOE announced its intention to sell up to 7 807 tU (20.3 million pounds U_3O_8) equivalent of natural uranium and 462 tU (1.2 million pounds U_3O_8) equivalent of LEU. The LEU is also equivalent to about 280 000 SWU. The USEC Privatisation Act directed that the Secretary of Energy "determines that the sale of the material will not have an adverse material impact on the domestic uranium mining, conversion, or enrichment industry." On 12 March 1997, the Secretary of Energy issued a determination that the intended sale of 1 230 tU (3.2 million pounds of U_3O_8) equivalent during Fiscal Year 1997 would not have an adverse impact on the domestic industry. However, no sales have been made as of end of August 1997.

In September 1996, DOE released its plan to dispose of approximately 174 tonnes of US surplus HEU. Some of the HEU declared as surplus is not suitable for commercial use without extensive purification; it will be stored for future conversion or disposed of as waste. Approximately 103 tonnes of HEU is considered for commercialisation over the next 15 years. This is equivalent to around 12 690 tU (33 million pounds U_3O_8) or 8 million SWU. Of this total, DOE had already completed the transfer of 13 tonnes of HEU without cost to USEC. As for the remaining quantity, DOE plans to transfer 50 tonnes of HEU without cost to USEC and to sell approximately 40 tonnes of HEU to the Tennessee Valley Authority (TVA). The HEU earmarked for TVA does not conform to commercial specifications. It must be purified to remove isotopic impurities before it can be blended down to LEU for use in fuel for TVA's nuclear power plants. TVA would pay for the uranium and enrichment components, but DOE would pay for the purification and blending down the HEU to LEU. Included with the 50 tonnes of HEU, DOE will also transfer without cost to USEC up to 7 000 tonnes of natural uranium-equivalent to about 18 million pounds of U_3O_8.

Plutonium

The USDOE reported in February 1996 that the US Plutonium inventory was 99.5 t Pu, of which 38.2 t was declared excess to national security needs.[11] The US government is investigating ways of disposing of this material. If used in MOX fuel, 38.2 t Pu would be equivalent to about 6 500 tU (natural equivalent). In addition, the government is investigating a proposal to burn this material in reactors at the rate of about 2.25 t Pu/year over the period 2005 to 2022.[12] This rate of burnup is equivalent to 385 tU (natural equivalent) per year, or to about 2 to 5 percent of US reactor fuel requirements over the period. Also, under a tri-lateral agreement between the Russian Federation, France and Germany, work is being conducted to investigate ways of disposing surplus Russian defence plutonium in MOX fuel for power reactors. This project includes plans for irradiation of three lead test assemblies in a VVER-1000 and for construction in the Russian Federation of a MOX fuel fabrication pilot facility.

3. *Recycled Materials*

A third, potentially substantial source of fissile material lies in the constituents of spent fuel from power reactors. As of January 1997, over 175 000 tonnes of heavy metal had been discharged from power reactors. About 118 000 tonnes remain in storage as spent nuclear fuel. The remainder has been reprocessed. The quantity of accumulated spent fuel is 20 times the present total annual reprocessing capacity.[13] To date, no country has licensed a permanent geological repository for spent fuel. The majority of the spent fuel is currently stored at reactor sites in special holding pools. In some countries such as France, Japan, the Russian Federation, Germany, Belgium, Switzerland, Korea, and the United Kingdom, spent fuel has been viewed as a national energy resource. In some of these countries, the use of recycled material is already taking place. There are 32 reactors worldwide licensed to use MOX fuel and facilities for the fabrication of this type of fuel exist in Belgium, France, Japan and the UK.[14]

4. *Trading Restrictions in the Uranium Market*

Some of the largest influences in uranium trade have arisen as a result of restrictions in the USA and in the European Community on sales of uranium produced in the New Independent States (NIS).

Restrictions in the United States[15]

On 8 November 1991, a coalition of US uranium producers and a union filed an antidumping petition with the US Department of Commerce (DOC) and the US International Trade Commission (ITC). The petitioners sought relief from unfair trade practices by the Former Soviet Union (FSU). Both the ITC and DOC made preliminary rulings in 1992 that the FSU exports had injured the US uranium industry.

The initial suspension agreements to the antidumping suit, signed with Kazakhstan, the Russian Federation and Uzbekistan in 1992, were amended during 1994 and 1995 to allow these countries a more realistic access to the US market. The amended agreements established different quotas for each country. In addition, the amendments address the enrichment bypass option in the agreements with Kazakhstan and Uzbekistan, and create matched sales transactions for Russian Federation imports.

The restrictions on imports to the United States from the Russian Federation, Kazakhstan and Uzbekistan are specified in the respective amended suspension agreements. The Russian Federation-origin U_3O_8 and enriched uranium (SWU) can be imported as long as the annual quotas are matched with newly produced US-origin U_3O_8 or SWU. This type of transaction is called a *matched sales transaction*. Sales of low-enriched uranium (LEU) derived from the blending down of Russian Federation highly enriched uranium (HEU) are covered under the United States Enrichment Corporation Privatisation Act of 1995. The quota for Kazakhstan is based on price determinations made semi-annually by the US Department of Commerce (DOC). Uranium from Kazakhstan that is enriched by a non-US firm must be certified as Kazakh-origin; therefore, the amount of U_3O_8 feed is counted against the quota for Kazakhstan. The Agreements with the Russian Federation and Kazakhstan end in 2003. The quota for Uzbekistan is based on US uranium production levels, except during 1995 and 1996 when the quota was based on price determinations made semi-annually by the DOC. The maximum amount of uranium allowed for these two years was 362 tU (940 000 pounds U_3O_8) annually, as long as the DOC- determined price was equal to or exceeded $12.00 per pound. Uranium from Uzbekistan that is enriched by a non-US firm must be certified as Uzbekistan-origin;

therefore, the amount of U_3O_8 feed is counted against the quota for Uzbekistan. The Agreement with this country ends in 2004.

Restrictions in the European Union

Of similar significance has been the restrictions imposed by the European Union (EU) on uranium supplies from the NIS. There were concerns about the potential market destabilising effects of large imports of NIS origin uranium that were being offered on the European Community market at prices judged to bear no relation to cost of production in Western terms; thus, corrective measures were established by the European Commission and the Euratom Supply Agency. The measures are essentially based on the Agency's exclusive right to conclude contracts as provided for in Article 52 of the Euratom Treaty. During the November 1992 session of the European Parliament, the European Commission summarised the situation as follows: *"By virtue of Article 2 (d) and (c) of the Euratom treaty, the Community must ensure that all users in the Community receive a regular and equitable supply of ores and nuclear fuels and ensure the establishment of the basic installations necessary for the development of nuclear energy. For this purpose, the Euratom Supply Agency was established which, under the provisions of Chapter VI of the Euratom Treaty and more particularly its Article 52, 2 (b) has inter alia an exclusive right to conclude contracts for the supply of nuclear materials. Massive imports at extremely low prices, coming from the CIS Republics, risk endangering the diversification of the Community's supply sources and hence its long-term security of supply and the viability of its production industries. That is why the Supply Agency, in exercising its right to conclude contracts, is ensuring the Community does not become overdependent on any single source of supply beyond reasonable limits and that the acquisition of nuclear materials from CIS Republics takes place at prices related to those on the market; that is to say prices which reflect cost of production and are compatible with prices in market economy countries."*

The European Commission reaffirmed its policy in 1996 by writing: *"The Commission and the Euratom Supply Agency are applying a policy of diversification of sources of supply, implemented in a flexible way by the exercise of the Agency's right to conclude contracts and aiming at avoiding over-dependence on any single source of supply."*[16]

Acquisitions by the European Union utilities from NIS republics in 1996 were in the order of 5 900 tonnes uranium. Additionally about 900 tU produced in these countries were acquired due to exchanges and return of loans, making a total for 1996 of about 6 800 tU. The NIS as a whole was the largest supplier in 1996, representing 43 per cent of total deliveries under purchasing contracts. The Russian Federation was once again the EU's largest single supplier country in 1996. Prior to 1990, NIS had no share of the Community's natural uranium market.

Two-tiered Pricing System

As a result of the Anti-Dumping Suspension Agreement between the US and the NIS, and the uranium import restrictions in the European Community countries, a two-tiered pricing system developed.[(4)] Beginning on 31 October 1992, the Nuclear Exchange Corporation (NUEXCO) published a "Restricted American Market Penalty" (or RAMP) which is defined as NUEXCO's judgement of the incremental price relative to the NUEXCO Exchange Value (NEV) that applies to

(4) The last time a tiered market concept evolved was in mid-1987 concerning the enrichment of non-US uranium for use in US reactors.

products or services that are both deliverable in and intended for consumption in the US. NUKEM likewise established two price ranges for bids and offers on the uranium spot market beginning in November 1992. Other traders and brokers also have adopted the two-tiered market concept in one way or another. Depending on the nature of the NIS import restrictions, either a “restricted” or an “unrestricted” spot market price range is applied.

5. Spot Market Activities

The uranium market no longer conforms to the traditional supply and demand model of producers selling only to utilities. Secondary market transactions have also been important in recent years. Such transactions include sales, loans and exchanges of natural and enriched uranium by utilities and brokers, including all transactions except direct purchasing by a utility from a domestic or foreign supply.

Long-term contracts are still the major purchase mechanism in many countries. The trend toward increased near-term, spot, and spot-related contracts in utility portfolios that characterised the market in the first half of the decade reversed in 1996. TradeTech[(5)] reported 68 uranium spot market transactions and 63 uranium term transactions in 1996. Uranium term transactions refer to contracts in which the delivery period exceeds one year from the transaction date. The spot market volumes experienced a drop of over 50 per cent (or 7 900 tU) from the 1995 volumes of 14 650 tU, to about 6 800 tU in 1996. The drop was primarily attributed to utilities. Conversely, term transaction volumes increased by over 36 per cent in 1996.[17] Nukem reported a similar large drop in spot market sales from 1995 to 1996. The 1995 spot volume of 16 300 tU fell by about 53 per cent to about 7 600 tU in 1996.[18] This followed the period of 1990 to 1995 during which reported spot market sales, which had increased from earlier years, ranged from 11 500 to 15 400 tU (TradeTech) or from 9 500 to 17 000 tU (Nukem).

Some national and international authorities make available aggregated price data which reasonably illustrate term contract price trends. Additionally, spot price estimates for immediate or near-term delivery are regularly provided by industry sources such as the TradeTech (NUEXCO), NUKEM and others. Figure 18 shows a comparison of historical annual average delivered prices reported by TradeTech (NUEXCO), Euratom, the US Energy Information Agency (EIA), Canada and Australia. With the exception of Euratom, the prices are based on variable amounts of both spot- and long-term sales. The Euratom prices correspond to multi-annual contracts. The TradeTech (NUEXCO) prices correspond to the NUEXCO Exchange Value (EV), and beginning in 1992 the spot prices represent the “unrestricted market”. The US prices are for both domestic and foreign purchases. Figure 18 clearly depicts the decreasing trend in world uranium prices that has characterised the market since 1982 and the price recovery in 1995 and 1996.

The average NUKEM uranium spot price in 1996 for the unrestricted market was US$36.71/kgU (US$14.12/lb U_3O_8) and for the restricted market was US$40.07/kgU (US$15.41/lb U_3O_8). Similar prices were reported by TradeTech as the 1996 average exchange values (Table 13). The 1996 prices represent increases over prices reported in 1994 in the unrestricted and restricted markets of 95 per cent and 64 per cent, respectively. However, since September 1996 and throughout the first half of 1997, NUKEM and TradeTech reported decreases in both the unrestricted and restricted

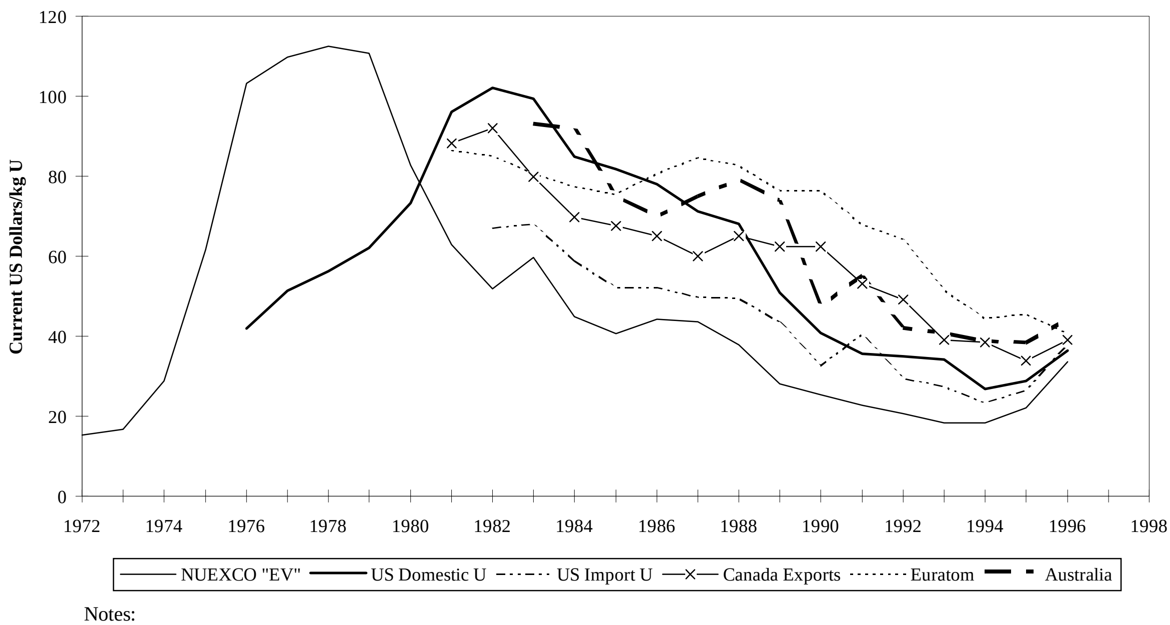
(5) TradeTech publishes *The Nuclear Review* which replaces *The NUEXCO Review* published prior to 1 January 1995.

market prices. By July 1997 the respective uranium prices had dropped about 36 per cent from their highest values in 1996.

The low spot price trend experienced throughout mid-1994 was supported by the perception that there was not going to be a shortage of uranium on the market in the near term. This perception was strengthened by the potential availability of new uranium sources, including former military stocks and production from Eastern Europe and the NIS. The increase in uranium prices observed since October 1994 and throughout mid-1996 was taken by some commentators to indicate the beginning of a recovery period for the uranium market. However, the renewed decrease in the spot price trend in mid-1996 indicates that the over-supply situation that existed in the past is still dominating the market.

With world nuclear capacity expanding and uranium production satisfying about 60 per cent of the demand, uranium stockpiles continue being depleted at a high rate. However, uncertainty continues both with respect to the remaining levels of world uranium stockpiles, and the amount of surplus defence material that will enter the market. It is therefore not clear when the low price trend will end, or at what level the market price will be when a closer balance is re-established between the supply and demand of uranium.

Figure 18. **Development of Uranium Prices**



Notes:

1) NUEXCO Prices refer to the “Exchange Value”. The values for 1992-1996 refer to the unrestricted market.
2) Euratom prices refer to multiannual contracts.

Sources: NUEXCO (TradeTech), EIA, Nukem and Euratom, Canada and Autralia.

Table 13. **Average Uranium Spot Prices**
US$/kgU (US$/lb U_3O_8)

	1996	Last quarter 1996	First half 1997
UNRESTRICTED MARKET VALUE			
Nukem Uranium Spot Price	36.71 (14.12)	38.58 (14.84)	31.38 (12.07)
TradeTech Exchange Value	36.89 (14.19)	37.31(14.35)	30.01 (11.54)
RESTRICTED MARKET VALUE			
Nukem Uranium Spot Price	40.07 (15.41)	39.55 (15.21)	33.57 (12.91)
TradeTech Exchange Value	40.51 (15.58)	39.00 (15.00)	32.46 (12.48)

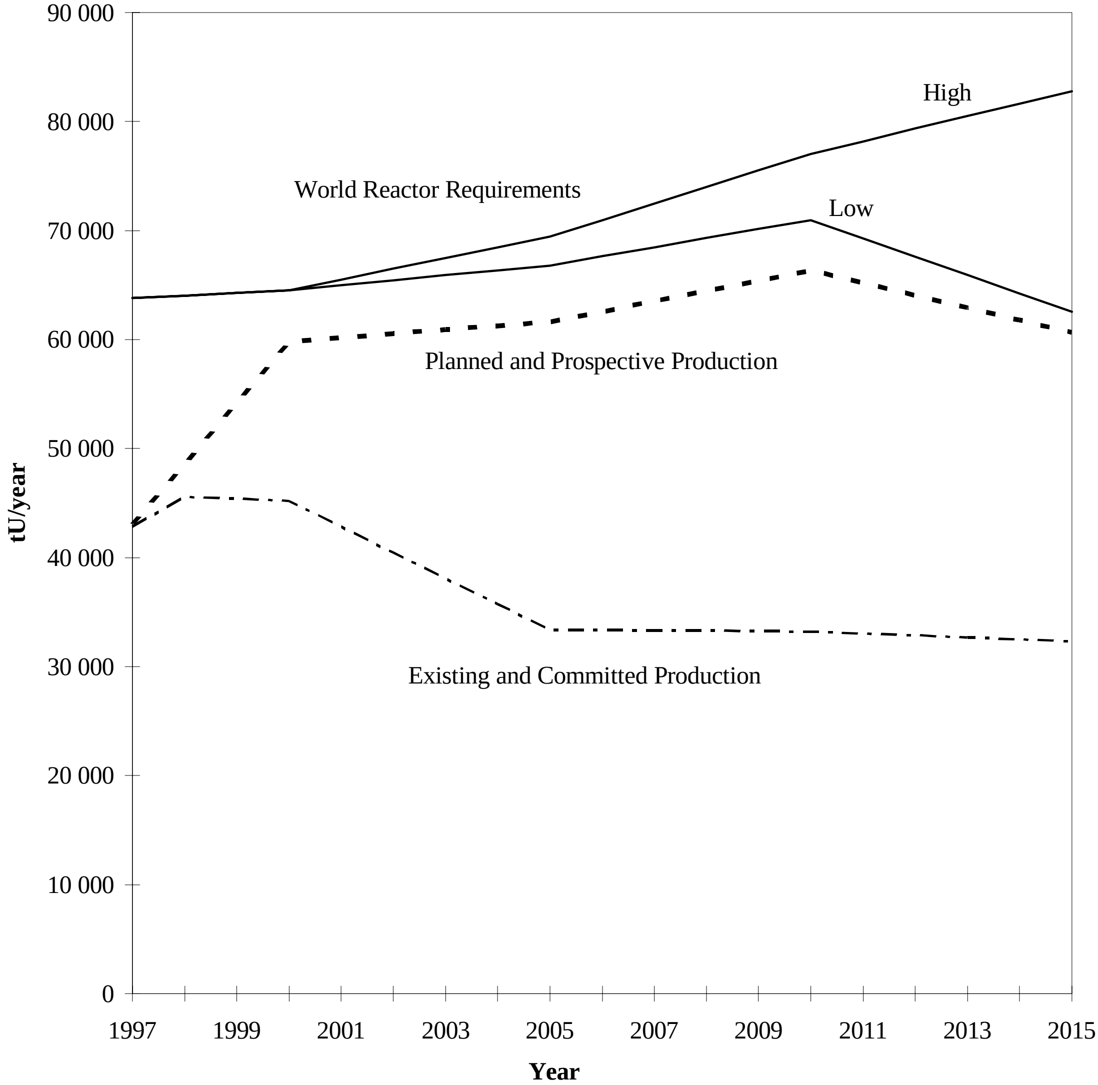
Outlook to 2015

Uranium demand over the short-term is fundamentally determined by nuclear capacity. Although there are uncertainties related to potential changes in world nuclear capacity, short-term uranium requirements are fairly predictable. Most of nuclear capacity is already in operation; there is only a limited degree of uncertainty regarding construction lead times and in the implementation of plans for new units in some countries. Improvements and modifications to nuclear reactor technology may also affect requirements; however, these factors are not likely to have a major impact before 2015. Fuel utilisation in thermal reactors can primarily be increased by: improving in-core management, lowering the tails assay in the depleted stream of enrichment plants, and by recycling plutonium. In-core management considerations such as higher capacity factor and reactor power levels increase uranium requirements of existing plants, while increased burnup reduces requirements. Another source of uncertainty is the possibility of early retirement of nuclear reactors. The potential for reductions of nuclear capacity exists in a few countries that have some relatively inefficient old nuclear units and where restructuring of the electricity supply industry may have an impact on nuclear plant lifetimes. Nevertheless, it is expected that the projected number of additions of nuclear plants worldwide would be sufficient to offset potential early plant retirements. Therefore, overall world reactor-related uranium requirements are expected to continue rising from about 60 488 tU in 1996 to levels ranging between 62 500 tU and 82 800 tU per year by the year 2015.

The supply side in the uranium market over the next eighteen years remains uncertain. The uncertainties are related to where these supplies will come from and the amount of weapons and defence-related uranium which may eventually reach the commercial market. The need for newly produced uranium will continue as long as nuclear electric generation continues. Mine production is expected to continue to be the supply source satisfying the largest share of requirements.

The low production levels and the drawdown of inventories experienced in the last few years point toward a market with a restricted uranium supply that must eventually reverse, creating a steadily increasing price trend and by consequence a revival of production activity. New information reported in this publication, with emphasis on Australia, Canada and the USA, indicate that substantial efforts are under way to increase the production capacity. Additional planned production capability is reported for these countries as well as several others, including China, Kazakhstan, Mongolia, the Russian Federation and Uzbekistan.

Figure 19. **Annual World Uranium Production Capability through 2015* (Resources Recoverable at $80/kg U or less) and World Reactor Requirements**



* Includes all current and identified potential uranium producers.

Source: Tables 10 and 12.

On the other hand, the increasing availability of new supplies from the conversion of warhead material imply a continuing downward pressure on prices and the possibility of further delays in the expansion of the production capability. This situation could reduce the prospects for a market recovery in the short-term.

As shown in Figure 19, production capability for all uranium producing countries, based on Existing, Committed, Planned and Prospective production centres and supported by low-cost RAR only could be brought from the current level to around 59 800 tU per year by 2000. This would be sufficient to cover about 93 per cent of the expected reactor requirements in 2000 which are estimated at about 64 500 tU per year. The gap could be met from the sale of existing inventories and the expected delivery of LEU derived from HEU warheads.

With the exception of the Russian Federation stockpile, which is not reported, it appears that the excess civilian stockpiles are approaching exhaustion. When supplies from excess stockpiles are no longer available, the requirements could be met through the expansion of existing projects, together with the development of Committed, Planned and Prospective production centres. Production may be supplemented by increasing sales of LEU from HEU, and government stockpiles. For this to happen it is necessary to have a systematic development of the new capacity and implementation of the plans for sale of weapons materials. Any delays or disruptions of these efforts to increase supplies could disrupt the market balance.

D. THE IMPACT OF RECENT DEVELOPMENTS ON THE LONG-TERM PERSPECTIVE

In the longer term, it is expected that reactor-related uranium requirements and production will achieve a closer balance. A balanced market may be achieved when stockpiles of excess materials have been drawn down and once a considerable amount of converted weapons material has entered the market.

Concerns about longer term security of supply of fossil fuels and the heightened awareness that nuclear power plants are environmentally clean with respect to acid rain and greenhouse gas emissions might contribute to even higher than projected growth in uranium demand over the long term. In particular, the increasing importance of the debate on global warming points toward accepting nuclear power as a valid alternative within the framework of long-term sustainable development.

Beyond the turn of the century, factors that are expected to have a significant impact on the supply/demand balance include: the rate of orders for new nuclear capacity, the rate of retirement of the existing world nuclear generating stock, the deployment of advanced reactor technologies and of advanced reprocessing and enrichment technologies.

Electricity has virtually doubled its share of energy consumption since 1960 on a worldwide basis; however, the growth has been unevenly distributed. In 1995, about 59 per cent of global electricity output was consumed in OECD countries.[19] In contrast non-OECD countries, with 75 per cent of the world population, consume only about 40 per cent of the world electricity. The difference in energy consumption on a per capita basis between OECD countries and developing regions is significant. The average electricity generation per capita in developing regions is about 660 kWh. In contrast, the per capita generation in the United States is 10 500 kWh and in OECD Europe and Japan about 6000 Kwh .[20] Therefore, there is a great potential for electricity growth in non-OECD areas. Estimates based on a variety of sources suggest that electricity growth rates in some developing countries will be two to three times the rate in developed countries beyond the year 2000.

World electrical energy use is expected to continue growing over the next several decades to meet the needs of rising population and sustained economic growth. In fact, electricity is expected to remain the fastest growing form of end-use energy worldwide through 2010.[21] Nuclear electricity generation might play a significant role in this growth. From 1990 until the year 2020, the World Energy Council expects the global production of nuclear electricity to grow by approximately 0.6 per cent to 2.3 per cent annually, depending on the scenario assumed.[22]

Efforts are also underway in most countries with nuclear power programmes to preserve or extend the lifetime of their nuclear facilities. In the United States, a new licensing process has been established to stimulate plant orders. Also, a license renewal rule has been put in place to extend the operating lives of existing plants. The license renewal provisions would allow current operating plants to extend their lifetime by 20 years.

Reprocessing is a technology that is currently available which could make noticeable impacts on uranium requirements in the next century, assuming it is fully implemented. Implementing a programme to recycle all plutonium in Light Water Reactors would reduce uranium requirements by 17 per cent.[23] Also, there has been a trend toward higher fuel burnups in commercial reactors which has the effect of reducing requirements for fresh uranium. For example, improving burnup from 40 to 50 Gigawatts day/tU decreases uranium requirements by 3 per cent.[24] Other technologies under development that could also make noticeable impacts if they are implemented include tandem cycle reactors such as the PWR-CANDU concept (which re-burns PWR spent fuel in CANDU reactors and thereby reduces CANDU uranium requirements by about 40 per cent) and new enrichment technologies. In France, Japan, South Africa and the USA, work has continued on the development of the Advanced Vapour Laser Isotope Separation (AVLIS) and Molecular Laser Isotope Separation (MLIS) enrichment technologies. These approaches are believed to have economic advantages over the current centrifuge and diffusion enrichment technologies. They could also result in reducing natural uranium requirements.

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III. NATIONAL REPORTS ON URANIUM EXPLORATION, RESOURCES AND PRODUCTION

INTRODUCTION

Part III of the report presents the national submissions on uranium exploration, resources and production. These reports have been provided by the official government organisations (Annex 2) responsible for the control of nuclear raw materials in their respective countries and the details are the responsibility of the individual organisations concerned. In countries where commercial companies are engaged in exploration, mining and production of uranium, the information is first submitted by these companies to the government of the host country and may then be transmitted to the NEA or the IAEA at the discretion of the government concerned. In certain cases, where an official national report was not submitted and where deemed helpful to the reader, the Secretariat has provided additional comments or estimates to complete the Red Book. Where utilised, the Secretariat estimates are clearly indicated. See Annex 8 for technical abbreviations.

The Agencies are aware that exploration activities are currently proceeding in a number of other countries which are not included in this report. They are also aware that in some of these countries uranium resources have been identified. It is believed that the total of these resources would not significantly affect the overall conclusions of this report. Nevertheless, both Agencies encourage the governments of these countries to submit an official response to the questionnaire for the next Red Book exercise.

Finally, it should be noted that the national boundaries depicted on these maps are for illustrative purposes and do not necessarily represent the official boundaries recognised by the Member countries of the OECD or the Member states of the IAEA.

Additional information on the world's uranium deposits is available in the IAEA publications: “World Distribution of Uranium Deposits” (STI/PUB/997), together with the “Guidebook to accompany the IAEA Map: World Distribution of Uranium Deposits” (STI/PUB/1021). The location of 582 uranium deposits is given on a geologic base map at the scale 1:30 000 000. The guidebook (which is available at no cost with purchase of the map) and map provide information on the deposit: type, tectonic setting, age, total resources, average uranium grade, production status and mining method. They may be ordered from:

INTERNATIONAL ATOMIC ENERGY AGENCY
Sales & Promotion Unit, Division of Publications
P.O. Box 100
Wagramerstrasse 5
A-1400 Vienna, Austria

Telephone: (43) 1-2060-22529
Facsimile: (43) 1-2060-29302
Electronic Mail: sales.publications@iaea.org

• Argentina •

URANIUM EXPLORATION

Historical Review

Uranium exploration activities in Argentina began in 1951-1952. The Huemul sandstone-type deposit was found in 1954 while exploring for red bed-type copper mineralization. The Tonco district, with the Don Otto and Los Berthos sandstone-type deposits, was discovered by airborne geophysical survey conducted in 1958. During the late 1950s and the early 1960s, airborne surveys also led to the discovery of Los Adobes sandstone-type deposit in Patagonia.

During the 1960s, the vein-type Schlagintweit and La Estela deposits, occurring in granitic rocks, were found by ground exploration. The resources hosted in these deposits were subsequently mined in Los Gigantes and La Estela production centres, respectively. In 1968, the Dr. Baulies deposit, occurring in volcanoclastic sediments, was discovered by airborne survey as part of the Sierra Pintada district in the Province of Mendoza.

During the 1970s, follow-up exploration in the vicinity of the previously discovered uranium occurrences in Patagonia, led to the discovery of two new deposits: the Cerro Condor and Cerro Solo sandstone-type deposits. An airborne survey carried out in 1978 in Patagonia, contributed to the discovery of the small Laguna Colorada deposits located in a volcanic environment.

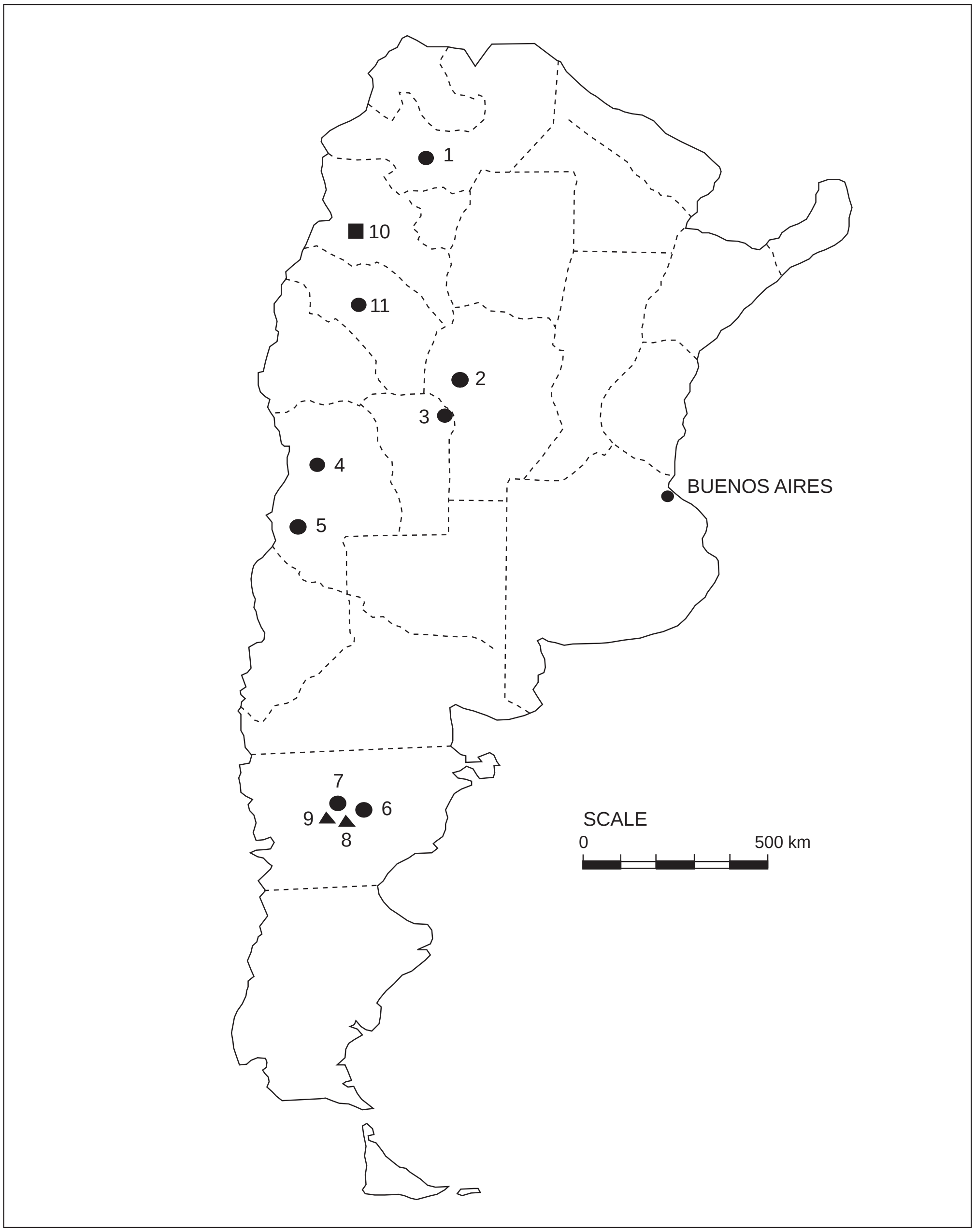
During the 1980s, an airborne survey conducted over granitic terrains identified a number of strong anomalies. These included some located over the Achala batholith, which were selected for further investigation. This resulted in the identification of several vein-type mineralizations, among them those extending the Schlagintweit and La Estela deposits. Subsequently in 1986, ground exploration identified the vein-type mineralization Las Termas. At the end of the 1980s, a nationwide exploration programme was started to evaluate those geological units which were believed to have uranium potential.

In 1990, an exploration drilling programme was initiated to further explore the Cerro Solo deposit in Patagonia. Through 1996, more than 52 000 metres were drilled to test the potential of the favourable portions of the paleochannel structure. The results include the delineation of several additional orebodies containing resources of several thousand tonnes. In addition to this work, the assessment of some favourable geological units were performed and the exploration of Las Termas mineralization continued.

Recent and Ongoing Activities

During 1995 and 1996, exploration continued both at the regional and local scale.

Uranium deposits of Argentina



- Being mined; uranium mill
- Mined out
- Being studied
- Exploration

1. Don Otto (Sandstone)
2. Schlagintweit (Vein)
3. La Estela (Vein)
4. Dr. Baulies (Volcanoclastic)
5. Huemul (Sandstone)
6. Los Adobes (Sandstone)
7. Cerro Condor (Sandstone)
8. Cerro Solo (Sandstone)
9. Laguna Colorada (Volcanoclastic)
10. Las Termas (Vein)
11. Los Colorados

The regional studies include the completion of the reprocessing of geophysical data obtained by airborne surveys over certain areas of Patagonia (100 000 km^2) and Cordoba (42 000 km^2). The regional assessment of the uranium potential of favourable geological units also continued.

Local investigations were directed at the further evaluation of the Cerro Solo deposit, where 16 300 metres drilling led to the identification of additional resources and to the reclassification of resources from lower confidence categories to those of higher confidence. In addition to these investigations, surface work was done to further evaluate portions of the Cerro Solo paleochannel.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
TOTAL EXPENDITURES*				
Pesos (x 1000)	700	950	700	1 100
US$ (x 1000)	700	950	700	1 100
Government Surface Drilling (Metres)	2 300	7 900	8 300	4 500
Number of Holes Drilled by Government Organisations	16	82	97	30

* Excluding related salaries.

URANIUM RESOURCES

Known Conventional Uranium Resources (RAR & EAR-I)

Argentina's known resources in the RAR and EAR-I categories, recoverable at costs below $130/kgU, total 11 950 tU as of 1 January 1997, as recoverable resources. This compares with an estimate of 8 900 tU, reported as of 1 January 1995.

The 1997 estimate includes 4 620 t RAR recoverable at below $80/kgU and 8 840 tU recoverable below $130/kgU. When compared to the previous estimate, there is an increase of 3 190 tU, of which 1 220 tU belong to the below $80/kgU category. This development is due to the reassignment of resources in the Sierra Pintada mining operation and the upgrading of resources in the Cerro Solo deposit. Resources recoverable at costs below $40/kgU are not reported.

The EAR-I estimate amounts to 900 tU recoverable at costs of below $80/kgU and 3 110 tU recoverable at below $130/kgU. This represents a minor decrease of 140 tU representing mainly the transfer of resources in the Cerro Solo deposit into the RAR category.

The resource estimates were made recently and represent net resources as of 1 January 1997, adjusted for past production.

A total of 43.5 per cent of Argentina's known resources recoverable at costs below $80/kgU is tributary to existing and committed production centres.

Undiscovered Conventional Resources (EAR-II & SR)

The EAR-II resources of Argentina are reported to total 1 100 tU as recoverable resources, at the cost category of up to $130/kgU, as of 1 January 1997. No Speculative Resources are reported.

The recent EAR-II estimate of 1 100 tU compares with 200 tU in the previous report.

URANIUM PRODUCTION

Historical Review

Argentina has been producing uranium since the mid-fifties. A total of seven commercial scale production centres were in operation at different times. In addition, a pilot plant operated between about 1953 and 1970. A detailed schedule of all Argentine uranium production centres is shown in Figure 1.

Between the mid-1950s and 1996, the cumulative uranium production was 2 482 tU. The 1995 production came from Los Colorados and San Rafael centres, while the 1996 production was mined in the San Rafael centre after the closure of Los Colorados. Production data are given in the following table.

HISTORICAL URANIUM PRODUCTION

(Tonnes U)

Production Method	Pre-1994	1994	1995	1996	Total through 1996	Expected 1997
• Open pit Mining	1 908	80	65	28	2 080	20
• Underground Mining	400	0	0	0	400	0
TOTAL	2 308	80	65	28	2 482 *	20

* Total does not represent the sum of the annual subtotals due to aggregation of decimals.

Los Colorados mine and mill complex, located in La Rioja province, was shut down at the end of 1995. Los Colorados had started production in 1993 and was owned and operated by Uranco S.A., a private company. Ore was mined from a small sandstone-type deposit located in the area and treated in the attached ion exchange (IX) recovery plant which had been relocated from La Estela project. The nominal annual capacity of Los Colorados mill was 30 tU.

The closure of Los Colorados operation, which was a privately-owned venture, resulted in a change in the ownership structure of uranium production in Argentina. As of 1996, the uranium mining industry is wholly owned by the Government Agency CNEA.

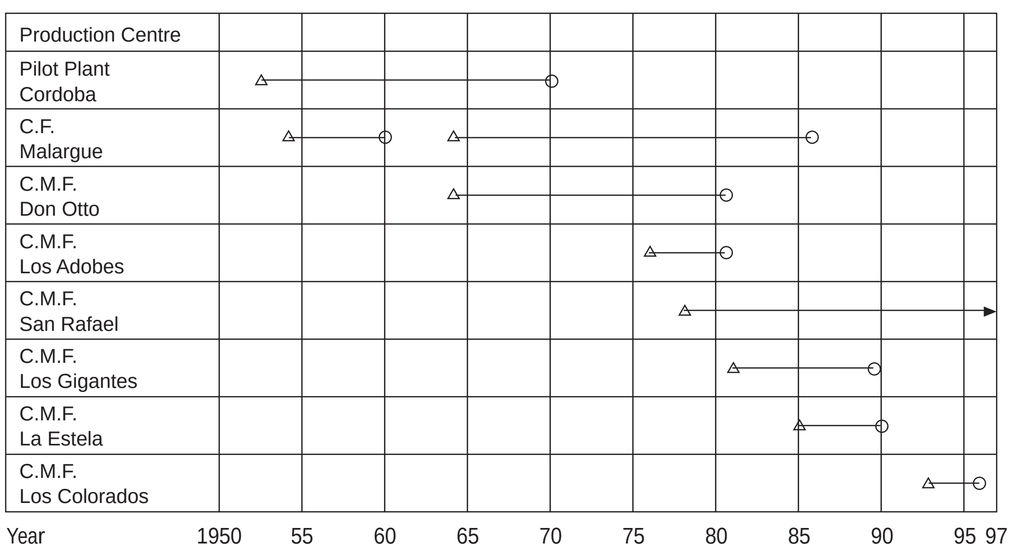
Status of Production Capability

At present, the only operating production centre is the San Rafael facility. Its annual production capability is about 120 tU. The technical details of the San Rafael mine/mill complex are summarised in the following table.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

Name of Production Centre	Complejo Minero Fabril San Rafael
Production Centre Class	Existing
Operational Status	In operation
Start-up Date	September 1979
Source of Ore • Deposit Name • Deposit Type	 Sierra Pintada Volcanoclastic
Mining Operation • Type • Size (Tonnes ore/day) • Average Mining Recovery (%)	 Open Pit 700 NA
Processing Plant • Type • Size (Tonnes ore/day) • Average Processing Capacity (tU/y)	 IX 700 83
Nominal Production Capacity (tU/y)	120
Plans for Expansion	NA

Figure 1. **Operating history of uranium yellowcake production centres in Argentina**



C.F. Uranium mill
C.M.F. Uranium mine and mill complex
△ Began operation
○ Shut down operation
⟶ In operation

Employment in the Uranium Industry

Employment in Argentina's uranium industry continues to decline. While employment in 1980 was approximately 450 persons, it decreased to 100 in 1996. A further reduction to 80 persons is planned for 1997.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	**1995**	**1996**	**Expected 1997**
180	120	100	80

Short-Term Production Capability Projection

Argentina does not provide short-term uranium production capability projections beyond the year 2000, as no further projections are available. The available data are summarised in the following table.

SHORT-TERM PRODUCTION CAPABILITY

(Tonnes U/year)

1997				1998				2000			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	120	120	0	0	120	120	0	0	120	120

Environmental Aspects

Contractual arrangements related to the return of the land occupied by the decommissioned Malargüe mill existed between the Government of Argentina (as owner of the previous operator) and the Province of Mendoza (as owner of the surface rights). This led to the expenditures of about US$ 12 million by CNEA in the final clean-up and restoration of the disturbed mill area. In addition, the restoration of the land occupied by the shut down Los Gigantes mine and mill complex is being investigated.

URANIUM REQUIREMENTS

Argentina's uranium requirements have been modified due to the uncertainty in the date of the completion of the Atucha II nuclear power plant. The currently available information on the installed nuclear electricity generating capacity and the related uranium requirements are summarised in the following tables.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe Net)

1996	1997	2000	2005	2010	2015
940	940	940	NA	NA	NA

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	1997	2000	2005	2010	2015
150	150	150	NA	NA	NA

NATIONAL POLICIES RELATING TO URANIUM

The recently approved nuclear legislation provides for the privatisation of the nuclear power plants currently owned by the CNEA. In this event, the uranium requirements will increase as the party acquiring the two nuclear power plants currently in operation will also be committed to completing the construction of the third plant, Atucha II, and bringing it into operation.

Under the uranium supply and procurement strategy followed by CNEA, it was decided to take advantage of the low uranium prices, and to reduce the internally produced portion to a minimum. Based on this strategy, approximately 100 tU/year are being bought on the spot market. It is expected that this strategy will be maintained until the current market situation changes.

URANIUM STOCKS

At the end of 1996 total uranium stocks held by the Federal Government amounted to 188 tU in the form of uranium concentrates.

URANIUM PRICES

Information on uranium prices is not available.

• Australia •

URANIUM EXPLORATION

Historical Review[1]

Exploration for uranium in Australia can be divided into two distinct periods: 1947 to 1961, and 1966 to the present. During the first period, the Australian Government introduced measures to encourage exploration, including a system of rewards for the discovery of uranium ore. There was active exploration, particularly by prospectors in most Australian mineral fields and many of the discoveries were made by prospectors equipped with Geiger counters. Several of the deposits discovered during this period produced uranium, the largest being Mary Kathleen and Rum Jungle.

As a result of the abrupt decline in demand, there was virtually no exploration for uranium between 1961 and 1966.

The second phase of uranium exploration in Australia from 1966 to the present resulted in an increase in Australia's low cost (<US$ 80/kgU) RAR from 6 200 tU in 1967 to 622 000 tU in 1996. Most of this exploration was undertaken by companies with substantial exploration budgets, utilising the more advanced geological, geochemical and geophysical techniques now available. Several major discoveries were made through the use of airborne multi-channel gamma ray spectrometers. The major uranium deposits which were discovered during the second phase of exploration included:

Unconformity related deposits

– Alligator Rivers uranium field:	Ranger (1969)[2], Nabarlek (1970), Koongarra (1970), Jabiluka (1971)
– Paterson Province:	Kintyre (1985)

Breccia complex deposit

– Stuart Shelf:	Olympic Dam (1975)

Surfical deposits

– Calcrete deposits in Yilgarn Block:	Yeelirrie (1971), Lake Way (1972), Lake Maitland (1972)

1. For a summary of the history of uranium exploration in Australia, please refer to Lambert, I., McKay, A., & Miezitis, Y., 1996: *Australia's Uranium Resources: "Trends, Global Comparisons and New Developments"*. Bureau of Resource Sciences, Canberra.

2. Year of discovery shown in parentheses.

Sandstone deposits

- Frome Embayment uranium field: Beverley (1970), East Kalkaroo (1971), Honeymoon (1972)
- Westmoreland / Pandanus Creek: Junnagunna (1976)
- Ngalia Basin: Bigrlyi (1970), Walbiri (1970)
- Amadeus Basin: Angela (1973), Pamela (1973)
- Carnarvon Basin: Manyingee (1974)
- Officer Basin: Mulga Rock (1978)

Volcanic deposits

- Georgetown / Townsville field: Maureen (1971), Ben Lomond (1976)

Recent and Ongoing Activities

Uranium exploration expenditure in Australia declined from the peak level of A$ 35.0 million in 1980 (A$ 86.5 million in constant 1995 A$) to an historic low of A$ 6.67 million (A$ 7.0 million in constant 1995 A$) in 1994. This decline was due to many factors including a progressive fall in both spot market and contract prices for uranium during this period, and the effects of the former government's "three mines" policy. Since the abolition of this policy in March 1996 by the Liberal-National Party Coalition Government there has been an increase in uranium exploration activity. Uranium exploration expenditure rose to A$ 8.26 million in 1995 and to A$ 14.92 million in 1996. This increase was also partly due to an improved market outlook. There were 17 active projects in 1995 and 13 active projects in 1996.

URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT – DOMESTIC

	1994	1995	1996	1997 (Expected)
INDUSTRY EXPENDITURES:				
A$ (x 1000)	6 670	8 260	14 920	NA
US$ (x 1000)	4 904	5 943	11 842	NA
Industry Surface Drilling in Metres	12 375	16 133	19 293	NA
Number of Industry Holes Drilled	not known	not known	not known	NA

The main areas where uranium exploration was carried out during 1995 and 1996 included:

- Arnhem Land (Northern Territory) – exploration continued for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstones;

- Paterson Province (Western Australia) – exploration continued for unconformity-related deposits in Palaeoproterozoic metasediments of the Rudall Metamorphic Complex which hosts the Kintyre orebody;

- Westmoreland area (north-west Queensland) – exploration continued for sandstone-type deposits in sediments of the McArthur Basin;

- Olympic Dam area (South Australia) – exploration drilling continued along the southern margins of the Olympic Dam deposit.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Over the two-year period from 1 January 1995 to 1 January 1997, estimates of Australia's uranium resources in the RAR and EAR-I categories have changed as follows:

– RAR recoverable at costs of <US$ 80/kgU have decreased by 11 000 tU;

– EAR-I recoverable at costs of <US$ 80/kgU have decreased by 18 000 tU;

– RAR recoverable at costs in the range US$ 80-130/kgU have increased by 16 000 tU;

– EAR-I recoverable at costs in the range US$ 80-130/kgU have increased by 4 000 tU.

These changes were due to:

- reassessments of the resources for the Ranger No. 3, Koongarra and Olympic Dam orebodies. The latest estimates for these orebodies were calculated either by the mining companies, or by the Bureau of Resource Sciences (BRS) in conjunction with the mining companies;

- new data on metallurgical recoveries achieved by the Ranger mill, as reported by Energy Resources of Australia Ltd, have altered the estimates of recoverable resources for the Ranger deposits;

- low cost RAR were reduced by uranium production from Ranger and Olympic Dam mines which totalled 8 687 tU for 1995 and 1996.

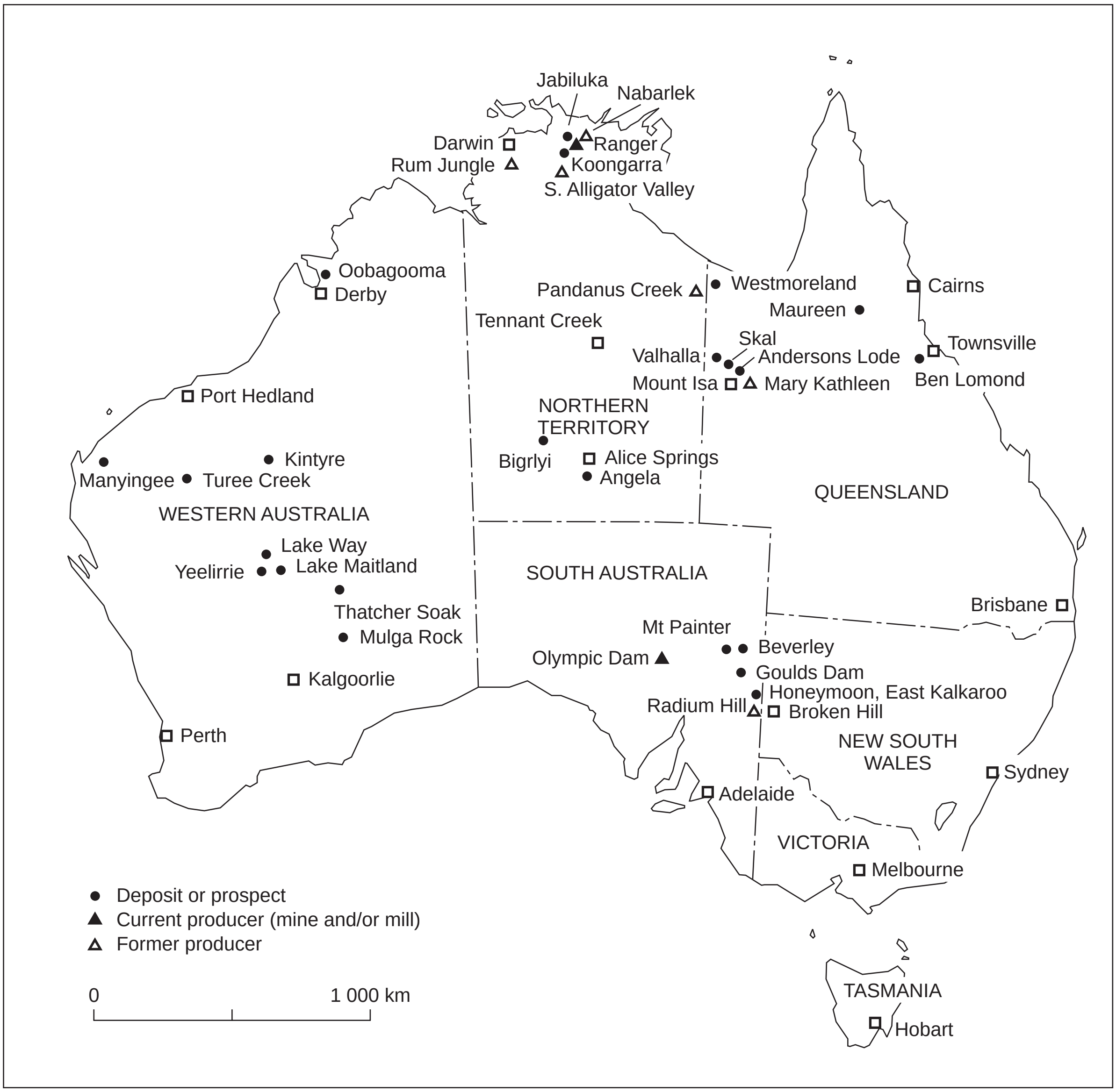
The uranium resources for the Olympic Dam deposit contain copper as co-product, and associated by-products of gold and silver.

Australia’s uranium resources in the RAR and EAR-I categories do not include any uranium recoverable as a by-product of the extraction of other minerals.

Deductions for anticipated mining and ore processing losses are determined for each deposit. The percentage of losses for mining and ore processing are dependent upon:

- mining methods (or proposed methods for undeveloped deposits),
- metallurgical processes (or proposed processes for undeveloped deposits),
- mineralogy of the ore and gangue.

Uranium deposits and prospects in Australia



For Ranger and Olympic Dam deposits, the latest figures for mining and ore processing losses reported by the companies were used to calculate recoverable resources.

BRS prepares an estimate of Australia's total recoverable resources of uranium in the RAR and EAR-I categories as at 31 December each year. In past years, BRS (or its predecessor organisations) calculated the resources for individual deposits using drillhole data provided by the companies, and these estimates were added to give Australia's total resources. However, in recent years, fewer staff have been allocated to this work. Consequently, for those uranium deposits currently being explored or mined, BRS now either accepts the company's latest estimates, or calculates the resources for some deposits in conjunction with the operating company.

Undiscovered Conventional Resources (EAR-II & SR):

Estimates are not made of Australia's uranium resources within the EAR-II & SR Categories.

URANIUM PRODUCTION

Historical Review

Production of uranium in Australia commenced in 1954. During the period 1954 to 1971, some 7 800 tU were produced to fulfil contracts with the UK Atomic Energy Authority or the Combined Development Agency (a joint UK-US defence purchasing agency). The major production was from two mines, Rum Jungle in the Northern Territory and Mary Kathleen in Queensland. The remainder of the production was from a number of small deposits in the South Alligator Valley in the Northern Territory and from Radium Hill in South Australia. Production ceased when the existing contracts were completed although at Rum Jungle, production continued until the orebodies were mined and the production which was in excess of the amount required to meet contracts was stockpiled.

The second phase of uranium production in Australia commenced in 1976 with the re-start of production from Mary Kathleen. Production commenced at Nabarlek (Northern Territory) in June 1980; at Ranger (Northern Territory) in August 1981; and at Olympic Dam (South Australia) in September 1988.

The Nabarlek orebody was mined in 1979 and stockpiled for later treatment. Production ceased in 1988 when the final portions of the stockpile were processed.

Status of Production Capability

Uranium oxide is currently produced at two mining/milling operations – Ranger and Olympic Dam. Australia's total production for 1996 was a record high of 4 975 tU (5 867 t U_3O_8) of which Ranger produced 3 509 tU and Olympic Dam produced 1 466 tU. Total production for 1996 was 34 per cent higher than 1995. At Ranger, there was a return to continuous milling and ore processing during 1996 which increased annual production. Production also increased at the Olympic Dam operations, following completion of the second optimisation project in mid-1995 and improved recovery rates.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4	Centre # 5
Name of Production Centre	Ranger	Olympic Dam	Jabiluka	Kintyre	Beverley
Production Centre Class	Existing	Existing	Planned	Planned	Planned
Operational Status	Mine and processing plant operating	Mine and processing plant operating	Government approval yet to be obtained	Government approval yet to be obtained	Government approval yet to be obtained
Start-up Date	1981	1988			
Source of Ore					
• Deposit Names	Ranger 1, No.1 Orebody Ranger 1, No.3 Orebody	Olympic Dam	Jabiluka, No. 2 Orebody	Kintyre Orebody	Beverley
• Deposit Type	Proterozoic unconformity-related	Breccia complex	Proterozoic unconformity-related	Proterozoic unconformity-related	Sandstone
Mining Operation					
• Type (OP/UG/ISL)	OP	UG	UG	OP	ISL
• Size (tonnes ore/year)	2.4 million (a)	3.1 million	0.3 million initial capacity	0.6 million	
• Average Mining Recovery (%)	NA	NA	NA	NA	NA
Processing Plant (Acid/alkaline):	Acid	Acid	(e)	Acid (Crush, Rad-sort, Dens-sep)	Acid
• Type (IX/SX/AL)	CWG, AL, SX	CWG, FLOT, AL, SX		AL, SX	IX, SX, AL
•					
• Size (tonnes ore/year) For ISL (kilolitre/ day or litre/hour)	1.4 million	3.1 million		45 000	NA
• Average Process Recovery (%)	85	66 (c)		NA	NA
Nominal Production Capacity (tU/year)	2 970	1 610	1 530	1 020	760
Plans for expansion	(b)	(d)	(f)		

a) Historically the tonnages of ore mined annually have ranged up to a maximum of 2.4 million tonnes. Mining at the Ranger open cut was completed in December 1994.

b) ERA (Energy Sources of Australia Ltd.) is expanding the Ranger mill from its present capacity of 1.4 million tonnes ore per annum (2 970 tpa U) to 2.0 million tonnes ore per annum (4 240 tpa U) by mid-1997. In the event that ERA's proposal to develop Jabiluka is approved, capacity of the mill would be increased further to approximately 5 090 tpa U. Under an agreement with the Commonwealth Government, ERA can increase production to 5 090 tpa U (6 000 tpa U_3O_8) when the company considers it commercially viable to do so.

c) Source: WMC Holdings Report to the Securities and Exchange Commission Washington DC, 1992.

d) Production capacity of the mill is to be expanded to 8.5 million tonnes ore per annum with production of 3 900 tpa U (4 600 tpa U_3O_8) by 1999.

e) ERA's preferred option for the Jabiluka project is to process the ore at the Ranger mill.

f) Production from Jabiluka will be increased to 3 400 tpa U (4 000 tpa U_3O_8) by year 14.

Ranger

Mining at the Ranger No. 1 open pit was completed in December 1994 and Energy Resources of Australia Ltd (ERA) reported that stockpiled ore is sufficient to maintain milling operations through to 1999. In August 1996, the company commenced disposal of tailings into the open pit.

ERA has two undeveloped uranium deposits: Ranger Orebody No. 3 which lies adjacent to the Ranger mill, and Jabiluka Orebody located 20 km north of the mill on an adjoining lease. In May 1996, the company received approval from the Northern Territory Department of Mines & Energy to develop Orebody No. 3. Development work for the open cut commenced in late 1996 and production from this deposit is scheduled to commence in mid-1997. Orebody No. 3 has proven plus probable reserves of 19.9 million tonnes ore with average grade 0.28 per cent U_3O_8, containing 55 700 t U_3O_8. Orebody No. 3 is within the Ranger Project Area and was included in the original Environmental Impact Statement to mine the Ranger Project Area following the Ranger Uranium Environmental Inquiry.

The company is currently expanding the capacity of the Ranger mill from its present level of 3 500 t per annum (tpa) U_3O_8 to 5 000 tpa U_3O_8. The mill expansion is scheduled to be completed by mid-1997 to coincide with the commencement of mining at No. 3 Orebody. In the event that ERA’s current proposal for the development of Jabiluka is approved (permitting processing of Jabiluka ore at Ranger mill) capacity of the mill would be increased further to approximately 6 000 tpa U_3O_8.

HISTORICAL URANIUM PRODUCTION

(Tonnes U contained in concentrate)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	Expected 1997
Conventional Mining						
• Open pit	56 399 (a)	1 240	2 550	3 509	NA	NA
• Underground		968 (b)	1 162 (b)	1 466 (b)	NA	NA
TOTAL	56 399	2 208	3 712	4 975	67 294	NA

(a) Total for pre-1994 is the combined production from both open cut and underground mining operations.

(b) Production from Olympic Dam is reported by the company as tonnes of uranium ore concentrates. The grades of these concentrates are not reported but are usually higher than 98 per cent U_3O_8. No allowance is made here for the grade of these concentrates.

Olympic Dam

Olympic Dam operations comprise an underground mine and a metallurgical complex. The metallurgical complex includes a grinding/concentrating circuit, hydrometallurgical plant, copper smelter, copper refinery and a recovery circuit for precious metals. Olympic Dam currently has an annual production rate of 85 000 t copper, 1 700 t U_3O_8 and associated gold and silver.

In July 1996, WMC Limited (WMC) announced that production will be increased to 200 000 tpa of copper, 3 700 tpa U_3O_8, 75 000 ounces gold and 950 000 ounces of silver, from an annual throughput of 8.5 million tonnes ore. Initially it was planned that the expansion would be completed by the year 2001. WMC also announced it would seek the necessary approvals for the project to ultimately expand to 350 000 tpa of copper and associated products, although there are currently no plans to expand beyond 200 000 tpa.

Following a revision of construction and production schedules, WMC announced it would accelerate the expansion timetable and achieve the designed rate of 200 000 tpa of copper by the end of 1999. As a result, the overall capital cost will increase from A$ 1.25 billion to A$ 1.48 billion. WMC also announced that the associated production of U_3O_8 would increase from an annual average rate of 3 700 t to approximately 4 600 t which, based on current production levels of existing mines, would rank Olympic Dam as one of the world's five largest uranium production centres.

Under the original Indenture between WMC and the State of South Australia, and existing Commonwealth/State environmental clearances, the Olympic Dam operation can produce up to 150 000 tpa of copper and associated products. The Indenture has been amended to allow the project, subject to environmental clearances, to expand to produce up to 350 000 tpa of copper and associated products. The proposal to expand the project beyond 150 000 tpa is currently undergoing a joint Commonwealth/South Australia environmental impact statement (EIS) process. The draft EIS was released for public comment in May 1997.

WMC reported the following ore reserves and resources for the Olympic Dam deposit as of June 1996:

RESERVES/RESOURCES		Ore million tonnes	Cu %	U_3O_8 kg/t	Contained U_3O_8 tonnes
Reserves:	Proved	73	2.5	0.8	58 400
	Probable	496	2.0	0.6	297 600
Resources:	Measured	0			
	Indicated	1 220	1.1	0.4	488 000
	Inferred	400	1.3	0.4	160 000

(Note: Resources are in addition to reserves).

Exploration – an exploration drilling programme to assess the potential of the southern section of the Olympic Dam Breccia Complex (which hosts the mineralization) continued during 1996 and 1997. Drillhole RD1090 intersected 84 metres of 2.1 per cent copper from 405 metres depth, and RD1095 which was drilled 300 metres west of RD1090, intersected two significant zones of mineralization – 60 metres of 1.4 per cent copper from 300 metres depth, and 90 metres of 1.1 per cent copper from 414 metres depth. Uranium grades for these intersections have not been reported to date.

Ownership Structure of the Uranium Industry

As at August 1996, ERA (Energy Resources of Australia Ltd), the operating company for the *Ranger* mine and mill, was owned by the following companies:

	% of issued capital
Peko Wallsend Ltd	34.29
North Broken Hill Peko Ltd	34.10
Other 'A class' Shareholders	6.51
Rheinbraun Australia Pty Ltd	6.45
UG Australia Developments Pty Ltd	4.19
Interuranium Australia Pty Ltd	1.98
Cogema Australia Pty Ltd	1.31
OKG Aktiebolag	0.54
Japan Australia Uranium Resources Development Co. Ltd	10.64

The *Olympic Dam* project is now wholly-owned by WMC.

Employment in the Uranium Industry

Employment in Australia's production centres has increased marginally in response to the resumption of continuous milling at Ranger at the commencement of 1996 and the completion in mid-1995 of the second optimisation project at Olympic Dam.

Future Production Centres

Since the removal of the "three mines" policy in March 1996, two companies, ERA and Canning Resources Ltd (a subsidiary of RTZ-CRA), have formally notified the Commonwealth Minister for Resources and Energy of their intention to proceed with development proposals for new uranium mines. The projects are Jabiluka in the Northern Territory, and Kintyre in Western Australia. A third company, General Atomics of the US, is seeking foreign investment approval for the possible development of the Beverley uranium deposit in South Australia.

Jabiluka

The draft Environmental Impact Statement (EIS) for the Jabiluka projects, which was released in October 1996, examines a number of options for the development of the Jabiluka deposit. ERA's preferred option is for an underground mining operation, with the ore to be processed at the Ranger mill. The ore would be trucked for a distance of 20 km to Ranger via a haul road entirely within the lease area.

The key aspects of ERA's proposal include:

- no tailings dam and no processing plant at Jabiluka,
- surface facilities will only cover 20 hectares,
- total disturbed land including the transport corridor is estimated at 80 hectares which is much less than other options,
- tailings will be placed in the Ranger open pits which will be rehabilitated at the end of the mine life.

ERA is planning to develop Jabiluka by 1999-2000. Initially 300 000 t of Jabiluka ore will be processed annually to produce approximately 1 800 tpa of U_3O_8. Production will increase to approximately 4 000 tpa of U_3O_8 in the fourteenth year from the processing of 900 000 t ore.

Total proved and probable ore reserves of 19.5 million tonnes ore averaging 0.46 per cent U_3O_8, and containing 90 400 t U_3O_8 were reported by ERA. The total geological resource (which includes the ore reserves) was estimated to be 28.7 million tonnes ore averaging 0.52 per cent U_3O_8.

The draft EIS for the project was released for public comment in October 1996. The final EIS was submitted to the Commonwealth Government in June 1997.

Kintyre

The Kintyre deposit is located on the western edge of the Great Sandy Desert in the Eastern Pilbara Region of Western Australia, approximately 1 200 km north to north-west of Perth. The project area is located immediately north of the Rudall River National Park.

Canning Resources propose to mine the four orebodies which make up the Kintyre deposit by a number of separate open pits. Ore processing will be in two main stages:

- a *dry upgrading phase* in which the ore from the mine will be crushed and screened by size. The larger size fractions will be concentrated by radiometric sorting; and the smaller size fraction will be concentrated using ferrosilicon heavy media separation. Mineralization at Kintyre occurs as veins of high grade uranium within barren host rock, which makes the ore suitable for radiometric sorting;

- a *wet phase* where the uranium is extracted from the ore in three stages – leaching, iron pre-precipitation and uranium precipitation.

Production is planned to start in 1999. Initially the operation will produce 1 200 tpa U_3O_8, with the potential to increase production up to 2 000 tpa U_3O_8 over a twenty-year period. Probable resources were estimated to be 24 500 t U_3O_8, with an additional 11 500 t U_3O_8 of inferred resources.

The Kintyre project is undergoing a joint Commonwealth/State (Western Australia) EIS process which is expected to be completed by the end of 1997.

Beverley

Beverley is a sandstone-hosted deposit located near Lake Frome, approximately 530 km north to north-east from Adelaide. Since 1990, Beverley has been owned by Heathgate Pty Ltd, a wholly owned subsidiary of General Atomics, a privately owned US company. The company is currently seeking foreign investment approval to proceed with further geological and metallurgical studies of the orebody in order to obtain the necessary approvals for its proposed in situ leaching operation.

Within an overall resource of 16 200 t U_3O_8, at an average grade of 0.27 per cent U_3O_8, there is approximately 11 600 t U_3O_8 that could be recovered by in situ leaching.

The current proposal, which is in the initial phase of a joint Commonwealth/State (South Australia) EIS process, is to develop an in situ leach operation, capable of producing 900 tpa U_3O_8 by 2000.

ENVIRONMENTAL CONSIDERATIONS

Northern Territory

While the Commonwealth Government controls uranium mining in the Northern Territory, the Northern Territory Government has responsibility for day to day regulation of mining activities and supervision of environmental programmes. The Ranger mine is currently the only operating uranium mine. The Nabarlek mine ceased production in 1988 and substantive rehabilitation of the mine was successfully completed in 1995. Environmental monitoring of the site is continuing. Both mines are located in the Alligator Rivers Region (ARR).

There are strict environmental requirements relating to the Ranger and Nabarlek projects. These include the requirement that the design of the mine and plant, and the mining and milling operations be carried out in accordance with best practicable technology (BPT). BPT is that technology which produces the minimum environmental pollution and degradation that can reasonably be achieved allowing for considerations of reasonableness, cost, evidence of detriment, project location, age of equipment and social factors.

A Commonwealth body, the Office of the Supervising Scientist (OSS), has overseen the environmental aspects of uranium mining operations in the ARR since mining commenced at Ranger and Nabarlek in the early 1980s. The Supervising Scientist, supported by the Environmental Research Institute of the Supervising Scientist (ERISS), co-ordinates and supervises measures for the protection and restoration of the environment of the ARR from the effects of uranium mining. The OSS measures environmental performance of the mines, including the rehabilitation of Nabarlek, through twice-yearly audit processes.

The Supervising Scientist has consistently attested, including in his report for the year ended 30 June 1996, to the high level of environmental protection achieved in the ARR and noted that mining operations have had a negligible impact on the surrounding environment.

Energy Resources of Australia Ltd (ERA) is finalising an Environmental Impact Statement (EIS) for development of its Jabiluka deposit which is also located in the ARR. A draft EIS, part of a joint Commonwealth/Northern Territory environmental assessment process, was released for public comment in October 1996. ERA received 83 submissions during the public consultation period which ended on 9 January 1997. The main issues raised in these submissions included social considerations, radiation protection, water management, and tailings disposal. These issues will be taken into account by ERA in the final EIS which is due to be submitted in May 1997.

South Australia

The initial environmental assessment process for the Olympic Dam project, including a comprehensive EIS, was completed in 1983 under a joint Commonwealth/State process. The assessment was for a project that would produce 150 000 tpa of copper plus associated products. The project currently has an annual production rate of 85 000 t copper, 1 700 t U_3O_8 and associated gold and silver.

In 1995, WMC notified Commonwealth and State agencies of its proposal to expand the Olympic Dam project to achieve a maximum production level of 150 000 tpa of copper plus associated products as specified in the original EIS. The proposal was subjected to Commonwealth environmental assessment in accordance with the *Environment Protection (Impact of Proposals) Act 1974*. The assessment included taking into account a State environmental review of the project covering the tailings retention system and metallurgical processes, and completion of a State assessment into a new borefield in the Great Artesian Basin from which the project draws its water requirements. The assessment was completed in January 1996 and WMC was given Commonwealth environmental clearance to implement any proposed expansion to 150 000 tpa of copper plus associated products.

In July 1996, WMC announced that Olympic Dam would be expanded to produce 200 000 tpa of copper plus associated products (including 3 700 tpa U_3O_8) by 2001. In order to provide flexibility for future expansion, the company reported that it would seek the appropriate regulatory and environmental approvals to ultimately produce up to 350 000 tpa of copper plus associated products. In February 1997, it was announced that the expansion would be accelerated to achieve the planned output level of 200 000 tpa of copper by the end of 1999. In April 1997, WMC further announced that annual production of uranium had been revised upward to approximately 4 600 tpa U_3O_8. Environmental assessment of the proposed expansion is being conducted jointly by the Commonwealth and State of South Australia. A comprehensive EIS was released by WMC for public comment in May 1997.

The Olympic Dam project is regulated under South Australian State Government legislation, principally through the Indenture between State Government and WMC. The Indenture provides for the drafting and implementation of an Environmental Management Programme for the project which must be revised and re-submitted for approval every three years. Consistent with this requirement, in 1996 WMC submitted its latest Environmental Management and Monitoring Plan (EMMP) to the South Australian Government. The EMMP, which is a public document, was approved by the Government.

A proposal to develop a second uranium mine in South Australia at Beverley has been submitted by Heathgate Pty Ltd. In December 1996, the Commonwealth Minister for the Environment determined that the proposal will be subject to a joint Commonwealth/State EIS process.

Western Australia

In September 1996, the Commonwealth Minister for the Environment determined that the proposal to develop the Kintyre deposit will be subject to a joint Commonwealth/State EIS process. The draft EIS guidelines were released for public comment in November 1996 and are expected to be finalised by mid-1997.

STATISTICAL DATA ON URANIUM PRODUCTION

Long-Term Production Capability

The abolition of the "three mines" policy means that several new uranium mines are likely to be developed to take advantage of market opportunities. Australia's annual production could increase from the 1996 level of 4 975 tU to approximately 10 800 tU by the year 2000 as a result of proposed increases in production at both Ranger and Olympic Dam, together with projected production from possible new mines (Jabiluka, Kintyre and Beverley). These increases in production will depend on market conditions.

In the longer term, Olympic Dam operation could expand further to a production level of 350 000 tpa of copper, resulting in further increases in uranium production. In addition, there are a number of major unconformity-related deposits in the Alligator Rivers Region and calcrete-hosted uranium deposits in Western Australia, which are likely to be developed in the long term. Production from these deposits will maintain Australia's position as a major producer of uranium.

NATIONAL POLICIES RELATING TO URANIUM

Following its election in March 1996, the Liberal/National Coalition Government removed the former Government's policy which restricted the development of new uranium mines in Australia (i.e. the "three mines" policy). The current Government's policy is to approve new uranium mines and exports subject to strict environmental, heritage and nuclear safeguards requirements being met. Where Aboriginal interests are involved, the Government is committed to ensuring full consultation with the affected Aboriginal communities.

Uranium export contracts remain subject to Government approval but are no longer scrutinised for pricing purposes.

In November 1996, the Government announced that, following removal of the "three mines" policy, the foreign investment policy applying to the mining sector generally would also now apply to the uranium sector. This means that foreign investment above the notification thresholds in the uranium sector will be subject to a 'national interest' test and that no special investment restrictions will apply. The establishment of a new uranium mine involving investment of A$ 10 million or more, or the acquisition of substantial interest in an existing uranium mine valued at A$ 5 million or more require prior approval and no objections will be raised unless the proposal is considered contrary to the national interest.

URANIUM STOCKS

For reasons of confidentiality, information on producer stocks is not available. The Commonwealth uranium stockpile, consisting of 1 900 tU accumulated as a result of uranium mining at Rum Jungle in the 1950s and 1960s, was disposed of by the Australian Government under a two-year phased sales programme which was completed in 1995. The stockpile was sold for electricity production in North America.

URANIUM PRICES

Average annual export prices for Australian uranium have been:

1996	A$ 55.74/kgU
1995	A$ 53.35/kgU
1994	A$ 53.06/kgU
1993	A$ 60.29/kgU
1992	A$ 57.42/kgU

• Belgium •

URANIUM EXPLORATION

Introduction

Until 1977, just a few uranium occurrences were known in Belgium. These were mainly connected with black shales of the Upper Visean-Namurian, in the Dinant Basin, and of the Revinian, in the Stavelot mountains, and also with breccia, in Visean and Frasnian chalk, in the Visé mountains.

From 1977 to 1979, there was renewed interest in uranium exploration, leading to a study of the uranium occurrences in the Visé mountains and a study on the uranium content of the phosphates in Cretaceous formations in the Mons Basin.

From 1979 to 1981, the European Communities and the Ministry of Economic Affairs financed a general reconnaissance survey for uranium in the areas of Paleozoic formations in Belgium. The Geological Service co-ordinated three types of exploration, covering an area of approximately 11 000 km^2: carborne radiometric survey, geochemical survey on alluvial deposits, and hydrogeochemical survey. The Belgian universities of Mons, Louvain (UCL), and Brussels (ULB), respectively, were entrusted with the work. The general report was published in 1983.

From 1981 to 1985, this research was conducted chiefly at the Mons Laboratory, with the aim of studying the geological environment of the main anomalies discovered in the course of general exploration (Visean-Namurian and Lower Devonian).

Recent and Ongoing Activities

From 1985 to 1988, an exploration programme financed by the Underground Resources Service (Walloon Region) led to the discovery of anomalies and deposits (over one per cent uranium equivalent at certain points) in schist sandstone formations of the Lower Devonian and surface formations in Upper Ardenne.

Strategic and tactical uranium exploration was pursued in the Lower Devonian, in the Belgian Ardenne and on the basis of isolated anomalies discovered during preliminary carborne prospecting. This project was jointly financed by the EEC and the Geological Service of Belgium, during 1979-1982. Different geochemical and geophysical methods were used (radon in spring water, ground radon survey, gamma spectrometry) for indications discovered during the second phase, and trenching and short drilling (about 10 metres). Deeper core sampling and drill hole-logging surveys were conducted on a regional basis by the Geological Service.

Currently, it is estimated that none of the areas investigated is of economic interest. Although the occurrences are numerous and varied, the uranium content of each indication showing more than 100 ppm amounts to less than one tonne.

The uranium content of phosphates in the Mons Basin have also been evaluated, and a new estimate of the P_20_5 resources in the Basin put unconventional uranium resources at approximately 40 000 tU metal. This includes approximately 2 000 tU of resources in areas suitable for phosphate mining, although the contents are below ten per cent P_20_5 and 100 ppm uranium equivalent.

URANIUM RESOURCES

No significant uranium resources were reported by Belgium.

URANIUM PRODUCTION

Status of Production Capability

Belgium reported a production capacity of 45 tU/year from imported phosphates. There is no production from uranium originating in Belgium.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

	Centre # 1
Name of Production Centre	PRT
Production Centre Class	Existing
Operational Status	Plant operating
Start-up Date	1980
Source of Ore • Deposit Name • Deposit Type	Phosphates from Morocco
Mining Operation • Type (OP/UG/In situ) • Size (tonnes ore/year) • Average Mining Recovery (%)	None
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/year) • Average Processing Ore Recovery (%)	 DEPA-TOPO process 130 000 TP_2O_5/year
Nominal Production Capacity (tU/year)	45
Plans for expansion	None

Ownership Structure of the Uranium Industry

Since the 1995 Red Book, there have been no changes in the Belgian uranium production ownership structure or uranium production employment sector. The 45 tonnes of uranium production capacity is 100 per cent owned by PRAYON RUPEL TECHNOLOGIES (PRT), a private company. All uranium production is sold to SYNATOM, the Belgian nuclear fuel cycle company.

Future Production

No new uranium production capability is currently foreseen for Belgium during the time period from the present day to 2010.

URANIUM REQUIREMENTS

The installed nuclear generating capacity in Belgium has been expanded from 5 528 MWe (net) to 5 713 Mwe (net) through various upratings of the following seven reactors: Doel-l, Doel-2, Doel-3, Doel-4, Tihange-l, Tihange-2 and Tihange-3. Nuclear electricity generation accounts for about

57 per cent of Belgium's electricity demand, making it the third largest in the world with respect to nuclear share of generation. The oldest plants, Doel-l, Doel-2 and Tihange-1, were placed into commercial service in 1974 and 1975. The nuclear capacity demand for uranium is not expected to change over the short term.

In 1990, the three largest private utilities in Belgium merged to form a single private electric utility named ELECTRABEL. SYNATOM is the Belgian company entrusted by ELECTRABEL with the management of the nuclear fuel cycle for the seven commercial reactors. Until 1994, SYNATOM was owned fifty per cent by the private sector, through ELECTRABEL, and fifty per cent by the public sector, through SNI (Société Nationale d'Investissement). In 1993, the Belgian State decided to privatise SNI and to sell to TRACTEBEL, the mother company of ELECTRABEL, the shares owned by SNI in the energy sector, including SYNATOM. The State has kept a "golden share", giving it a veto right on any decision that would be contradictory with the governmental energy policy.

URANIUM STOCKS

Synatom is holding a strategic U-stockpile equivalent to two years requirements. This inventory consists of U_3O_8 , natural UF_6 and enriched UF_6.

NATIONAL POLICIES RELATING TO URANIUM

At the end of 1993, the Belgian Parliament held an extensive debate on the back-end of the fuel cycle and passed a resolution approving the continuation of the reprocessing contract signed in 1978 by SYNATOM with COGEMA. This enables the recycling of plutonium arising as MOX in Doel-3 and Tihange-2, which will reduce the annual demand for natural uranium by around four per cent in the coming years.

URANIUM PRICES

Information on uranium prices is not available.

• Brazil •

URANIUM EXPLORATION

Historical Review

Systematic prospecting for radioactive minerals began in 1952 by the Brazilian National Research Council. These efforts led to the discovery of the first uranium occurrences at Poços de Caldas (State of Minas Gerais) and Jacobina (State of Bahia). In 1955 a technical co-operation agreement with the US-Government was concluded for the assessment of the Brazilian uranium potential. After the creation of the National Nuclear Energy Commission (CNEN) a mineral exploration department was organised with the support of the French CEA in 1962.

In the 1970s, CNEN's exploration for radioactive minerals increased due to the availability of more financial resources. An additional impetus was given in 1974, when the Government founded NUCLEBRAS, an organisation with the exclusive mandate of uranium exploration and production. One of the early achievements of the Government Organisations was the discovery and development of the Osamu Utsumi deposit in the Poços de Caldas plateau.

In late 1975, Brazil and Germany signed a co-operation agreement for the peaceful use of nuclear energy. This provided for an ambitious nuclear development programme, which also required an increase of NUCLEBRAS' exploration activities. This led to the discovery of eight areas hosting uranium resources including the Poços de Caldas plateau, Figueira, the Quadrilátero Ferrifero, Amorinópolis, Rio Prieto/Campos Belos, Itataia, Lagoa Real and Espinharas (discovered and evaluated by NUCLAM, a Brazilian-German joint venture).

In 1991, INB (Indústrias Nuclares Do Brasil S.A.) stopped all its uranium exploration activities, following the reorganisation of the Brazilian nuclear development programme of 1988.

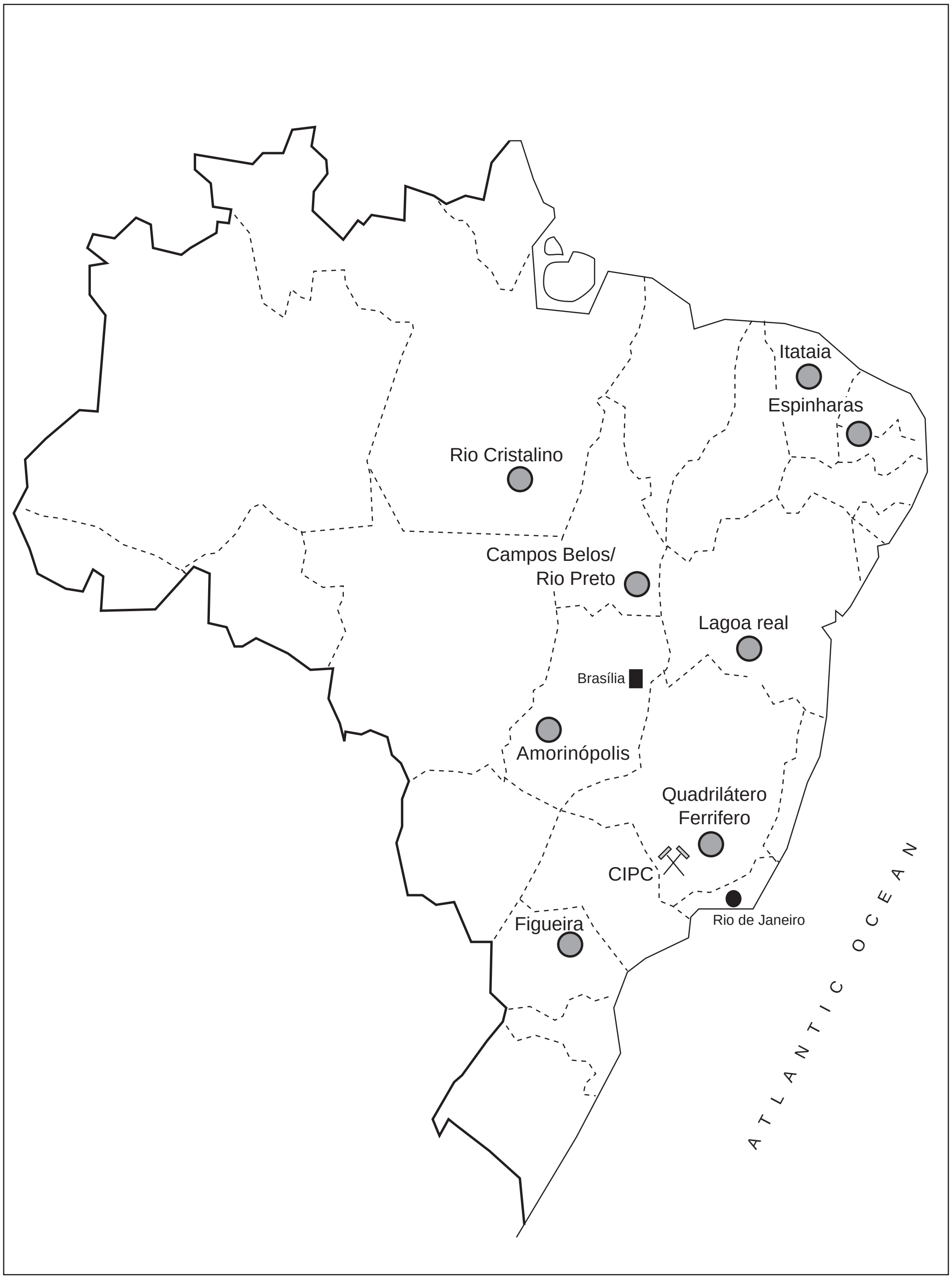
Recent and Ongoing Activities

Following the reorganisation of the Brazilian nuclear programme in 1988, the uranium activities were delegated to a special organisation known as “Urânio do Brasil S.A.”, which was organised as a subsidiary of a holding company Indústrias Nucleares do Brasil (INB), responsible for the nuclear fuel cycle activities. Following another reorganisation in 1994, Urânio do Brasil was disbanded and its activities were transferred to INB.

In 1995, feasibility studies for the mining project Lagoa Real were initiated. They were completed in 1996. The start of development of the Lagoa Real operation is planned for 1998.

Data on uranium exploration expenditures and drilling efforts 1994 through 1996 was not provided.

Uranium deposits and occurrences of Brazil



Note: Espinharas and Rio Cristalino are uranium occurrences. All of the other named sites host deposits. CIPC is the production facility located at Poços de Caldas.

URANIUM RESOURCES

Brazil's both conventional uranium resources are hosted in the following deposits:

- Poços de Caldas (Osamu Utsumi Mine) with the orebodies A, B, E and Agostinho (collapse breccia pipe-type);
- Figueira and Amorinópolis (sandstone);
- Itataia, including the adjoining deposits of Alcantil and Serrotes Baixos (metasomatic);
- Lagoa Real, Espinharas and Campos Belos (metasomatic (albititic)); and
- others including the Quadrilátero Ferrifero with the Gandarela and Serra des Gaivotas deposits (quartz pebble conglomerate).

Known Conventional Uranium Resources (RAR & EAR-I)

Brazil reported known conventional resources estimated prior to 1992. As of 1 January 1997, the known resources of Brazil total 262 200 tU as in situ resources producible below $80/kgU. This estimate is unchanged from the previously reported one. Of the total, 162 000 tU are RAR producible at costs below $80/kgU of which in turn, 56 100 t belong to the below $40/kgU cost category. The remaining 100 200 tU are EAR-I recoverable at costs below $80/kg. Lower cost EAR-I are not reported.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
56 100	162 000	162 000

* As in situ resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	100 200	100 200

* As in situ resources.

Information on the availability of the known resources is not available.

Undiscovered Conventional Resources (EAR-II & SR)

The estimates of the undiscovered resources are summarised in the following tables.

ESTIMATES ADDITIONAL RESOURCES – CATEGORY II*
(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	120 000	120 000

* As in situ resources.

SPECULATIVE RESOURCES*
(Tonnes U)

Cost Range	Cost Range	TOTAL
<$130/kgU	Unassigned	
0	500 000	500 000

* As in situ resources.

URANIUM PRODUCTION

The Poços de Caldas uranium production facility which started production in 1981 with a design capacity of 425 tU/y, was owned by the state owned company NUCLEBRAS until 1988. At that time Brazil's nuclear activities were restructured. NUCLEBRAS was liquidated and its assets transferred to Urânio do Brasil S.A. With the dissolution of Urânio do Brasil in 1994, the ownership of uranium production is 100 per cent controlled by Indústrias Núcleares do Brasil, a state owned company.

Between 1990 and 1992, the production centre at Poços de Caldas closed because of escalated production costs and reduced demand. Production restarted in late 1993 and continued until October 1995. A summary of uranium production is provided in the following table.

HISTORICAL URANIUM PRODUCTION

(Tonnes U contained in concentrate)

Production Method	Pre-1994	1994	1995	1996	Total through 1996	1997 (Expected)
Conventional Mining • Open pit	818	106	106	0	1 030	0

Status of Production Capability

The Poços de Caldas production centre was closed in 1997 and a decommissioning programme will start in 1998; its production will be replaced by the Lagoa Real centre, planned to begin in 1998.

The technical details of the current and future production centres are summarised in the following table.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

Name of Production Centre	Poços de Caldas	Lagoa Real	Itataia
Production Centre Class	Existing	Committed	Planned
Operational Status	Closed	Feasibility	Feasibility
Start-up Date	1981	1998	NA
Source of Ore • Deposit Names • Deposit Types	 Cercado Mine Collapse Breccia Pipe	 Cachoeira Metasomatic	 Itataia Phosphorite
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 OP 2 500 80	 OP/UG 350 80	 OP NA NA
Processing Plant • Type • Size (tonnes ore/day) • Average Ore Processing Recovery (%)	 SX 2 500 90	 HL/SX 350 90	 SX NA NA
Nominal Production Capacity (tU/year)	425	300	350
Plans for Expansion	No	No	NA
Other Remarks	Closed in 1997	–	–

Ownership Structure of the Uranium Industry

The current ownership in the Brazilian uranium mining industry is 100 per cent Government represented by the State-owned company Industrias Nucleares do Brasil. This company controls the Poços de Caldas operating company, referred to as Complexo Minero-Industrial do Planalta de Poços de Caldas (CIPC). Information on the ownership of the committed and planned production centres is not available.

Employment in the Uranium Industry

During the period 1988-1996, CIPC reduced its staff by about 50 per cent. Recent and current staffing is shown in the following table.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	**1995**	**1996**	**Expected 1997**
408	390	305	305

Future Production Centres

The start of production at the Lagoa Real production centre is firmly planned for 1998. The deposit was discovered in 1977 and its known resources were estimated to total 85 000 tU of the below $80/kgU cost category. The ore will initially be mined by open pit methods initially from the Anomalies 13 and 8, now referred to as the Cachoeira and Quebradas mines, respectively. The uranium will be extracted by acid heap leaching. Total production is planned to reach 250 tU/year. Investment costs of US$ 23 million are reported. The Poços de Caldas facility was closed in 1997 and production will be replaced by the uranium mined and processed in Lagoa Real. This centre will have a nominal production capacity of 300 tU/year.

In the Itataia planned production centre, uranium would be recovered as co-product together with phosphate from apatite and collophanite-bearing episyenites. If and when the uranium-phosphate Itataia project is developed depends on numerous factors including the markets for both products. In any case, a production start-up is not expected before the turn of the century.

A projection of production capability through the year 2015 is shown in the following table.

SHORT-TERM PRODUCTION CAPABILITY

(Tonnes U/year)

1997				1998				2000			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	400	400	0	0	400	400	500	500	500	500

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	1 360	0	1 360	0	1 360	0	1 360	0	1 360	0	1 360

Environmental Aspects

The main environmental issues associated with the current uranium mining industry include the monitoring of the Poços de Caldas operation as well as the planning for the decommissioning of the mine and mill complex. In addition, an environmental impact assessment of the firmly planned Lagoa Real production centre is being prepared.

URANIUM REQUIREMENTS

Brazil's present uranium requirements for the Angra I nuclear power plant, a 630 MWe PWR, are about 120 tU/year. With the completion and startup of the Angra II nuclear power plant, a 1 245 MWe PWR, the uranium requirements will increase by 250 tU/year after the first core, which would require 560 tU. At present, it is expected that Angra II will be completed in about 1999.

The installed nuclear generating capacities and the related uranium requirements through the year 2010 are given in the following tables.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe Net)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
626	626	1 871		1 871		3 110	NA	NA

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	1997	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
400	400	120		370		620	NA	NA

NATIONAL POLICIES RELATING TO URANIUM

No current information is available.

URANIUM STOCKS

No current information is available.

• Bulgaria •

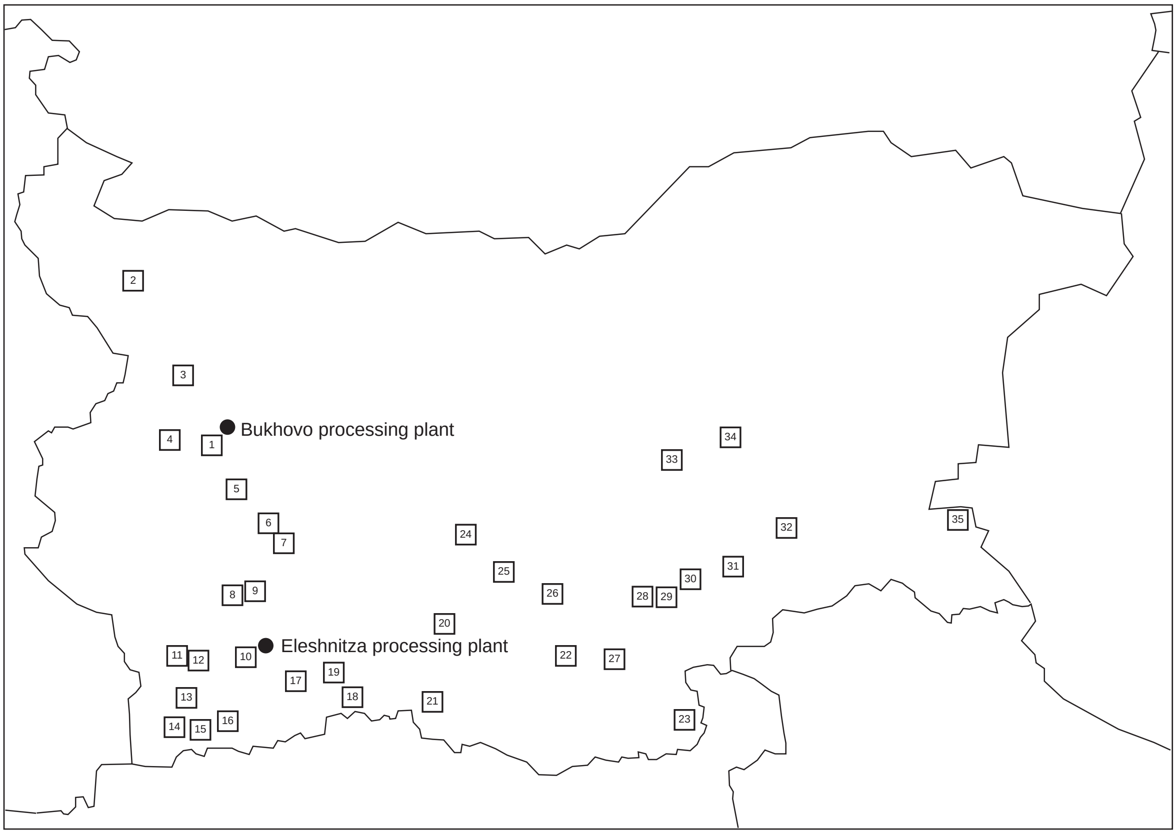
INTRODUCTION

Bulgaria has a long history of uranium related activities including exploration and production. Uranium production started in 1946 and continued to 1994 using both conventional and leaching technology. All activities took place under a government programme. All production ended in 1994 following a government decision to close the uranium production industry. During the nearly 50 years of operation, 16 720 tU were produced. Details of uranium geology, resources and production are given in the 1993 and 1995 editions of this report.

During 1995 and 1996, neither exploration nor production took place in Bulgaria. No further production is planned as all production facilities have been closed and are being dismantled.

The current activities involve technical and biological reclamation (i.e. revegetation). Environmental monitoring is continuing during reclamation activities. No information is provided regarding the expenditures or workforce.

Uranium deposits in Bulgaria



1 Bukhovo
2 Smolianovtzi
3 Proboinitza
4 Kurilo
5 Gabra
6 Biala Voda
7 Kostenetz
8 Partisanska Poliana
9 Beli Iskar
10 Eleshnitza
11 Simitli
12 Senokos
13 Graved
14 Igralichte
15 Pripetchen-Deltchevo
16 Melnik
17 Beslet
18 Dospat
19 Selichte
20 Narretchen
21 Smolian
22 Sarnitza
23 Planinetz
24 Momino
25 Belosem
26 Pravoslaven
27 Haskovo
28 Maritsa
29 Navasen-Troian
30 Orlov Dol
31 Isgrev
32 Okop-Tenebo
33 Sborishte
34 Sliven
35 Rosen

HISTORY OF PRODUCTION CLOSURE

In 1992 the Government of the Republic of Bulgaria passed Ordinance Number 163 which decreed an end to uranium production activities and directed the liquidation of uranium production and processing sites. This Governmental Act was complemented and expanded in 1994 by Ordinance Number 56. It created rules and regulations for implementation of an overall programme of environmental restoration of the affected areas.

The Committee of Energy was made responsible for implementing the governmental decisions. Subsequently an Inter-institutional Experts Council of representatives of all organisations formerly involved in uranium production was formed. The Council includes the: Committee on the Use of Atomic Energy for Peaceful Purposes, Committee on Geology and Natural Resources, Committee on Forests, Ministry of Health Care, Ministry of Agriculture, Ministry of Finance and the Ministry of the Environment. The task of the Experts Council was to evaluate all identified sites and prepare a list of approved sites eligible for environmental restoration under the programme. The Council is also responsible for co-ordinating and directing all activities for liquidation of uranium production.

An additional Governmental Act is planned to determine the structure of the organisation responsible for these activities. The objective of this act is to improve the organisation and plan for payment required for implementing the remaining reclamation stages: technical and biological reclamation; decontamination, management and monitoring of waters.

Work conducted under this programme involved defining the environmental parameters of areas affected by uranium production. A total of 128 studies including radio-ecological and hydrological surveys were conducted by expert teams. The studies were conducted to define environmental problems and evaluate the feasibility of alternative proposals for liquidation. The stages of liquidation and restoration activities for all sites were divided into 5 activities: 1) technical liquidation; 2) technical reclamation; 3) biological reclamation; 4) decontamination of mine and flowing surface waters; and 5) monitoring.

By April 1995 technical liquidation had been approved for 61 uranium production sites. The plans called for the implementation of this work by September 1995 (with the exception of the two processing sites). By the end of March 1995, seventy per cent of the work had been implemented at a cost of 50 million Deutsche Marks (DM). This sum is considerable for the scale and economic situation of the country.

Of the sites remaining to be restored, the environmental problems are greatest in the town of Bukhovo, village of Eleshnitza, Plovdiv District, Haskovo District and Smolyan. Problems at these sites are associated with tailings ponds, contaminated ground water, mine waste dumps and lack of adequate monitoring systems.

ENVIRONMENTAL ASPECTS

The suspension of uranium production and the reclamation of the affected areas related to uranium mining activities resulted in the following tasks:

- Selection of a cost effective technology for treatment of mine and surface waters contaminated with radionuclides.
- Selection of an equipment for environmental monitoring of uranium production sites undergoing closure.
- Design and/or selection of cost effective methods for treating and restoration of tailings ponds and waste dumps associated with uranium production.

A table giving the status of uranium production sites in Bulgaria undergoing closure activities is given in the 1995 edition of this report.

• Canada •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Canada began in 1942, with the focus of activity traceable through several distinct phases from Great Bear Lake, Northwest Territories, to Beaverlodge, Saskatchewan, to Blind River/Elliot Lake, Ontario, and back to Saskatchewan's Athabasca Basin in the late 1960s. These latter two areas have been Canada's most prolific, supporting all domestic uranium production until the closure of the Stanleigh mine at the end of June 1996. With this closure, bringing to an end over 40 years of uranium production in the Elliot Lake area of Ontario, Saskatchewan became Canada’s sole producer of uranium.

Recent and Ongoing Activities

As in previous years, uranium exploration remains concentrated in areas favourable for the occurrence of deposits associated with Proterozoic unconformities, most notably in the Athabasca Basin of Saskatchewan, but also in the Thelon Basin of the Northwest Territories.

In Canada, the number of companies with major exploration programmes has declined. However, more than half of the 70 uranium projects maintained in good standing in 1996-1997 were actively explored. As in recent years, exploration expenditures were highest at the advanced uranium projects. While expenditures of C$ 39 million were reported, a significant portion of this total is attributable to various activities, including care-and-maintenance, at projects awaiting production approvals. Basic "grass-roots" uranium exploration is therefore likely to be in the order of C$ 20 million for Canada during the 1996/97 field season; Saskatchewan reported C$ 17 million for the 1996-1997 field season compared with C$ 12.5 million for 1995-1996.

Combined exploration and surface development drilling in 1995 and 1996 approached 75 000 metres and 80 000 metres, respectively, well over 90 per cent of which occurred in Saskatchewan. In 1997, total combined uranium drilling could exceed 100 000 metres.

The top five operators, accounting for virtually all of the C$ 39 million expended are: Cameco Corporation, Cigar Lake Mining Corporation, Cogema Resources Inc., PNC Exploration (Canada) Co. Ltd, and Uranerz Exploration and Mining Limited. (Note: expenditures by Cogema include those of Urangesellschaft Canada Limited).

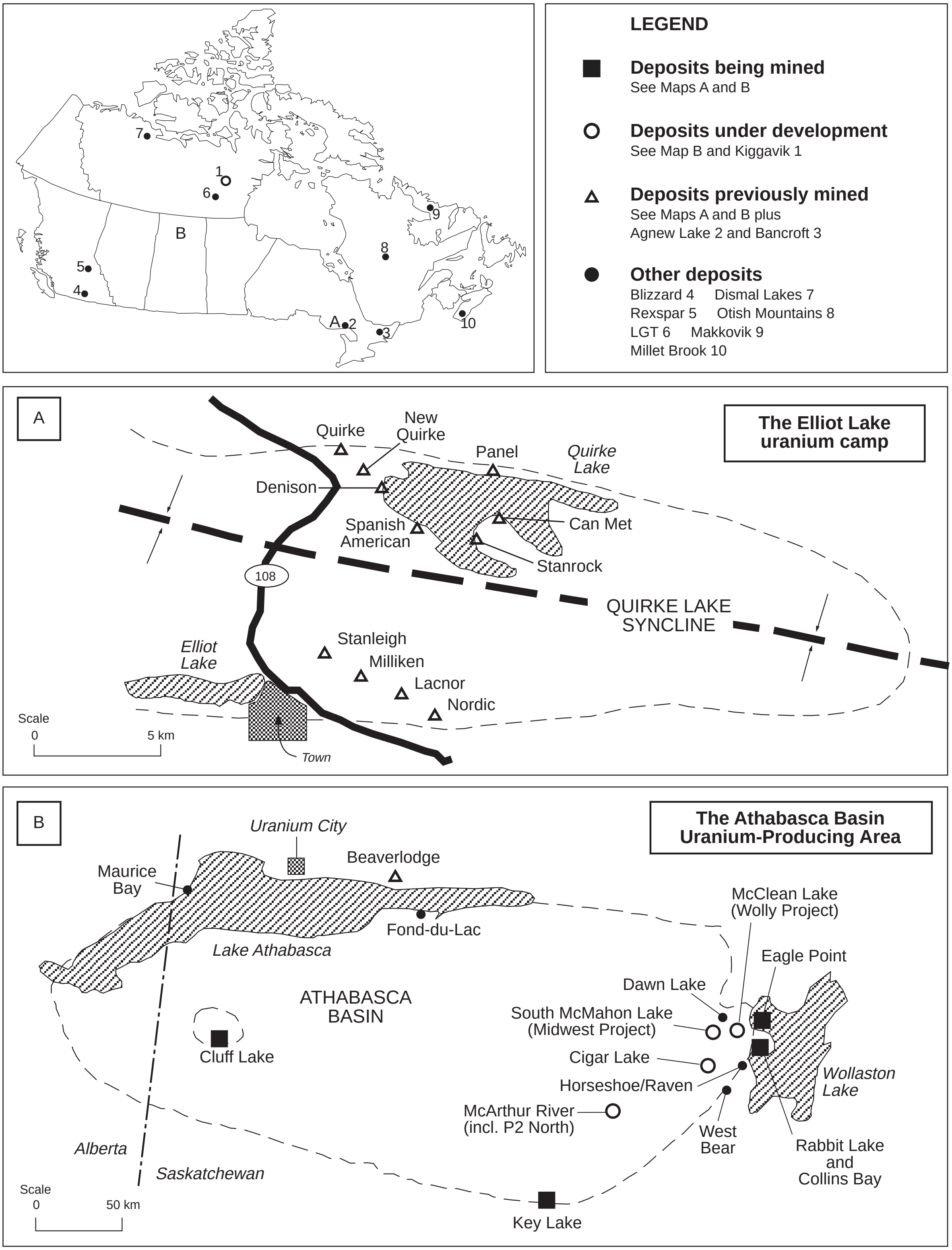
Uranium exploration continues in essentially the same areas as in the recent past, with geophysical and geochemical surveys and surface drilling focused on the extensions of mineralised zones, and on deeper targets in frontier areas of Saskatchewan's Athabasca Basin. Similarly, in the Northwest Territories, exploration was carried out on the Kiggavik Trend and along the western edge and north-eastern portion of the Thelon Basin. Geological research and grass-roots exploration continues in the Great Bear Magmatic Zone, NWT, and in the western Athabasca Basin, Alberta.

URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT – DOMESTIC

	1994	1995	1996	1997 (Expected)
Industry Expenditures Millions of current C$	36	44	39*	NA
Government Expenditures Millions of current C$	<0.1	<0.1	<0.1	<0.1
TOTAL EXPENDITURES Millions of current C$	36	44	39	NA
US$ 1000	26 087	32 353	28 467	NA
Industry Surface Drilling in Metres	68 000	75 000	79 000	100 000
Number of Industry Holes Drilled	NA	NA	NA	NA
Government Surface Drilling in Metres	NIL	NIL	NIL	NIL
Number of Government Holes Drilled	NIL	NIL	NIL	NIL
TOTAL SURFACE DRILLING (Metres)	68 000	75 000	79 000	100 000
TOTAL HOLES DRILLED	NA	NA	NA	NA

* *Note*: Much of this total relates to "care-and-maintenance" costs at projects awaiting production approvals.

Uranium deposits in Canada



Source: Uranium and Radioactive Waste Division, NRCan.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Estimates of Canada's “known” domestic uranium resources as of 1 January 1997, recoverable at costs of C$130/kgU or less, decreased to about 430 000 tU compared with the 490 000 tU assessed as of 1 January 1996. The decrease relates primarily to the loss of resources resulting from the closure of Rio Algom Limited’s *Stanleigh* mine, and the increase in overall uranium production in 1996.

The bulk of Canada's “known” uranium resources occur in Proterozoic unconformity-related deposits of the Athabasca Basin, Saskatchewan, and the Thelon Basin, Northwest Territories. These deposits host their mineralization at the unconformity boundary, or above and/or below it, in either monometallic or polymetallic mineral assemblages. Pitchblende prevails in the monomineralic deposits, whereas uranium-nickel-cobalt assemblages prevail in the polymetallic assemblages. The average grade varies from less than 1 per cent uranium to those grading between 2 per cent and 5 per cent uranium, although parts of some deposits exceed 10 per cent uranium. Until the closure of the *Stanleigh* mine, almost all the remaining “known” uranium resources occurred in Proterozoic quartz-pebble conglomerate deposits of the Elliot Lake area which host their mineralization at the base of the Huronian Supergroup in several beds (reefs) containing ores grading on average between 0.05 per cent and 0.1 per cent uranium.

None of the uranium resources referred to or quantified herein are associated with co-product or by-product output of any other mineral of economic importance.

Undiscovered Conventional Resources (EAR-II & SR)

The 1 January 1997 assessment did not result in any change to EAR-II and SR tonnages reported as of 1 January 1996. Areas favourable for the discovery of uranium resources continue to be examined in the Athabasca Basin, Saskatchewan, and in the Thelon Basin, Northwest Territories, where deposits associated with Proterozoic unconformities are most likely to occur. Continued work has led to positive results in the eastern Athabasca Basin, and along the Kiggavik trend in the Northwest Territories, where discoveries have been made in areas with previously estimated prognosticated (EAR-II) resources.

URANIUM PRODUCTION

Historical Review

Canada's uranium industry began in the Northwest Territories with the 1930 discovery of the Port Radium pitchblende deposit. Exploited for radium from 1933 to 1940, the deposit was re-opened in 1942 in response to demand for uranium for British and US defence programmes. A ban on private exploration and development was lifted in 1947, and by the late 1950s some twenty uranium production centres had started up in five producing districts. Production peaked in 1959 at 12 200 tU. No further defence contracts were signed after 1959 and production began to decline. Despite government stockpiling programmes, output fell rapidly to less than 3 000 tU in 1966, by which time only four producers remained. While the first commercial sales to electric utilities were signed in 1966, it was not until the mid-1970s that prices and demand had increased sufficiently to promote expansions in exploration and development activity. By the late 1970s, with the industry firmly re-established, several new facilities were under development. Annual output grew steadily throughout the 1980s, as Canada's focus of uranium production shifted increasingly from east to west. In the early 1990s, the poor markets and low prices led to the closure of three of four Ontario production centres. The last remaining Ontario uranium production centre closed in mid 1996.

HISTORICAL URANIUM PRODUCTION*

(Tonnes U)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	Expected 1997
Conventional Mining						
• Open pit	NA	6 514e	5 816e	6 528e	NA	NA
• Underground	NA	3 133e	4 657e	5 178e	NA	NA
TOTAL	266 847	9 647	10 473	11 706	298 673	12 000

* Primary output. In 1996, an additional 48 tU was recovered at Elliot Lake from Cameco’s refinery/conversion facility by-products; about 55 tU was recovered in 1995, and some 53 tU in 1994.

(e) Estimated split between open pit and underground.

Status of Production Capability

Overview

Production capability from Canada's existing operations declined in the early 1990s, with the closure of several Elliot Lake facilities. However, increased output in Saskatchewan through the mid-1990s, particularly at the Rabbit Lake and Cluff Lake operations, returned Canadian uranium production capability to the levels of the late 1980s. The renewal in March 1996 of the Cluff Lake operating licence by the Atomic Energy Control Board (AECB), which authorised an increase in annual production from 1 500 tU to 2 020 tU, offset the impact of closing the Stanleigh operation in June 1996. Canadian uranium output remains below full capability, as producers continue to avoid selling on the spot market and gear output to their existing contract commitments, but the recent increase in spot prices could bring Canada’s production closer to full capability, which is presently in excess of 12 000 tU.

Ontario

Production levels were maintained until June 1996 at the Stanleigh operation of Rio Algom Limited under its contract with Ontario Hydro. Production from the Stanleigh operation in 1996 exceeded 400 tU, including the tonnage recovered from Cameco's refinery/conversion by-products; this is well below the 700 tU produced in 1995, which included 55 tU recovered from by-products. The closure of Stanleigh winds up 40 years of uranium production in Canada for the company, and likely brings to an end the exploitation of the relatively low-grade, deep underground, quartz-pebble conglomerate uranium deposits in Canada.

Saskatchewan

The Key Lake production facility which exploits the higher-grade, unconformity-related type uranium deposits by open pit mining, is operated by Cameco in partnership with Uranerz. Late in 1995, Cameco announced that when the McArthur River ore begins being processed, the mill would be operated at an annual rate of 6 900 tU. Key Lake production in 1996 exceeded 5 400 tU, down from the 1995 level of 5 464 tU, and below licensed annual capacity. By increasing feed volumes and blending in lower grade ore, Key Lake can produce through 1998 relying on stockpiled Deilmann ore. Given the necessary environmental and regulatory approvals in 1997 to come on stream in 1999, the McArthur River project will provide sufficient ore to double the useful life of the Key Lake processing facility. (See *Environmental Considerations* below for further information on the environmental panels reviewing the new uranium mining proposals in Saskatchewan).

The Rabbit Lake production facility, also operated by Cameco in partnership with Uranerz, exploits higher-grade, unconformity-related type uranium deposits by open pit and underground methods. In June 1995, the AECB amended the Rabbit Lake operating licence to permit construction of a steel-cell cofferdam into Collins Bay to isolate the A-zone orebody from Collins Bay. Early in 1996, the Collins Bay "D" zone was mined, and construction of the Collins Bay "A" zone dike was completed, in preparation for mining in the winter of 1996-1997. Ore from Collins Bay "A" and "D" zones is sufficient to provide feed to the mill for about two years. Together with ore from the Eagle Point mine, the mill can operate beyond the year 2000. The Rabbit Lake mill produced in excess of 3 900 tU in 1996, up sharply from the 3 148 tU produced in 1995, but below licensed capacity. On 24 October 1996, the AECB announced the renewal of the Rabbit Lake operating licence for a 2-year period ending 31 October 1998. The new licence permits an increase in the annual mine production limit from 5 400 to 6 500 tU, should market conditions warrant bringing output well beyond current levels later in the decade.

The Cluff Lake uranium-production facility, owned by Cogema Resources Inc. and located in the western Athabasca Basin, also exploits higher-grade, unconformity-related type uranium deposits by open pit and underground methods. Late in 1995, the mill began operating at full capacity, having previously alternated operations on a weekly basis. On 8 March 1996, the AECB renewed the Cluff Lake operating licence, authorising an increase in the annual production limit from 1 500 to 2 020 tU. The Dominique-Janine (DJ) Extension open pit reached a depth of 50 metres in September 1996, and is scheduled to be mined out in 1997. While known reserves at the Dominique-Peter (DP) underground mine could be depleted in the 1990s, overall resources in other parts of the mineralised structure, including the DJ underground mine and the newly established areas at West DJ, will permit operations to continue until around the year 2005. Production from the Cluff Lake facility exceeded 1 900 tU in 1996, well above the 1 214 tU produced in 1995.

The McClean Lake uranium-production facility being developed on the eastern margin of the Athabasca Basin, is majority-owned and operated by Cogema Resources Inc. Since financing was finalised in March 1995, site construction at the C$ 250 million project has proceeded rapidly. However, the scheduled production start-up on 1 July 1997, has been postponed to early in 1998. By late 1996, project construction was half completed, with the on-site power system, permanent camp, mill office and warehouse, water treatment plant and dewatering wells at the JEB deposit in place. By year-end, the mill building, ore receiving and grinding facilities, and remainder of processing plant were either in place or well advanced. Mining out of the JEB open pit was scheduled for the first quarter of 1997, in preparation for its use as a tailings management facility.

When the last ore from the JEB and Sue open pit deposits is processed through the McClean mill around 2003, milling of the underground Midwest ore will begin. If approved, milling of the Cigar Lake ore would begin, perhaps in 1999 or 2000, followed by ore from the McClean underground mine around 2009. The throughput capacity of the McClean mill will be expanded to handle the Cigar Lake ore, increasing annual production capability fourfold from 2 300 to 9 200 tU. The McClean project is owned 70 per cent by Cogema, 22.5 per cent by Denison Mines Limited and 7.5 per cent by OURD (Canada) Co., Ltd, a subsidiary of Overseas Uranium Resources Development Corporation (OURD) of Japan.

Ownership Structure of the Uranium Industry

The governments of both Saskatchewan and Canada have continued with their plans toward the full privatisation of Cameco Corporation. Share offerings in 1993, 1994 and 1995 significantly reduced government ownership in Cameco. By 9 February 1995, federal ownership in Cameco had ceased. On 26 February 1996, Cameco announced that its major shareholder, Crown Investments Corporation of Saskatchewan (CICS), would offer 9.5 million common shares of Cameco in Canada, the United States and internationally, with an option to purchase up to one million “over-allotment” shares. These shares were quickly purchased at C$ 75.50 each, netting the Saskatchewan government some C$ 580 million. On 24 April 1996, Cameco announced that 620 500 “over-allotment” shares had been sold. With the divestiture of the aggregate 10,120,500 shares by CICS, the public holds 89.7 per cent of Cameco’s common shares, while the provincial government through CICS holds the remaining 10.3 per cent.

On 20 August 1997, Cameco announced the sale of 4 million common shares for C$ 51 each; the successful completion of this share offering was announced on 4 September 1997.

Employment in the Uranium Industry

The mid-1996 closure of the last uranium mining operation at Elliot Lake, Ontario, reduced direct employment in Canada's uranium industry. However, this decline was partly offset by counting employment at the McClean Lake project in Saskatchewan. As a result, year-end 1996 direct employment at Canadian uranium operations was about 1 155 workers. Over the next few years, the start-up of the new high-grade operations in Saskatchewan should mean that direct employment in Canada’s uranium industry again exceeds 1 300 workers.

Future Production Centres

In 1991, six uranium mining projects in Saskatchewan were referred for environmental review, namely the Dominique-Janine Extension at Cluff Lake, the McClean Lake project, the Midwest Joint Venture project, the Cigar Lake project, the McArthur River project, and the Eagle Point/Collins Bay Expansion at Rabbit Lake. As noted above, only the McClean/Midwest Joint Venture project is being developed as a single new production centre. The remaining projects will simply extend the lives of the existing or committed production centres. Cigar Lake will provide feed to the new McClean Lake mill and McArthur River will extend the life of the Key Lake operation. Beyond these Saskatchewan projects, Kiggavik in the Northwest Territories is the only other project currently envisaged as an additional production centre in Canada, but it is unlikely to proceed until after the turn of the century. The start-up dates of any of these new projects are contingent on the receipt of the necessary regulatory/environmental approvals and licences, on developments in the international uranium market, and on economic decisions made by the project owners.

Exploitation of the Midwest deposit will be integrated with development of the McClean and Cigar Lake orebodies. In situ resources at the Midwest property are estimated to contain 13 000 tU, at an average grade of 3.8 per cent U. The Midwest Joint Venture project is owned 56 per cent by Cogema, 19.5 per cent by Denison, 20 per cent by Uranerz, and 4.5 per cent by OURD (Canada). (See *Environmental Considerations* below for further information on the environmental panels reviewing the planned uranium mining proposals in Saskatchewan).

At Cigar Lake, Saskatchewan, test mining of high-grade ore was proven successfully and the deposit has been maintained on a care-and-maintenance basis while the Environmental Impact Statement (EIS) was prepared. The project is jointly held 48.75 per cent by Cameco, 36.375 per cent by Cogema, 12.875 per cent by Idemitsu Uranium Exploration Canada Ltd., and 2 per cent (non-voting) by Korea Electric Power Corporation. In mid-1997, the Tokyo Electric Power Co., Japan's largest nuclear power utility, acquired a 5 per cent interest in Cigar Lake from Idemitsu Kosan. In situ resources are estimated at 148 000 tU averaging 7.7 per cent U. Initial testing of the orebody after being frozen permitted a boxhole-boring machine to remotely extract 53 tonnes of ore grading almost 15 per cent U, and a newly developed jet-boring method, which uses high-pressure water jets, effectively excavated more than 100 tonnes of ore grading over 13 per cent U.

At McArthur River, Saskatchewan, exploration and ore reserve definition continued in 1995 to permit completion of an EIS so that the public environmental review process could begin. Timely receipt of the necessary approvals will enable site construction to be completed in time for uninterrupted milling of McArthur ore at Key Lake (see above). The ownership share at the production stage will be: 56.435 per cent Cameco, 27.331 per cent Uranerz, 16.234 per cent Cogema. In 1995, resources at the McArthur River property were increased from 100 000 tU averaging 4.2 per cent U, to 160 000 tU, averaging 12.7 per cent U, and mineable reserves totalled 73 000 tU, grading 16 per cent U.

The Kiggavik uranium project is located west of Baker Lake in the Northwest Territories. Until early 1997, the project was held 79 per cent by Urangesellschaft Canada Limited – an operating subsidiary of Cogema, 20 per cent by CEGB Exploration (Canada) Ltd., and 1 per cent by Daewoo Corporation of South Korea. In 1990, an environmental review identified several deficiencies in the

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

	Centre # 1	Centre # 2	Centre # 3
Name of Production Centre	Key Lake	Rabbit Lake	Cluff Lake
Production Centre Class	Existing	Existing	Existing
Operational Status	Operating	Operating	Operating
Start-up Date	1983	1976	1980
Source of Ore • Deposit Names Deposit Types	 Gaertner & Deilmann Unconformity	 Rabbit Lake & Collins Bay & Eagle Point Unconformity	 Dominique-Peter/Janine Unconformity
Mining Operation: • Type (OP/UG/In situ) • Size (tonnes ore/day) • Average Mining Recovery (%)	 Open pit NA 90 estimated	 Open pit & underground NA 90 estimated	 Open pit & underground NA 85 estimated
Processing Plant: • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Recovery (%)	 AL2-SX 800 98	 AL-SX 2 500 97	 AL-SX 900 98
Nominal Production Capacity (tU/year)	5 400 (licensed - 5 700)	3 900 (licensed - 6 500)	1 900 (licensed - 2 020)
Plans for expansion	Relates to McArthur River	Relates to Eagle Point *et al*	Relates to D-J Extension
Other Remarks	McArthur River ore to feed mill	Eagle Point ore to feed mill	D-J Extension ore to feed mill

Note: Mill recovery data are for 1996.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

	Centre # 1A	Centre # 5	Centre # 6	Centre # 7
Name of Production Centre	McArthur River	Cigar Lake	McClean/ Midwest	Kiggavik
Production Centre Class	Planned	Planned	Committed (McClean) Planned (Midwest)	Planned
Operational Status	Public review in 1996; Joint Panel report early 1997	Undergoing public review by Joint Panel	McClean output in mid 1997 & Midwest reviewed	Feasibility Study Ongoing
Start-up Date	Late 1990s	Late 1990s	Mid 1997 & 2003	Early 2000s
Source of Ore • Deposit Names • Deposit Types	 P2N *et al*, Unconformity	 Cigar Lake, Unconformity	 Jeb, McClean, Sue, Midwest, Unconformity	 Kiggavik, Unconformity
Mining Operation • Type (OP/UG/In situ) • Size (tonnes ore/day) • Average Mining Recovery (%)	 Underground NA NA	 Underground NA NA	 Open pit and underground NA NA	 Open pit NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Ore Recovery (%)	Ore will be processed at Key Lake	Ore will be processed at McClean Lake	 NA NA NA	 NA NA NA
Nominal Production Capacity (tU/year)	6 900 (estimated)	4 600 (estimated)	2 300 (estimated)	1 200 (estimated)
Plans for expansion	Mill capacity to 6 900 tU/year	Unknown at this stage	McClean first; Midwest last	Unknown at this stage
Other Remarks	> 15 year mine life	> 20 year mine life	> 15 year mine life	>10 year mine life

EIS project, and the proponents, allowed more time to supply additional information, have been re-evaluating the project. It is not expected that Kiggavik will be brought on-stream during the 1990s. In late 1996, Cameco sought to diversify its resource base by agreeing to purchase the North American assets of British-government owned Magnox Electric plc, and in January 1997 successfully acquired Power Resources Inc's Gas Hills and Highland uranium projects in Wyoming, and CEGB's holdings in Saskatchewan and the Northwest Territories, including 20 per cent of Kiggavik. In June 1997, Cameco sold this 20 per cent interest to Cogema Resources Inc.

ENVIRONMENTAL CONSIDERATIONS

Saskatchewan Environmental Assessment and Review Panels

Background

In 1991, six uranium mining projects in Saskatchewan were referred pursuant to the federal *Environmental Assessment and Review Process (EARP) Guidelines Order*. A joint federal-provincial panel reported on three projects in October 1993, namely the Dominique-Janine Extension at Cluff Lake, the McClean Lake project, and the Midwest Joint Venture project. Federal and provincial governments responded to the recommendations of the Joint Panel in December 1993. Essentially, both governments stated that the Cluff Lake and McClean Lake projects should proceed, subject to the phased AECB licensing process, but that the Midwest project should *not* be approved as then designed. A second panel, representing only the federal government, reported on the Eagle Point/Collins Bay Expansion at Rabbit Lake in December 1993. The federal government responded to the recommendations of this federal-only panel in March 1994, also stating that this project should proceed subject to the AECB licensing process.

Update

In 1995, environmental impact statements for the Cigar Lake and McArthur River projects, and the revised Midwest Joint Venture project, were submitted for review. Additional information was provided in early 1996 in response to further requests. In April, the *Joint Federal-Provincial Environmental Assessment Panel on Uranium Mining Developments in Northern Saskatchewan* reconvened, and held its review of the redesigned Midwest project in May and June. Public hearings began for the Cigar Lake and McArthur River projects and were held through September and early October 1996. Panel review of these proposals determines their acceptability in terms of environmental, health, safety and socio-economic impacts. The hearings provide an opportunity for review participants to present their views and opinions on the acceptability of the proposals, by focusing on EIS data prepared by Cameco (McArthur River), Cogema (Midwest) and Cigar Lake Mining Corporation. In the two months of public hearings scheduled for these three projects, the Joint Panel heard from some 75 groups, agencies and government representatives.

On 26 August 1996, Cogema Resources Inc., operator of the McClean Lake project, informed the Joint Panel that it would change its tailings disposal plan for the JEB pit. The “pervious surround” disposal method had been approved for McClean Lake in 1993. However, use of the improved technologies of paste tailings and sub-aqueous deposition for the disposal of all tailings from the McClean Lake, Midwest and Cigar Lake projects would be better, provided the new technologies were approved. The time required to get approval for these new technologies led Cogema to put forward its new proposal. The McClean Lake tailings would be deposited using the approved pervious surround technology, followed by sub-aqueous deposition of paste tailings, if approved, from the Cigar Lake and Midwest projects.

As the proposed change would result in a new disposal scheme, for which the Joint Panel had no information, Cogema was asked to submit complete data describing the combination of pervious surround and sub-aqueous paste tailings management technologies, including data relevant for the Midwest project. The Joint Panel noted that until such information was received, released for appropriate public review and comment, and discussed at public hearings, it could not complete its Midwest project review. As Cigar Lake tailings would also be deposited in the JEB pit, the supplementary hearings scheduled for discussing Midwest tailings disposal would also address Cigar Lake tailings disposal.

On 31 October 1996, the proponents of the Cigar Lake and Midwest projects submitted documentation on the new tailings disposal plan, which the Panel released for a 30-day public review. However, after reviewing these data, the Panel announced that insufficient information had been provided to proceed with supplementary hearings, and that additional data was needed. The proponents supplied this additional information on 2 May 1997. The final public hearings were concluded during August 1997 and the Joint Panel should be able to submit its recommendations to governments on these two project reports before year-end. This should permit government responses to the Panel reports early in 1998.

By year end 1996, the Joint Panel had completed its review of the McArthur River project, and reported its recommendations to governments in late February 1997. The Joint Panel recommended that the project be permitted to proceed, subject to a number of conditions. Provincial and federal government responses to the Joint Panel’s McArthur River report were released on 5 May and 8 May 1997, respectively. Both governments agreed with the panel report that the McArthur River project be permitted to proceed to the licensing stage.

Decommissioning Elliot Lake Uranium Tailings

In June 1996, the *Elliot Lake Environmental Assessment Panel* submitted its recommendations to the federal Minister of the Environment, agreeing with the tailings decommissioning proposals of Rio Algom and Denison. Earlier in the year, the Panel had completed its review of the proponents’ plans to decommission their uranium mill tailings sites in the Elliot Lake, Ontario, area. The Panel’s recommendations are not expected to significantly change the estimated costs for closing and reclaiming the Quirke, Panel, Denison and Stanrock tailings facilities. The federal response was released in early April 1997, and indicated agreement with most of the Panel’s 29 recommendations.

Canada's New Policy Framework on Radioactive Waste

On 10 July 1996, the Government of Canada announced its *Policy Framework on Radioactive Waste*. Aimed at guiding Canada's approach for radioactive waste disposal into the next century, it lays out ground rules, defines the role of government, waste producers and owners. It recommends that the long-term management and disposal of nuclear fuel waste, low-level radioactive waste, and uranium mine wastes and mill tailings proceed in a safe, comprehensive, environmentally sound, cost-effective and integrated manner. It states that waste producers and owners are responsible, in accordance with the "polluter pays" principle, for the funding, organisation, management and operation of disposal and other facilities required for their wastes. This principle recognises that arrangements may be different for nuclear fuel waste, low-level radioactive waste, and uranium mine wastes and mill tailings.

STATISTICAL DATA ON URANIUM PRODUCTION

Long-Term Production Capability

There are no planned production centres beyond those described above, and no prospective centres have been identified that could be supported by known resources. Some of the new projects described above will extend the lives of the existing or planned production centres e.g., McArthur River, Dominique-Janine, Eagle Point and Midwest. Beyond the Kiggavik project, which is unlikely to proceed until after the turn of the century, no further uranium production centres are foreseen. Uranium production capability may approach 20 000 tU around the turn of the century, but it should return to around 15 000 tU shortly thereafter and could be maintained at about this level for many years.

Factors most likely to influence Long-Term Capability

The level of uranium production capability that could be in place during the next decade depends on a number of factors. The two principal considerations affecting the timing of any new capability will be the developments in the international uranium markets, and the lead-time required for the public environmental review process noted above. Given the requisite environmental and regulatory approvals, the decision to proceed to production will be an economic one, ultimately made by the proponents, as the investors in the projects, based on their perceptions of the uranium market and their success in their marketing efforts.

URANIUM REQUIREMENTS

At the start of 1997, 21 CANDU reactors with a combined generating capacity of about 14 700 megawatts electric (MWe) were in service in Canada. At the Bruce "A" Nuclear Generating Station (NGS), unit 2 was taken out of service on 8 October 1995, but remains in Ontario Hydro's generation plans as an option to meet demand beyond the year 2000. This and other recent events have reduced Canada's uranium requirements from some 1 900 tU/year to roughly 1 800 tU/year.

Supply and Procurement Strategy

For the first time in 1992, Ontario Hydro requested bids for uranium supply from producers in Australia, Namibia, the United States, as well as in Canada. In 1993, four producers were selected to supply 35 per cent of the utility's requirements from 1996 through 2002, three from Canada and one from abroad. Cameco, Uranerz, Cogema and Western Mining Corporation (Olympic Dam) each agreed to supply about 150 tU/year over the contract period. In late 1993, Ontario Hydro issued a second bid request, from the above noted sources, to supply 20 per cent of its requirements from 1997 to 2000. In 1994, the utility chose Energy Resources of Australia (Ranger), and Cameco to supply about 100 tU/year each, and Uranerz to supply about 75 tU/year, over the contract period. In June 1995, Ontario Hydro issued a third bid request, to supply 50 tU and/or 100 tU annually for the years 1997 to 1999. In addition to sourcing the uranium from Canada, Australia, the United States, Namibia or South Africa, the request gave consideration to proposals from joint ventures or a mixture of supply arrangements involving western and CIS suppliers, that is, 50 per cent from the above-named countries and 50 per cent from republics of the Former Soviet Union (FSU). In November 1995, in its first request for significant quantities in the spot market, Ontario Hydro asked for proposals on amounts varying between 38 tU and 230 tU, specifying that some 154 tU was to be delivered in January 1996, with additional quantities delivered in mid year. There were no limitations placed on the origin of the uranium, which may be purchased from one or more suppliers, but the origin must be specified. In all cases, the successful bidders must assure that their production operations are in compliance with all regulations, including environmental protection, and that the proposals submitted offer both a market-related price with a ceiling, and a base price with escalation.

NATIONAL POLICIES RELATING TO URANIUM

The most recent overall review of Canada's uranium export policy was completed in 1990. The review focused on the commercial components of the policy and resulted in a relaxation of several requirements in line with the government's commitment to freer trade (results reported in the 1991 Red Book). Since then, there have been changes relating to the policy's further processing and pricing requirements (results reported in the 1995 Red Book).

In March 1993, Canada formalised an agreement with the United States whereby Canadian uranium can be exported for use in Chinese Taipei nuclear reactors for the generation of electricity. Such uranium must be transferred from Canada to the United States for enrichment and fabrication into nuclear fuel elements in the United States prior to retransfer to Chinese Taipei. The arrangements put in place by this agreement satisfy the objectives of Canada's nuclear non-proliferation policy.

In January 1995, the new Canadian Environmental Assessment Act (CEAA) was proclaimed by Order in Council, complementing the earlier creation of the Canadian Environmental Assessment Agency. All projects subject to federal environmental assessment will henceforth be reviewed under the Canadian Environmental Assessment Process (CEAP), formerly known as EARP. The establishment of this new agency and the proclamation of the new act will not affect the review of uranium projects in Saskatchewan, as the review of the six uranium mining projects was initiated, and will be completed, under EARP.

On 21 March 1996, Bill C-23, *The Nuclear Safety and Control Act (NSCA)*, was introduced in the House of Commons. While the existing *Atomic Energy Control Act (AECA)* encompasses both the regulatory and developmental aspects of nuclear activities, the new legislation will repeal portions of the *AECA* that established and governed the operation of the Atomic Energy Control Board, and will establish in its place the Canadian Nuclear Safety Commission (CNSC). The new legislation will change the remaining portions of the *AECA* to the *Nuclear Energy Act*, which will continue to govern the developmental aspects of nuclear power, including the operation of Atomic Energy of Canada Limited (AECL), the federal nuclear research, development and marketing organisation. In disconnecting the two functions, the new act will provide a distinct identity to the new CNSC, while underlining its separate role from that of AECL. This should provide for more explicit and effective regulation of nuclear energy in Canada. On 20 March 1997, Royal Assent was granted to the *Nuclear Safety and Control Act*.

URANIUM STOCKS

The Canadian government does not maintain any stocks of natural uranium and data are not available for producers and utilities. Since Canada has no enrichment or reprocessing facilities, there are no stocks of enriched or reprocessed material in Canada.

Although Canadian reactors use natural uranium fuel, small amounts of enriched uranium are used for experimental purposes and in booster rods in certain CANDU reactors. Small amounts of depleted uranium are occasionally imported into Canada for custom fabrication of depleted metal castings by Cameco.

There have been no significant changes to utility stockpiling practices since those reported in the 1989 Red Book.

URANIUM PRICES

Uranium Export Price* Statistics

	1990	1991	1992	1993	1994	1995	1996
Average Price C$/kgU	C$ 71	C$ 61	C$ 59	C$ 50	C$ 51	C$ 47	C$ 53.60
Average Exchange Rate	1.1668	1.1458	1.2083	1.2898	1.366	1.373	1.364
Average Price USC$/lb U_3O_8	C$ 24	C$ 21	C$ 19	C$ 15	C$ 14	C$ 13	C$ 15.10
Percentage Spot Deliveries	<1%	<2%	<1%	<1%	<1%	2%	1%

* Average Price of All Deliveries under Export Contract.

Note: Only 1996 prices are available in two decimal accuracy.

• Chile •

URANIUM EXPLORATION

Historical Review

Uranium exploration activities in Chile started in the early 1950s. Over the next few years the US Atomic Energy Commission, working in co-operation with several Chilean state organisations, discovered uranium mineralization associated with hydrothermal and high temperature vein-type copper deposits, copper-molybdenum tourmaline breccia pipes, as well as pegmatitic dykes.

Little follow-up work was done until 1974, when a longterm uranium exploration programme was started. The project was carried out by the Chilean Nuclear Energy Commission (CChEN) with support of UNDP/IAEA. Funding and technical assistance, as well as field and laboratory equipment were supplied by UNDP. Several aerial and carborne radiometric surveys, as well as geochemical sampling programmes were completed. These activities together with similar work by private companies, resulted in the confirmation of uranium mineralization in several geologic environments. They include vein, intrusive breccia pipe, contact metamorphic and surficial-type deposits, as well as others associated with radiometric anomalies.

In 1983, the planned Chilean nuclear power programme was postponed until 2000. The deferral together with the weak uranium market have resulted in budget reductions and CChEN staff cuts.

In the latter years of the 1980s and the beginning of the 1990s CChEN was investigating the uranium potential of certain geological environments. They included areas affected by Permotriassic magmatism and upper Cretaceous acid to intermediate volcanism, as well as depressions filled with evaporitic sediments of upper Cenozoic age.

Recent and Ongoing Activities

The Government policy for meeting national energy requirements does not consider the possibility of introducing nuclear energy before sometime in the next century. However, the possibility of using nuclear energy for the desalination of sea water is being discussed. Based on this very modest scenario for a nuclear development programme, the activities of the Geology and Mining Section of the CChEN were reduced to a minimum.

Despite the budget and staff limitations, the Geology and Mining Section continues some research activities. To maximise efforts, co-operation agreements were concluded with other Governmental Institutions and universities.

Recently the project involving the stratigraphy and regional uranium reconnaissance within a belt associated with the metallogenetic iron province has been completed. This study covers the coastal area between the towns Chanaral (North) and Ovalle (South) measuring 820 km (North-South) by 50 km (East-West). It resulted in the identification of a number of radiometric anomalies, as well as the zonal relationship of the Fe-, Cu-, Au-, U-, and Th-mineralization. Rare earth element (REE) occurrences were also discovered.

Based on the association between U-Th and REE, a joint project between CChEN and the National Mining Corporation, ENAMI, is being carried out to investigate the presence of REE in the Coastal Cordillera in the III Region, Atacama.

In addition a research project is being developed. It will search for new sources of both radioactive minerals and other minerals of nuclear interest; develop deposit models and continue to periodically assess the U-Th-potential of the country.

URANIUM EXPLORATION EXPENDITURES

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
CLP (x 1000)	39 751	81 621	58 057	65 379
US$ (x 1000)	93.53	217.66	143.35	155.66

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Chile reports known conventional resources totalling 296 tU without cost category. This includes 60 tU RAR in the Salar Grande surficial (28 tU) and in the Estación Romero vein-type (32 tU) occurrences, as well as 366 tU EAR-I in the Estación Romero and Pejerreyes occurrences.

Undiscovered Conventional Resources (EAR-II & SR)

Undiscovered conventional resources are estimated to total 758 tU as EAR-II with no assigned cost category. The majority of these resources (630 tU) occur in the Estación Romero and Los Mantos-El Durazno vein-type occurrences. The remaining 128 tU are located in the surficial-type occurrences at Salar Grande (100 tU), Pampa Camerones (4 tU) and Quillagua-Qda. Amarga (24 tU).

URANIUM REQUIREMENTS

According to the national energy plan, the construction of a nuclear power reactor may not be required in the short term. Private industry, however, is considering the construction of a nuclear power plant to generate electricity which could be used for the desalinisation of sea water.

CChEN has considered the purchase of enriched uranium in the form of UF_6, as part of its fuel fabrication project for the La Reina research reactor.

NATIONAL POLICIES RELATING TO URANIUM

As provided for in Law No. 16.319, the CChEN has the mandate to advise the Supreme Government in all matters related to the peaceful use of nuclear energy. It is also responsible for developing, proposing and executing the national plans for research, development, utilisation and control of all aspects of nuclear energy.

• China •

URANIUM EXPLORATION

Historical Review

Uranium prospecting and exploration began in China in 1955. The 40 years since then can be divided into four stages. The main work of the early stage (1955 until 1960s) included organising prospecting teams, keeping abreast of prospecting techniques and carrying out overall uranium prospecting in China. During the 1960s the prospecting achievements were expanded by studying and gaining a better understanding of uranium metallogenesis. During the 1970s, comprehensive geophysical and geochemical prospecting methods were widely used for locating unexposed uranium deposits. Since the 1980s, research on the regional geological setting has been strengthened to search for new types of uranium deposits including large and high grade and more economical deposits.

The Bureau of Geology (BOG) of China National Nuclear Corporation (CNNC) is responsible for the administration of uranium prospecting and exploration in China. It has the following government functions: registering the prospecting and exploration of radioactive mineral resources, collecting and delivering prospecting and exploration materials and data, and approving reserves. Six regional administrative agencies of the Bureau of Geology have been established: the East China Geological Bureau (Nanchang), the Central-South China Geological Bureau (Changsha), the Northwest China Geological Bureau (Xi'an), the Northeast China Geological Bureau (Shenyang), the South China Geological Bureau (Shaoguan), and the Southwest China Geological Bureau (Guanghan). Under the supervision of BOG there are 52 geological teams, 1 airborne survey and remote sensing centre, 8 research institutes, 1 college, 3 technical schools, 6 training centres for technical workers, 1 engineering exploration institute, 8 manufacturing facilities and 3 hospitals. The total staff is 45 000 including 14 000 technicians.

Exploration activities completed in the last 40 years include: 3 000 000 km^2 of surface radioactive surveys, 2 500 000 km^2 of airborne radioactive surveys, 30 000 000 metres of drilling and tunnelling. This work resulted in the recognition of 12 uranium metallogenic belts and 8 prospective uranium regions.

Following the development of the international uranium market, BOG in 1990 has shifted its exploration strategy from the granitic, carbonaceous-siliceous-pelitic and volcanic deposit targets located mainly in North China to sandstone-type deposits amenable to in situ leaching techniques in South China.

The main uranium prospecting and exploration methods used are: surface and airborne gamma spectrometric surveys, radon surveys, radioactive hydrochemical surveys, structure-geophysical exploration methods, isotope-geological methods, remote sensing, mathematical geology and undiscovered resource prediction and assessment.

Recent and Ongoing Activities

Uranium exploration continues to be directed at the discovery of sandstone-type deposits. The majority of projects are carried out in the Xinjiang and the Inner Mongolian Autonomous Regions. Only a few projects are undertaken in the Northeast and Southwest of China.

Up to recently, ISL amenable sandstone-type occurrences have been found in the Yili Basin, Xinjiang. Two occurrences are being investigated at various stages. At present, most exploration projects consist of geological and geophysical surveys aimed at the assessment of favourable areas or basins both in Xinjiang and Inner Mongolia. In 1997, a total of 75 exploration projects are being implemented by the Bureau of Geology, most of which are located in the two regions.

The concentration of China's exploration efforts on sandstone-type deposits has led to a substantial reduction in exploration for other deposit types in South China. The few projects still under way in granitic and volcanic terrains are directed at either the regional evaluation of the uranium potential or on leaching experiments with hard rock uranium ores.

In addition to the exploration projects BOG is undertaking on its own, there are two joint venture projects being carried out in co-operation with Japanese organisations. One of these projects is concerned with the exploration for unconformity related deposits in the eastern part of the Liaoning Province, and the second one includes the establishment of an exploration model for volcanic deposit types. Both joint venture projects will terminate in 1998.

Detailed information on uranium exploration expenditures and drilling activities is not provided. However, it is stated that in view of the expected rapid increase of uranium requirements, uranium exploration activities have been increased in recent years, both in terms of expenditures incurred and meters drilled.

URANIUM RESOURCES

The known uranium reserves are divided into the following types, according to the host rock lithology:

Host Rock	Share of Total Reserves (%)
Granite type	38.11
Sandstone type	21.34
Volcanic type	19.51
Carboneous-siliceous-pelitic rock type	16.40
Migmatic, pegmatitic type	3.05
Quartzite type	0.61
Alkaline rock type	0.61
Phosphate type	0.31

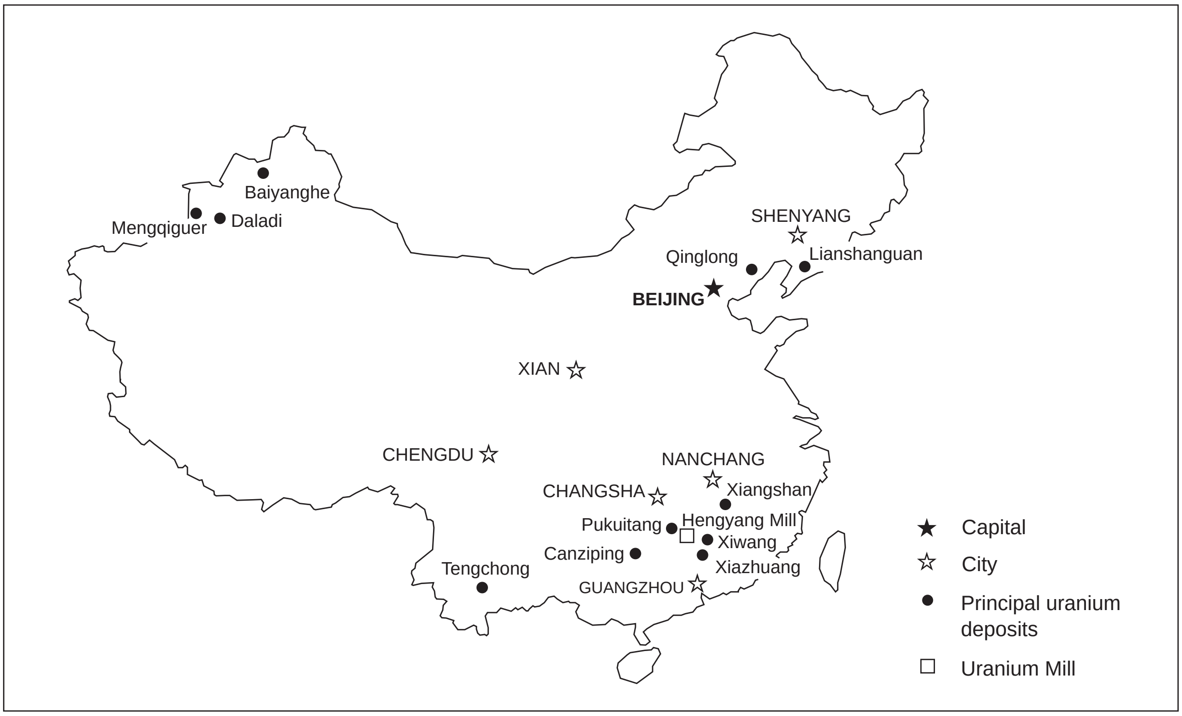
The known granite-type uranium deposits are mainly located in the Guidong granite massif, Guangdong Province, Zhuguanshan granite massif in South China, Taoshan granite massif, Jiangxi Province and Jiling Caledonian granite massif in Northwest China. The discovered volcanic-type uranium deposits are primarily distributed in Xiangshan, Jiangxi Province; Xiaoqiuvuan, Zhejiang Province; Baiyanghe, Xinjiang Autonomous Region, and at the northern margin of the North China Platform. Sandstone-type uranium deposits predominantly occur in Yili Basin, Xinjiang Autonomous Region; Hengyang Basin, Hunan Province; Xunwu, Jiangxi Province; Jianchang, Liaoning Province and the western part of Yunnan Province. Carbonaceous-siliceous-pelitic rock-type uranium deposits are mainly situated in Huangcai, Laowolong, Central-South China; Canziping, Guangxi Province; and Ruoergai at the boundary between Sichuan and Gansu Provinces.

There are a total of 64 000 tU known resources in China as reported for the previous Red Book. The resources are in situ and are not classified by-production cost.

These known uranium resources in some of the uranium deposits or fields in China are:

1.	Xiangshan uranium field in Jiangxi Province	26 000 t
2.	Xiazhuang uranium field in Guandong Province	12 000 t
3.	Qinglong uranium field in Liaoning Province	8 000 t
4.	Canziping uranium deposit in Guanxi Province	5 000 t
5.	Cengxian uranium deposit in Hunan Province	5 000 t
6.	Tengchong uranium deposit in Yunnan Province	6 000 t
7.	Lantian uranium deposit in Shanxi Province	2 000 t
TOTAL		64 000 t

Principal uranium deposits in China



Active exploration areas in China

URANIUM PRODUCTION

Historical Review

In recent years China has made many changes in its uranium production industry and supporting activities. In addition to continuing technical progress, a series of adjustments and refinements were made over the last decade to better meet market economy requirements. These include reducing uranium production and closing uranium mines and mills with comparatively high production costs. The remaining producers are required to define proper uranium grade cut-offs and reduce ore dilution, while reducing manpower and cutting consumption of materials, supplies and energy.

China also expanded the mandate of the uranium production industry to non-uranium products and techniques, including titanium pigment, magnesium metal, rare earth elements and phosphorus.

Special attention has been placed on improving both technology and management with the objective of increasing China's competitive position by reducing uranium production costs*. Cost reducing technologic improvements include implementation of trackless mining and the development and use of radiometric sorting equipment for ores from conventional mining. The use of leaching has been expanded including underground leaching following blasting, as well as implementation of heap and in situ leach (ISL) technologies. Heap leaching using concentrated acid curing and ferric sulphate trickle is being used in production.

The application of trackless mining, started in the 1980s in the Quzhou uranium mine, is also planned for the Renhua and Benxi mines. Use of this technology has increased the amount of ore produced by 2 to over 4 times, while reducing required staff by 40 to 60 per cent. Ore loss and dilution has decreased and the operating cost has been reduced by 15 to 40 per cent.

Radiometric sorting is used with annual production of up to 150 000 t ore. The technology was first introduced at the Fuzhou mine in the 1980s.

In-place leaching after blasting was put into production at the Lantian mine in 1990. The orebody Number 30 had a geological reserve of 7 160 tU at an average grade of 0.171 per cent. The ore occurred in a technoclastic zone consisting of fractured granite with an average thickness of 6.6 metres. The top of the orebody was near the ground surface and the hydrogeological conditions were simple. Leaching solution was injected at the top and collected at the bottom of the orebody. Recovery was over 83 per cent.

China is placing emphasis on ISL mining in its future planning. The Research Institute of Uranium Mining of CNNC has studied ISL mining since 1970**. Small scale ISL tests were conducted in Guangdong Province until 1979, Deposit Number 501 (1978–1981) and Deposit Number 381 (Tengchong, Yunnan Province). Based on a small field test conducted as of October

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* Zhang, Rong, 1995, *Improvement of uranium production efficiency to meet China's nuclear power requirement*, TCM on Recent Changes and Events in Uranium Deposit Development, Exploration, Resources, Production and the World Supply/Demand Relationship, Kiev, Ukraine, May 1995.

** Yunbin, Du, 1995, *In situ Leaching of Uranium in China*, paper presented at Workshop on In Situ Leach Mining, Harrachov, Czech Republic, May 1995.

1982 at Deposit Number 381, a pilot plant with an annual capacity of 3 to 5 tU was completed by year-end 1991. A total of 72 wells develop a reserve of 47 tU.

Production test work was conducted on Deposit Number 512 in Yili, Xinjiang Autonomous Region, in the far west of China from 1987 to 1991. The pilot mine with a 10 tU per year production capacity uses a sulfuric acid leach and a five-spot well pattern with 25 metre by 25 metre spacing. Production capacity was expanded to 20 tU/year in 1993 and to 40 tU/year in 1994. Plans were called for completing a commercial mine with a capacity of 100 tU/year in 1995. The ore consists of pitchblende occurring in an unconsolidated oxidised porous sandstone as a roll front-type deposit. It is reported to be similar to sandstone hosted deposits in Texas, USA and in the former USSR. There is a large potential for expanding the uranium reserve base in the Yili basin. Plans were called for starting development of a test ISL programme at Deposit Number 511 in 1996. ISL leach capacity in the area is expected to expand to about 400 tU/annum by 2000.

Several other uranium deposits hosted in unconsolidated sandstone have been identified. There are deposits of this type located south of Xinjiang with potential for ISL mining including Numbers 506, 508, 509 and 510, in addition to Number 511. In Longchan, Yunnan Province deposits Numbered 381, 382, 384 and 50 are known. Deposit Number 205 is located in Linchang. Similar Inner Mongolian deposits include Numbers 505, 512, 861, 2 022 and 9 131, as well as others. Additional analysis is required before the ISL amenability of these deposits is established. Research continues to improve the technology and to further develop China's uranium production capacity using ISL mining.

In 1995 and 1996 the adjustments of the uranium industry were completed. In addition to the closure of high cost mines and mills or placing them on standby, new production centres including the Yining ISL facility, the Lantian heap leaching facility and the Benxi mine were put into production. While the total Chinese production capability is reduced, a certain scale is maintained.

The improvements on technical and managerial levels have led to significant increases in the uranium production efficiency of 3-4 times in the average. This development included, for example, the reduction of personnel from 45 000 in 1984 to a current level of 9 000 persons. Details are provided below.

Status of Production Capability

In 1996, processing of ore at the Hengyang plant was stopped and the facility was placed on standby. However, the attached uranium refinery plant is still operating. In the same year, the new Yining, Lantian and Benxi production centres supplied a total of 260 tU.

The current average uranium production costs in the new production centres is reduced by 30 to 50 per cent compared to the recently closed facilities.

Tables summarising the technical details of the uranium production centres are provided as follows.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of Production Centre	Hengyang	Fuzhou	Chongyi	Tengchong
Production Centre Class	Existing	Existing	Existing	Existing
Operational Status	Standby	Operating	Operating	Operating
Start-up Date	1963	1966	1979	1991
Source of Ore • Deposit Names • Deposit Types	 Chenxian and other mines Siliceous schist and sandstone	 Volcanic	 Chongyi mine Granite	 Dep. #381 Sandstone
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/year) • Average Mining Recovery (%)	 UG 3 000 85-90	 UG, OP 700 92	 UG, OP 350 90	 ISL NA NA
Processing Plant • Type (IX/SX/AL) • Size (t ore/day for ISL) (kilolitre/day) • Average Processing Recovery (%)	Conventional IX, AL 3 000 85-88	Conventional IX, AL 700 90	Heap leach IX, AL 350 NA	ISL IX, AL NA NA
Nominal Production Capacity (tU/year)	500	300	120	20

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

	Centre # 5	Centre # 6	Centre # 7
Name of Production Centre	Yining	Lantian	Benxi
Production Centre Class	Existing	Existing	Existing
Operational Status	Operating	Operating	Operating
Start-up Date	1993	1993	1996
Source of Ore			
• Deposit Names	Dep. #512	Lantian	Benxi
• Deposit Types	Sandstone	Granite	Granite
Mining Operation			
• Type (OP/UG/ISL)	ISL	NA	NA
• Size (tonnes ore/year)	NA	200	100
• Average Mining Recovery (%)	NA	80	85
Processing Plant		Heap leach	Heap leach
• Type (IX/SX/AL)	IX, AL	IX, AL	SX, AL
• Size (t ore/day for ISL) (kilolitre/day)	NA	NA	NA
• Average Processing Recovery (%)	NA	90	90
Nominal Production Capacity (tU/year)	100	100	120
Plans for expansion	To 400 tU/y		

Ownership Structure of the Uranium Industry

No changes in ownership of China's state owned uranium industry have occurred since 1994. It is 100 per cent government-owned.

Employment in the Uranium Industry

Following the closure of some mine and mill operations the employment in the Chinese uranium industry has continued to decline. This development for the period 1994 to 1996 is shown in the following table.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	1995	1996	Expected 1997
9 100	8 800	8 500	8 500

Future Production Centres

At present, the most promising production centre is the Yining ISL facility, which produces from the Jurassic sandstone-type deposit Number 512. It is expected that its nominal production capacity will be increased from the current 100 tU/year to 400 tU/year or more in the short term.

Environmental Aspects

With the partial or total closure of 12 uranium mills a large amount of waste and tailings require decommissioning and long-term management. Related activities are being planned for 4 sites and preliminary investigations are under way for the remaining 8 sites.

Long-Term Production Capability

The long-term uranium production capability in China will be determined by the uranium reactor requirements which are expected to increase rapidly in the near future.

URANIUM REQUIREMENTS

China has two nuclear power plants in operation. They include the 300 MWe Qinshan plant in Zhejiang Province, designed and built by China, and the Chinese-French joint venture project Daya Bay NPP in Guangdong Province with an installed capacity of 2 x 900 MWe. The Qinshan NPP reached full power in July 1992, while the Daya Bay plant was connected to the grid in 1994. The total uranium requirements for the aggregated nuclear generating capacity of 2 100 MWe amounts to 300 tonnes by the end of 1995.

In 1996 a number of far reaching decisions have been made regarding China's nuclear development. For the period 1996-2002 it is planned to build a further 8 nuclear power plants with an aggregate nuclear generating capacity of approximately 6 900 MWe. In more detail these plans include:

- a second project in Qinshan consisting of 2 units with a total capacity of about 1 360 MWe. This project is being carried out by CNNC. Construction of the two units started in 1996 and 1997 respectively;

- also in Qinshan, a Chinese-Canadian joint venture will start the construction in 1998 of two Candu-type reactors with a total capacity of 1 450 MWe;

- a Chinese-Russian project will construct 2 reactors with a total capacity of 2 120 MWe in Lianyungang, Jiangsu Province. This project had been originally planned to be carried out in the Liaoning Province, but was moved to the present location where construction will start in 1998;

- a Chinese-French project started the construction of two Framatome plants in 1997 with a combined capacity of 1 970 MWe.

These projects will increase the total nuclear generating capacity to about 9 000 MWe in 2005. Additional capacities are being planned some time between 2005 and 2015 as shown in the following tables, together with the associated uranium requirements.

INSTALLED NUCLEAR GENERATING CAPACITY
(MWe Net)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 100	2 100	3 300	7 000	9 000	17 000	21 000	22 000	27 000

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS
(Tonnes U)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
300	300	600	900	1 500	2 400	3 000	3 200	4 000

SUPPLY AND PROCUREMENT STRATEGY

The known uranium reserves and resources together with the recently expanded uranium production capability will be sufficient to fill the requirements for China's nuclear development programme for the short term. Further requirements will have to be met by still undiscovered resources. To convert this uranium potential into known resources and reserves, China is placing emphasis on its uranium exploration activities.

NATIONAL POLICIES RELATING TO URANIUM

In 1996, the China Uranium Corporation was established to meet the market economy needs of the uranium industry. It represents the uranium production entity controlled by the China National Nuclear Corporation, CNNC.

• Colombia •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Colombia started in 1967. Approximately 300 uranium anomalies were identified along the Eastern Cordillera and the eastern slope of the Central Cordillera.

Initially foreign uranium companies were exploring under association contracts with the Colombian Government. After the withdrawal of these companies some drilling was done in the 1980s by INEA, the Colombian institute responsible for nuclear sciences and alternative energy. In 1992 all uranium activities were terminated.

There are no known RAR and EAR-I resources in Colombia.

NATIONAL POLICIES RELATING TO URANIUM

The Colombian Government is not pursuing any projects related to uranium exploration and production.

• Cuba •

URANIUM EXPLORATION

Historical Review

In 1985, the relevant organisation, the Centre for Studies Applied to Nuclear Development of the Ministry of Science, Technology and Environment, initiated uranium exploration in Cuba. This activity was closely related with the construction starts of two nuclear reactors.

The efforts, aimed at the assessment of the uranium potential of the country, included the following activities:

- review and evaluation of available geological information,
- the surface investigation of the anomalies identified in a previously completed country-wide airborne radiometric survey,
- some limited drilling totalling approximately 6 000 metres in one area in Northwest Cuba,
- the application of track-etch and charcoal radon detection methods, as well as,
- uranium favourability studies of 70 per cent of the Cuban territory.

Due to budgetary limitations uranium exploration was reduced in 1990.

Recent and Ongoing Activities

During 1993-1994, in view of the budgetary situation, only minor field work could be done. Office based investigation continued, however, including favourability studies.

Future plans through the year 1998 include the continuation of these studies which should by the end of the century cover all of Cuba. Further steps, such as the field assessment of the areas showing a high uranium favourability will depend on the economic situation of the Centre.

The uranium exploration expenditures incurred in recent years by the Centre are summarised in the following table.

URANIUM EXPLORATION EXPENDITURES

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
Current Pesos (x 1000)	169	105.4	86.5	50
US$ (x 1000)	228	142	86	50

URANIUM RESOURCES

Cuba does not report any uranium resources. The exploration organisation, however, did report one uranium occurrence with surficial values of up to 3 500 ppm U associated with the contact between a granitic intrusive and upper Cretaceous limestones. As this geological setting exhibits a wide extension, a certain potential is assigned to this area referred to as Escambray, in central Cuba.

• Czech Republic •

URANIUM EXPLORATION

Historical Review

Following its start in 1946, uranium exploration in Czechoslovakia (CSFR) grew rapidly and developed into a large scale programme in support of the country's uranium mining industry. A systematic exploration programme including geological, geophysical and geochemical surveys and related research, was carried out to assess the uranium potential of the entire country. Areas with identified potential were explored in detail using drilling as well as underground workings.

Exploration continued in a systematic manner until 1989 with annual exploration expenditures in the range of US$ 10-20 million and an annual drilling effort in the range of 70-120 km.

In 1989, the decision was made to reduce all uranium related activities. In 1990, the first year following the decision, expenditures decreased to about US$7 million and continued to decline, reaching US$660 000 in 1992.

Exploration has been traditionally centered around vein-type deposits located in metamorphic complexes (Jáchymov, Horní Slavkov, Príbram, Zadní Chodov, Rozná, Olsí and other deposits), granitoids (Vítkov deposit) of the Bohemian massif and around the sandstone-hosted deposits in northern and north-western Bohemia (Hamr, Stráz, Brevniste, Osecná-Kotel, Hvezdov, Vnitrosudetská pánev, Hájek and other deposits).

Recent and Ongoing Activities

No field exploration has been carried out since the beginning of 1994. Exploration activities have been focused on the conservation and processing of previously collected exploration data.

Processing the exploration information data and building the exploration database will continue in 1997.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
Industry Expenditures (Million Kc)	0.50	1.20	0.50	0.70
Government Expenditures (Million Kc)	12.50	6.20	5.00	6.00
Total Expenditures (Million Kc)	13.00	7.40	5.50	6.70
TOTAL EXPENDITURES (US$ 1000)	468	282	201	244

URANIUM RESOURCES

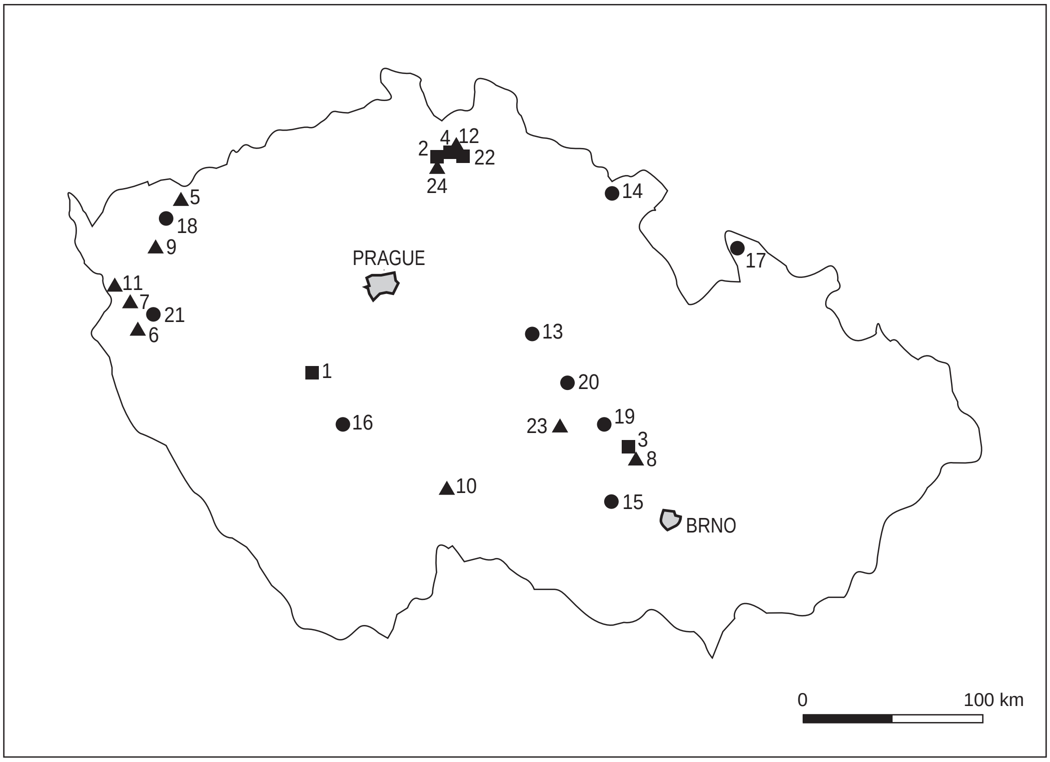
Historically, known uranium resources of the Czech Republic occurred in 24 deposits, of which 20 have been mined out or closed. Of the four remaining deposits, two are being mined (Stráz and Rozná), and two, including Osecná-Kotel and Brzkov have resources that may be mined in the future.

Undiscovered uranium resources are believed to occur in the Rozná, Brzkov and Hvezdov deposits, as well as in the Northern Bohemian Cretaceous basin (Stráz block, Tlustec block and Hermánky region).

Known Conventional Resources (RAR & EAR-I)

Known conventional resources as of 1 January 1997, decreased by 1 478 tU in comparison with the previous estimate. In detail, the RAR recoverable at cost below $80/kgU decreased by 5 140 tonnes. This quantity was moved into the $80-$130/kgU cost category. The RAR resources below $130/kgU decreased from 31 210 tU at the end of 1994, to 30 220 as of 1 January 1997, representing a decrease of almost 1 000 tU. The decrease in RAR was the result of the re-evaluation of the Hamr deposit in connection with its closure in 1995 and the depletion of resources at the Rozná and Stráz operating production centres.

Major uranium deposits in the Czech Republic



No.	Deposit	Size	Status	Type	No.	Deposit	Size	Status	Type
1.	Příbram	B	V	H	13.	Licoměřice–Březinka	S	V	H
2.	Stráž *	B	T	S	14.	Vnitrosudetská pánev	S	V	S
3.	Rožná *	B	T	Z	15.	Jasenice	S	V	Z
4.	Hamr	B	V	S	16.	Předbořice	S	V	H
5.	Jáchymov	M	V	H	17.	Javorník–Zálesí	S	V	H
6.	Vítkov	M	V	M	18.	Hájek	S	V	S
7.	Zadní Chodov	M	V	Z	19.	Slavkovice–Petrovice	S	V	H
8.	Olší	M	V	Z	20.	Chotěboř	S	V	H
9.	Horní Slavkov	M	V	H	21.	Svatá Anna	S	V	H
10.	Okrouhlá Radouň	M	V	Z	22.	Osečná–Kotel	B	P	S
11.	Dyleň	M	V	Z	23.	Brzkov	M	P	H
12.	Břevniště	M	V	S	24.	Hvězdov	M	P	S

Legend

Size:
- ■ B > 10 000 tU
- ▲ M > 1 000 and < 10 000 tU
- ● S > 100 and < 1 000 tU

Status:
- V = mined out
- T = being exploited
- P = planned, prospective

Type:
- H = vein deposits ("classic" veins)
- Z = vein deposits ("zone" deposits)
- M = vein deposits (metasomatic deposits)
- S = stratiform, sandstone – type

* Milling plant

EAR-I resources declined slightly by 490 tonnes to 18 960 tU as of 1 January 1997. The decrease has occurred in the cost category below $80/kgU.

For EAR-I, the below $80/kgU decreased slightly from 1 660 tU to 1 180 tU, while the below $130/kgU estimate as of 1 January 1997 declined by 490 tonnes to 18 960 tU.

Eighty-one per cent of the known uranium resources recoverable at cost below $80/kgU are tributary to existing production centres, the remainder occurs in the Brzkov deposit.

The known uranium resources between $80-$130/kgU are partly associated with the Osecná-Kotel deposit, resources of which are estimated somewhat less than 15 000 tU.

No new discoveries to previously reported resources have been made.

REASONABLY ASSURED RESOURCES

(Tonnes U – as of 1 January 1997)*

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	6 630	30 220

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I

(Tonnes U – as of 1 January 1997)*

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	1 180	18 960

* The estimate refers to mineable resources. Mining losses of 4.5 per cent were deducted for resources to be mined by conventional methods. Ore processing losses were not taken into account.

Undiscovered Conventional Resources (EAR-II & SR)

No new areas favourable for the discovery of resources have been identified in the last two years.

EAR-II are practically the same as of 1 January 1995, and these resources are associated with the Rozná, Brzkov and Hvezdov deposits.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II

(Tonnes U – as of 1 January 1997)*

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	5 480	8 480

* As in situ resources.

In addition to the EAR-II, there are SR totalling 179 000 tU as in situ resources, unassigned to any cost category. The SR are believed to exist in the Stráz block, Tlustec block and Hermánky region, all in the Cretaceous basin of the Northern Bohemia.

URANIUM PRODUCTION

Historical Review

The industrial development of uranium production in Czechoslovakia began in 1946. Between 1946 and the dissolution of the Soviet Union, all uranium produced in Czechoslovakia was exported to the Soviet Union.

The first production came from the Jáchymov and Slavkov mines, which completed operations in the mid-sixties. Príbram, the main vein-type deposit, operated in the period 1950-1991. The Hamr production centres, supported by sandstone-type deposits, started operation in 1967. The peak production of about 3 000 tU was reached in about 1960 and production remained between 2 500 and 3 000 tU/year from 1960 until 1989/1990, when it began to decline. During the period 1946-1996, a cumulative quantity of 104 748 tU was produced in the Czech Republic. Eighty-six per cent of the total was produced by conventional mining methods while the remainder was recovered using in situ leaching (ISL).

The uranium production statistics for the period 1992-1996, together with the planned production for 1997 are summarised in the following table.

HISTORICAL URANIUM PRODUCTION

(Tonnes U contained in concentrate)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	Expected 1997
Conventional Mining						
• Open pit	320	0	0	0	320	0
• Underground	89 083	306	300	298	89 987	300
Subtotal	89 403	306	300	298	90 307	300
In situ Leaching	13 600	235	298	300	14 433	290
By-Product Production	0	0	0	0	0	0
Other Methods	0	0	2	6	8	19
TOTAL	103 003	541	600	604	104 748	609

Status of Production Capability

Production capability from Czech existing operations fell in the last two years as a result of the Hamr mine closure in 1995.

In March 1996, the government of the Czech Republic decided to start decommissioning and restoring Stráz ISL mine in the Northern Bohemian Cretaceous basin. Together with deposit restoration, decreasing amount of uranium will be extracted in the course of the next years. In addition to the Stráz deposit, only one mine remains in operation at present - Rozná underground mine in the metamorphic complex of Western Moravia.

Ownership in the Uranium Industry

All uranium related activities, including exploration and production have been carried out by the government-owned Diamo enterprise, based in Stráz pod Ralskem. Consequently, the entire production, totalling 604 tU in 1996, was owned by the National government.

Employment in the Uranium Industry

With the closure of mining operations at Hamr mine, direct employment in the Czech uranium industry has declined to some 3 600 workers, as of the end of 1996. This employment is engaged in uranium production, decommissioning and restoring activities.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	**1995**	**1996**	**Expected 1997**
5 400	4 500	3 600	3 000

Future Production Centres

In compliance with the Government decision, uranium production will continue at a reduced level. Under the current scenario, the Rozná underground mine will continue annual production of 300 tU until 1998. The Stráz ISL operation will produce 300 tU annually in the next years under the remediation regime which was started in 1996.

A future production centre could be reactivated at the Brzkov deposit. Brzkov is a vein-type deposit with known resources in the RAR and EAR-I categories. It is located in the western part of the Moldanubian of Moravia. The mine was closed but could be re-opened under more favourable market conditions.

Based on a prefeasibility study, elaborated in 1996, the Hvezdov deposit with EAR-II in sandstones from the Northern Bohemian Cretaceous basin is not economically viable for exploitation in the near future.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

Name of Production Centre	Dolní Rozínka (Rozná)	Stráz
Production Centre Class	Existing	Existing
Operational Status	Operating	Operating
Start-up Date	1957	1967
Source of Ore • Deposit Name • Deposit Types	 Rozná Vein	 Stráz Sandstone
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average Mining Recovery (%)	 UG 800 94.5	 In situ – 60 (estimated)
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Recovery (%)	 ALKPL/IX/CWG 680 94.4	 ISL/AL/IX 55 500 kl/day –
Nominal Production Capacity (tU/year)	370	500

Short-Term Production Capability

The projected production capability to the year 2015 is shown in the following table:

SHORT-TERM PRODUCTION CAPABILITY
(Tonnes U/year)

1997				1998				2000			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	680	680	0	0	680	680	0	0	680	680

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	110	110	0	0	60	60	0	0	50	50

Environmental Aspects of Uranium Production

Mining and milling of uranium ores in the Czech Republic led to important impacts on the environment, the removal of which will require a long-lasting remediation procedure. It will continue for many years beyond 2000 and will need considerable financial resources.

Nowadays, in conjunction with the continuing reduction of uranium production, the decommissioning and restoring activities are becoming the main programme of s.p. DIAMO.

A comprehensive review of environmental impacts caused by uranium mining and milling was given in the 1995 Red Book.

At present, the main decommissioning and restoring activities being carried out are the following:

1. *Decommissioning of the Hamr mine*

   The technical project for the decommissioning has been approved. The work is being carried out underground where the mined-out space is being filled with backfill. The backfilling will be finished in 2001.

2. *Decommissioning of the Stráz ore processing mill*

   At present, the technological equipment is being decommissioned and the buildings of the processing plant will be decontaminated. It is proposed that it will be possible to release the decontaminated buildings for further use.

3. *Remediation of the Stráz tailings impoundments*

   The conception of the remediation measures has been prepared. Apart from other measures, the liquidation of the free water is suggested which will be followed by the transfer of the tailings deposited in the stage II impoundment and the material of its contaminated dams into the basin of the first stage.

4. *Remediation of the Stráz ISL mine*

   The remediation target in the deposit after ISL extraction is to gradually lower the content of dissolved solids in the underground water of the Cenomanian and Turonian aquifers and gradually integrate the surface of the leaching fields into the ecosystems with regard to the regional systems of ecological stability.

   On 1 May 1996, the preparatory period of the remediation was put into action. This requires the evaporation of approximately 6.5 m^3 per minute of the distillate into the surface watercourse. The operation of the evaporating plant started in October 1996.

5. *Decommissioning of the Olší mine*

   The continuing work involves the recultivation of the dumps and of the plant area and also the continuation of mine water processing.

6. *Decommissioning of the Jasenice-Pucov mine*

   R*ecultivation* has been completed. At this site only, the processing of mine water is continuing which involves the removal of U and Ra.

7. *Decommissioning of the Licomerice-Brezinka mine*

   At present, the recultivation work is being projected. At the site, mine water is processed to remove U, Ra, Fe and Mn. A peculiarity of the site is the continuing biological leaching in the shaft.

8. *Remediation of tailings' impoundments at Príbram*

   Restoring activities are being carried out to prevent higher gamma dose rates on the surface and dusting.

9. *Recultivation and processing of mine water at Zadní Chodov and Okrouhlá Radoun*

   The recultivation of the waste rock dump and the pumping and processing of mine water for the removal of radionuclides is ongoing.

10. *Construction of a mine water processing plant at Horní Slavkov*

    This is one of the major remediation measures of s.p. DIAMO. The need for this construction emerged from the stocktaking of old liabilities. The water will be decontaminated by removing radionuclides, Fe, Mn and some other elements. Processed water will be from abandoned Horní Slavkov shafts.

11. *Recultivation of the tailings' impoundments of the MAPE Mydlovary ore processing plant*

    This is one of the most extensive remediation projects of s.p. DIAMO, the duration of which is estimated at several tens of years. At present, a study for the selection of the optimal remediation concept is being prepared. At the same time, several options are being evaluated by pilot projects. The seepage water in the area of the impoundments is processed at the rate of 6 to 7 m^3/hour.

Long-Term Capability

The two existing and operating Rozná and Stráz production centres will be depleted respectively by the year 2003, and sometime before 2020.

The planned production Brzkov centre is assumed to be depleted before the year 2010. In case of favourable market and political conditions, two additional prospective production centres could become operational sometime after the year 2010. They include the Hvezdov and Osecná-Kotel deposits, both associated with the Northern Bohemian Cretaceous sedimentary basin.

URANIUM REQUIREMENTS

The joint stock company CEZ, a.s., operates the Dukovany nuclear power plant. Since 1985, it has been providing the base load electricity supply for the Czech Republic. The current annual uranium requirements for the four 408 MWe units fluctuate between 335 and 380 tU. The total uranium requirements will almost double to 700 tU/year when the two 942 MWe units of the Temelin nuclear power plant become operational. The updated plans provide for production of Unit 1 to start in April 1999, and Unit 2 in the second half of 2000.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe Net)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 632	1 632	2 604	3 516*		3 516*		3 516*	

* Best estimate.

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
370	370	525	700*		700*		700*	

* Best estimate.

SUPPLY AND PROCUREMENT STRATEGY

CEZ, a.s., the only uranium consumer in the Czech Republic, could fully rely on domestic uranium supply by the year 2000. This is in line with the Governmental Raw Materials Policy which restricts the import of uranium. On the other hand, CEZ intends to diversify its uranium supply through purchases from foreign sources. This diversification could also include the purchase of uranium from the Government stockpile.

NATIONAL POLICIES RELATING TO URANIUM

Exploration, mining and processing of uranium is the exclusive right of Diamo. Continued production is planned at both the Stráz (under decommissioning and restoring programme) and Rozná mines, which still have sufficient resources for several years' production. The strategy balances uranium production with reactor-related uranium requirements.

URANIUM STOCKS

Stocks in the form of natural uranium are held by the Government (>2 000 tU) as well as by Diamo (700 tU).

URANIUM PRICES

Uranium is supplied to the CEZ on the basis of non-market cost-based prices.

• Denmark (Greenland) •

URANIUM EXPLORATION

Historical Review

Uranium exploration activities have been performed in South, East and West Greenland. In South Greenland exploration of the Kvanefjeld U-Th-deposit took place during the 1955-1984 period. This is a large low-grade deposit associated with alkaline intrusive rocks. Exploration methods included: radiometric (geiger and later gamma spectrometric) ground surveys, drilling, drill hole logging, drill core gamma-spectrometric scanning, drill core chemical assaying, detailed geological mapping, test mining and assaying, and metallurgical work. Resources are estimated at 27 000 tU with 16 000 tU in the "additional resources" category. Additional activities in South Greenland included a regional exploration programme during the 1979-1986 period involving helicopterborne gamma spectrometry, drainage geochemistry and geological studies. Three prospects were found: 1) uraninite in mineralised fractures and veins; 2) uranium rich pyrochlore mineralization in alkaline rocks; and, 3) uraninite in hydrothermally mineralised metasediments. These prospects are believed to represent 60 000 tU in the "speculative resources" category.

In East Greenland, exploration activities were performed during the 1972-1977 period. A reconnaissance uranium exploration programme was conducted involving airborne gamma spectrometry, drainage geochemistry, ground scintillometry, and geological studies. The programme concluded with no major discovery. Reconnaissance airborne gamma spectrometry with ground follow-up performed in West Greenland also resulted in no major discovery.

Recent and Ongoing Uranium Exploration Activities

In Greenland, stream sediment surveys including analysis for uranium and thorium, and also scintillometer readings (total gamma) are performed at each sample station. A 1995-survey covered 7 000 km^2 in North-West Greenland but no prospects were recorded.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Denmark reports known conventional resources totalling 43 000 tU in South Greenland. This includes 27 000 tU of Reasonably Assured Resources and 16 000 tU of Estimated Additional Resources – Category I. All the conventional resources are recoverable at costs of $130/kgU or less.

Undiscovered Conventional Resources (EAR-II & SR)

Denmark reports Speculative Resources totalling 60 000 tU in South Greenland. This includes 50 000 tU recoverable at $130/kg or less and 10 000 tU with unassigned cost range.

• Egypt •

URANIUM EXPLORATION

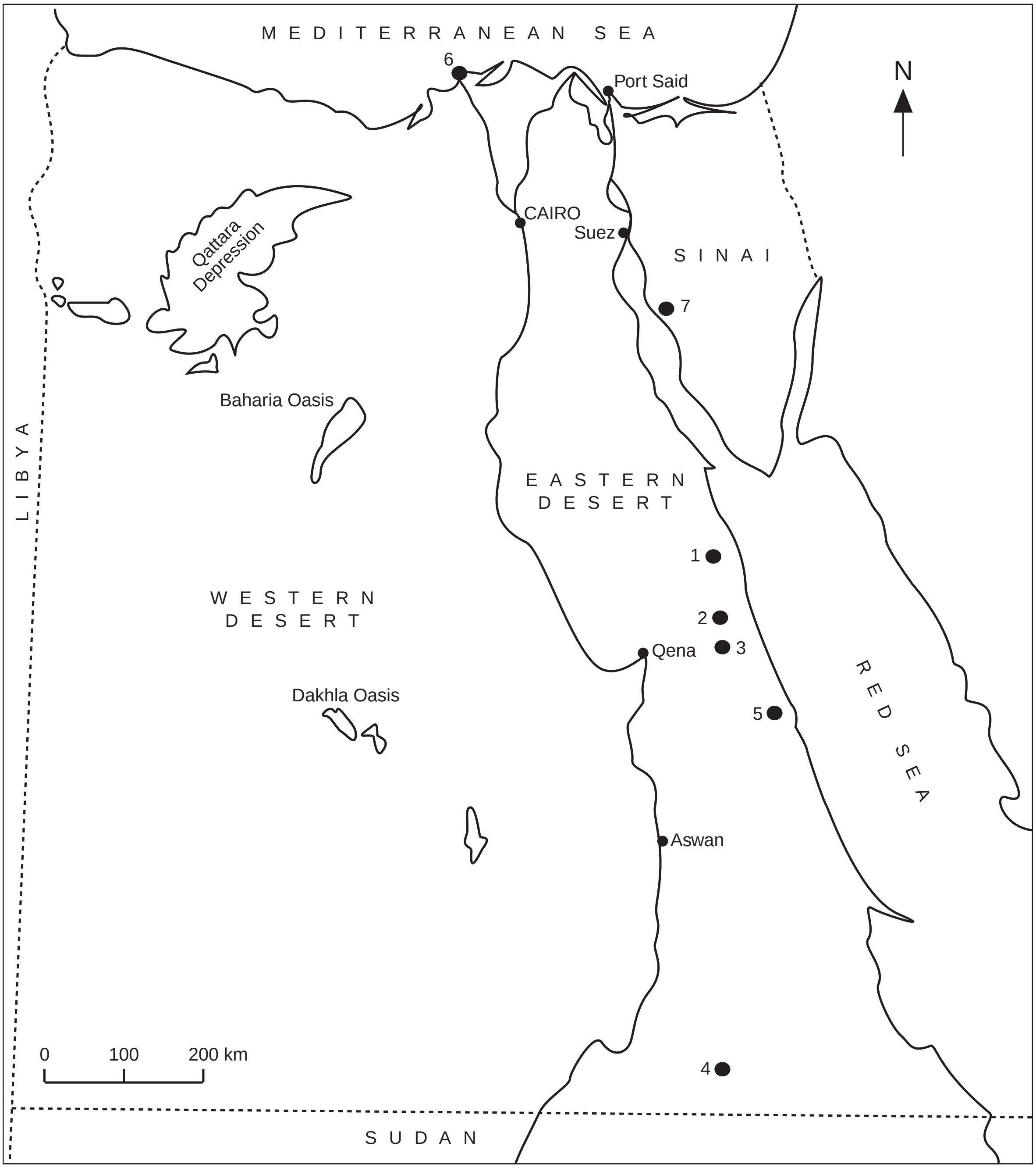
Recent and Ongoing Activities

The Nuclear Materials Authority concentrated its main exploration activities in the development of three mineralised areas discovered in the Eastern Desert: Gabal Gattar, El Missikat and El Erediya, and Um Ara. Generally, the operations included deep trenching, tunneling, core and percussion drilling, and well logging, supported by laboratory analysis. The volume of the operations during the 1990-1997 period are listed in the table below. The activities also include detailed topographic, geologic and radiometric mapping and sampling of the uraniferous lenses for the purpose of grade estimation and reserve evaluation.

OPERATIONS IN URANIUM EXPLORATION DURING THE 1990-1997 PERIOD

Locality	Trenching (m^3)	Drilling	Exploratory mining (metres)
Gabal Gattar	600	–	735
El Missikat and El Erediya	–	1 243	4 950
Um Ara	2 500	230	

Uranium occurrences in Egypt



Uranium occurrences:

1. G. Gattar
2. El Missikat
3. El Ereidya
4. Um Ara
5. G. Kadabora
6. Rossetta
7. West Sinai

Gabal Gattar

Exploratory mining operations are ongoing and are being used to follow the uranium-bearing shear zone in the granitic mass. Work in the vertical shaft is continuing which provides access to horizontal tunnels (Location 1 on map).

El Missikat and El Erediya

These deposits have already been explored by means of about 4 000 metres of tunnels. Subsurface core drilling was started in 1991 and is continuing to delineate and evaluate the uranium-bearing veins in granite in both areas (Locations 2 and 3).

Um Ara

This area is characterised by closely spaced joints and fractures in highly tectonised microcline granite and by a shear zone near the contact between granite and the intruded Precambrian sediments and volcanics. The uranium is present as secondary fracture fillings. The area is now being evaluated with closely spaced drilling (Location 4).

An intensive programme using airborne spectrometric surveying will be executed to discover new prospective areas. The most promising areas will be covered gradually during the programme. The annual expenditures from 1994-1996 are indicated below.

URANIUM EXPLORATION EXPENDITURE STATISTICS

	1994	1995	1996
GOVERNMENT EXPENDITURES			
Egyptian Pounds	11 000 000	12 000 000	22 000 000
US$ (x 1000)	3 244.84	3 560.83	6 528.19

New Discoveries

Gabal Kadabora

This area has been discovered in the Central Eastern desert, and it is in a semi-detailed and detailed exploration stage. Uranium mineralization is present in a younger granitic mass which occupies an area of about 320 km². The uranium is associated with pegmatite veins, particularly along the outer boundary of this granite body (Location 5).

West Sinai

This is a uraniferous siltstone and shale of upper Palaeozoic age. The thickness of the uraniferous horizon ranges from 0.5 metres to 3.5 metres. The uranium content ranges from 200 to 500 ppm. It is nearly free of thorium, and is associated with copper and manganese. Some areas have xenotime which has a high rare earth content. Several secondary uranium minerals have been identified, including phosphates, sulphates, vanadates, arsenates and carbonates. The extent of the uranium occurrences is about 10 km by 15 km.

URANIUM RESOURCES

Known Conventional Uranium Resources (RAR & EAR-I)

Egypt does not report any known uranium resources according to the standard IAEA/NEA classification system.

Unconventional and By-Product Uranium Resources

Unconventional resources occur in Egypt in sedimentary phosphate deposits as well as in association with monazite deposits. These undiscovered resources roughly include:

4 000 tU as EAR-II subdivided into	3 000 tU in phosphates and 1 000 tU in monazite deposits, and
4 000 tU as SR subdivided into	3 000 tU in phosphates and 1 000 tU in monazite deposits.

URANIUM PRODUCTION

Status of Non-Conventional Uranium Production Capability

1. The construction of a semi-pilot plant for the extraction of uranium from phosphoric acid is completed and will be commissioned during early 1998. The design capacity of the plant is about 15 m^3/d of acid which contains about 65 ppm uranium.
2. The Nuclear Materials Authority is taking over the exploitation of the Egyptian black sands at Rosetta beach on the Mediterranean coast. This deposit contains monazite, zircon and rutile, as well as ilmenite and magnetite. The proposed project includes wet and dry mills with a capacity of 200 m^3/h of wet sand treatment. The evaluated area is estimated to contain about six million tons of economic heavy minerals at an average grade of 2 per cent. This reserve contains about 3 000
3. tons of monazite in the EAR-II category. The monazite contains 0.46 per cent U and 6.05 per cent Th, as well as 65 per cent rare earths (Location 6).

• Estonia •

URANIUM PRODUCTION

History[1]

The history of uranium production in Estonia is related to the Sillamäe Metallurgy Plant, located in north-eastern Estonia at the town of Sillamäe. The town is 185 km east of Tallinn near the shore of the Gulf of Finland. Ownership of the plant is being privatised under the company: SILMET AS. At the time the report was prepared the state retained about 30 per cent of the company shares.

The Sillamäe plant was constructed in 1948 to process uranium bearing ores. It was first used to recover uranium from alum-shale mined in Estonia. Alum-shale mining continued until 1963 when the mines were closed. The difficulties in recovering the low and variable uranium content of the alum-shale were the main reasons for closing the mines. During this period about 240 000 tonnes of locally mined alum-shale were processed. In following years higher grade uranium ores containing up to 1 per cent U were imported from Europe for processing. Uranium production continued until about 1977. The plant was also used for processing ores to recover products (including rare earths) other than uranium.

The concentration of uranium in the Sillamäe alum-shale is highly variable from place to place. It averages about 0.03 per cent U, with maximum values of up to 0.1 per cent U. The alum-shale was extracted from underground mines located to the west of the plant. The mines had an area of about 2 km^2 and were accessed through an entrance located about half a kilometre from the plant.

An estimated 4 013 000 t of uranium ores were processed at the plant. The uranium ore processing technology resulted in the estimated average recovery of about 92 per cent of the contained uranium. The total uranium production of the plant is estimated to be at least 23 000 tU, with an error of plus or minus 10 to 20 per cent. The total uranium production from the alum-shale mined in Estonia is estimated to be about 65 tU.

Most of the ore was brought from Czechoslovakia (2.2 million t) and from Hungary (1.2 million t). Small amounts of ore were also brought from Poland, Romania, Bulgaria and the German Democratic Republic. An estimated total of about 12 million tonnes (i.e. about 8 million cubic metres) of tailings and other waste material, including the 4 million tonnes of tails from processing uranium ores, are present at the site.

In 1970, processing of loparite (an ore of niobium, tantalum and rare earths) from the Kola Peninsula was also started. No uranium was recovered from this material which contained about 0.03 per cent U and 0.6 per cent thorium. From 1977 to 1989 the waste repository was used for the

1. There is no formal written documentation available on the history and production details of the Sillamäe facility. This information was classified and the archives have not been opened. Most of the information in this report was obtained in interviews with workers at the plant and through investigations and analysis of the plant site.

disposal of wastes from processing loparite, as well as for oil shale ash. The ash is the combustion residue (bottom, cyclone and filter ash) from an oil-shale-fired thermal power plant located in the area and belonging to the Sillamäe plant. Loparite ores were shipped to the plant until 1989. After that date processing of loparite continued to the present from stockpiled ores.

While no enrichment of uranium (with respect to ^{235}U) was carried out at the plant, enriched uranium and its compounds were shipped to the plant from outside of Estonia. Following processing or manufacturing the material was shipped out of the country. The details of manufacture are not available.

Environmental Considerations

From 1992 to 1994, an international co-operation project assisted Estonian specialists in conducting an environmental site assessment of the Sillamäe mill tailings. The results of this assessment are being used to estimate the impact on the environment and for planning site remediation and long-term closure of the uranium tailing impoundment. The findings of the investigation are summarised below.

From 1948 to 1959 the uranium tailings were heaped on the surface of the lower coastal terrace near the plant on the immediate waterfront of the Gulf of Finland. The waste depository was established in the same area in 1959. The depository has been reconstructed several times since then. During the 1969-1970 reconstruction part of the solid uranium tailings from the depository was used as fill material to construct a higher dam. At present the depository has the form of an oval retention impoundment with an area of 330 000 m^2. The impounded material is surrounded by a dam with a height of 25 metres above sea level. No cover material has been placed over the impoundment.

Radon and its progeny are emitted from the uncovered depository. This is the major source of radiological impact on the population of Sillamäe. The resulting annual individual doses are of the order of 0.2 millisievert (mSv). The impact of water leaking through the depository and from the neighbouring closed mines and discharging into the Gulf of Finland is much less. The resulting impact is observable only near the depository. This discharge results in the collective committed 50-year dose of about 1 man.Sv, and in an individual committed effective dose of about 1 microsievert. The main environmental concern defined by the international co-operation project of 1992-1994 was the stability of the depository. The potential for collapse of the dam, or of a landslide should not be neglected.

Environmental concerns also arise in connection with contamination present at the former transportation (railway) terminal and the storage area for imported ores located outside the plant. The dose-rates are rather high at many locations in these areas. Only limited funding has been available to pay for environmental cleanup. Therefore, these areas have been only partly cleaned by the plant staff.

• Finland •

URANIUM EXPLORATION

Historical Review

Uranium exploration was carried out in Finland from 1955 to 1989, first by several organisations but from the late 1970s mainly by the Geological Survey (see the 1995 Red Book). Since their beginning in the early 1970s, the regional aerogeophysical and geochemical mapping programmes have played an important role in uranium exploration.

The distribution of uranium provinces and the geological settings of uranium deposits can be summarised as follows: the grades (per cent U) and tonnages of (in situ) uranium of the deposits are given in brackets:

1. The Kolari-Kittilä province in western Lapland, including the Kesänkitunturi sandstone-type deposit (0.06 per cent; 950 tU) and the Pahtavuoma vein deposit (0.19 per cent; 500 tU) in Paleoproterozoic quartzite and greenstone-associated graphitic schists, respectively;

2. The Kuusamo province in north-eastern Finland, with metasomatite uranium occurrences associated with mineralizations of Au and Co in a sequence of Paleoproterozoic quartzites and mafic volcanics;

3. The historical Koli province in eastern Finland, with several small sandstone-type (Ipatti, Martinmonttu and Ruunaniemi: 0.08 – 0.14 per cent; 250 tU) and epigenetic uranium deposits (the former Paukkajanvaara mine) and occurrences of U & Th-bearing quartz-pebble conglomerate in Paleoproterozoic quartzites, with an additional prospect of unconformity-related type in a Paleoproterozoic regolith.

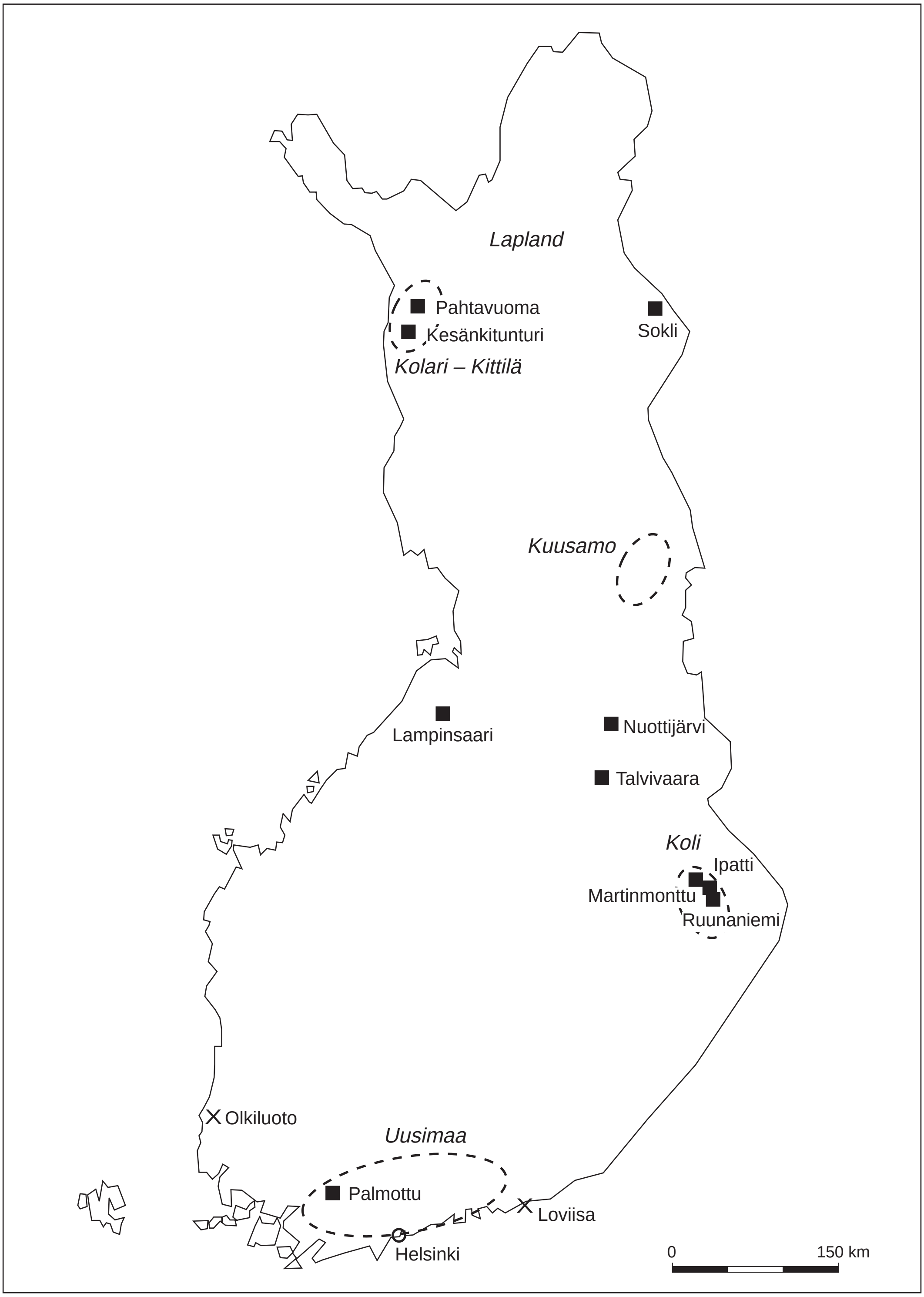
4. The Uusimaa province of intrusive-type uranium occurrences in Paleoproterozoic granitic migmatites of southern Finland, represented by the Palmottu deposit (0.1 per cent; 1 000 tU).

The geological settings further include:

- uraniferous phosphorites associated with sedimentary carbonates of the Paleoproterozoic sequences: e.g., the Lampinsaari and Nuottijärvi uranium deposits (0.03 per cent; 700 tU and 0.04 per cent; 1 000 tU);
- uranium mineralizations and uraniferous carbonate veins in Paleoproterozoic albitite and albite diabase dykes, mostly in northern Finland;
- U & Th-bearing dykes and veins of Paleoproterozoic pegmatite granites;
- surficial concentrations of young uranium in recent peat.

Possible by-product uranium occurs in the low-grade Ni-Cu-Zn deposit of Talvivaara (0.001 - 0.004 per cent U), hosted by Paleoproterozoic black schists, in central Finland, and in pyrochlore of the Paleozoic Sokli carbonatite (0.01 per cent U) in eastern Lapland.

Uranium deposits and occurrences in Finland



Recent and Ongoing Uranium Exploration Activities

There are no ongoing exploration activities in Finland for uranium. Regional low altitude aerogeophysical mapping is being continued, with an annual coverage of 10 000 to 15 000 km^2.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Finland reports 1 500 tU of Reasonably Assured Resources in the $80-130/kgU cost range, included in the Palmottu and Pahtavuoma deposits.

Additional 2 900 tU in the RAR $130-260/kgU cost range are contained in the Nuottijärvi, Lampinsaari and Kesänkitunturi deposits, and in those of the Koli area (Ipatti, Martinmonttu and Ruunaniemi).

Unconventional Resources and Other Materials

As by-product resources, from 3 000 to 9 000 tU could be recovered from the Talvivaara black schists, and another 2 500 tU from the Sokli carbonatite.

URANIUM PRODUCTION

Historical Review

Uranium production in Finland has been confined only to the now restored Paukkajanvaara mine, operated as a pilot plant between 1958 and 1961. A total of 40 000 tonnes of ore was hoisted, and the amount of the concentrates produced equalled to about 30 tonnes U.

ENVIRONMENTAL CONSIDERATIONS

A research programme on radionuclide transport analogy has recently been started in the surroundings of the Palmottu deposit, where the remaining prospecting drill holes offer suitable sites for hydrogeological and geochemical studies. Five European countries are participating in this project.

According to the present legislation in Finland, export of spent nuclear fuel is not permitted after the year 1996. Both major Finnish power companies, Teollisuuden Voima Oy (TVO) and Imatran Voima Oy (IVO), are co-operating in the final disposal of spent nuclear fuel into the Finnish bedrock. At the beginning of 1996, they established a joint company (Posiva Oy) for a nuclear waste disposal programme. Three investigation sites have officially been selected for detailed studies and two extra sites also exist. The final site will be selected in 2000.

Low and intermediate wastes are to be disposed in underground repositories. A repository has been working at the TVO power plant site in Olkiluoto already since May 1992. The other repository, at the IVO power plant site in Loviisa, will be operational during 1997.

URANIUM REQUIREMENTS

At the beginning of 1997, Finland had four reactors in operation: Olkiluoto-1 and Olkiluoto-2 owned by TVO, and Loviisa-1 and Loviisa-2, owned by IVO. The installed capacity was 2.3 GWe, as of 31 December 1996. The power utilities have projects for gradually upgrading the capacity of the existing units to 2.65 GWe in 1998. No new reactors are under construction or planned.

Uranium requirements for the four reactors have been about 465 tU/year. The uranium requirements are increasing to about 550 tU/year due to the power upgrades.

Supply and Procurement Strategy

TVO procures natural uranium, enrichment services and fuel fabrication from several countries. IVO purchases fuel assemblies from the Russian Federation but lead test assemblies have been ordered from an alternative source.

NATIONAL POLICIES RELATING TO URANIUM

There have been no significant changes to the Finnish uranium policies since the 1995 Red Book publication.

URANIUM STOCKS

The nuclear power utilities maintain reserves of fuel assemblies for about one year's use (720 tonnes of natural uranium equivalent). TVO also possesses abroad enriched uranium for another year's use (400 tonnes natural uranium equivalent) and 730 tonnes natural uranium. Stockpiling of feed uranium in Finland is not considered necessary.

URANIUM PRICES

Due to confidentiality aspects the price data are not available.

• France •

URANIUM EXPLORATION

Background

Uranium prospecting in France began in 1946, focusing on already known uranium ore deposits and the few mineralization occurrences discovered during radium exploration.

In 1948, exploration work based on foot, carborne and airborne radiometric surveys, and very early on geological mapping, led to the discovery of the La Crouzille deposit, formerly of major importance. By 1955, deposits had been identified in the granite areas of Limousin, Forez, Vendée and Morvan.

Based on geological mapping and radiometric, geophysical and geochemical techniques, prospecting activities first concentrated on the areas surrounding known deposits. They were subsequently extended to sedimentary formations in small intragranitic basins and terrigeneous formations, arising from eroded granite mountains and mainly located north and south of the Massif Central.

Between 1977 and 1981, prospecting was subsidised by the government (Plan for Uranium Exploration Aid) for a total of approximately US$ 38 million. The purpose of this aid was to encourage exploration activities in France and abroad, at sites considered to be promising but with a significantly high risk. In theory, there was a subsidy ceiling of 35 per cent of the total cost of the project, and the subsidy was to be reimbursed if a commercially viable discovery were made within the specified sites.

Recent and Ongoing Activities

Since 1987, uranium exploration activities have been declining in France. After focusing on areas around production centres in the hope of finding, in their vicinities, deposits more likely to be mineable, exploration activities are now restricted to those only connected with exploitation.

The work is confined to the north-western part of the Massif Central (where the Société des Mines de Jouac, a subsidiary of COGEMA, is continuing to mine the Bernardan deposit). The exploration activities at the Lodève deposit, scheduled to be closed down early 1997, have definitely ceased.

Abroad, COGEMA has been focusing on targets aimed at the discovery of exploitable resources, even in a difficult market economy.

In Australia and Canada, COGEMA is directly or indirectly involved in uranium exploration activities through subsidiaries. In Canada, the United States and Niger, it is also involved in uranium mining operations. On the other hand, without being an operator, it holds shares in several mining operations and research projects in different countries.

French exploration companies, operating in mainland France or abroad, are all private companies in which the French Government holds shares through the parent companies.

URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT – DOMESTIC

	1994	1995	1996	1997 (Expected)
TOTAL EXPENDITURES				
French Francs (x 1000)	35 000	14 095	5 992	5 800
US$ (x 1000)	6 217	2 882	1 152	1 105
Total Surface Drilling [1, 2] (Metres)	83 370	59 570	24 400	25 700
Total Holes Drilled	NA	NA	NA	NA

URANIUM EXPLORATION EXPENDITURES – ABROAD

	1994	1995	1996	1997 (Expected)
TOTAL EXPENDITURES[2]				
French Francs (x 1000)	174 300	50 100	35 400	61 000
US$ (x 1000)	30 959.10	10 245.40	6 807.70	11 619.00

(1) Most of the exploration drilling is carried out from the bottom due to the type of deposit being sought;

(2) The companies involved in uranium exploration in France are private companies in which the French Government has a majority shareholding and in which shares are also held by private investors. If for statistical reasons, expenditures need to be split into two parts corresponding to public and private participation in the capital of companies, the values indicated should be multiplied by a factor of 0.89 and 0.11, respectively.

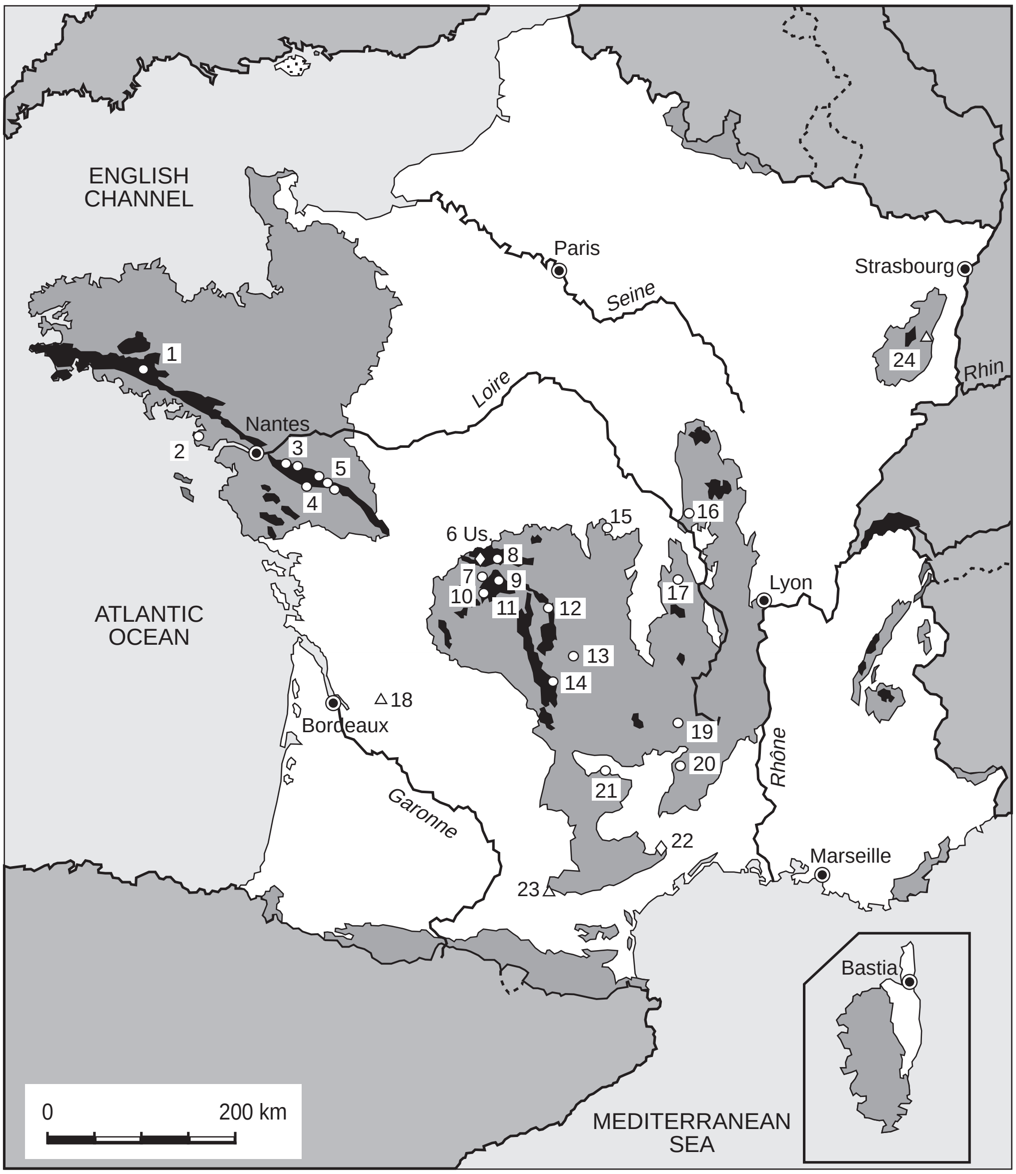
URANIUM RESOURCES

Known Conventional Resources (RAR and EAR-I)

The depletion of resources through mining in 1995 and 1996 has not been offset by new discoveries. As uranium exploration activities have ceased outside the immediate vicinity of existing production centres, this process is unlikely to be reversed.

Known resources (RAR and EAR-Category I) as of 1 January 1997 are 12 per cent down from 1 January 1995.

Main uranium deposits in France



Uranium deposits:

- ◇ Being mined
- △ To be mined
- ○ Mined out
- Us. Operating uranium mill
- ■ Leucogranite
- ■ Variscan Massif

1. Pontivy
2. Pennaran
3. Le Chardon
   L'Écarpière
4. Beaurepaire
5. La Chapelle Largeau
   La Commanderie
   La Dorgissière
6. Le Bernardan (Maihac)
7. Le Brugeaud
8. Bellezane
9. Fanay
   Le Fraisse
10. Magnac
    Vénachat
11. Henriette
12. Hyverneresse
13. S[t]-Pierre-du-Cantal
14. La Besse
15. Cerilly
16. Grury
17. Les Bois Noirs
18. Coutras
19. Le Cellier
    Les Pierres Plantées
20. Les Bondons
21. Bertholène
22. Mas Laveyre
23. Tréville
24. S[t]-Hyppolyte

Source: CEA-DCC/MNC, June 97.

The known resources belonging to the cost category below $80/kgU are reassessed each year. Most of the RAR and EAR-I resources in the cost category $80/kgU-130/kgU (those not located in orebodies actually mined) were assessed more than 5 years ago.

Undiscovered Conventional Resources (EAR-II and SR)

No systematic appraisal is made of undiscovered resources in France.

URANIUM PRODUCTION

Production Trend

As a result of the mine closures mentioned in the previous questionnaires, French uranium production has declined since 1990. From 1 106 tU in 1995, mill production has declined to 930 tU in 1996, and with the closure of the Lodève mining site, it is expected to reach 761 tU in 1997.

The main fact in the uranium mining industry in France in 1997 is the closure of the Lodève mining centre. The reclamation of site has already started in some parts of the area. In fact, after the closure of the Lodève mine, the Bernardan mine is the only uranium mine in activity in France. This mine should be able to produce until the years 2000-2001.

With regard to the storage of depleted uranium, a site is under construction on the COGEMA Bessines site. A railway junction is already in place and the first two buildings were to be constructed before the end of 1997. It has to be mentioned that in France the depleted uranium fluoride (gas) is converted at the Pierrelatte centre into depleted uranium oxide, a powder which is quite easily stored in containers.

Status of Production Capability

The maximum production capability still stands at 1 500 tU/year (as of 1 January 1997), which represents the combined output of the two ore-processing plants at Lodève and Bernardan. It should be noted, however, that after the final closure of the Lodève centre, the overall estimated production capability for 1997 should be around 760 tU.

Ownership Structure of the Uranium Industry

With the exchange of shares between COGEMA and TOTAL S.A. in June 1993, COGEMA, which has acquired all of Total's uranium mining operations, is the only French group operating in the uranium mining field. In France, its subsidiary, the “Société des Mines de Jouac”, has been operating the Bernardan deposit whereas the Lodève has been operated by COGEMA.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

	Centre # 1	Centre # 2
Name of Production Centre	Lodevois SIMO (Cogema)	Le Bernardan SMJ (Cogema)
Production Centre Class	Existing	Existing
Operational Status	Closing stage	Average
Start-up Date	1981	1979
Source of Ore • Deposit Names • Deposit Types	Mas Laveyre Orebodies in faults in pelites	Bernardan Veins and orebodies in granites
Mining Operation • Type (OP/UG/In situ) • Size (tonnes ore/year) • Average Mining Recovery (%)	UG 165 000	UG 100 000
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Ore Recovery (%)	ALKPL/SX 1 400 90	AL/IX 500 98
Nominal Production Capacity (tU/year)	1 000	500
Plans for expansion	NIL	NIL
Other remarks	Closure in 1997	NIL

Employment in the Uranium Industry

The decline in the uranium mining industry in France since 1984 has resulted in job losses in this sector, a trend that has been accelerated by subsequent mine closures.

Future Production Centres

Given the current status of the uranium market, there are no plans to develop new production centres in the near future.

ENVIRONMENTAL CONSIDERATIONS

Uranium resources can only be considered as reserves provided that the mining of such resources is environmentally acceptable.

The constraints on the mining and processing of uranium ore are those that apply to any form of mining operation; however, the fact that uranium is radioactive means that the mining operator must take steps to prevent the dispersion of radionuclides in compliance with existing regulations, which are becoming increasingly stringent.

Operators must take steps to minimise the environmental impact of mining operations by: stabilising underground and open-pit mining work; managing mine tailings and processing waste as well as waste generated by plant dismantling operations; and keeping full control over the main vectors for the dispersion of radionuclides (air and water).

STATISTICAL DATA ON URANIUM PRODUCTION

Long-Term Production Capability

Although there are resources in France within the cost category <$80/kgU which have not yet been assigned to a given production centre, there are no specific plans for the time being to develop such resources.

To meet the uranium requirements of its nuclear power plants, France, which has imported uranium since it first developed a nuclear capacity, will continue to use uranium imported from mines abroad.

Only if there were very substantial increases in the use of nuclear power, resulting in sharp increases in demand for uranium worldwide, would considerations be given to opening new uranium mines in France in the near future.

URANIUM REQUIREMENTS

Uranium Requirements and Strategy Towards Procurement and Supply

Since France is a net importer of uranium, its policy towards procurement is one of supply diversification. French mining operators participate in exploration and uranium exploitation or mining operations outside France within the regulatory framework of the host countries. They also purchase uranium, under short or long-term contracts, either from mines in which they have shareholdings or from mines operated by third parties.

NATIONAL POLICIES RELATING TO URANIUM

There have been no significant changes to national policy since the last report. Uranium exploration and production in France are unrestricted within the framework of existing regulations. On the whole, France is an uranium importing country and there are no tariff barriers for imports.

URANIUM STOCKS

Électricité de France (EDF) possesses emergency uranium stocks, the minimum level of which has been fixed at the equivalent of three years' forward consumption to face possible supply interruptions.

URANIUM PRICES

Information on uranium prices is not available.

• Gabon •

URANIUM EXPLORATION

Historical Review

Prompted by the sudden demand for uranium following World War II, the French "Commissariat à l'Énergie Atomique" (CEA) initiated uranium exploration in Central Africa. Based in the then Congo, CEA geologists extended their activities into Gabon. In 1956, using surface scintillometry, a uranium discovery was made in Precambrian sandstones of the Franceville Basin, in the vicinity of the village Mounana.

Further evaluation identified the Mounana deposit containing approximately 5 000 tU. The CEA and a group of mining companies then incorporated the Compagnie des Mines d'Uranium de Franceville (COMUF) in February 1958.

Since then, COMUF, working in close co-operation with the CEA, has continued exploration in the Franceville basin, where the following additional deposits were discovered:

Mikouloungou	1965
Boyindzi	1967
Oklo	1968
Okelobondo	1974
Bagombe	1982

Production started in 1961 in the Mounana production centre. At present, after depletion of the Mounana, Boyindzi and Oklo deposits, COMUF's production is supported by the Okelobondo deposit. The ore is processed in the Mounana plant.

The largest portion of exploration activities done in 1993 and 1994 was devoted to the review of current reserves, and the drilling for further resource development in the Okelobondo deposit and its satellite orebodies. In addition, some reconnaissance drilling was carried out in the area of the southern portion of the Lekedi River, referred to as Lekedi-Sud.

Recent and Ongoing Activities

Recent exploration is essentially devoted to the reassessment of the economically interesting areas surrounding known deposits. These areas include the Lekedi dome, located at the axis of the Okelobondo South, Bagombe and Mikouloungou deposits.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
INDUSTRY EXPENDITURES				
(Million FCFA)	591.1	459	696	180
(Thousand US$)	1049.9	938.65	1338.46	342.86
Industry Surface Drilling (Metres)	5 100	4 740	14 352	4 100
Number of Industry Holes Drilled	NA	NA	NA	NA

URANIUM RESOURCES

The major portion of the uranium mineralization in the Franceville basin is considered to be hosted by sandstone. Only the Mikouloungou deposit is classified as an unconformity-related deposit type.

In earlier years, the host sandstone for many of the Gabonese deposits had been interpreted as channel sandstone. Under this assumption, the potential of the deposits in this environment is considered as limited to the areas of channel development. A more recent sedimentological study, conducted between 1992 and 1993, concluded that the host sandstone was deposited in a littoral environment, based on a revised interpretation. This finding increases the potential of the area because extension of the mineralization is considered a distinct possibility.

INSERT MAP OF **GABON** HERE

Known Conventional Uranium Resources (RAR & EAR-I)

Gabon's known resources in the RAR and EAR-I categories, recoverable at costs below $40/kgU, total about 7 000 tU, as of 1 January 1997, as in situ resources. Mining and milling losses are reported to be 10 and 5 per cent respectively, to facilitate the adjustment to recoverable amounts. Higher cost known resources are not reported. The 1997 estimate (7 000 tU) may be compared with the 1995 Red Book total estimate of 15 872 tU. This decline in the known resource categories is due to the reassessment of resources and their adjustment to current market conditions.

The resources of the RAR category amount to 6 026 tU recoverable at costs below $40/kgU as compared to 6 812 tU, as reported in the previous Red Book.

The EAR-I estimate of the below $40/kgU cost category totals only 970 tU as compared to 1 360 tU reported previously.

Of the known resources, 28.9 per cent are tributary to existing production centres.

The distribution by area and resource category of the total known resources of 6 996 tU contained in ore, averaging 0.313 per cent U, is as follows:

Mounana:

RAR: 437.8 tU (in ore grading between 0.35 and 0.76 per cent U)
EAR-I: 260.4 tU (in ore grading 0.41 per cent U)

Outside of Mounana:

EAR-I: 4 274 tU (Mikouloungou, in ore grading between 0.23 and 0.36 per cent U, averaging 0.311 per cent U)
1 055 tU (Bangombe, in ore grading 0.196 and 0.269 per cent U).

Undiscovered Conventional Resources (EAR-II & SR)

The EAR-II resources of Gabon are reported to total 1 610 tU as in situ resources, recoverable at costs of below $40/kgU. Higher cost EAR-II and SR are not reported.

URANIUM PRODUCTION

Historical Review

The uranium production of COMUF has experienced significant fluctuations since the company started producing in 1961. Impacting parameters were the ore processing capacity as well as the international uranium market. The main steps showing the changes were:

1961-1969: attainment of a production level of approximately 400 tU/year;
1970-1973: gradual production increase to 500 tU/year;
1974-1979: rapid production increase to 1250 tU/year;
1980-1989: production decrease to 900 tU/year;
1990-1993: further reduction to 550 tU/year;
1994-1996: maintenance of a production level of 600 tU/year with the possibility of an adjustment to 550 tU/year.

The historical uranium production between 1985 and 1996 is compiled in the following table.

HISTORICAL URANIUM PRODUCTION*

(Tonnes U)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	Expected 1997
• Open pit	11 242	0	0	0	11 242	0
• Underground	12 997	650	652	568	14 867	587
TOTAL	24 239	650	652	568	26 109	587

* Of the total production, 94 tU were found to be depleted in ^{235}U. The uranium was produced from the natural reactor sites of the Oklo deposits.

Status of Production Capability

The present theoretical production capability of the mill is 1 500 tU/year, but the actual production of COMUF amounts to only 600 tU/year, depending upon market conditions.

The underground Okelobondo mine is the only mine presently in operation. As the remaining resources in this mine total approximately 700 tU based on the current production rate, the depletion of the orebody is imminent.

Future plans include the construction of a mine at the Mikouloungou deposit with known resources of 4 270 tU contained in ore grading 0.311 per cent U. Technical details for this project are included in the following table.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

	Centre # 1	Centre # 2
Name of Production Centre	Mounana	Mikouloungou
Production Centre Class	Existing	Existing
Operational Status	Operating	Prepared for Production
Start-up Date	1988	June 1997
Sources of Ore • Deposit Name • Deposit Types	 Okelobondo Sandstone	 Mikouloungou Sandstone
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 UG 800 80	 OP 850 90
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Ore Recovery (%)	 SX 1 300 95	 SX 1 300 95
Nominal Production Capacity (tU/year)	1 500	1 500
Plans for Expansion	No	No

Ownership Structure of the Uranium Industry

COMUF operates under a mutual “Convention d'Établissement” agreement concluded between the Government of Gabon and the company.

The ownership of the 1996 uranium production totalling 568 tU is divided between the various parties in the following ratio:

25 per cent	or	142 tU:	domestic government;
7 per cent	or	40 tU:	domestic private;
68 per cent	or	386 tU:	foreign government.

Employment in the Uranium Industry

Employment in COMUF's mining operations continues to decrease. This is due to the decline of the production rate and the closure of the mines planned to take place in 1999.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	**1995**	**1996**	**Expected 1997**
263	276	259	150

Short-Term Production Capability

Gabon reported its short-term production capability projection through the year 1999. It is based on the existing production centres and known resources recoverable at costs of below $40/kgU.

SHORT-TERM PRODUCTION CAPABILITY

(Tonnes U/year)

1997				1998				1999			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
587	0	0	0	540	0	0	0	540	0	0	0

ENVIRONMENTAL CONSIDERATIONS

The most important environmental concerns are related to the impacts caused by the mining and milling activities. This includes the long-term management of the tailings and other waste produced at the mill site.

• Germany •

URANIUM EXPLORATION

Historical Review

A review of historical events was given in the 1991 Red Book.

Recent and Ongoing Uranium Exploration Activities

No exploration activities were performed in Germany during 1995 and 1996 and the national government is not involved in uranium exploration abroad. German mining companies, however, have continued exploration in Canada. Uranerz carries out exploration projects through its Canadian subsidiary Uranerz Exploration and Mining (UEM) in Saskatchewan. Urangesellschaft activities are conducted by Cogema.

URANIUM EXPLORATION EXPENDITURES – ABROAD

	1994	1995	1996	1997 (Expected)
INDUSTRY EXPENDITURES				
D-Mark (x 1000)	4 366	4 102	4 760	6 755
US$ (x 1000)	2 646	2 951	3 111	4 358

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Due to the termination of uranium mining and the closure of production centres, the known conventional resources were reassessed in 1993. The reassessment resulted in a shift of both RAR and EAR-I from the less than $80/kgU cost category into the $80-130/kgU cost category and an overall decrease of known conventional resources in the less than $130/kgU cost category.

The known conventional resources in the above $130/kgU cost category remain unchanged from those reported in the 1991 Red Book.

The known conventional resources occur mainly in the closed mines which are in the process of being decommissioned. Their future availability remains uncertain.

Undiscovered Conventional Resources (EAR-II & SR)

Due to a reassessment, all EAR-II are reported in the cost category above $130/kgU. A minor portion, yet unassessed, may be recoverable at costs between $80/kgU and $130/kgU.

URANIUM PRODUCTION

Historical Review

A description of historical production was given in the 1991 Red Book.

Status of Production Capability

There is no commercial production of uranium in Germany. Uranium recovered from cleanup operations is estimated at 30 tU for 1997.

Two production centres, Ellweiler mill and Crossen mill, were closed permanently in 1989. Both mills will be dismantled and the areas reclaimed. At the Seelingstädt mill in Thuringia, only parts remained operational for the treatment of slurry produced by underground leaching at the Königstein mine. Production since 1992 is derived from cleanup operations of the underground leaching mine at Königstein, Saxony.

Ownership Structure of the Uranium Industry

There are no new changes in the ownership structure of the uranium industry in Germany since the ones reported in the 1993 Red Book. These changes included: Urangesellschaft and Interuranium, merged in 1992 under the name of Urangesellschaft. In the same year, Cogema obtained 69.4 per cent of Urangesellschaft. In addition, Urangesellschaft is 10.3 per cent owned by Steag and Preussenelektra each, and 5 per cent by Badenwerk and EVS, each. Ownership of Uranerzbergbau remained unchanged (Rheinbraun and Preussag Energy Co., each 50 per cent).

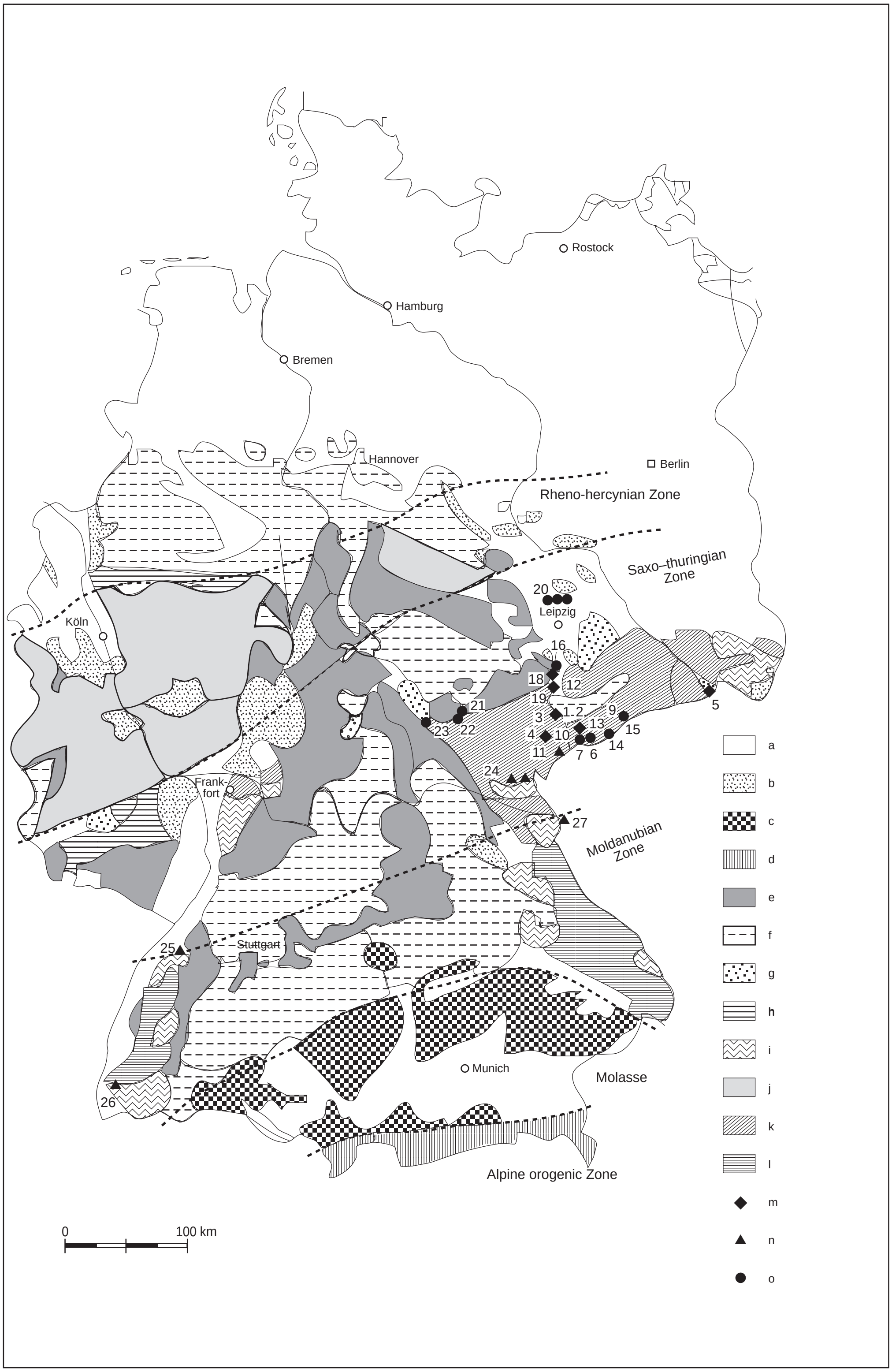
Employment in the Uranium Industry

All present employment at Wismut is engaged in decommissioning and rehabilitation activities. At the end of 1996, employment in the company totalled 4 200 persons, decreasing from 4 400 at the end of 1995 and 4 613 at the end of 1994.

Future Production Centres

There are no future production centres planned for Germany.

Uranium deposits and occurences in the Federal Republic of Germany



LEGEND

I GEOLOGY

a. Quaternary
b. Tertiary
c. Alpine molasse (Tertiary)
d. Alpine orogenic zone (Mesozoic)
e. Mesozoic sandstones
f. Mesozoic
g. Permian vocanics (rhyolite)
h. Permocarboniferous
i. Variscian granites
j. Rheno-hercynian zone (Paleozoic)
k. Saxo-thuringian zone (metamorphic)
l. Moldanubian zone (metamorphic)
m. Uranium deposits > 5 000 tonnes of uranium
n. Uranium deposits 500 - 5 000 tonnes of uranium
o. Uranium occurrences

II URANIUM DEPOSITS AND OCCURRENCES

1 Ronneburg/Thuringia
2 Schlema/Saxony
3 Culmitzsch-Sorge-Gauern/Thuringia
4 Zobes/Saxony
5 Königstein/Saxony
6 Tellerhäuser/Saxony
7 Johanngeorgenstadt/Saxony
8 Freital/Saxony
9 Annaberg/Saxony
10 "Weisser Hirsch" (Antonsthal) Saxony
11 Schneckenstein/Saxony
12 Hauptmannsgrün-Neumark/Saxony
13 Rittersgrün/Saxony
14 Bärenstein/Saxony
15 Marienberg/Saxony
16 Zeitz-Baldenhain/Thuringia
17 Prehna/Thuringia
18 Untitz/Thuringia
19 Gera-Süd/Thuringia
20 Serbitz, Kyhna-Schenkenberg and Werben/Saxony
21 Rudolfstadt/Thuringia
22 Dittrichshütte/Thuringia
23 Schleusingen/Thuringia
24 Grossschloppen/Bavaria
25 Müllenbach/Baden-Württemberg
26 Menzenschwand/Baden-Württemberg
27 Mähring-Poppenreuth/Bavaria

ENVIRONMENTAL CONSIDERATIONS

Mining and milling of uranium ore in Germany was conducted between 1946 and 1990 in the eastern part of the country (former GDR) by the joint Soviet-German company SDAG Wismut. In the western part of the country, only limited mining and milling activities occurred. As all the sites in the western part have been decommissioned and were reclaimed before 1992, the bulk of remediation has occurred since 1991, in the eastern part (former GDR).

Uranium mining and milling by SDAG Wismut led to important developments as about 216 000 tU were produced from numerous mines, both open pit and underground. The area affected by uranium production activities covers a total of about 240 km^2, mainly in the mountainous part of the Erzgebirge and in eastern Thuringia.

The total volume of ore produced between 1949 and 1990 was estimated at about 240 million tonnes. In addition, about 760 million tonnes of waste rock were removed and piled up in the vicinity of the mines.

During the mining period, limited rehabilitation activities were carried out, mostly to avoid immediate impact on populated areas. Abandoned mine sites have been returned to local authorities, however the extent of rehabilitation has been limited.

In 1991, immediately after the reunification of Germany, a programme for the evaluation of necessary cleanup activities was initiated. Areas still held by the mining company (37 km^2) were commissioned for rehabilitation to Wismut which was legally transferred to a privately organized company (GmbH) with the Federal Government as sole shareholder, represented by the Federal Ministry of Economics. Expenses for decommissioning and rehabilitation are paid out of the Federal budget.

Areas outside the actual mining zones were commissioned to the Federal Office of Radiation Protection for the evaluation of environmental impacts resulting from previous uranium mining and milling activities. These areas cover about 1 500 km^2, with about 5 000 abandoned mining sites including sites for medieval silver mining, base metal mining and more recently, uranium mining. After a detailed investigation, it was determined that an area of about 250 km^2 required further investigation and cleanup, to be carried out by local authorities.

In the area held by Wismut at present, a selected number of decommissioning and restoration activities being carried out include:

1. *Reclamation of the Lichtenberg open pit*

   The open pit, which is about 1.6 km^2, is located near the city of Ronneburg. During the mining period, approximately 160 million m^3 were excavated to a depth of 200 metres. Later, the open pit was partly backfilled with about 80 million m^3 of waste rock from underground mines. Presently, waste rocks piled around Ronneburg with a volume of about 100 million m^3 have been partly removed and backfilled into the open pit.

   Monitoring of the groundwater is required as the flooding of the adjacent underground mines will have an impact on the reclamation both of the mines and the open pit.

2. *Reclamation of underground mines*

   During mining, a total of about 1 400 km of drifts and shafts have been driven at numerous sites. Controlled backfilling, underground dams and additional measures are required to safely rehabilitate the sites. In addition, continuous monitoring of groundwater after flooding is necessary.

3. *Remediation of waste rock piles*

   During underground mining, about 300 million m^3 of material were removed, of which about 150 million m^3 were ore shipped for processing to the mills. In the Aue mining district only, about 45 million m^3 of waste rock have been piled at 40 different sites, most of them close to populated areas. Their stabilisation, reshaping, covering and revegetation has, for the major part, already been concluded.

4. *Remediation of mill tailings*

   Two major mills, at Crossen, near Zwickau and at Seelingstädt, near Ronneburg, have been operated besides a number of smaller ones.

   The tailing pond of the Crossen mill is about 2 km^2 and contains approximately 45 million m^3 of tailings and about 6 million m^3 of water.

   The two tailing ponds of the Seelingstädt mill cover an area of 3.4 km^2 and contain a total volume of 107 million m^3 of tailings.

   Both sites are presently under reclamation by dewatering and covering with barren material.

   Major monitoring programmes will be required to control effluents from the tailing ponds and to prevent any contamination of the surrounding area (groundwater, surface water, prevention of dust and radon exhalation).

5. *Remediation of the Königstein ISL mine*

   At Königstein, underground leaching of ore has been applied following the termination of conventional mining. In 1991, when the decision to close was made, parts of the orebody were prepared for leaching with sulfuric acid. A programme for a gradual decommissioning is under way, still producing limited quantities of uranium (30 to 40 tU per year). Final decommissioning and site rehabilitation will continue over some years. Due to the vicinity of the site with the Elbe river and the densely populated area of Dresden (with approximately 500 000 inhabitants and located about 30 km downstream), preventive measures for ground and surface waters need to be taken into consideration. Therefore the total cost for decommissioning and rehabilitation is estimated at about 2.3 billion DM.

   The total costs for decommissioning and rehabilitation of all the Wismut sites were estimated at 13 billion DM and the completion of these activities will take about 15 years.

   Five billion DM have already been spent between 1991 and 1996. Most of the expenditures relate to the complex programme of the Ronneburg sites where a number of deep mines (up to 1 000 metres) have been active, the open pit of Lichtenberg has to be backfilled and contaminated material has to be removed. Expenditures for this area were estimated at 4.3 billion DM. In addition, about 3.2 billion DM will be required for the nearby Seelingstädt mill site.

Details on the rehabilitation programme are described in the BMWi publications, identified as BMWi Documentation No. 335 and No. 370, or can be obtained directly by writing to Wismut.

URANIUM REQUIREMENTS

There are no significant changes to future uranium requirements described in previous editions of the Red Book. The annual reactor-related requirements are adjusted to present conditions.

Supply and Procurement Strategy

There are no changes to the supply and procurement strategy.

NATIONAL POLICIES RELATING TO URANIUM

There is no restriction for private and/or foreign participation in uranium exploration, production and marketing as long as these activities are carried out under existing laws.

Government funding of uranium exploration was terminated by the end of 1990.

URANIUM PRICES

See information from the Euratom Supply Agency.

• Greece •

URANIUM EXPLORATION

Historical Review

Numerous uranium exploration surveys have been carried out at various stages from 1955 to the present. From 1955 to 1970, various reconnaissance surveys were performed over potential areas in Greece. They included airborne radiometric surveys over northern regions of the country in 1966 and carborne scintillometry in the same areas during the 1969-1977 period. Beginning in 1971, systematic uranium exploration was undertaken in Macedonia and Thrace where the results of carborne surveys and geochemical water and stream sediment sampling combined with radiometric measurements on sampling sites of the reconnaissance phase indicated the necessity of a detailed "follow-up" phase. This part of exploration was performed by the Greek Atomic Energy Commission in co-operation with the UNDP and the IAEA.

Since 1978, work has focused on the definition of uranium deposits by trenching, drilling and test mining, conducted by the two government organisations concerned – the Greek Atomic Energy Commission (GAEA) and the Department of Energy Resources (DER) of the Institute of Geology and Mineral Exploration (IGME). The reconnaissance surveys continued covering the whole country and an effort was made to estimate more accurately the uranium resources contained in the Serres lignites and coal-bearing shales.

In the 1983-1986 period, the carborne scintillometer survey (CBS) was completed covering the whole country. In Serres tertiary basin, the detailed exploration in some prospects was also completed and the uranium was estimated. Follow-up work and detailed exploration was mainly focused in northern Greece, Macedonia and Thrace.

In the Paranesti district, activities included the detailed exploration on the Archontovouni, Fteroto and Spilia prospects and the construction of a small pilot plant (a joint project between IGME and EEC) for testing the recovery of uranium from Archontovouni oxidised ore, mainly autunite.

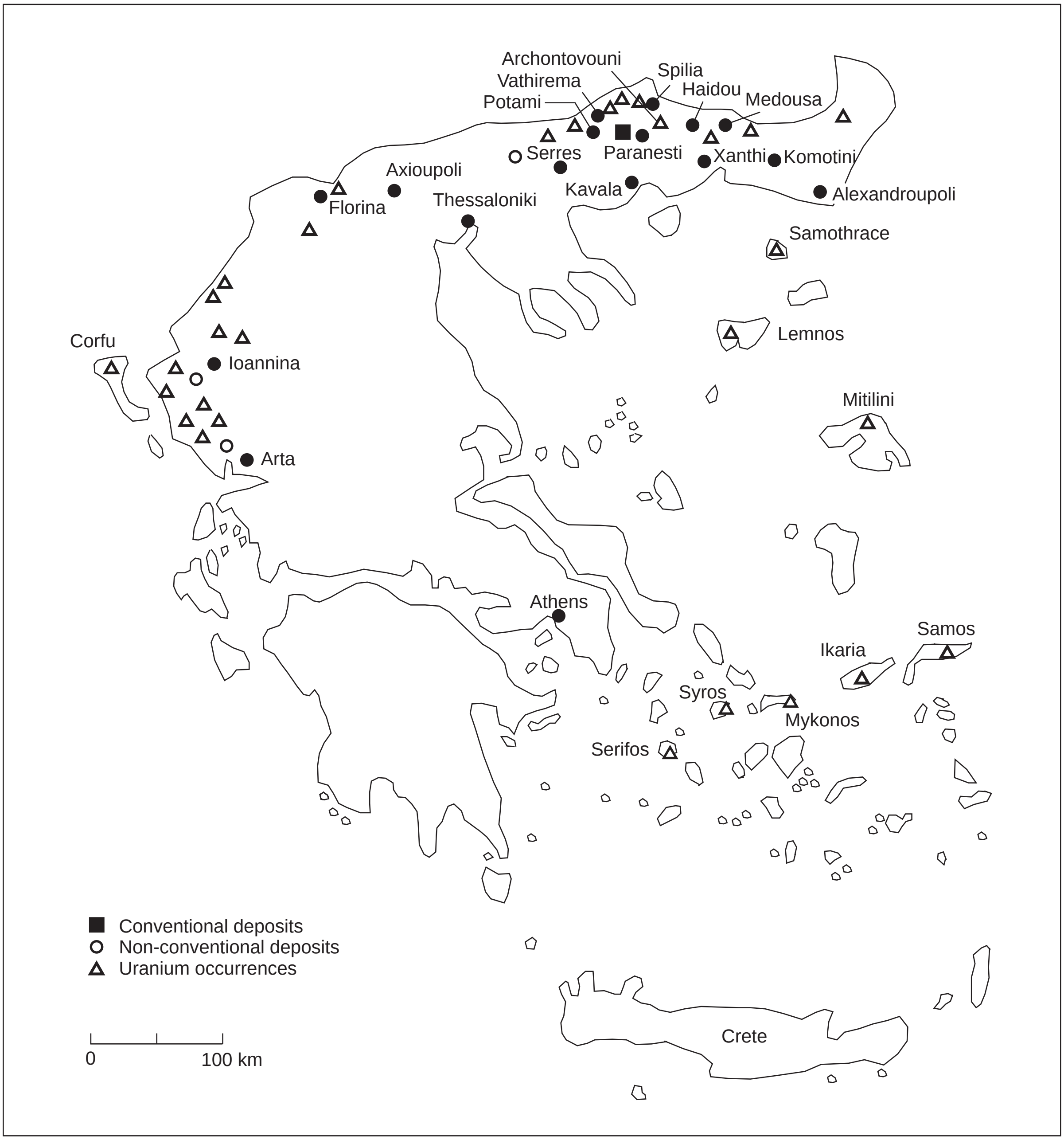
During the 1984-1985 period, the merging and incorporation of GAEA and IGME uranium exploration activities took place. From 1986 to the present, the level of exploration activities has been stabilized mainly as a result of a planning programme implemented by IGME. Most of the uranium exploration projects were carried out in northern Greece where pitchblend mineralization was located in three projects: Spilia, Ktima in the Paranesti district and Mavrorema in Thrace.

Recent and Ongoing Uranium Exploration Activities

Plans for the near and medium-term period include:

- Uranium potential estimation in the following regions: Lesbos island, Thrace, Eastern Macedonia, north-eastern Chalkidiki, Serres, the Rhodope Massif and the Strymon Gulf for uranium and rare earths mineralization.
- Preliminary exploration and evaluation in potential areas located in previous years.

Uranium deposits and occurrences in Greece



URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT – DOMESTIC

	1994	1995	1996	1997 Expected
GOVERNMENT EXPENDITURES				
Greek Drachmas (x 1000)	36 600	33 500	66 373	70 000
US$ (x 1000)	154	148	273	290
Government Surface Drilling in Metres	2 895	1 897	1 500	
Number of Government Holes Drilled	30	16	18	
TOTAL SURFACE DRILLING (Metres)	2 895	1 897	1 500	
TOTAL HOLES DRILLED	30	16	18	

Known Conventional Resources (RAR & EAR-I)

The uranium estimates that have been made in the years up to 1994 have included the calculated reserves for two prospects in the localities of Spilia, Paranesti area and Maramena in Serres Basin, all in metallogenic districts in northern Greece.

The known conventional resources (RAR & EAR-Category I) refer to the Archontovouni, Spilia, disseminated and vein-type U deposits, related to granitoid host rocks of the crystalline basement of the Rhodope metamorphic massif and Maramena in Serres Basin where uranium is related to tertiary sandstones and carbonaceous silts. According to recent results from mineral processing procedures they are now included in the reasonably assured conventional resources.

The drilling surveys have crossed vein-type pitchblend in Spilia prospect. In Archontovouni the mineralization consists mainly of secondary uranium minerals.

It is important to mention that one of the potential uranium deposits is found rich in rare earths. The average grades of the recently discovered deposits are in the range of 0.03 to 1 per cent U with rare earths in the yellow cake concentrate. The granitoid rocks hosting the uranium mineralization are of Pre-Paleozoic age and the mineralization is believed to be of a younger age.

Undiscovered Conventional Resources (EAR-II & SR)

Preliminary surface exploration and in certain cases drilling surveys have delineated a number of potential regions. More specifically, the areas of interest are:

- Andiro and Fteroto, where mineralization is of a disseminated type;
- Alexandroupolis, where pitchblend occurs in crystalline metamorphic host rocks of the Rhodopi massif;
- Xanthi and Lesbos Island, where mineralization is located in volcanic rocks of the Eocene Age, in the form of disseminated ore.

Concentrations of uranium, thorium rare earths, titanium, and the like, are found in the following locations:

- Florina, which is a basin in tertiary sandstone formations;
- Ikaria Island, which has silcrete formations of the Quaternary Age;
- the Strymon Gulf, which has quaternary clastic sediments in both coastal and submarine areas.

• Hungary •

URANIUM EXPLORATION

Historical Review

The first reconnaissance for uranium started in 1952 when, with Soviet participation, material from Hungarian coal deposits was checked for its radioactivity. The results of this work led in 1953 to a geophysical exploration programme (airborne and surface radiometry) over the western part of the Mecsek mountains. The discovery of the Mecsek deposit in Permian sandstones was made in 1954. Further work aimed at the evaluation of the deposit and its development. In 1956, the Soviet-Hungarian Uranium Joint Venture was dissolved and the project became the sole responsibility of the Hungarian State. In the same year, uranium production from the Mecsek deposit started.

Exploration conducted by the geological staff of the Mecsek uranium mine continued through 1989 until it was terminated because of changed market conditions.

URANIUM RESOURCES

Hungary's reported uranium resources are limited to those of the Mecsek uranium deposit.

The ore deposit occurs in Upper Permian sandstones which may be as thick as 600 metres. The sandstones were folded into the Permian-Triassic anticline of the Mecsek mountains. The ore bearing sandstone occurs in the upper 200 metres of the unit. It is underlain by a very thick Permian siltstone and covered by a Lower Triassic sandstone. The thickness of the green ore bearing sandstone, locally referred to as the productive complex, varies from 15 metres to 90 metres.

The ore minerals include uranium oxides and silicates associated with pyrite and marcasite.

Known Conventional Resources (RAR & EAR-I)

The uranium resources include both known and undiscovered resources as detailed in the following tables.

The known uranium resources, as of 1 January 1997, include RAR and EAR-I recoverable, at costs below $130/kgU and total 15 775 tU as compared to 16 317 tU, reported in the previous report.

Total RAR recoverable at below $80/kgU amount to only 368 tU (2.3 per cent of total known resources) while no resources of the below $40/kgU category were reported.

EAR-I resources in the $130/kgU cost category total 15 407 tU, about 238 tU less than estimated previously while no resources are listed below the $80/kgU category.

All known uranium resources recoverable at costs of below $130/kgU are tributary to the existing and operating Mecsek production centre.

The 1 January 1997 resources of the RAR and EAR-I categories are summarised in the following tables.

REASONABLY ASSURED RESOURCES

(Tonnes U – as of 1 January 1997)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	368	368

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I

(Tonnes U – as of 1 January 1997)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	0	15 407

Undiscovered Uranium Resources

Hungary reports 15 482 tU as undiscovered resources of the EAR-II category. The entire amount is estimated to be recoverable at costs of below $130/kgU. No Speculative Resources are estimated.

URANIUM PRODUCTION

Historical Review

The Mecsek mine is an underground operation and is the only uranium producer in Hungary. Prior to 1 April 1992, it was operated as the state-owned Mecsek Ore Mining Company (MÉV). The complex began operation in 1956 and is now producing ore from a depth of 600 metres to 800 metres. It has been producing about 500 000 to 600 000 tonnes ore/year at an average mining recovery of 50 to 60 per cent. The ore processing plant has a capacity of 1 300 to 2 000 tonnes ore/day and employs radiometric sorting, agitated acid leach (and heap leaching) with ion exchange recovery. The nominal production capacity of the plant is about 700 tU/year.

The Mecsek mine consisted of 5 sections with the following history:

Section I: operating from 1956 to 1971;
Section II: operating from 1959 to 1988;
Section III: operating from 1961 to 1993;
Section IV: operating from 1971 to today;
Section V: operating from 1988 to today.

The ore processing plant became operationable in 1963. Until that time, raw ore was exported to the USSR. A total of 1.2 million tonnes ore was shipped to the Sillimäe Metallurgy Plant in Estonia. After 1963, uranium concentrates were shipped to the Soviet Union.

At present, the Mecsek operation is in a state of adjustment to the new economic and political conditions. This includes a reduction of both uranium production and the work force. Uranium mining and milling operations in sections IV and V are expected to be closed down at the end of 1997.

Heap and In Situ Leaching Activities

Mecsek Ore Mining Enterprise actively prepared for heap leaching of low grade uranium ores from 1965 until 1989, when the building of heaps was stopped. During this period about 7.2 million tonnes of low-grade ore with a uranium content of 100 to 300 grams U/t were crushed to under 30 millimetres and placed in 2 piles for leaching. The first pile, designated Site Number I, containing 2.2 million tonnes is no longer being leached. Rehabilitation of the site is being planned.

Site Number II, including 5.0 million tonnes, is located in an isolated basin and is still undergoing leaching. Following leaching with sodium carbonate solutions, uranium is recovered using ion exchange resins. Annual uranium production ranged from 5.5 tU, in the first year of operation, to 24.2 tU recovered in 1980. Production continued in 1994 with 8.2 tU recovered. Total production for the project is 525.2 tU. The average recovery is about 60 per cent.

During the early 1980s Hungary conducted exploration for sandstone hosted uranium deposits amenable to in situ leaching. A potentially favourable deposit was identified at the Dinnyeberki site about 20 km west of Pecs in southwestern Hungary. The uranium deposit occurs in an organic rich non-consolidated tuff layer in a sedimentary sequence of Tertiary age. The associated sediments occupy troughs of structural and erosional origin developed in the pre-Cenozoic basement. During 1988 test leaching was carried out using acid solutions injected through wells. The tests were discontinued and no further in situ leaching was conducted.

Status of Production Capability

The Mecsek Uranium Company had to decrease its production because of changing delivery and market conditions. Production has decreased from over 400 tU in 1994 to about 200 tU in 1995 and 1996. In addition, the Hungarian Government decided in December 1994 to stop uranium mining as of 31 December 1997. An earlier decision to suspend uranium mining was made in September 1989. This decision was later reversed following a reassessment of the situation.

Ownership Structure of the Uranium Industry

The Mecsek operation had been an affiliate of the state-owned property agency through 1992. Following an evaluation of all the assets, Mecsekuran Ltd. was incorporated. The assets were divided between the state and the company in such a way that the resources remain state property, while the mining concession was transferred to Mecsekuran. The production is considered to be controlled by domestic private industry.

Employment in the Uranium Industry

The employment in the Mecsek mine and mill has been significantly reduced from the peak work force in 1985 of about 7 454 to 1 766 in 1994. In the subsequent years 1995 and 1996 employment totalled 1 250 and 1 144 persons, respectively. In view of the production decrease planned for 1997, employment is expected to further decrease to 1 100 persons (see table).

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	**1995**	**1996**	**1997**
1 766	1 250	1 144	1 100

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January, 1997)

	Centre # 1
Name of Production Centre	Mecsekuran Ltd.
Production Centre Class	Existing
Operational Status	Operating
Start-up Date	1956
Sources of Ore • Deposit Name • Deposit Type	 Mecsek Sandstone
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 UG 1 000 70
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Ore Recovery (%)	 IX 1 000 90
Nominal Production Capacity (tU/year)	500

Short-Term Production Capability

Following the decision of the Hungarian Government to discontinue uranium production at the end of 1997, the capability projection is only through that time as shown in the following table.

SHORT-TERM PRODUCTION CAPABILITY

(Tonnes U/year)

1997				1998			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
0	0	200	0	0	0	30	0

ENVIRONMENTAL CONSIDERATIONS

In 1996, Mecsekuran Ltd. and the Mecsek Ore Mining Company (MÉV) prepared the conceptual plan for the decommissioning of the uranium industry in the Mecsek region. This plan sets out the methodology and schedules for the shut-down of mines and processing plants. It also contains details on dismantling and demolition together with land restoration and environmental rehabilitation.

The competent Hungarian authorities (mining, environmental and water agencies) have examined this plan and the financing requirements have recently been provided to the Government for consideration and approval.

URANIUM REQUIREMENTS

Hungary operates the Paks nuclear plant consisting of four NPPs of the WWR-230 type with a total net nuclear electricity generating capacity of 1 760 MWe. At present, there are no firm plans for the construction of additional plants.

The annual uranium requirements for these NPPs are reported to be about 415-430 tU. Until 1994, the requirements could be met by uranium mined domestically. As production will cease by the end of 1997, uranium requirements in the future will be solely satisfied by imports.

URANIUM PRICING

The COMECON contract prices for nuclear fuel cycle materials and services were in force until the end of 1990.

Since 1991, an agreement between the Mecsek Ore Mining Company and the Hungarian Electric Works, operator of the Paks nuclear power plants, provides for a uranium price of $60/kgU. This arrangement applied to the total reactor-related requirements through 1994. As a portion of the post 1994 requirements will have to be imported, the average uranium price of the total can be expected to be lower.

NATIONAL POLICIES RELATING TO URANIUM

In 1994, the Hungarian Government decided to discontinue domestic uranium production at the end of 1997.

• India •

URANIUM EXPLORATION

Historical Review

The history of uranium exploration in India dates from 1949. Until the mid 1970s, uranium exploration was mainly confined to known uranium provinces in the Singhbhum, Bihar and Umra-Udaisagar belt in Rajasthan where vein-type mineralization was already known. One deposit at Jaduguda in Singhbhum, Bihar has been exploited since 1967 and many other deposits in nearby areas were earmarked for future exploitation.

Subsequently, investigations were expanded to other geologically favourable areas, based on conceptual models and an integrated exploration approach. This resulted in the discovery of two main types of deposits:

- a relatively high grade, medium tonnage deposit in the Cretaceous sandstones of Meghalaya in North-eastern India;

- low grade, large tonnage, stratabound deposit in the Middle Proterozoic dolostones of Cuddapah Basin in Andhra Pradesh.

However, other small, moderately low grade deposits discovered during this phase of exploration are:

- Lower Proterozoic amphibolites at Bodal, Madhya Pradesh;
- Lower Proterozoic sheared migmatites of Chhottanagpur gneiss Complex at Jajawal, Madhya Pradesh;
- Basal quartz pebble conglomerates at Walkunji, Western Karnataka and Singhbhum, Bihar.

During the early 1990s, a near-surface deposit was discovered adjacent to the unconformity surface of basement granites with overlying Proterozoic sediments at Lamabapur, Nalgonda district, Andhra Pradesh.

Recent and Ongoing Uranium Exploration Activities

During 1995 and 1996, based on the favourable geological criteria and preliminary exploration, the following five thrust areas were identified for intensive investigations.

1) Cuddapah Basin, Andrah Pradesh;
2) Cretaceous sandstones of Meghalaya;
3) Son Valley, Madhya Pradesh and Uttar Pradesh;
4) Singhbhum, Bihar and Orissa;
5) Aravallis, Rajasthan.

Exploratory drilling in the environs of the Lambapur area, where a near-surface uranium deposit was located along the Proterozoic unconformity between basement granites and overlying Srisailam quartzite, has established an additional 1 950 tU (EAR-I) at the Peddagattu area in the north-western part of the Cuddapah Basin. The major part of the basin, however is still to be explored.

Cretaceous sandstones in Meghalaya have already been established as a potential horizon for uranium concentration. Survey and exploration in the environs of the Domiasiat uranium deposit have brought to light promising anomalies.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
Million Rupees	292.13	297.52	251.40	285.7
US$ (x 1000)	9 363.14	9 535.90	7 394.12	8 047.89
Government Surface Drilling (Metres)	31 510	35 249	32 762	35 450

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

As in the past, India's uranium resources have been categorised as RAR and EAR-I without assigning any cost category.

These resources are located mainly in the following deposits:

- Vein and disseminated-type deposits associated with the Singhbhum Shear Zone, Bihar.
- Sandstone-type deposits in the Cretaceous sediments of Meghalaya.
- Unconformity-related type deposits at the base of the Proterozoic sediments along the north-west of the Cuddapah Basin in Andra Pradesh.
- Dolostone-hosted stratabound-type of the Cuddapah Basin in Andra Pradesh.

Since the publication of the last resources estimates, the total EAR-I resources have increased by 1950 tU, contributed by the unconformity-related deposits along the north-western margin of the Cuddapah Basin. Exploration results from the Cretaceous sandstones of Meghalaya, north-west of Cuddapah, are quite encouraging and substantial resources are likely to be established.

INSERT MAP OF **INDIA** HERE

KNOWN URANIUM RESOURCES*

(Tonnes U)

Cost Range Unassigned	
RAR	EAR-I
52 080	24 245

* As in situ resources.

Undiscovered Conventional Resources (EAR-II & SR)

There is no change in the EAR-II estimate reported in the Red Book of 1995. Additional Speculative Resources of 17 000 tU have been assessed in the Proterozoic metasediments of the Cuddapah Supergroup, Andhra Pradesh; Aravalli Supergroup, Rajasthan; Singhbhum-Orissa Craton, Bihar and Orissa; Son Valley area, Uttar Pradesh and the Cretaceous sandstones of Meghalaya.

UNDISCOVERED RESOURCES*

(Tonnes U)

Cost Range Unassigned	
EAR-II	SR
14 725	17 000

* As in situ resources.

UNCONVENTIONAL OR BY-PRODUCT RESOURCES*

Deposit	**Location**	**Tonnes U**		**Production Centre Name**
Copper deposits of Singhbhum Thrust Belt	Singhbhum district, Bihar	6 615	Recoverable	Jaduguda
Phosphorite	Distributed over the country	1 695	Recoverable	none

* From 1993 Red Book.

URANIUM PRODUCTION

Historical Review

The Uranium Corporation of India Limited (UCIL) was formed in October 1967 under the administrative control of the Department of Atomic Energy, Government of India. UCIL is now operating three underground mines at Jaduguda, Bhatin and Narwapahar in the eastern part of the Singhbhum District, Bihar State. The ore is processed in the process plant located at Jaduguda.

Uranium is recovered as a by-product from the copper tailings available from the copper concentrator plants of M/s Hindustan Copper Ltd., at Rakha, Mosaboni mines. The uranium is then further processed in the Jaduguda mill.

Status of Production Capability

The total installed capacity of the Jaduguda mill is about 2 100 t ore/day.

Jaduguda Mine

The Jaduguda deposit consists of two ore bodies. The Foot Wall Lode (FWL) and the Hanging Wall Lode (HWL) are separated by a distance of about 60 to 100 metres. The FWL extends over a length of about 800 metres in the southeast-northwest direction. The HWL is about 200 to 300 metres long and is confined to the eastern part of the deposit. The average width is 3 to 4 metres, with a maximum of 20 to 25 metres. The FWL is more heavily mineralised and in addition to uranium, contains copper, nickel and molybdenum sulphide minerals. Both lodes have an average dip of 40 to 45 degrees to the north-east. The deposit has been explored to a depth of 800 metres and is open below this level. The ore occurs in veins located in the metamorphic rocks of the Singhbhum Thrust Belt. The host rocks are of Proterozoic age.

The Jaduguda Mine was commissioned in October 1967. It uses a 5 metre diameter, 640 metre deep shaft to access the steeply dipping orebody. An auxiliary blind shaft is under development to access ore at depths between 555 and 900 metres below the surface. The new shaft is located 580 metres north of the main shaft. Mine levels are to be developed at depths of 620, 685, 750, 815 and 880 metres. The crushing and loading stations are, respectively, at the 835 and 865 metre levels.

In the main shaft, ore is hoisted in a 5-tonne skip from the 605 metre level. The main working levels are developed at 65 metre intervals. Development and mining is by conventional drill and blast operation using a drilling jumbo. A cut-and-fill stopping method is used to give about 80 per cent ore recovery. Load-Haul-Dump (LHD) equipment is used to transfer ore to loading pockets where it is transferred to diesel powered track haulage for transport to the shaft for lifting to the surface. De-slimed tailings are used for backfill.

Narwapahar Mine

The conventional Narwapahar Mine, located about 10 km from Jaduguda, is also under construction. The Narwapahar Deposit consists of uraninite in chlorite-quartz schist with associated magnetite. The underlying schist is similar in composition but contains a greater amount of magnetite. The maximum strike length of the orebodies is 2 100 metres and they extend to a depth of 600 metres. There are six uranium bearing units or lodes. The orebodies are lens shaped, with an average north-easterly dip of 30 to 40 degrees. The thickness of individual orebodies varies from 2.5 to 20 metres.

The deposit is being developed by a 350 metre-deep vertical shaft and a 7 degree decline from the surface. The decline provides access for trackless mining equipment. By May 1995 the shaft had reached a depth of 200 metres. Room and pillar development is being used where the orebody is narrow, while cut and fill is used in areas of increased thickness.

Bhatin Mine

The Bhatin deposit is located 4 km north-west of the Jaduguda deposit. A major fault occurs between the two deposits. The Bhatin Mine came into production in 1986. It is developed on an orebody with a thickness of 2 to 10 metres and an average dip of 30 to 40 degrees. The geology is similar to the Jaduguda Deposit. The host rock is chlorite biotite schist. The small deposit is developed using adits and inclines and is mined using the cut and fill method. Trucks are used to transport the ore to the Jaduguda Mill.

Uranium recovery from copper tails

Three Uranium Recovery Plants at Rakha, Surda and Mosaboni also recover uranium from mill tails from copper concentrators. They were placed in production in the 1970s and 1980s. Following extraction of copper, the tails, with an average content of about 0.01 per cent U_3O_8, are sent to the Uranium Corporation of India Limited (UCIL) plants for uranium mineral recovery. A uranium bearing heavy mineral concentrate is produced by tabling the tails. The concentrates are transported by truck to the Jaduguda Mill for further processing. The combined output of the three plants is about 150 t/day concentrates.

Jaduguda Mill

Uranium ore produced from the Jaduguda, Bhatin and Narwapahar Mines, together with uranium mineral concentrates transported from Uranium Recovery Plants, are processed in the mill located at Jaduguda. It has an installed capacity of 1 370 t/day ore and an annual uranium production capacity of 170 tU. The mill is being expanded to process 2 000 t/day ore and to produce 230 tU/year. The mill was commissioned in October 1967. Jaduguda is in eastern India, about 150 km west of Calcutta.

Following crushing and grinding to 60 per cent passing 200 mesh, ore is leached in pachuca tanks at a temperature of about 37°C using sulphuric acid. Following drum filtration of the pulp, ion exchange resin is used to recover uranium. Following elution, the product is precipitated using magnesia to produce magnesium di-uranate containing 74 per cent U_3O_8. Mill recovery is about 95 per cent.

A system of water treatment and reclaiming of tailings water implemented in March 1990 resulted in reduction of fresh water requirements, as well as increasing purity of the final effluent.

UCIL also operates a flotation plant to recover by-product copper and molybdenum sulphides from uranium ore, as well as a Magnetite Plant to recover magnetite also present in some of the ore.

Ownership Structure of Uranium Industry

The uranium industry is wholly owned by the Department of Atomic Energy, Government of India.

The Atomic Minerals Division under the Department of Atomic Energy is responsible for uranium exploration programmes. Following discovery and deposit delineation, analysis is conducted to confirm the existence of a viable orebody. The evaluation stage may include exploration mining.

Once a deposit of sufficient tonnage and grade is proved, it is turned over to UCIL for commercial mining and production of uranium concentrates. UCIL was established on 16 October 1967 as a Public Sector Enterprise with the objective of mining and processing of uranium ore. The registered office is at Jaduguda, Singhbhum District, Bihar State, the principal location of India's uranium mining and milling operations.

Future Production Centres

The uranium deposit located at Domiasiat in the West Khasi Hills District, Meghalaya State, north-eastern India, is being developed and construction has commenced. It is proposed that an open-pit mine and a process plant be established at Domiasiat to exploit the orebody.

Environmental Aspects

There are no environmental issues related to existing uranium mines. However, provisions are made for the management of environmental impacts. The organisation responsible for this task is the Health Physics Group of the Bhabha Atomic Research Centre, located in Bombay. It carries out environmental health monitoring of radiation, radon and dust at uranium production facilities. The Health Physics Group operates an Environmental Survey Laboratory at Jaduguda.

SUPPLY AND PROCUREMENT STRATEGY

In India, the exploration for uranium is carried out by the Atomic Minerals Division, a wholly government-owned organisation. No private or foreign companies are involved in exploration, production and/or marketing of uranium. The Uranium Corporation of India Limited, a Public Sector Undertaking under the Department of Atomic Energy, is responsible for the production of yellow cake. The rest of the fuel cycle, through the manufacture of fuel assemblies is the responsibility of the Nuclear Fuel Complex, another wholly government-owned organisation.

The investment in uranium production in India is directly related to the country's nuclear power programme. For planning purposes the lead-time between exploration and development of a uranium mine and mill is seven years.

• Indonesia •

URANIUM EXPLORATION

Historical Review

Uranium exploration by the Nuclear Minerals Development Centre of the Indonesian National Atomic Energy Agency (BATAN) started in the 1960s. The first stage regional reconnaissance covered approximately 78 per cent of a total of 533 000 km^2 estimated to be favourable for uranium mineralization. Methods employed during the reconnaissance phase included integrated geochemical stream sediment, heavy mineral and radiometric surveys. Several geochemical and radiometric anomalies were found in granitic, metamorphic and sedimentary environments. Subsequently, uranium occurrences were identified in Sumatra, the Bangka Tin Belt and Sulawesi. A more detailed evaluation of these occurrences has not been made as all exploration activities conducted since 1988 were concentrated in the Kalan area, West Kalimantan.

During 1991-1992, exploration continued in this area, directed both in the surroundings and at the uranium occurrence Kalan. A significant drilling programme was completed in 1992. The statistical details are summarised in the table below. The results of the exploration to date were summarised and incorporated in a pre-feasibility study for a possible uranium mining operation at Kalan. Uranium exploration expenditures have been in the US$ 500 000 to 600 000 range in 1995 and 1996. They are expected to remain at about this level in 1997. During 1995-1996 reconnaissance mapping was completed over a total area of 3 000 km^2 and 3 050 km^2, respectively. Reconnaissance mapping is expected to decrease to 50 km^2 in 1997. About 1 km^2 was mapped in detail respectively in 1995 and 1996. This is expected to increase to about 2.6 km^2 in 1997.

Recent and Ongoing Activities

In 1993-1996, BATAN continued its uranium exploration activities at the Kalan uranium occurrence and in the surrounding West Kalimantan region. In 1993-1995, BATAN also carried out a reconnaissance over 3 000 km^2, on Irian Jaja Island.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
Ruphias (x 1000)	1 390	1 492	NA	NA
US$ (x 1000)	648	573.85	643.36	539.8
Government Surface Drilling in Metres	1 963	1 100	470	500
Number of Government Holes Drilled	6	17	4	5

During 1993-1994, at Kalan, exploration including drilling was concentrated in the several sectors referred to as Jeronang, Kelawai Inau and Bubu, and aimed at increasing resources. In addition, work was done in the Seruyan and Mentawa areas and in the area surrounding Kalan, where similar geological conditions were found. No details are available for the 1995-1996 period.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

RAR and EAR-I resources occur in the Lemajung and Rabau sectors of the vein-type Kalan prospect. Drilling carried out in 1993-1994 led to a minor reassessment of the previously reported RAR and EAR-I resources. No revisions have been made since then.

As of 1 January 1997, RAR amount to 6 273 tU, as in situ resources, recoverable at costs below $130/kgU. EAR-I of the same cost category are reported as 1 666 tU as in situ resources. When compared to the previously published resources, there is a small addition of approximately 850 tU in the RAR and a decrease of 480 tU in the EAR-I. These changes are based upon new drilling completed prior to 1995.

REASONABLY ASSURED RESOURCES*

(as of 1 January 1997)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	0	6 273

* As in situ resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(as of 1 January 1997)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	–	1 666

* As in situ resources.

RAR AND EAR-I DISTRIBUTION BY GEOLOGIC TYPE

(as of 1 January 1997)

Type of Deposit	In Situ Resources (tU)		Production Centres
	RAR	EAR-I	Existing and Committed
Vein	6 273	1 666	–

• Islamic Republic of Iran •

URANIUM EXPLORATION

Uranium exploration began in Iran in support of an ambitious nuclear electric power programme launched in the mid-1970s. The programme continued over the last two decades despite sharp fluctuations in the level of activities, and suspension of the nuclear power programme for a period of time.

The main activity started with airborne surveys conducted by foreign companies. These surveys covered the one third of the area of Iran judged to be most favourable for uranium deposits and other radioactive materials.

This work was followed up by reconnaissance and detailed ground surveys. The regional and detailed exploration activities were started in the most prospective regions, depending on the available infrastructure and exploration manpower. Follow-up of about one-sixth of the area covered by the airborne surveys led to definition of a few small deposits.

URANIUM RESOURCES

Deposits with RAR and EAR-II resources have been evaluated. The RAR of 840 tU are primarily of the metasomatite and vein-type occurring in the Saghand 1 and 2 deposits. The Bandarabass calcrete-type deposit contains additional RAR.

The resources of the polymetallic vein-type Talmesi deposit are estimated to be 162 tU EAR-II. The cost of production of these resources is not reported.

Based on the results of geological, geochemical and geophysical work done to date, it is estimated that Speculative Resources in Iran may be at least 25 000 tU, producible at a cost of up to US$ 100/kgU.

FUTURE PRODUCTION CENTRES

Supporting research activities, in addition to those related to the geology of uranium deposits, have been conducted on a wide range of topics. This work was primarily focused on the development of technology for the production of uranium concentrate. This programme has been quite successful in solving many problems. One of these has been to develop the detailed flowsheet for processing metasomatite-type ores. This ore type is different from the ores commonly found in other deposit types.

Most of the work has been implemented at the laboratory scale. Some of the work has, however, been done at the pilot scale. Additional experience has been obtained with heap-leaching techniques. This test work was done in both test columns and at the pilot scale. This work is focused on processing ore from deposits where the reserve is either small or the grade is low.

With respect to unconventional uranium ores such as uranium bearing phosphate, experimental work has been conducted regarding the recovery of uranium in conjunction with phosphoric acid production.

Based on the results to date, sufficient basic and detailed engineering work has been completed to support construction of a plant to produce uranium concentrate in the next five years.

• Ireland •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Ireland commenced in 1976 with support from DGXVII of the European Commission. The principal reconnaissance exploration techniques used were car-borne scintillometry and regional geochemical surveys of soil, stream sediments and water. Limited airborne radiometric surveys were flown over parts of counties Kerry, Cork, Waterford and Donegal, but the results were disappointing.

The ground surveys succeeded in defining targets in Leinster, Connemara and Donegal, mainly associated with late Caledonian granite plutons. Exploration companies carried out more detailed follow-up surveys in the areas under licence. The results of these investigations are available publicly through the Exploration Open File in the Geological Survey of Ireland. No economic discoveries were made and exploration for uranium had ceased by 1982.

Recent and Ongoing Activities

There has been no licensed exploration of uranium since before 1993, and there have been no applications since then for prospecting licences.

URANIUM PRODUCTION

Historical Review

No mining for uranium has taken place in Ireland.

Status of Production Capability

Ireland does not have a production capacity.

ENVIRONMENTAL CONSIDERATIONS

As no production of uranium is taking place in Ireland, there are no current or potentially significant environmental issues relating to uranium mining. However, a national survey is being conducted on the incidence of radon and a significant problem has been identified so far in certain areas of the country. This survey will not be fully completed until the end of 1998 when all areas of the country will have been examined for radon incidence.

• Italy •

URANIUM RESOURCES

With an international market of low oil prices, no nuclear debate was promoted in Italy and no new nuclear plants are planned at present. Nevertheless, an important research programme, concerning analytical and experimental aspects of some promising innovative reactors, is being accomplished.

URANIUM REQUIREMENTS

In the present situation, with no nuclear power plants in operation, there are no uranium exploration and production activities. With respect to uranium resources, the estimates published in the 1991 Red Book are still valid.

• Japan •

URANIUM EXPLORATION

Historical Review

The Power Reactor and Nuclear Fuel Development Corporation (PNC), a government organisation, was established in 1967 in accordance with the Atomic Energy Basic Law, with the aim of developing its own fast breeder reactors, heavy water reactors, and also for systematically supplying and developing uranium resources, enrichment technology, and reprocessing technology. Exploration of uranium has been carried out by PNC's predecessor since 1956. About 6 600 tU of uranium reserves have been detected in Japan. The domestic uranium exploration in Japan ended in 1988.

Recent and Ongoing Activities

Recently PNC has concentrated its uranium exploration efforts abroad, mainly in Canada and Australia, and in other countries such as China and Zimbabwe.

URANIUM EXPLORATION EXPENDITURES – ABROAD

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
Million Yen	1 344	1 226	806	556
US$ (x 1000)	12 923	14 771	7 532	4 801

URANIUM PRODUCTION

Historical Review

A test pilot plant with a capacity of 50 tonnes ore per day was established at the Ningyo-toge mine in 1969 by PNC. The operation ceased in 1982 with a total production of 87 tU. In 1978, the vat leaching test of the Ningyo-toge ore began on a small scale with a maximum capacity of 12 000 tonnes ore per year, consisting of three of 500 tonnes ore vats. The vat leaching test was terminated at the end of 1987.

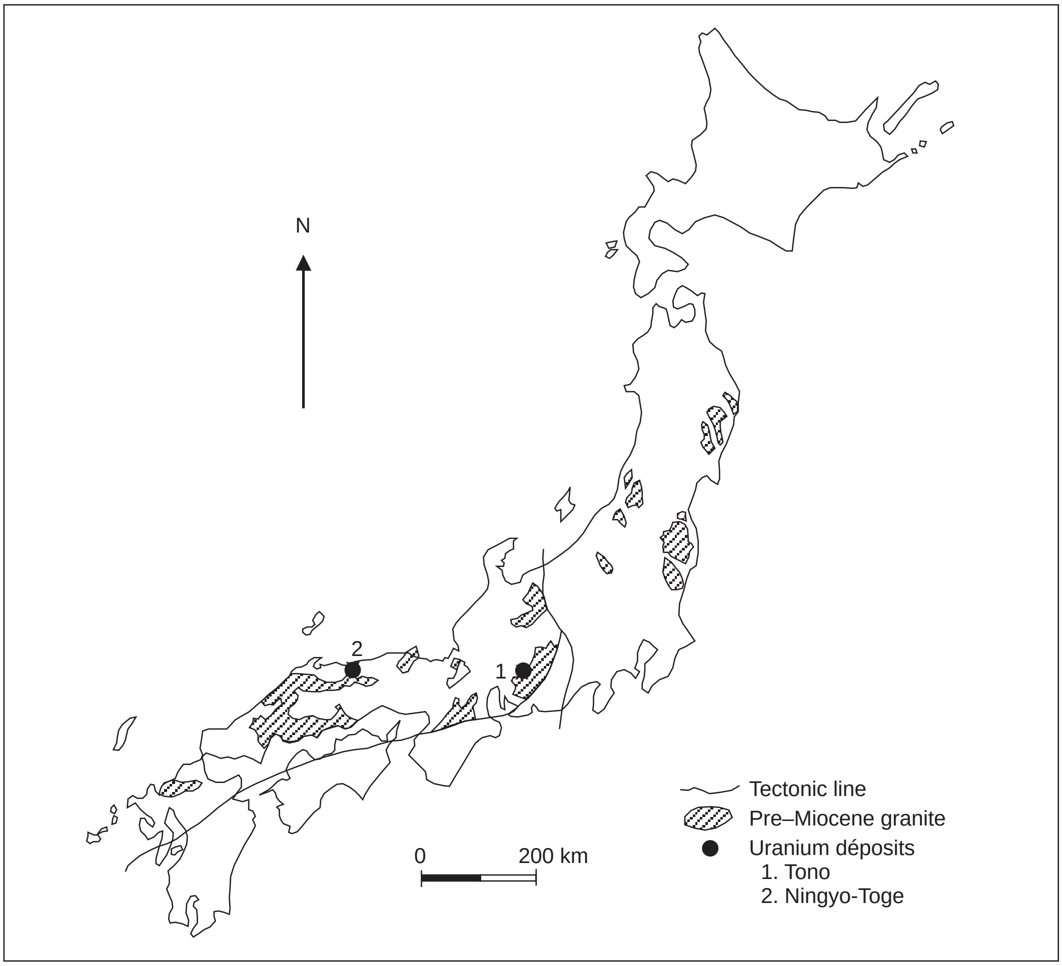
URANIUM REQUIREMENTS

As of 1 January 1997, Japan had 51 operable reactors with a total (gross) power capacity of 42 712 MWe, providing approximately 30 per cent of the electricity generated in Japan. Two reactors began commercial operation in 1995 and 1996. Four additional reactors are currently under construction and two reactors have been planned.

As for the future scale of development of nuclear power generation, the approximate goals are 45.6 GWe (gross) of installed capacity by the year 2000 and 70.5 GWe (gross) by 2010. Looking further ahead, it is hoped that the installed capacity of nuclear power generation will reach approximately 100 GWe by 2030.

The cumulative requirement of natural uranium is expected to reach about 160 000 tU by 2000, about 280 000 tU by 2010 and about 600 000 tU by 2030.

Distribution of major granitic bodies and uranium deposits in Japan



Supply and Procurement Strategy

Japan has relatively scarce domestic uranium resources and, therefore, must depend to a great extent on overseas supplied uranium. Its procurement strategy is as follows:

- Utilities are expected to procure the uranium through long-term purchase supply contracts with overseas uranium suppliers.

- In order to assure the supply security, PNC and the private sector are expected to procure uranium in conjunction with the exploration and exploitation arrangements in foreign countries. It is also requested that the supplier countries should be diversified.

NATIONAL POLICIES RELATING TO URANIUM

Since 1975, there has been no special legislation for uranium exploration and exploitation under the Japanese Mining Laws and Regulations. The uranium exploration and exploitation is open to private companies incorporated in Japan. However, no private company has pursued uranium exploitation in Japan.

URANIUM PRICES

Uranium import prices are contracted by private companies. Government information is not available for these data.

• Jordan •

URANIUM EXPLORATION

Historical Review

In 1980, an airborne spectrometric survey covering the entire country was completed. By 1988, ground based radiometric surveys of anomalies identified in the airborne survey were complete. During the 1988-1990 period, Precambrian basement and Ordovician sandstone target areas were evaluated using geological, geochemical and radiometric mapping and/or surveys.

During the period 1990-1992, a regional geochemical sampling programme involving stream sediments and some rock samples, was completed over the basement complex area. Geological and radiometric follow-up was carried out at locations within the basement complex and Precambrian sandstone areas. An evaluation of the uranium potential of the Jordanian phosphate deposits was completed. The average uranium content of four phosphate deposits in central and southern Jordan was found to range from 50 to 140 ppm. Based on these results, the unconventional or by-product resources of Jordan are estimated to be 100 000 tU.

Recent and Ongoing Exploration

Over the 1994 to 1996 period, annual uranium exploration expenditures by the Government increased from US$ 10 000 to US$ 100 000. A total of 26 drill holes comprising 250 metres were drilled in 1995. No drilling was done in 1994 or 1996.

The evaluation of airborne gamma anomalies carried out since 1995 has resulted in the identification of a zone related to non-phosphatic formations. The results of ground gamma surveys and radon (track-etch) measurements indicated several surficial uranium occurrences, associated with Pleistocene and Paleocene sediments in different parts of the Kingdom. In these areas, uranium in concentrations of 100 to 500 ppm, occurs over a thickness of about 1.5 metres. The mineralization occurs as either minutely disseminated grains within the sediments or as yellowish secondary uranium minerals filling fractures and small pockets in the sediments.

Work planned for 1997 includes:

- Delineation of the uraniferous sediments using radiometric methods;
- Pitting, trenching and rock sampling in favourable areas based on grid cells;
- Preliminary leachability testing; and
- Petrologic, mineralogic and geochemical studies of the uranium bearing sediments.

URANIUM EXPLORATION EXPENDITURES

	1994	1995	1996	1997 (Expected)
Total Government Expenditure - US$	10 000	30 000	100 000	100 000

URANIUM PRODUCTION

Jordan does not produce uranium. In 1982, a feasibility study for uranium extraction from phosphoric acid was presented by the engineering company LURGI AG. of Frankfurt, Germany, on behalf of the Jordan Fertilizer Industry Company. This company was later purchased by the Jordan Phosphate Mines Company (JPMC). One of the extraction processes evaluated was found to be feasible. At that time no decision was taken for the construction of an extraction plant. As uranium prices fell drastically, the process became uneconomic.

The work in this field was resumed in 1989 by establishing a micro-pilot plant funded by the IAEA. The testing was terminated in 1990. The result of the work was the preparation of a project document for a pilot plant for uranium extraction from phosphoric acid. The uranium plant was to be installed at the phosphoric acid plant of the Aqaba Fertilizer Complex of JPMC. No decision was made to continue such research work at this level owing to lack of funds and low-uranium prices.

ENVIRONMENTAL CONSIDERATIONS

To assess the environmental effects of uranium bearing phosphates deposits, a systematic study and evaluation of the uranium concentration in Jordanian phosphates is being conducted. The Shidia phosphate deposits, which constitute the overwhelming phosphate reserve in Jordan, are characterized by relatively low levels of contained uranium (i.e. varying between 35-50 gU/t). This is judged to be highly positive, from the environmental point of view regarding raw phosphates, derived phosphoric acid and phosphatic compounds, and derived fertilizers products. More details of the uranium contents in Jordanian phosphates are given in the 1993 edition of the Red Book.

• Kazakhstan[1] •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Kazakhstan started in 1948, when the now independent Republic was a part of the USSR. The subsequent activities can be divided into distinct stages, based on target areas and exploration concepts applied.

During the first stage which lasted through 1957, those portions of the Republic which were not overlain by young unconsolidated sediments, were covered by regional ground and airborne radiometric surveys. Investigations carried out in this period resulted in the discovery of several uranium deposits in what later became the uranium districts of Pribalkhash, Kokchetau and Pricaspian. These districts are respectively, near Lake Balkhash (in southeastern Kazakhstan), in northern Kazakhstan and near the Caspian Sea. Some details of these districts, which are shown in the map, are as follows:

1. This report is primarily based on the reply of a questionnaire submitted to the IAEA. The reply was provided by the Atomic Energy Agency of the Republic of Kazakhstan. Further information used in this report is based on a paper "Uranium and Environment in Kazakhstan, resources, supply and demand, environmental impact regulations and required studies" by G. Fyodorov, E. Bayadilov, V. Zhelnov, M. Akhmetov and A. Abakumov, presented at the IAEA Technical Committee Meeting, 22-27 May 1995, Kiev, Ukraine.

- The deposits of Pribalkash, including Kurdai, Botaburum and Djidely are of the endogenous vein-stockwork type associated with effusive volcanic complexes of Devonian age. From 1953 to 1990, this district provided ore and/or yellow cake slurry. The Pribalkash district was operated by the Kyrgyz Mining Combinate, later renamed the Yuzhpolymetal Production Company based in Bishkek, Kyrgyzstan.

- The Kokchetau district included the Grachev, Kamyshovoe, Kosachinoe, Vostok as well as numerous other deposits. These deposits host endogenous uranium in vein-stockworks in folded sedimentary formations of Silurian-Devonian age. This district was discovered in 1953, and became the base for the Tselinny Production Centre set up in 1957.

- The Melovoye, Tomak, Taybogar and Tasmurun deposits form the Pricaspian district. Exogenous uranium in phosphatised fish bone detritus in Paleogene clays make up the deposits. Discovered in 1954, the Melovoe deposit provided the base for the Pricaspiski Mining and Metallurgical Combinate which became operational in 1959 and produced uranium through 1993.

After 1957, the conceptual models developed during the regional assessment of sedimentary basins led to the discovery of sandstone-type uranium deposits associated with oxidation-reduction interfaces. During this period, the Chu-Sarysu basin, located in central Kazakhstan was explored. The discoveries made in this environment included the Uvanas and Zhalpak deposits, among others.

In addition, uranium mineralization was discovered in the Koldjat deposit in the Ily basin in eastern Kazakhstan. The uranium grading up to a tenth of a per cent, is associated with coal and did not receive further attention due to economic reasons.

During 1970 and 1971, in situ leach (ISL) mining tests were successfully conducted at the Uvanas deposit. Since that time, exploration has been concentrated on Mesozoic and Cenozoic sedimentary basins having the potential for ISL amenable deposits.

During this work additional deposits were discovered in the Chu-Sarysu basin. These include the Kandjugan and Moynkum deposits in Paleocene sediments and the Mynkuduk deposit in upper Cretaceous sandstones. The Stepnoye and Central Mining Companies are currently operating ISL operations in this district.

Applying the exploration experience gained in the Chu-Sarysu basin, subsequent investigation was carried out between 1970 and 1975 in the Syr-Darya basin, located southwest of the Chu-Sarysu basin. This led to the discovery of the North Karamurun, South Karamurun, Irkol, and Zarechnoye deposits.

These and additional discoveries associated with Cretaceous and Paleocene sediments of the Chu-Sarysu and Syr-Darya basins significantly increased the resource base of Kazakhstan. In addition, the ISL amenable resources have placed Kazakhstan in a very advantageous position to compete successfully with other low cost uranium producers in the world. Based on this favourable resource position, early stage exploration has declined. It is now restricted to the northern part of the country.

Recent and Ongoing Activities

In 1995-1996, the exploration organisation Stepgeologia carried out early stage exploration (without drilling) aimed at the discovery of unconformity-related deposits.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
(in million tenge)	40	7	16	20
(in 1000 US$)	1 290.32	112.9	242.42	275.86

URANIUM RESOURCES

The uranium resources of Kazakhstan occur in several types of deposits. The two main uranium deposit types include vein-stockwork and sandstone deposits. Both types, are further subdivided according to their geological settings.

The vein-stockwork deposits include two subtypes: in folded sedimentary complexes of Silurian-Devonian age, and those associated with continental effusive volcanics of Devonian age.

The vein-stockwork deposits in Silurian-Devonian sediments occur in the Kokchetau uranium district with the main deposits Grachev, Manybai, Vostok, Zaozyornoe.

The vein-stockwork deposits in continental Devonian volcanics occur in the Pribalkhash district with the Botaburum, Kurdai and Djidely deposits.

The sandstone-type uranium deposits in Kazakhstan are classified by Kazak geologists in the following four subtypes:

- organic phosphate subtype;
- epigenetic sandstone uranium subtype;
- epigenetic coal-bearing sediment subtype;
- surficial valley-fill subtype.

The organic phosphate subtype occurs in the Pricaspian district on the Mangyshlak Peninsula at the eastern shore of the Caspian Sea. Sediments of lower Oligocene-lower Miocene age host the uranium mineralization, which is associated with phosphatised bone detritus of fossil fish in a pyrite-bearing clay. The largest deposits in this district are Melovoye, Tomak, Tasmurun and Taybogar.

The epigenetic sandstone uranium subtype occurs in two approximately north-south trending sedimentary basins: the Chu-Sarysu and the Syr-Darya, separated by the Karatau uplift. In both basins, the uranium mineralization is associated with Cretaceous-Paleocene clastic sediments, consisting of several sandstone-clay sequences. In the case of the Chu-Sarysu basin, there are about six sandstone-clay sequences with sandstone horizons between 50-70 metres thick and separated by impermeable clays. In both districts, the uranium mineralization occurs along oxidation-reduction interfaces forming asymmetric rollfronts and lenses. Conditions of high porosity and permeability of the host horizons, and their separation by impermeable clays, make this deposit subtype amenable to ISL methods. The deposits in the Chu-Sarysu district include Zhalpak, Uvanas, Mynkuduk, Sholak-Espe and Inkay in the northern part of the basin and Kandjugan and Moynkum in the southern part.

The Syr-Darya district includes roll-front deposits in Cretaceous sediments with the deposits Irkol, North-Karamurun (Yushny Karamurun), South-Karamurun (Severny Karamurun) and Zarechnoe.

The epigenetic coal-bearing sediment subtype occurs mainly in the Ily and its down-faulted portion referred to as Nishny-Ily basin in southeast Kazakhstan. These basins include early-middle Jurassic continental coal-bearing sediments. Uranium mineralization was found mainly in the coal horizons. The Koldjat deposit belongs to this subtype. The resources in this environment have lost their importance due to current unfavourable economic conditions.

The surficial valley-fill subtype occurs only in a few cases. The most important one is the Semizbai deposit, located at the eastern rim of the Kokchetau province.

There are 51 uranium deposits in Kazakhstan (see map). This includes 26 deposits that have been investigated and for which uranium resource estimates have been prepared. The deposits occur in 6 uranium bearing districts.

Known Conventional Uranium Resources (RAR & EAR-I)

The known uranium resources of Kazakhstan recoverable at costs of below $130/kgU total 860 560 tU as of 1 January 1997. When compared to the estimate published in the previous Red Book, there is an insignificant increase of 2 560 tU. The known resource portion which can be recovered at costs of below $40/kgU amounts to 436 540 tU or to over 50 per cent of the total.

It is reported that over 50 per cent of Kazakhstan's known resources recoverable at costs below $40/kgU are tributary to existing and committed production centres. This percentage increases to 74 per cent considering the $80/kgU known resource portion.

The RAR reported as in situ resources net after considering the resources mined, are estimated as of 1 January 1997 to amount to 601 260 tU recoverable at costs of below $130/kgU. The portions which can be recovered at below $80 and $40/kgU respectively, are 439 220 and 323 340 tU, as shown in the following table.

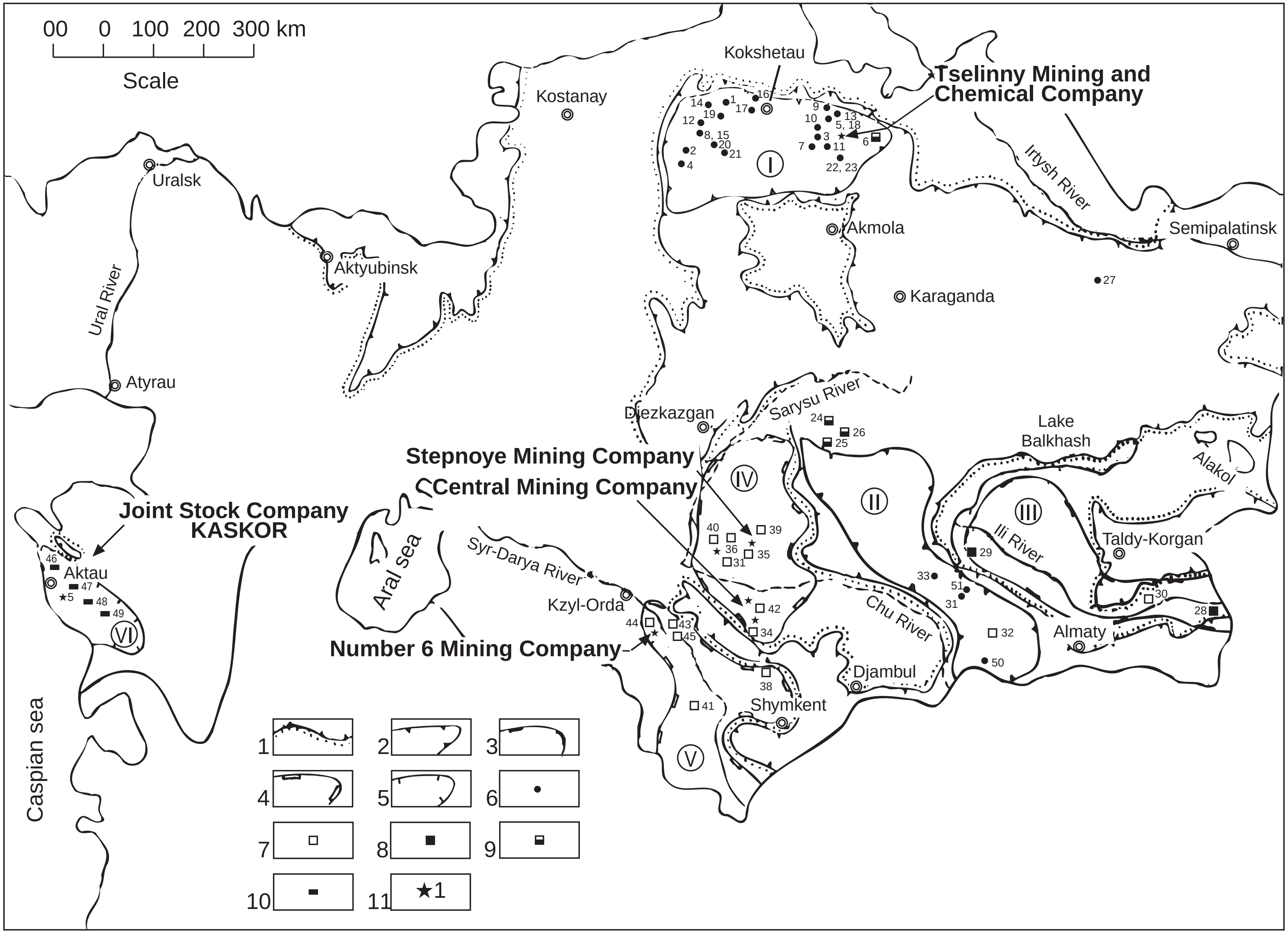
REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
323 340	439 220	601 260

* As in situ resources, adjusted for depleted resources.

Uranium metallogenic provinces, deposits and production facilities of Kazakhstan



1. Borders of (a) Pre-Mesozoic and (b) Mesozoic-Cenozoic sediments

2. Uranium ore provinces with endogenic deposits in Pre-Mesozoic sediments
(I- Kokshetau, II- Pribalkhash)

3-5. Uranium ore provinces with exogenic deposits in Mesozoic to Cenozoic sedimentary formations:
3- with soil oxidation of coal beds (III- IIy)
4- with stratal oxidation (roll-front) in sandstone sequences (IV- Chu-Sarysu, and V- Syr-Darya)
5- with phosphatic fossil fish bone detritus (VI- Pricaspian)

6-10. Uranium deposits:
6- endogenic of different ore types
7- infiltration with stratal oxidation (i.e. roll-front)
8- infiltration with soil oxidation
9- infiltration with stratal oxidation (i.e. roll-front) in sediments of paleovalley
10- with phosphatic fossil fish bone detritus.

11. Production Centres/Mines:
1) Central Mining Company (Kandjugan)
2) Stepnoye Mining Company (Uvanas)
3) Number 6 Mining Company (Mynkuduk)
4) Tselinny Mining and Chemical Company (Grachev and Vostok)
5) Joint Stock Company “Kaskor” (Melovoye)

Deposits shown on map:
1. Grachev*
2. Shokhpak
3. Zaozyornoe
4. Kamyshevoe*
5. Shatskoe
6. Semizbay*
7. Tastykol
8. Akkan-Burluk
9. Glubinnoe
10. Koksorskoe
11. Vostochno-Tastykolskoe
12. Victorovskoe
13. Agashskoe
14. Fevralskoe
15. Burlukskoe
16. Slavyanskoe
17. Chaglinskoe
18. Shatskoe-I
19. Kosachinoe
20. Vostok*
21. Zvyozdnoe
22. Manybaysk*
23. Yuzhno-Manybayskoe
24. Shorly
25. Talas
26. Granitnoe
27. Ulken-Akzhal
28. Koldjat*
29. Nizhne-Iliyskayay*
30. Suluchokinskoe
31. Djusandalinskoe
32. Kopalysayskoe
33. Kyzyltas
34. Kandjugan*
35. Uvanas*
36. Mynkuduk*
37. Sholak-Espe
38. Kyzylkol
39. Zhalpak
40. Inkay* (planned)
41. Zarechnoe
42. Moynkum* (planned)
43. South Karamurun
44. Irkol*
45. North Karamurun*
46. Melovoe*
47. Tomak
48. Taybogar
49. Tasmurun
50. Kurdai
51. Botaburum

* Operating and closed mines.

The EAR-I recoverable at costs of below $130/kgU remain unchanged and total 259 300 tU as in situ resources. The lower cost portions amount to 195 900 tU recoverable below $80/kgU and 113 200 tU recoverable below $40/kgU, as shown in the following table.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I[*]

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
113 200	195 900	259 300

* As in situ resources adjusted for depleted resources.

Undiscovered Conventional Uranium Resources (EAR-II & SR)

Kazakhstan reports EAR-II resources totalling 310 000 tU recoverable at costs below $130/kgU, as well as SR of 500 000 tU recoverable in the same cost range. Both estimates are reported as in situ resources.

ESTIMATED ADDITIONAL RESOURCES - CATEGORY II

(Tonnes U)

Cost Ranges		
<$40/kg	<$80/kg	<$130/kgU
200 000	290 000	310 000

SPECULATIVE RESOURCES

(Tonnes U)

Cost Ranges		TOTAL
<$130/kgU	Unassigned	
500 000	0	500 000

Uranium Resources (RAR, EAR-I, EAR-II) by Mining Methods

Based on the 1994 resource estimates, Kazakhstan provided information on the amenability of the uranium resources to the ISL and conventional (open pit and underground) mining methods. The resources considered in this listing include RAR, EAR-I, as well as EAR-II, recoverable at costs of below $130/kgU. The relative distribution of the resources by mining methods is provided below.

DISTRIBUTION OF RESOURCES BY MINING METHOD

	RAR	**EAR-I**	**EAR-II**
ISL	73.4%	38.5%	83.9%
Conventional Methods (OP, UG)	26.6%	61.5%	16.1%
Total	100.0%	100.0%	100.0%

URANIUM PRODUCTION

Historical Review

Uranium has been produced from deposits located in Kazakhstan since 1953. The first organisation responsible for the production of uranium was the Kyrgyz Combinate, which later became the Yuzhpolymetal Production Company, headquartered in Bishkek, Kyrgyzstan. The ores were mined from the Kurdai deposit located in the Pribalkhash district in Kazakhstan, and processed in Kyrgyzstan.

In 1957, the Tselinny Mining and Processing Combinate in Stepnogorsk came into production, supported by the resources of the Kokchetau district. This complex is mothballed since 1995.

In 1959, the Pricaspiski Mining and Metallurgical Combinate in Aktau began producing uranium and other co- and by-products from the Pricaspian district.

In addition to the conventional mining and processing operation in the Pribalkhash, Kokchetau and Pricaspian districts, there are three ISL operations in the Chu-Sarysu and Syr-Darya districts that have operated for several years. The production companies Central, Stepnoye and No. 6, produce from ISL operations at the Kandjugan, Uvanas and Mynkuduk, as well as at the Karamurun sandstone uranium deposits. The aggregate ISL production capability of these established facilities is 2 600 tU/year.

Uranium production in 1995 and 1996, totalled 1 630 and 1 210 tonnes U, respectively. The decline from previous years is due to the closure of the conventional underground operations, Grachev and Vostok, of the Tselinny Mining and Processing Company in Stepnogorsk, in 1995.

HISTORICAL URANIUM PRODUCTION

(Tonnes U)

Production Method	Pre-1994	1994	1995	1996	Total through 1996	Expected 1997
Conventional Mining						
• Open Pit	21 618	0	0	0	21 618	0
• Underground	37 503	660	170	0	38 333	0
Subtotal	59 121	660	170	0	59 951	0
In Situ Leaching	18 381	1 580	1 460	1 210	22 631	1 500
TOTAL	77 502	2 240	1 630	1 210	82 582	1 500

Status of Production Capability

The economic and political modifications which Kazakhstan experienced in recent years had a significant impact on the uranium industry. The subsequent changes included discontinuing shipping of uranium ore mined in the Pribalkhash district to the ore processing plant of the Yuzhpolymetal Production Company in Bishkek, Kyrgyzstan, in 1990. Consequently, the Yuzhpolymetal Production Company lost its base for activities. At the end of 1993, the operations of the Pricaspiski Mining and Metallurgical Combinate located in Aktau, which had become the KASKOR Company, were discontinued due to economic reasons.

In 1995, the Tselinny Mining and Processing Company stopped production at its Grachev and Vostok underground operations. It consequently suspended the operation of the ore processing plant located at Stepnogorsk. All installations were mothballed.

To replace the conventional uranium production, in 1996 two additional ISL operations, Katko and Inkay were making preparations for production, each with a production capability of 700 tU/year. The first is operated by a joint venture between the Kazak uranium company KATEP and Cogema. The second one is operated by KATEP and Uranerz Exploration and Mining Limited Almaty together with Cameco.

In summary, the entire current uranium production capability is associated with the five ISL production centres Tsentralnoe, Stepnoye, No 6, Katko and Inkay with an aggregated production capacity of 4 000 tU/year.

The technical details of the operating and existing ISL production centres are summarised in the first part of the relevant table, while the technical characteristics of the mothballed production centres are listed in the second part.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

Part 1: Existing and Operating Centres

Name of Production Centre	Tsentralnoe Mining Co	Stepnoye Mining Co	No.6 Mining Company	Katko	Inkay
Production Centre Class	Existing	Existing	Existing	Existing	Existing
Operating Status	Operating	Operating	Operating	Operating	Operating
Start-up Date	1982	1978	1981	1996	1996
Source of Ore • Deposit Names • Deposit Types	 Kandjugan Sandstone	 Uvanas Sandstone	 Karamurun Sandstone	 Moynkum Sandstone	 Inkay Sandstone
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 ISL NA NA	 ISL NA NA	 ISL NA NA	 ISL NA NA	 ISL NA NA
Processing Plant • Type • Size (tonnes ore/day) For ISL (kilolitre/day or litre/hour) • Average Ore Processing Recovery (%)	 IX NA NA	 IX NA NA	 IX NA NA	 NA NA NA	 NA NA NA
Nominal Production Capacity (tU/year)	1 000	1 000	600	700	700
Plans for Extension	None	None	None	None	None

Ownership Structure of the Uranium Industry

The mining companies Tsentralnoe, Stepnoye and No. 6 are controlled by the State Company Kazatomprom which was created at the end of 1996. The Inkay and Katko companies are joint operating companies with Cogema and Uranerz/Cameco, respectively as partners.

This ownership structure implies that the entire uranium production of Kazakhstan is controlled by the Kazakh Government.

Employment in the Uranium Industry

The development of the employment in the existing production centres between 1994 and 1996 including the projection for 1997, is compiled in the following table. In the period 1992 to 1996 the employment continuously decreased from 11 800 persons in 1992 to 6 000 in 1996, or by nearly 50 per cent.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES
(Persons-Years)

1994	1995	1996	Expected 1997
8 050	6 850	6 000	5 350

Future Production Centres

No recent plans regarding future production centres were reported.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
Part 2: Mothballed

Name of Production Centre	Joint Stock Co. Kaskor	Telinny Mining co.
Production Centre Class	Existing	Existing
Operational Status	Mothballed since 1993	Mothballed since 1995
Start-up Date	1959	1958
Source of Ore • Deposit Name • Deposit Types	 Tomak, Melovoye Fish bone detritus	 Grachev, Vostok Stockwork-vein
Mining Operation • Type • Size (Tonnes ore/dayr) • Average Mining Recovery (%)	 OP NA NA	 UG NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day for ISL) (kilolitre/day or litre/hour) • Average Processing Recovery (%)	 IX NA NA	 IX NA NA
Nominal Production Capacity (tU/year)	2 000	2 500

Based on the existing, committed and planned production capabilities, the capability projections through the year 2015 are summarised in the following table:

SHORT-TERM URANIUM PRODUCTION CAPABILITY

(Tonnes U/year)

1997				1998				2000			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
1 650	1 650	2 300	2 300	2 050	2 050	2 500	2 500	2 800	2 950	2 800	2 950

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 000	2 500	2 800	3 000	3 000	3 500	3 800	4 000	4 000	4 500	4 800	5 000

For 1997, it is planned that the Tselinny Mining and Metallurgical Company will restart its uranium production operation. The project is to be operated by the state-owned mining company Kazuran, with the participation of the Canadian company, Worldwide Minerals, Ltd.

For the longer term, both the extension of existing production centres and the development of new production centres are considered. A total production of up to 5 000 tU/year could be reached in 2015 under the assumption that RAR and EAR-I resources recoverable at costs up to $80/kgU are mined using tributary existing, committed, planned and prospective production centres. Details of such plans, however, are not available.

In general, Kazakhstan's known uranium resources could support a relatively rapid production increase in response to a sudden increase in international demand.

ENVIRONMENTAL ASPECTS

Kazakhstan has significant environmental concerns about the wastes associated with its previous and presently operating uranium production facilities. It is also concerned with the environmental aspects of its large volume of uranium resources occurring as sandstone-type deposits that are amenable to mining using in situ leach technology.

The sandstone hosted uranium deposits occur in sedimentary basins that also host large volumes of groundwater. The contamination of groundwater related to the uranium deposits, both naturally occurring and resulting from leaching, led to the development of an exclusion zone equal in size to 150 km by 15 km. The extraction of drinking water from this zone is prohibited.

In addition, mining and ore processing have accumulated low level radioactive waste rock dumps and mill tailings as a result of over 40 years of uranium production. The volume of radioactive waste from mining and ore processing is estimated to total 200 million tonnes. As a large portion of this waste was generated by operations which are closed now, the previous operators, in this case Soviet State Enterprises, do not accept responsibility for the cleanup. As no financial provisions were made to pay for the required remedial activities, the Republic of Kazakhstan has no other choice than to provide the necessary funding.

To avoid further contamination of those mineralised aquifers from which uranium is recovered by acid ISL technology, research is under way to better understand and reduce the environmental impacts of mining.

URANIUM REQUIREMENTS

Kazakhstan operates the fast-breeder reactor BN-350 with a net capacity of 70 MWe, at Aktau on the Mangyshlak Peninsula at the Caspian Sea. The electricity produced is primarily used for a desalination plant. The current uranium requirement for this reactor is estimated to be 50 tU/year. It is assumed that the power reactor will continue operation through the time frame covered in the tables below.

In addition, plans were made in co-operation with the Russian Federation for the development of additional nuclear power capabilities to become operational sometime after the turn of the century. These plans provide for the installation of 2 000 MWe and an additional 4 800 MWe of a nuclear generating capacity sometime between 2005 and 2010. The related uranium requirements are projected to start earlier, approximately in 2003, to allow for the nuclear fuel fabrication lead times.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
70	70	70	2 070	NA	6 870	NA	NA	NA

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
50	50	50	450	NA	1 050	NA	NA	NA

SUPPLY AND PROCUREMENT STRATEGY

At present, all uranium produced in Kazakhstan is exported for sale on the world market. The country does not maintain uranium stockpiles in any form.

•   Republic of Korea   •

URANIUM EXPLORATION

Recent and Ongoing Activities

The Korea Electric Power Corporation (KEPCO), as part of its exploration programme, participates in a number of projects abroad. In the Crow Butte in situ leaching project in Nebraska, USA, KEPCO holds a 10 per cent share. In Saskatchewan, Canada, KEPCO participates in the Cigar Lake and Dawn Lake projects with 2 per cent and 4.67 per cent share, respectively. Another Korean company, the Dae Woo Corporation, has participated in the Baker Lake project in Canada since 1983.

URANIUM EXPLORATION EXPENDITURES – ABROAD

	1994	1995	1996	1997 (Expected)
TOTAL EXPENDITURES - US$ (x 1000)	175 (Canada)	178 (Canada)	373 (Canada)	895 (Canada)

URANIUM REQUIREMENTS

KEPCO had eleven nuclear power plants in commercial operation as of 31 December 1996. The nuclear generating stock includes 10 PWR and 1 PHWR plants. The nuclear installed capacity of 9 616 MWe accounted for 27 per cent of the country's total generating capacity in 1996. According to the long-term power development plan in Korea, 17 additional nuclear power plants, including 6 PWR and 3 PHWR plants already under construction, will be on line by the year 2010, with a total nuclear capacity of 26 329 MWe.

Along with the steady increase in nuclear capacity, the requirements for uranium concentrates and fuel cycle services are rising continuously.

INSTALLED NUCLEAR GENERATING CAPACITY
(MWe)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
9 600	10 300	13 700	18 700	18 700	26 300	26 300	–	–

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	1997	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 810	2 760	2 890	3 010	3 010	4 290	4 290	–	–

NATIONAL POLICIES RELATING TO URANIUM

In order to support the nuclear expansion programme effectively, KEPCO has pursued a stable, economic and secured programme of uranium supply. Accordingly, the uranium requirements are mostly supplied through long-term contracts with various countries such as Canada, Australia, France and the USA. KEPCO also imports uranium through the spot market and its subsidiary company, KEPRA, which owns a 10 per cent share in the Crow Butte project in the USA.

URANIUM STOCKS

KEPCO maintains a stock level of one-year forward reactor-consumption for the operating plants, as a strategic inventory. Recently, KEPCO increased the stock level as two-years forward reactor-consumption. One half of the stock is stored as natural uranium in overseas conversion facilities and the other half will be stored as enriched uranium in fabrication facilities in Korea.

• Lithuania •

URANIUM EXPLORATION, RESOURCES, AND PRODUCTION

Lithuania has no uranium resources and is not currently undertaking any uranium exploration.

URANIUM REQUIREMENTS

The short-term nuclear generating capacity projections for Lithuania are based on two RBMK units of a total capacity of 2 760 MWe at Ignalina and the related uranium requirements are given in the following tables. Fuel for the reactor is supplied by the Russian Federation. There is no stockpile of natural uranium material in Lithuania. A six-month stock of enriched fuel is generally maintained by Ignalina NPP.

There have been no changes in Lithuania's uranium requirements over the past two years. The supply and procurement strategy has remained the same during the period. The long-term requirements will depend on the country's policy of whether or not to further develop nuclear power.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
2 760	2 760	2 760	NA	NA	NA	NA	NA	NA

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS*

(Tonnes U)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
385	415	425	NA	NA	NA	NA	NA	NA

* The Uranium requirements provided by Lithuania refer to tU enriched; the above natural U requirements are IAEA estimates, based on CYBA, 1995, a generic model for the assessment of the amount of nuclear materials needed and generated during the nuclear fuel cycle.

SUPPLY AND PROCUREMENT STRATEGY

The fuel element requirements for the Ignalina nuclear power plant are being met by the Russian Federation. As there is a surplus fabrication capability for fuel assemblies in the Russian Federation, Lithuania is assured a long-term supply of fuel from that country. Nevertheless, Lithuania is looking for supply alternatives.

URANIUM PRICES

Information concerning uranium prices is not available.

• Malaysia •

URANIUM EXPLORATION

Historical Review

Uranium exploration, both on the Peninsula and in Sabah and Sarawak on the Island of Borneo, has taken place intermittently in Malaysia since the 1950s. Exploration then increased, and has been maintained at a somewhat higher level since the 1970s. The main project was an integrated airborne survey over 31 000 km^2 in the Central Belt, on the Peninsula.

Since 1984, an exploration programme with limited funding has been carried out only on the Malaysian Peninsula. During 1991-1992, the Geological Survey of Malaysia (GSM) conducted an integrated ground exploration programme over 8 600 km^2 of granitic terrain in the Pahang, Perak, Selangor, Negeri Sembilan, Johore and Kelantan States. Five fertile granitic plutons were identified through this work. The digital data from the airborne radiometric survey completed in 1980 was also reprocessed. The results were used to produce stacked profiles and new maps.

Recent and Ongoing Activities

During 1995-1996, the GSM continued uranium exploration on the Malaysian Peninsula. Carborne radiometric surveys were carried out in parts of Pahang and Kelantan states, utilising the GR650 Spectrometer System provided by the IAEA. A total of 1 000 km of traverse line was covered with the collection of about 11 500 gamma-ray measurements. Fourteen areas, totalling about 100 km of traverse lines, were found to have uranium potential.

URANIUM EXPLORATION EXPENDITURES – DOMESTIC

	1994	1995	1996*	1997 (Expected)
GOVERNMENT EXPENDITURES				
Ringgit Malaysia	1 080 000	400 000	598 000	NA
US$ (x 1000)	398	163	239	NA

* It was reported in November 1997 that about 588 000 Ringgit, budgeted for exploration in 1996, were deferred for expenditure in 1997.

• Mexico •

URANIUM EXPLORATION

Uranium exploration was stopped in May 1983, and URAMEX, the organisation responsible for this activity, was dissolved in February 1985. Some of URAMEX's responsibilities have been taken over by the Mineral Resources Board (Consejo de Recursos Minerales).

URANIUM RESOURCES

Estimates of Mexico's uranium resources were prepared in 1982. Known uranium resources total 2 400 tU at recoverable costs between \$80/kgU and \$130/kgU. Additional undiscovered resources include 12 700 tU, of which 2 700 are EAR-II and 10 000 are Speculative Resources. In addition, there are unconventional resources in marine phosphates in Baja California, totalling 150 000 tU, as well as approximately 1 000 tU, which were previously classified as conventional resources. This last resource is associated with hydrothermal non-ferrous mineralization in Tayata (Oaxaca), Noche Buena (Sonora) and La Preciosa (Durango).

URANIUM PRODUCTION

From 1969 to 1971, the Mining Development Commission operated a plant in Villa Aldama, Chihuahua. The facility recovered molybdenum and by-product uranium from ores mined in the Sierra de Gomez, Domitilia (Peña Blanca) and other occurrences. A total of 49 tU was produced. At present, there are no plans for additional uranium production.

URANIUM REQUIREMENTS

Mexico's only uranium requirements are for the two units at Laguna Verde Nuclear Power Plant, with a capacity of 654 MWe each.

The uranium requirements are based on the Energy Utilization plan for the plant whose objectives are to enhance fuel utilization, by using advanced fuel designs and also reducing spent fuel production.

Uranium deposits of Mexico

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe)

1996	1997	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 308	1 308	1 370	1 370	1 370	1 370	2 370	1 370	3 370

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	1997	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
325.01	170.04	256.70	215.29	215.29	252.74	581.598	216.26	748.750

Supply and Procurement Strategy

All the purchases made by the Mexican utility, the Comisión Federal de Electricidad (CFE), must be by an open call for bids. In the case of uranium, the strategy has been to have contracts for five years or less.

URANIUM PRICES

CFE has established medium term contracts for supply of natural uranium in the form of uranium hexafluoride (UF_6).

In 1996, there was a call for bids to supply seven reloads of both units of the Laguna Verde Nuclear Power Plant (LVNPP) in Veracruz. The bidders were required to make the proposals including financing. Two contracts were awarded, the details of which are described below:

Reload and Unit	**Date**	**Quantity** (kg/U)	**Unit Price** (US$)	**Price per reload** (US$)	**Supplier**
R6-U1	01-Jan-97	151 117	US$ 50.75	US$ 7 669 187.75	NUKEM
R3-U2	01-Sep-97	158 701	US$ 52.30	US$ 8 300 062.30	NUKEM
R7-U1	01-Jul-98	177 660	US$ 55.15	US$ 9 797 949.00	NUKEM
R4-U2	01-Jan-99	185 863	US$ 56.30	US$ 10 464 086.90	NUKEM
R8-U1	01-Jan-00	178 182	US$ 58.41	US$ 10 407 610.62	CAMECO
R5-U2	01-Jul-00	190 976	US$ 59.46	US$ 11 355 432.96	CAMECO
R9-U1	01-Jul-01	182 358	US$ 61.54	US$ 11 222 311.32	CAMECO
TOTAL		1 224 857		US$ 69 216 640.85	

URANIUM STOCKS

The purchases are generally made one year before the scheduled date of delivery of the fuel bundles, at the LVNPP site.

The natural uranium stocks correspond to one or two reloads at the enrichment facilities based on the purchase schedule.

The policy has been not to have stockpiles of enriched or fabricated fuel.

• Mongolia •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Mongolia started immediately after World War II with investigations directed at the search for uranium associated with various other mineral deposits. During the period 1945-1960 numerous uranium occurrences were discovered in lignite deposits in Eastern Mongolia.

Between 1970 and 1990, under a bilateral agreement between the Governments of the Mongolian Peoples' Republic and the USSR, geological investigations were carried out by the Geological Reconnaissance Expedition of the Ministry of Geology of the USSR. During that period airborne gamma spectrometer surveys covering over 1 million km^2, or nearly 70 per cent of the country, were completed at scales varying from 1 : 25 000 to 1 : 1 000 000. The area surveyed represented the entire country, with the exception of the Central Mongolian mountains and the territory along the international boundary with China. A metallogenetic appraisal of undiscovered uranium resource potential was completed for an area of 500 000 km^2, and more detailed geological exploration was completed at scales between 1 : 200 000 and 1 : 50 000, covering an aggregate area of 50 000 km^2. This included nearly 2 700 km of surface drilling, as well as significant amounts of trenching and underground exploration.

Based on the results of these investigations, four metallogenetic uranium provinces were defined. They include the Mongol-Priargun, Gobi-Tamsag, Hentei-Daur and Northern Mongolia districts (see map). Each of these provinces host different uranium deposit types, mineral associations, ages of mineralization and geological structures. Within these provinces, six uranium deposits, about 100 uranium occurrences and 1 400 mineral showings and radioactive anomalies were identified.

The Mongol-Priargun province includes the Northern Choibalsan uranium district, as well as the Berkh, Eastern and Central Gobi uranium districts.

The Northern Choibalsan uranium district includes the Dornod volcanic-tectonic structure. This structure is filled with more than 1 000 metres thick Jurassic-Cretaceous volcanic rocks, ranging in composition from rhyolite to basalt, and associated sediments. The Dornod structure covers about 2 000 km^2 and hosts the Dornod, Gurvanbulag, Mardain-gol and Nemer uranium deposits, in addition to a number of polymetallic, gold and fluorite deposits.

The Haraat deposit occurs in the Eastern Gobi area (see map) in the large (150 x 15 km) Choir sedimentary basin of Mesozoic age. Based on the large number of uranium occurrences in this basin, it is estimated that other basins in this area, including the Baga Nuurt, Ulaan Nuur, Alagtsav and Tavansuvaa basins have a potential for the discovery of additional sandstone type uranium deposits.

The Gobi-Tamsag province in southeast Mongolia (see map) hosts the Nars uranium deposit, associated with the Sainshand sedimentary basin of Cretaceous age. In addition, numerous uranium occurrences were found in the Tamsag, North-Sainshand, Zuunbayan and other sedimentary basins. *The Hentii Daur province* is located in the Hangai and Hentii mountains and hosts granitic type uranium occurrences including those of the Janchivlan area.

The Northern Mongolian province covers portions of Northern and Western Mongolia. The uranium occurrences of this province are associated with alkaline intrusives and metasomatic pegmatites, as well as with schists.

Recent and Ongoing Activities

Uranium exploration is conducted by the following three organisations: the "Uran" company, a state-owned enterprise controlled by the Main Directorate of Geological Exploration of the Territory of Mongolia; the "Gurvansaikhan" company, a Mongolian-Russian-American Joint Venture, which is exploring the Choir, Hairkhan, Undurshil, Ulziit and Gurvansaikhan sedimentary basins (the Choir basin, hosts the Haraat uranium deposit); and the Koge-Gobi Mongolian-French Joint Venture, which is working in the Sainshand, Oshiin Nuur, Nyalga and Tamsag basins.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 Expected
Industry Expenditures (US$ x 1000)	532	1 400	2 440	3 100
Government Expenditures (US$ x 1000)	168	250	120	35
Total Expenditures (US$ x 1000)	700	1 650	2 560	3 135
Industry Surface Drilling (Metres)	8 000	40 000	41 500	52 000
Number of Industry Holes Drilled	200	1 000	1 035	1 300

The Government of Mongolia continues to support uranium exploration. It has plans through 2005 to carry out grass-roots geological surveys over 32 000 km^2 and exploration over 40 000 km^2, as well as detailed evaluation of prospects covering a total of 4 000 km^2.

URANIUM RESOURCES[1]

The known uranium resources of Mongolia occur in the six deposits including Dornod, Gurvanbulag, Mardain-gol, Nemer, Haraat and Nars. They belong to the four metallogenetic provinces mentioned above. In more detail, their characteristics are as follows:

The *Mongol-Priargun province* is located in Eastern Mongolia and covers a continental volcanic belt of the same name. The belt measures approximately 1 200 km by 70-250 km and reaches from the the Mongolian Altai to the Lower Priargun. The province includes U-Mo-F mineral associations of the volcanic deposit type. Within this province are the uranium districts of Northern Choibalsan, Berkh, Eastern Gobi (also referred to as Dornogoby), as well as the Central Gobi (Dund-Goby). The most important known mineralised district is the Northern Choibalsan including the Dornot uranium area. It includes the Dornod, Gurvanbulag, Mardai-gol and Nemer uranium deposits, as well as polymetallic and fluorite deposits. In addition to the volcanic type uranium deposits, sandstone uranium mineralization occurs in the Choir basin. It is located in the Eastern Gobi district and includes the Haraat deposit.

The total resources of the Mongol-Priargun province are reported to be: 31 000 tU as C1 resources, 28 000 tU as C2 resources, and 14 000 tU, 261 000 tU and 136 000 tU belonging respectively, to the P1, P2 and P3 categories.

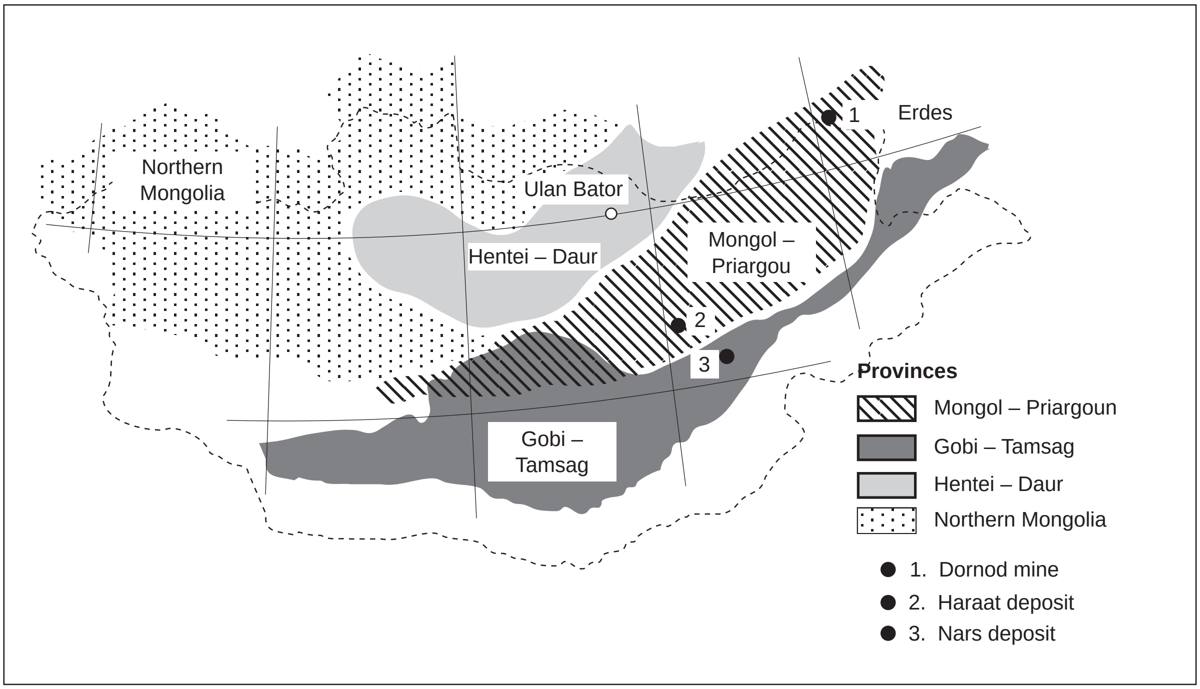
The Dornod deposit is located in the Dornod volcano-tectonic structure which is filled with Mesozoic volcanic flows and sediments. The uranium mineralization extends over an area of 20 km^2 and is concentrated in thirteen orebodies, ore shoots and stockworks. The uranium mineralization consists of pitchblende, coffinite, and brannerite, as well as uranium bearing leucoxene. The average ore grade is about 0.28 per cent U, ranging from 0.05 to nearly 0.6 per cent.

The Gurvanbulaag deposit is associated with the same Dornod volcano-tectonic structure. At this site, the Dornod structure includes two rock types. The lower, 300-400 metre thick series, consists of volcanic flows ranging in composition from rhyolite to andesitic basalts, interlayered with tuffaceous sediments. The upper, 300-800 metre thick series, includes acid effusive volcanics and their tuffaceous equivalents. The uranium mineralization, including coffinite, pitchblende and uranophane, is reported to be controlled both by lithology of the host rocks (preferably tuffaceous ashes) and favourable structures. It extends over a depth ranging from 15-40 metres to 720 metres. The highest grade ore is concentrated in a zone affected by low-angle faulting, at the contact between the lower and upper series. Stratiform orebodies are spread over 3 km^2. These orebodies also appear to be controlled by tectonic features. Seventeen orebodies of different sizes have been found. The highest grade ore covers about 1 500 m^2 with an average thickness of 3.5 metres and an average grade of 0.17 per centU.

1. Mongolia's RAR and EAR resources are not strictly consistent with NEA-IAEA standard terminology.

The Mardain-gol and Nemer occurrences are also associated with the Dornod structure. They are geologically similar to the Dornod and Gurvanbulag deposits. Resource estimates for these occurrences have not been completed.

Uranium metallogenic provinces and deposits of Mongolia



In addition to the deposits and occurrences in the Dornod structure, the Northern Choibalsan area hosts several other uranium occurrences including the Ugtam, Turgen and Engershand occurrences. These occurrences have not yet been fully evaluated.

The Haraat sandstone deposit occurs in the upper portion of lower Cretaceous sediments of the Choir basin which overlies Proterozoic crystalline schists, gneisses and marbles intruded by Paleozoic granitoids. The ore occurs in alternating sandstone and clays, with interbedded lignitic layers. These rocks were originally geochemically reduced but are now oxidized to a depth of 25-30 metres. The mineralization occurs in this oxidized environment. Common minerals include autunite, torbernite and schroeckingerite. Associated elements include cerium, lanthanum, scandium, yttrium, ytterbium, rhenium, germanium, molybdenum and silver.

In addition to the resources associated with the Choir basin, other sedimentary basins in the Eastern Gobi district have a potential to host uranium deposits. These basins include the Ulaan Nuur, Nyalga and Tavansuvaa basins. Exploration of these basins is still incomplete.

The Gobi-Tamsag province covers an area 1 400 km by 60-180 km in Southern Mongolia. Uranium in this province is generally associated with Cretaceaous to Paleocene sediments deposited in a number of basins including the Tamsag, Zuunbayan and Sainshand. The Saaiinshand basin hosts the Nars deposit. Exploration of these basins is still incomplete.

The total resources of the Gobi-Tamsag province is reported to amount to 3 000 tU as P1 resources, as well as 74 000 tU and 423 000 tU as P2 and P3 resources, respectively.

The Nars deposit is located in the southern part of the Sainshand sedimentary basin. The basin is filled with sediments of Cretaceous to Paleocene age. The known uranium mineralization occurs in both reduced and oxidized sandstones and tuffitic sediments, with interlayered claystones. Mineralogically, the ore consists of pitchblende and coffinite, associated with pyrite and galena. No resource estimate for the Nars deposit is reported.

Additional uranium occurrences have been found in other parts of the Sainshand basin. They occur in oxidized sedimentary environments, similar to those in the Haraat deposit in the Mongol-Priargun province. These resources are reported to be amenable to low cost extraction methods including heap leaching and ISL mining.

The Hentii-Daur province measures 700 km by 250 km and covers the Hangai and Hentii mountains. The uranium occurrences discovered in this province are associated with fault zones in leucogranites. A concentration of occurrences in the Janchivlan area is considered to be of interest.

The resources of the Hentii-Daur provinces total 4 000 tU of the P1 category, as well as 30 000 tUand 116 000 tU in the P2 and P3 categories, respectively.

The Northern Mongolian province is the largest of the Mongolian uranium provinces. It measures 1 500 km by 450 km and is located in Northern and Western Mongolia. The uranium was found to be hosted by a variety of rock types including alkaline intrusives, metasomatic albitites, pegmatites and other magmatic rocks. Uranium in this province also occurs in quartzitic schists. The province appears to be the least explored one. It is expected, however, that explorers will in the future recognise the potential of this province. The resources of this province are reported to total 25 000 tU and 325 000 tU in the P2 and P3 categories, respectively. A table with the uranium provinces and resource position of the individual areas is shown below.

SUMMARY OF URANIUM RESOURCES OF MONGOLIA

(Tonnes U)

U. Met. Prov.*	Known Resources		Undiscovered Resources		
	C1	C2	P 1	P 2	P 3
M-P	31 000	28 000	14 000	261 000	136 000
G-T	0	0	3 000	74 000	423 000
H-D	0	0	4 000	30 000	116 000
N.M	0	0	0	25 000	325 000
TOTAL	31 000	28 000	21 000	390 000	1 000 000

* Uranium Metallogenetic Provinces: M-P = Mongol-Priargun, G-T = Gobi-Tamsag, H-D = Hentii-Daur, N.M = Northern Mongolian.

Known Conventional Uranium Resources (RAR & EAR-I)

There is no resource estimate update reported for Mongolia. Therefore, the 1 January 1995 estimate will also be presented for this edition of the Red Book. Although the estimate is in compliance with the cost ranges suggested by NEA-IAEA, the resources still include previously mined resources, i.e. depletion is not considered.

The known uranium resources as of 1 January 1995, total 83 000 tU as in situ resources recoverable at costs below $80/kgU. Of the total, 62 000 tU are in the RAR category, recoverable at costs below $80/kgU. The $40/kgU portion of the RAR amount to 11 000 tU located in the Haraat deposit.

EAR-I total 21 000 tU, recoverable at below $80/kgU, of which 11 000 tU are believed to be recoverable at below $40/kgU.

Of the known resources recoverable at below $40/kgU, 26 per cent are tributary to existing and committed production centres, and 100 per cent of the $ 80/kgU known resources are tributary to existing and committed production centres. Attention must be paid to the fact that the resources include exploited material.

A summary of the resources as of 1 January 1995 is given in the following tables.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
11 000	62 000	62 000

* As in situ resources. Depletion not considered.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
11 000	21 000	21 000

* As in situ resources. Depletion not considered.

Undiscovered Conventional Uranium Resources (EAR-II & SR)

Mongolia does not report any EAR-II resources. The SR are shown in the following table.

SPECULATIVE RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	1 307 000	1 307 000

* As in situ resources.

URANIUM PRODUCTION

Uranium production in Mongolia started with operation of the Dornod open pit mine in the Mardai-gol district (see map) in 1989, based on the known uranium resources in the Dornod and Gurvanbulag deposits. Both open pit and underground mines were developed. This operation has a design capacity of 2 000 000 t ore/year. Assuming an ore grade of 0.12 per cent, this equals a mining production capability of 2 400 tU/year. Mongolia has no processing facilities. The ores mined in the Mardai-gol district have been transported by rail 484 km to the Priargunsky Mining and Processing Combinate in Krasnokamensk, Russia, for processing. The mines have been operated by the Erdes Mining Enterprise, a joint venture between Mongolia and the Russian Federation. Marketing was done by Techsnabexport. Due to the political and economical changes both in Mongolia and the neighbouring areas of Russia, uranium production of Erdes was terminated in 1995. The historical uranium production between 1989 and 1995 is shown in the following table.

HISTORICAL URANIUM PRODUCTION*

(Tonnes U)

Year	Tonnes Ore	Ore Grade % U	Tonnes U
1989	79 882	0.117	94
1990	91 154	0.098	89
1991	100 724	0.1	101
1992	98 209	0.118	105
1993	52 321	0.104	54
1994	63 378	0.114	72
1995	13 919	0.145	20
1996	0	–	0
TOTAL	499 587	–	535

* Produced by conventional mining methods.

Technical details of the Erdes production centre are not available.

Status of Production Capability

It is reported that the Central Asian Uranium Company, a joint venture between Mongolian, Russian and US organisations, is preparing to restart production at the Mardai-gol deposits.

The planned production capability of the different producers between 1998 and 2005 is shown in the following table. Information on the status of the relevant production centres as well as details on the uranium resources supporting these centres are not available.

Future Production Centres

Production plans are being made by the three uranium organisations including in addition to the Central Asian Uranium Company, Gurvansaikhan, a joint venture of Mongolian, Russian and US organisations and Koge-Gobi, a Mongolian-French joint venture. As indicated, the Central Asian Uranium Company is planning to restart production from the Mardai-gol deposits in 1998. Gurvansaikhan is active in a number of sedimentary basins including the Choir, Hairkhan, Undurshil, Ulziit and Gurvansaikhan. A production start is envisaged for the year 1998. Koge-Gobi is also actively exploring for sandstone type uranium deposits in the Sainshand, Oshiin Nuur, Nyalga and Tamsag basins. Production is planned to start in 2003. It can be assumed that all production centres planned for mining sandstone type uranium deposits will employ ISL techniques.

The following table provides on overview of the production plans for the three producers: Central Asian Uranium Company, Gurvansaikhan, and Koge-Gobi.

PLANNED URANIUM PRODUCTION

(Tonnes U)

YEAR	Central Asian Uranium Company	Gurvansaikhan Company	Koge-Gobi Company	TOTAL
1998	150	100	0	250
1999	250	200	0	450
2000	300	200	0	500
2001	300	400	0	700
2002	300	400	0	700
2003	350	400	100	850
2004	400	400	200	1 000
2005	400	400	300	1 100

NATIONAL POLICIES RELATING TO URANIUM

At present, the Mongolian Parliament is discussing proposed amendments to the Minerals Act. The concepts guiding the amendments of the Act include the following principles:

- national and foreign investors have equal rights in the process of obtaining mineral exploration and production licenses;
- introduction of simple, open and efficient procedures for the issue of exploration and mining licenses;
- the holder of a mining license has the right to mine every mineral found on the license and has the right to sell, to use as collateral and/or to inherit the issued license;
- to pay a royalty of 2.5 per cent of the sales value to the Government regardless of the commodity;
- to grant the provision of accelerated depreciation for mining investments to provide a faster payback of investments.

In addition, the draft amendment includes numerous other provisions to attract investments in the mining sector. As regards uranium production, the Mongolian Government places a high priority on uranium mining and domestic processing. The Government introduced special policies and guidelines including:

- to reduce Government involvement in uranium exploration, production and marketing, in favour of foreign investors;
- to investigate potential effects of uranium exploration and production on the biosphere and assurance of its protection;
- to intensify the co-operation with international organisations in the areas of exploration, production and marketing of uranium and other raw nuclear materials;
- to issue legislation for all activities related to uranium production;
- to initiate exploration for sandstone type uranium deposits;
- to initiate investigation of extraction of uranium from phosphate and coal deposits;
- to train national personnel in activities related to uranium exploration and production, and to introduce advanced technology and high precision instruments;
- to create a governmental organisation responsible for the monitoring of uranium exploration and production; to ensure the observation of Government policies and the employment of national specialists.

• Morocco •

URANIUM EXPLORATION

Historical Review

Uranium exploration began in Morocco in 1946 and continued through to 1987. Although geological and geophysical investigations defined numerous uranium and uranium/thorium occurrences, the results of the work were discouraging, as no economic uranium concentrations were found. No further work was conducted.

See the 1989 edition of this publication for additional information.

URANIUM RESOURCES

There are no known conventional uranium deposits in Morocco.

However, numerous uranium occurrences are known to exist, in the *Anti-Atlas*, *the Haut Atlas Occidental et Central,* the *Meseta* and *Moyen Atlas* and the *Haute Moulouya*. Geologically, these occurrences are mainly associated with Precambrian, Cambrian and Palaeozoic granites and sediments, ranging in age from Cambrian to Cretaceous.

In addition, there are very large resources of uranium contained in phosphate deposits, as compiled below:

UNCONVENTIONAL BY-PRODUCT SOURCES FROM PHOSPHATES

Deposit Name	Location	Deposit Type	Quantities (tU)	Grade (gU/t)
Oulad Abdoun	Khourigba	Phosphate	3 220 000	120
Gantour	Youssoufia	Phosphate	966 000	130
	Ben Guerir		240 000	180
Oued Eddahab	Boucraa	Phosphate	57 000	60
Meskala	Essaouira	Phosphate	2 043 000	100

As of 1997, studies continue to evaluate uranium in phosphates, including:

- characterisation and chemical analysis of uranium phosphates and their derivatives, and;
- laboratory test of uranium extraction from phosphoric acid. These tests are carried out in relation with the quality of the products and the process for producing phosphoric acid.

There are, however, no plans to recover uranium as a by-product of phosphate.

• Namibia •

URANIUM EXPLORATION

Historical Review

The first significant discovery of radioactive mineralization within Namibia was made in 1928 in the Rössing region by autoradiograph tests on a sample containing supposed pitchblende minerals.

As a result of an upswing in the uranium market demand and prices, extensive uranium exploration started in Namibia in the late 1960s. Several airborne radiometric surveys were conducted by the Geological Survey during this period and numerous uranium anomalies were identified. One of these developed into the Rössing deposit, where Rio Tinto Zinc had obtained exploration rights in 1966. This deposit was developed into a large scale open pit mine which started production in 1976.

The development of Rössing, combined with a sharp upward trend in uranium prices, stimulated extensive exploration activity, mainly in the Namib Desert. Two major types of deposits were identified including the intrusive type, associated at Rössing, with alaskite and the surficial, calcrete type.

Of the intrusive deposits other than Rössing, the Valencia deposit has significant resources. The Langer Heinrich deposit is the most promising deposit of the surficial, calcrete type. Feasibility studies were carried out on several of these low grade deposits but the fall in the market saw the cessation of any further work.

The combined effect of political uncertainty and the decline of uranium prices caused the rapid curtailment of exploration and development work in the early 1980s. This was indeed unfortunate as the refinement of exploration techniques which had proved so successful in the Namib Desert were poised to locate a number of new deposits.

Since that time, the continued weakness of the uranium market discouraged further exploration activities, except in the immediate vicinity of the Rössing mine. These expenditures are included in the table below.

However, should a sustained upturn in demand for uranium occur, it remains possible that the development of one of the identified deposits may prove commercially viable, with Langer Heinrich generally regarded as having the best potential.

Recent and Ongoing Activities

Currently there is only one uranium exploration license issued and the information on the work done and expenditure is confidential.

Figure 1. **Uranium deposits of Namibia**

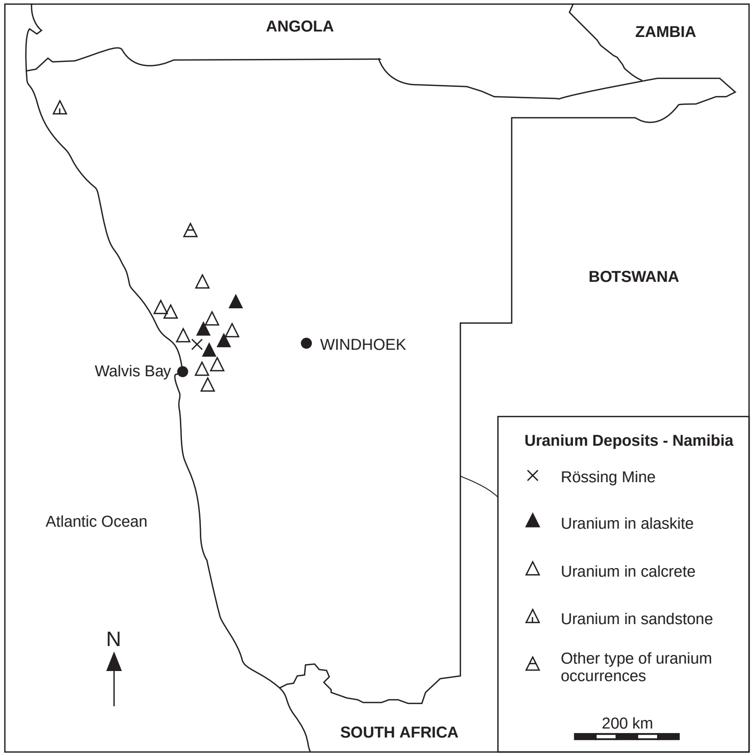
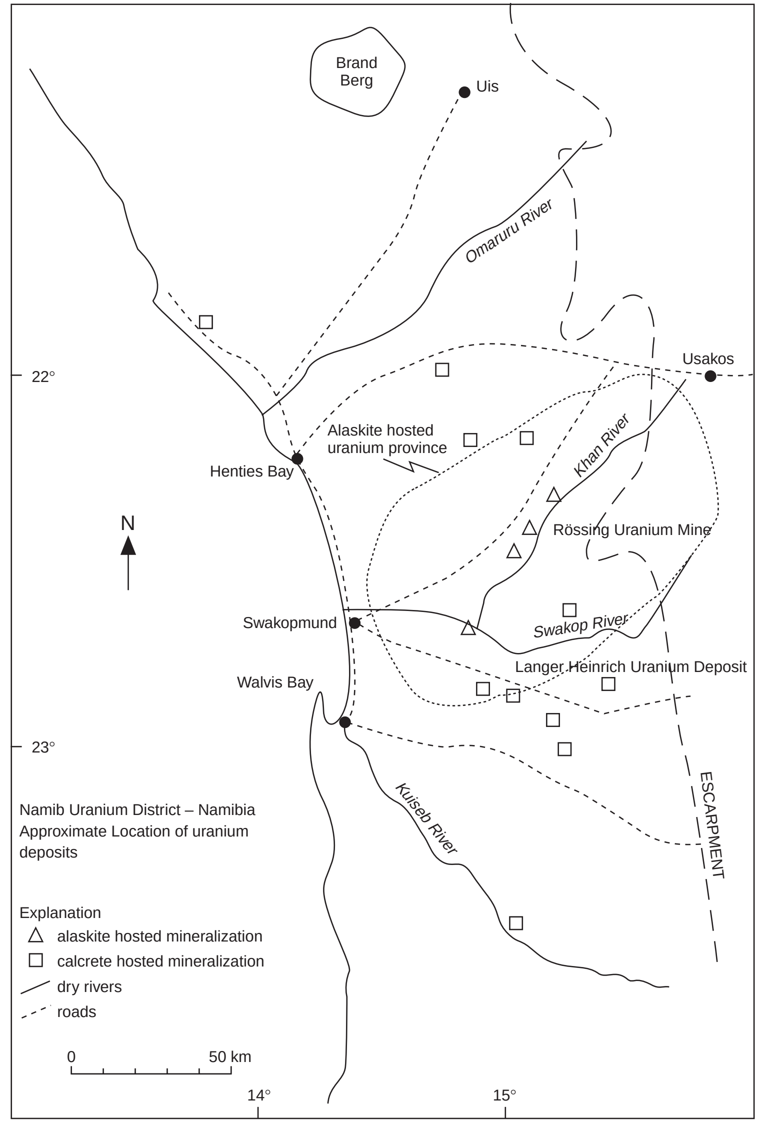


Figure 2. **Location of uranium deposits in the Namib Uranium District**



The government recently acquired high resolution airborne geophysical data (radiometrics and magnetics) over the highly prospective areas of the country. The greater portion of central western Namibia, which hosts most of the uranium deposits, was also covered by these surveys.

The surveys were sponsored by the SYSMIN Fund and cost approximately N$ 7 500 000, but were not flown exclusively for uranium exploration.

The exploration expenditure of private industry are confidential and no other government expenditure was incurred.

URANIUM EXPLORATION EXPENDITURES

	1994	1995	1996	1997 (Expected)
Industry Expenditures (N$)	0	0	NA	NA
Government Expenditures (N$)	0	7 500 000	0	0
TOTAL EXPENDITURES (US$)	0	2 150 000	NA	NA

URANIUM RESOURCES

The uranium resources of Namibia, including both known and undiscovered categories, occur in a number of geological environments and consequently belong to several deposit types. The known resources are mainly associated with the intrusive deposit type. In addition, about 10 per cent of the total known resources are hosted in surficial type deposits.

In addition to the known resources in the intrusive-type Rössing and Trekkopje deposits, located in the granite associated district of the Precambrian Damara Orogenic Belt, and those associated with surficial calcretes of the Langer Heinrich deposit, there is a large undiscovered uranium potential. Although it is not quantitatively assessed, the potential is in the following geological environments:

- The granitic terrain of the Damara Belt covers 5 000 km^2. This area is largely overlain by surficial deposits and/or wind-blown semi-consolidated sand. Past investigations concentrated on follow-up of airborne radiometric anomalies. Substantial additional resources, potentially the size of the Rössing deposit, are suspected under the post-mineral cover.

- Tertiary to recent surficial sedimentary terrains exist in semi-arid areas. This environment has further potential for calcrete type deposits. Eleven of 38 identified regional airborne anomalies were successfully investigated by intensive drilling. This drilling provided known resources included in the estimate. In most cases the drilling encountered low grade mineralization associated with calcrete-filled palaeo-river channels.

- Another type of potentially favourable geological environment is the sandstone basins. The corresponding model includes the Permo-Triassic Karoo sediments which were intensively investigated in neighbouring countries in the early 1970s. These basins were explored to a limited extent in Namibia as well. These sediments are extensively dissected by river systems in the north-western part of Namibia and the airborne radiometric expressions are very pronounced. Ground follow-up including substantial drilling delineated nearly 6 million tonnes of low grade uranium mineralization. However, this was excluded from the known resources due to high costs of recovery. It is believed that economically recoverable resources may be present within similar age sedimentary basins in other unexplored parts of Namibia.

Known Conventional Resources (RAR & EAR-I)

Namibia's known resources as of 1 January 1997 total 294 872 tU, recoverable at costs below $130/kgU. While the RAR portion amounting to 187 359 tU is expressed as recoverable resources, adjusted for mining (10-16 per cent) and ore processing losses (14-30 per cent), the EAR-I are reported as in situ resources.

Of the total RAR of 187 359 tU recoverable at costs of below $130/kgU, there are 156 124 tU recoverable at costs below $80/kgU and 74 089 tU or 40 per cent recoverable at costs below $40/kgU. No uranium exploration has taken place over the last two years thus the resources are unchanged except for the depletion resulting from production of 4 463 tU.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
74 089	156 124	187 359

* As in situ resources.

The EAR-I as of 1 January 1997 amount to 107 513 tU recoverable below $130/kgU, as in situ resources. The lower cost portions amount to approximately 91 000 tU recoverable at below $80/kgU and 70 000 tU below $40/kgU. Lack of exploration has resulted in these resources remaining unchanged from the previous report.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
70 546	90 815	107 513

* As in situ resources.

Undiscovered Conventional Resources (EAR-II & SR)

Due to the availability of only limited data, EAR-II and SR were not estimated. The undiscovered potential, however, is considered excellent, especially for intrusive type deposits. A more detailed summary on additional environments with uranium potential is included in the first part of this report.

URANIUM PRODUCTION

The only uranium producer in Namibia is the Rössing production centre of Rössing Uranium Limited.

Historical Review

In 1928, Captain G. Peter Louw prospected and found uranium mineralization in the vicinity of the Rössing Mountains in the Namib Desert. Over many years he tried to promote the prospect, but it was only in the late 1950s that Anglo American Corporation of South Africa prospected the area by drilling and some underground exploration. Due to erratic uranium values and poor economic prospects for uranium, Anglo American abandoned the search.

In August 1966, Rio Tinto Zinc (RTZ) acquired the exploration rights and conducted an intensive exploration programme until March 1973. Surveying, mapping, drilling, bulk sampling and metallurgical testing in a 100 t/day pilot plant indicated the feasibility of establishing a production centre.

Rössing Uranium Limited was formed in 1970 to develop the deposit. RTZ was the leading shareholder with 51.3 per cent of the equity (at the time of the formation of the company).

Mine development commenced in 1974, and the commissioning of the processing plant and the initial production was in July 1976 with the objective of reaching full design capacity of 5 000 short tons U_3O_8/year (3 845 tU/year) during 1977. Due to the highly abrasive nature of the ore, which was not identified during the pilot plant testing stage, the production target was not reached until 1979 after some major plant design changes.

HISTORICAL URANIUM PRODUCTION
(Tonnes U contained in concentrate)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	1997 (Expected)
Conventional Mining • Open pit	54 679	1 895	2 016	2 447	61 037	3 000
TOTAL	54 679	1 895	2 016	2 447	61 037	3 000

Ownership Structure of the Uranium Industry

Rössing Uranium Limited is a mixed enterprise with private and governmental shareholders as detailed in the following list:

RTZ Corporation	56.3 per cent
Namibian Government	3.5 per cent
Rio Algom Limited	10.0 per cent
IDC South Africa	10.0 per cent
Others	20.2 per cent

The uranium production is 100 per cent owned by domestic private organisations.

Status of Production Capability

Production is increasing from an all time low in 1992 during which production was at about 41 per cent capacity. During 1996 production improved to 60 per cent of capacity and this is expected to increase to 75 per cent during 1997.

Employment in the Uranium Industry

The reduced production during the early nineties forced a downsizing of staffing levels, but with increased production the staff levels will increase slightly. The employment numbers are summarised in the following table.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES
(Persons-Years)

1994	**1995**	**1996**	**Expected 1997**
1 246	1 246	1 189	1 300

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

Name of Production Centre	Rössing
Production Centre Class	Existing
Operational Status	Operating
Start-up date	May 1976
Source of Ore • Deposit Name • Deposit Type	 Rössing Intrusive
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 OP 30 000 84
Processing Plant • Type • Size (tonnes ore/day) • Average Ore Processing Recovery (%)	 Al/IX/SX 30 000 86
Nominal Production Capacity (tU/year)	4 000

Future Production Centres

No future production centres are envisaged.

Short-Term Production Capability

Namibia provided the following projection of its short-term production capability:

SHORT-TERM PRODUCTION CAPABILITY
(Tonnes U/year)

1995		1996		2000		2005		2010	
A-II	**B-II**	**A-II**	**B-II**	**A-II**	**B-II**	**A-II**	**B-II**	**A-II**	**B-II**
3 000	3 000	3 000	3 000	4 000	4 000	4 000	4 000	4 000	4 000

Long-Term Production Capability

Under favourable market conditions Rössing, the only uranium producer in Namibia, could return to full production of close to 4 000 tU/year. The known resources could support production at least through the year 2017.

Favourable market conditions would allow the development of one additional production centre with a production capacity of 1 000 tU/year.

Factors influencing the long-term production capability from a possible new centre include, in addition to uranium demand and price, the availability of water.

Environmental Considerations

Namibia's Constitution provides that the State actively promotes and maintains the welfare of the people by adopting policies aimed at ensuring that the ecosystem, essential ecological processes and the biological diversity of Namibia are maintained. However, environmental legislation that stems from this provision still remains in draft as the country addresses the more pertinent issues of education and development of its people.

Under the provisions of the Minerals (Prospecting and Mining) Act 1992, the applicant for a mining licence has to complete an environmental assessment study and prevent any damage to the environment due to exploration and mining activities. In case of mining, the rights holder is obliged to rehabilitate land disturbed by mining.

While the Namibian environmental legislation and standards remain to be established, the management of Rössing Uranium has adopted standards and performance criteria used by other developed countries. Presently a comprehensive review of environmental standards and performance criteria is being carried out by the Rössing uranium mine to develop site specific, risk-based environmental objectives and thresholds.

As Namibia's only producing uranium mine and a substantial percentage of its uranium resources are located within the Namib Desert, the principal environmental consideration is the management of available water resources.

Potable water for the Rössing mine, as well as for the coastal towns of Walvis Bay and Swakopmund is supplied from aquifers at the Kuiseb and Omaruru river deltas. To preserve the limited water resources and to save the cost of pumping over long distances, the management of Rössing has undertaken an integrated water management programme. This programme has resulted not only in the reduction of water consumption by the mine but also minimized groundwater contamination. A new tailings deposition method was developed by the mine to minimize the amount of water lost from the tailing impoundment due to the high evaporation rates in the area. Addition of carbonate rich tailings has also neutralised the acid mine drainage, a large percentage of which is returned to the mine.

Radiological concerns are addressed, and the recommendations included in the International Commission on Radiological Protection's Publication 60 of 1990 ("ICRP 60") have been implemented at Rössing. The challenge of radiological exposure is thus not to achieve compliance with minimum dose limits, but in the application of the principle of ALARA ("As Low As Reasonable Achievable) to reduce radiological exposure. There have been concerns about the potential for the incidence of cancers related to occupational radiation exposure. These can, however, only be addressed in comparison with national vital statistics, which at the present time are not available for Namibia.

NATIONAL POLICIES RELATING TO URANIUM

The Namibian Government recognises that the country's uranium deposits represent a major economic resource both for Namibia and uranium consumers of the world. It is thus committed to development of those deposits in a manner which is safe for its workers and environmentally sustainable in the long term. This policy has been expressed through legislation in the Minerals (Prospecting and Mining) Act of 1992.

Namibia achieved independence on 21 March 1990 and the Act was promulgated on 1 April 1994. With the introduction of the Act, a number of South African laws that previously regulated uranium production activities were repealed or amended. These laws include the Nuclear Installations (Licensing and Security) Act of 1963, the Atomic Energy Act of 1967 and their amendments.

URANIUM STOCKS

No uranium stocks are held in Namibia.

URANIUM PRICES

The Rössing Uranium Limited is the only uranium producing company in Namibia. The release of contract price information could be detrimental to the company's long term interest.

• Netherlands •

NATIONAL POLICIES RELATING TO URANIUM

The Netherlands has no uranium resources and is not currently undertaking any uranium exploration.

URANIUM REQUIREMENTS

The Netherlands currently has two nuclear reactors connected to the grid. These are the Borssele PWR reactor (481 MWe net) and the Dodewaard BWR reactor (56 MWe net). The date of decommissioning for Dodewaard is set at mid-1997. The provisional final reload for the Borssele reactor will be manufactured in 2001. The uranium requirements by this time will be 140 tU. The date of decommissioning is set at 2004.

URANIUM STOCKS

The natural uranium stocks were disposed of by 31 December 1995. Since then, the Netherlands have held no further stocks.

• Niger •

URANIUM EXPLORATION

Historical Review

Uranium exploration in the Arlit area of Niger began in 1956 and was conducted by the *Commissariat à l'Energie Atomique* (CEA), later followed by Cogema. Discovery of mineralised areas eventually led to the mining of the Arlette-Artois-Ariège deposits by the *Societé des Mines de l'Aïr* (SOMAIR), and the Akouta-Akola deposits by the *Compagnie Minière d'Akouta* (COMINAK). Exploration along the northwest extension of the Arlette flexure fault resulted in the discovery of the Taza deposit. The *Societé Minière de Tassa N'Taghalgue* (SMTT) was organised to own the deposit, but assigned part of its mining rights to SOMAIR in 1986.

In subsequent years, both SOMAIR and COMINAK were involved in exploration solely for the purpose of better evaluating known deposits. SOMAIR delineated the Taza Nord, and COMINAK evaluated a mineralized area, south-east of the Akola deposit.

During 1993 and 1994, both SOMAIR and COMINAK carried out significant drilling programmes. Part of the drilling results led to a reassessment of the resource estimate of the Takriza and Tamou deposits.

Recent and Ongoing Activities

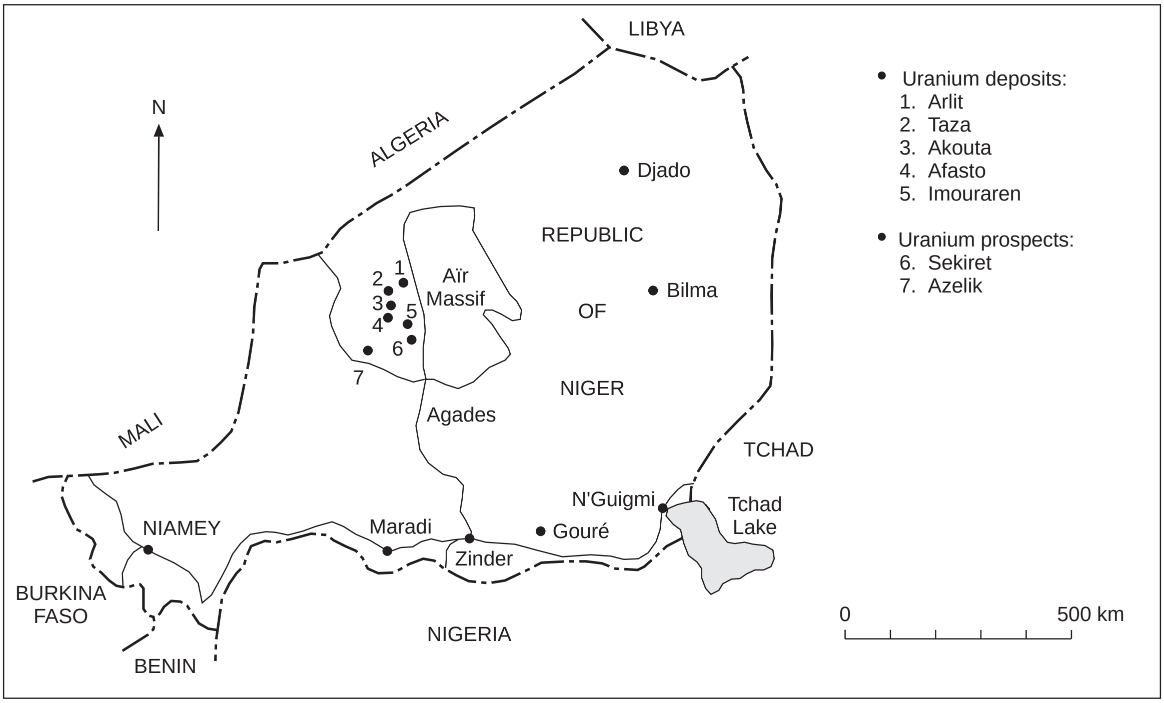
During the years 1995 and 1996, SOMAIR and COMINAK continued their drilling activities. These included the further evaluation of the Takriza and Tamou deposits by SOMAIR and of the South Akouta and Akola deposits by COMINAK. In 1996, the *Societé Minière de Tassa N'Taghalgue* (SMTT) was dissolved and its assets, including the mining properties, were sold to SOMAIR.

Plans for 1997 include the continuation of the drilling programmes.

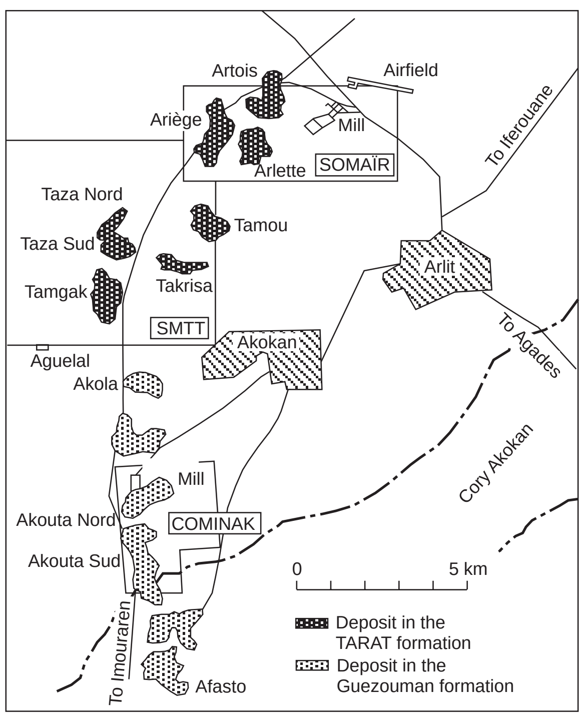
URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
Industry Expenditures (in million Francs CFA)	834	814	222	868
Industry Expenditures (in thousand US$)	1 481	1 664	427	1 653
Industry Surface Drilling (Metres)	58 139	57 469	16 103	52 000
Number of Industry Holes Drilled	NA	NA	NA	NA

Uranium deposits and prospects in Niger



Uranium deposits in the Arlit region, Niger uranium producing district



URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Niger's known resources, estimated as of 1 January 1997 total 71 158 tU, recoverable at costs of below $130/kgU. These resources are reported as recoverable with mining (10 per cent) and processing losses (approximately 6 per cent) deducted.

When compared to the 1 January 1995 estimate of 93 100 tU, recoverable at the same cost category, there is a decline of nearly 22 000 tU, or 15 700 tU net adjusted for production in 1995 and 1996. The remainder is assumed to be due to a reassessment of resources.

Niger's known resources are mainly RAR. In the cost category of below $130/kgU, they amount to 69 958 tU as recoverable resources, a decline from the previous estimate of 87 100 tU. Of the 1997 total, 41 800 tU, or 60 per cent are recoverable at costs below $40/kgU, with the remainder being recoverable at costs of below $80/kgU.

EAR-I as of 1 January 1997 are estimated at 1 200 tU, recoverable below $40/kgU. There are no higher cost EAR-I. This represents a decline of 4 800 t which probably results from a better understanding of the deposits provided by recent drilling results.

The estimates of the RAR and EAR-I recoverable at costs up to $130/kgU are listed in the following tables.

REASONABLY ASSURED RESOURCES[1]

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
41 800	69 958	69 958

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I[2]

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
1 200	1 200	1 200

1. As recoverable resources after deduction of mining (10 per cent) and metallurgical losses (6-8 per cent).
2. As recoverable resources.

Of the known resources, 15 per cent of the below $40/kgU resources and 25 per cent of the below $80/kgU are tributary to existing and committed COMINAK production centres.

Undiscovered Uranium Resources (EAR-II and SR)

Niger does not report any undiscovered resources.

URANIUM PRODUCTION

Historical Review

The uranium in Niger is produced by the two following companies: SOMAIR and COMINAK. They have operated mines on sandstone type deposits since 1970 and 1978, respectively. A third company, the *Société Minière de Tassa N'Taghalgue* (SMMT), which controlled the Taza deposit, assigned its mining rights to SOMAIR in 1996 . SMMT was subsequently dissolved.

SOMAIR has a production capability of 1 500 tU/year from open pit operations, while COMINAK's production capability increased to 2 300 tU/year, supported by underground mining.

URANIUM PRODUCTION CENTRES TECHNICAL DETAILS

(as of 1 January 1997)

Name of Production Centre	Arlit (SOMAIR)	Akouta (COMINAK)
Production Centre Class	Existing	Existing
Operational Status	Operating	Operating
Start-up Date	1970	1978
Source of Ore • Deposit Names • Deposit Types	 Taza-Takriza Sandstone	 Akouta-Akola Sandstone
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 Open pit 1 600 90	 Underground 1 800 90
Processing Plant • Type • Size (tonnes ore/day) • Average Processing Recovery (%)	 AL/Solvent Extraction 1 800 95	 AL/Solvent Extraction 1 900 93
Nominal Production Capacity (tU/year)	1 500	2 300
Plans for expansion	No	No

URANIUM PRODUCTION

(Tonnes U)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	1997 (Expected)
• Open pit	29 047	1 002	1 001	1 207	32 257	1 200
• Underground	30 443	1 973	1 973	2 114	36 503	2 200
TOTAL	59 490	2 975	2 974	3 321	68 760	3 400

Ownership Structure of the Uranium Industry

There were no changes of ownership of the uranium industry during 1995 and 1996. The ownership of the production companies remained:

COMINAK: 31 per cent Niger, 69 per cent foreign;
SOMAIR: 37 per cent Niger, 63 per cent foreign.

The ownership of the 1996 production of 3 321 tU is divided between the participating parties in the following manner: 33 per cent (or 1 096 tU) domestic government, 44 per cent (or 1 461 tU) foreign government, and the remaining 23 per cent (or 764 tU) private foreign mining companies.

Employment in the Uranium Industry

Restructuring of the production industry has been implemented progressively since 1990. This has resulted in a continuous decrease in employment from 3 173 in 1990 to 2 077 in 1996. This number is expected to further decrease to about 2 000 persons in 1997.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	**1995**	**1996**	**Expected 1997**
2 104	2 109	2 077	2 001

Environmental Considerations

The environmental impact of Niger's uranium mining industry results from corresponding activities spanning more than 25 years. During this period, a large amount of waste material has accumulated from both mining and milling activities. In addition, existing surface disturbances caused by the uranium mining industry include 4 depleted open pit mines.

Short-Term Production Capability

Niger's short-term production capability through the year 2015 is shown in the following table.

SHORT-TERM PRODUCTION CAPABILITY

(Tonnes U/year)

1995				1996				2000			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
3 800	NA	NA	NA	3 800	NA	NA	NA	3 800	NA	NA	NA

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
3 800	NA	NA	NA	3 800	NA	NA	NA	3 800	NA	NA	NA

Long-Term Production Capability

Niger expects to maintain the current production capability for the long term. Important factors, which may impact this plan, however, include the international uranium market prices, as well as plans made by competitors.

URANIUM STOCKS

As of 31 December 1996, the producers held a stockpile of 340 tU, in the form of natural uranium concentrates. This material was listed as stocks, as the book transfer from the producer to the converter was delayed.

URANIUM PRICES

The following prices of uranium sales made in the years 1991-1996 were reported as:

1991	1992	1993	1994	1995	1996	1997 (Expected)
FF 380/kgU	FF 340/kgU	FF 309/kgU	FF 265/kgU	FF 244/kgU	FF 235/kgU	FF 230/kgU

NATIONAL POLICIES RELATED TO URANIUM

One of the main objectives of the national uranium policy is for Niger to achieve a higher degree of international competitiveness in the uranium industry.

• Norway •

URANIUM EXPLORATION

Historical Narrative

The latest uranium programme at the Geological Survey of Norway was active during a ten-year period starting in 1975. A great deal of new data were collected and a number of databases were established including natural gamma radiation from bedrock, based on country-wide car-borne surveys and, for smaller area coverage, by helicopter-borne detailed surveys. Uranium values for stream sediment samples (15-20 000) taken on a detailed scale cover extensive areas. In addition uranium, thorium, and 20 other trace elements from country-wide bedrock samples (3 000) were analysed. These data have led to the recognition of uranium-enriched provinces and the discovery of a number of new interesting areas of mineralization. Today there is fairly good knowledge concerning areas that deserve further investigation for potential uranium resources, and for which the known mineralization could potentially be economic. However, at present no active uranium prospecting is being carried out in Norway.

URANIUM PRODUCTION

There has not been any production of uranium in Norway.

URANIUM REQUIREMENTS

Norway reports uranium requirements of a few hundred kilograms for the two research reactors during the next decade.

Supply and Procurement Strategy

Uranium will be bought on the world market in order to cover the future reactor-related uranium requirements.

• Pakistan •

URANIUM EXPLORATION

Historical Review

Extensive uranium exploration has been conducted in Pakistan using techniques including surface prospecting through systematic geological and geophysical surveys. A wide variety of geologic environments have been investigated, including: the igneous and metamorphic rocks of northern Pakistan and the sedimentary Siwalik Group. The Siwalik Group extends across the country from Kashmir in the northeast to the Arabian Sea in the southwest.

Igneous and/or metamorphic rocks of northern Pakistan have been evaluated including granites, graphitic metapelites and carbonatites. Extensive prospecting has been carried out over both the metapelites and granite terrain. Although a large number of radioactive anomalies have been discovered in these rocks there has been little success in locating any significant uranium concentrations.

During routine prospecting activities some of the carbonatites have been found to be radioactive. The main source of radioactivity is the mineral pyrochlore. Preliminary analysis of one carbonatite body indicates the presence of uranium in the rock samples, which also contain rare metals, rare earths, phosphate and to a lesser degree magnetite. Geological investigations were therefore undertaken to determine the trend and size of the radioactive zones in the carbonatite body and to evaluate its potential for exploitation as a multi-mineral prospect.

Pakistan's geographic (geologic) position is in a tectonically active collision zone where the Indo-Pakistan Plate, located to the south is subducting under the Island Arc Assemblage along the Main Mantle Thrust, which in turn is subducting under the Eurasian Plate. This siltation is of particular importance in northern Pakistan where the tectonic activity is responsible for both the very rugged terrain and the unstable geologic environment. The rugged topography makes exploration very difficult. In addition, the tectonically active conditions have left few stable areas to trap and preserve uranium deposits.

Exploration of the Siwalik Group

The Siwalik Group, of Miocene to Pleistocene age, consists of interlayered sandstone and shales, with occasional conglomerates developed as channel lag and terrace deposits. The rocks of the Siwalik Group have been a target for uranium exploration in Pakistan since the discovery of the first radioactive anomaly in these rocks in the Dera Ghazi Khan district. The Siwalik Group occurs from Kashmir in the Northeast through the Potwar Plateau, Bannu Basin, Sulaiman Range and extend to the Arabian Sea in the southwest.

The Siwalik sequence has been divided into the Lower, Middle and Upper Siwaliks on the basis of lithology. The Lower Siwaliks are dominantly bright coloured (shades of red and orange) shales with minor sandstones overlain by massive sandstone and alternating beds of shale and sandstone of the Middle Siwaliks. These are in turn overlain by coarser facies comprising sandstone, conglomerate, boulder beds, and subordinate shales of the upper Siwaliks. The sandstones in the Middle Siwaliks (subdivided into Nagri and Dhok Pathan Formations) are mainly sub-graywackes and lithic arenites. The fine grained facies of Nagri fall into the clay and siltstone category, whereas those of Dhok Pathan include mudstone and siltstone with rare clay.

The exposures of the Dhok Pathan formation, which hosted the first uranium discovery, have been surveyed using airborne radiometry. They have also been extensively prospected on foot. As a result, a large number of uranium anomalies were encountered in the Dhok Pathan formation in Kashmir, the Potwar Plateau, Bannu Basin and Sulaiman Range. Further to the west, where the character of the Siwaliks changes from continental to marginally marine, argillaceous material dominates. No radioactive anomalies were found in these rocks. The exploratory work resulted in definition of a few minable uranium deposits in the Sulaiman Range and Bannu Basin. The Potwar Plateau has, however, not yet yielded any uranium ore bodies.

Bannu Basin

Tectonics appear to have played the key role in the genesis of uranium ore bodies in the Bannu Basin. The basin has experienced repeated upheavals, accompanied by successive lowering of the water table. This caused leaching of uranium after each upheaval, which was subsequently followed by re-precipitation of uranium below the water table. The presently confined geohydrological regime has apparently been responsible for preservation of uranium below the water table.

The uranium mineralization in this area has a very low radioactive signature when compared with the amount of contained uranium. Thus there is a strong disequilibrium in favour of chemical uranium; a relationship indicating a very recent emplacement age.

Recent Activities

Platform Survey of Potwar Plateau

The Potwar Plateau area has a number of sites where widespread surface radioactivity has been identified. Conventional exploration activities at these areas have, however, failed to identify uranium mineralization and the results have been inconclusive at most of the sites. This is due to the difficulty in properly selecting and testing prospective areas in an active collision zone environment. This problem was compounded by lack of detailed data analysis.

To both upgrade the technical skills of the local geoscientists and to overcome the deficiencies in exploration methodology, a resource potential evaluation programme based on geological modelling was developed. The programme, generally referred to as a “Platform Survey” was started under the guidance of an IAEA supported programme.

The Platform Survey has set an example for systematic exploration strategy. Through this work an area of 15 000 km^2 of Potwar Plateau was reduced to 2 000 km^2. Detailed prospecting was then conducted in the southwestern part of the area. This has been further reduced to about 400 km^2 where detailed studies of the subsurface are planned.

URANIUM RESOURCES

No quantitative report of uranium resources is reported.

URANIUM PRODUCTION

No quantitative information on uranium production is reported.

In Situ Leach Mining

A major portion of the uranium deposits outlined at various locations in Sulaiman Range has been mined out. The ore bodies discovered at Nangar Nai, Bannu Range, are being tested for mining using in situ leach (ISL) mining technology.

The uranium ore bodies outlined in Bannu Basin are hosted in poorly consolidated sandstones. Their exploitation through conventional mining methods was considered impracticable and hazardous due to bad ground conditions and the influx of large quantities of water. Alternatively, application of ISL technology was investigated. It was found to be feasible because the ore bodies are located below the water table in highly permeable sandstones. Some less favourable geologic characteristics in the area include a dipping rather than a horizontal sandstone hosts and structural imperfections. Furthermore confining shale is frequently not present below the orebearing horizon.

Subsequently, ISL tests were conducted on several 5 spot patterns over a period of 4 years. Based on the test results ISL parameters were established to plan for the start of semi-commercial scale operations in mid-1995. Research and Development is continued at the site to fine tune the operations with a view to improving recovery and reducing production costs.

The ISL mining technique now employs both 5 and 7 spot well patterns. Ammonium bi-carbonate and hydrogen peroxide are used, respectively, as lixiviant and oxidant. They are injected at atmospheric pressure. The uranium bearing leach liquor is recovered using submersible pumps. The system operates at low pH to prevent mobilization of calcium. The lateral excursion of the leaching fluids is controlled by maintaining a balance between injection and production. The wellfield is regularly monitored using monitor boreholes.

Evaluation of Carbonatites

Surface radiometric maps of the carbonatite body were prepared to understand the relationship of uranium mineralization to lithology and structure. The maps indicate that roughly 25 per cent of the carbonatite body is radioactive and has potential for further subsurface exploration. Subsurface exploration on these two blocks was subsequently undertaken and diamond core drilling was initiated to test the sub-surface extension of surface radiometric anomalies. The information obtained from the drill holes established the subsurface continuation of radioactivity along well defined subsurface zones. Core samples were analysed for determination of chemical uranium values. Results show that uranium mineralization continues with depth, thus considerably increasing the workable volume of the carbonatite body. The resource potential of this carbonatite body could be a few thousand tonnes of uranium at an average grade of 0.02 per cent U.

Beneficiation studies of carbonatites

The chemical and mineralogical analyses of the carbonatite are as follows:

PYROCHLORE	0.4 per cent
Uranium	200 ppm
Rare metal	600-800 ppm

APATITE	7.1 per cent
Phosphate	3 per cent P_2O_5
Rare Earth Elements	0.2 per cent
MAGNETITE	5.0 per cent
Fe	3.0 per cent
CALCITE	70 per cent
$CaCO_3$	68 per cent

The analyses of the uranium bearing carbonatites indicate a rather low uranium content. Beneficiation studies for concentrating the uranium were therefore, conducted at the laboratory, as well as the pilot scale. The results indicate that the ore may be upgraded using physical concentration methods such as wet magnetic separation, wet gravity separation and froth floatation. The preliminary results indicate the recovery percentage of different fractions, and attainable degree of upgrading as shown below:

Mineral Concentration	Assay	Upgrade Ratio	Recovery
Pyrochlore	3% U	150.0	78.75%
Apatite	30% P_2O_5	10.0	70.00%
Magnetite	71% Fe	19.7	95.00%
Calcite	95% $CaCO_3$	1.4	83.00%

This indicates that the uranium content in the carbonatite can be upgraded by 150 times before subjecting it to chemical processing. Pyrochlore concentrates containing up to 3 per cent U can be processed for recovery of uranium. Phosphate (P_2O_5) can also be upgraded from 3 per cent to 30 per cent using froth flotation techniques. This is the acceptable grade for manufacturing fertilizer.

• Peru •

URANIUM EXPLORATION

Historical Review

Uranium exploration carried out by the Peruvian Nuclear Energy Institute (IPEN) resulted in the discovery of more than 40 uranium occurrences in the Department of Puno, in the southeastern part of Peru. These occurrences, referred to as the uranium district of Macusani, are associated with acid volcanics of Miocene to Pliocene age, filling the Macusani basin eroded into a Palaeozoic basement.

The main occurrences are referred to as Chapi, Pinocho, Chilcuno VI, Cerro Concharrumio, and Cerro Calvario, etc. Of these, Chapi is considered the most important occurrence. Consequently, most exploration activities took place in this area. These investigations resulted in the identification of uranium mineralization associated with subvertical structures. They are distributed in structural lineaments measuring 15-90 metres in length and 20-30 metres in width. The uranium grades vary between 0.03 and 0.75 per cent with an average of 0.1 per cent U. Based on the geological information obtained it is estimated that this occurrence has a potential of about 10 000 tU.

Due to the budgetary reductions of IPEN, all uranium exploration activities were stopped in 1992. However, exploration expenditures of Soles 10 500 were reported for 1994.

URANIUM RESOURCES

The conventional uranium resources of Peru are primarily located in the Macusani area, Department of Puno. In this area the uranium mineralization is associated with acid volcanics of Miocene to Pliocene age, underlain by Palaeozoic basement rocks.

Within the Macusani area there are a number of uranium prospects named Chapi, Chilcuno VI, Pinocho, Cerro Concharrumio and Cerro Calvario. The mineralization consists of pitchblende, gummite, autunite, meta-autunite, and other minerals filling subvertical and subhorizontal fractures. Chapi is the most important prospect.

Known Conventional Resources (RAR & EAR-I)

Peru reports known resources of both RAR and EAR-I categories of the Macusani uranium district. More details are given in the following tables.

REASONABLY ASSURED RESOURCES

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	1 790	1 790

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	1 860	1 860

* As in situ resources estimated within the last 5 years.

Undiscovered Conventional Resources (EAR-II & SR)

The total undiscovered uranium resources are estimated to be 26 350 tU. They are further subdivided by resource and cost category in the following tables.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	6 610	6 610

SPECULATIVE RESOURCES**

(Tonnes U)

Cost Range <$130/kgU	Cost Range Unassigned	TOTAL
19 740	0	19 740

* As in situ resources.

** Based on the the distribution of the volcanic host rock over a surface of 1 000 km^2.

NATIONAL POLICIES RELATING TO URANIUM

The exploration and exploitation of uranium is open to private investors within a framework that ensures long-term stability and assurance of investments. Currently, the Peruvian Government invites offers from mining companies interested in the exploration and subsequent exploitation of the domestic uranium resources. To facilitate this process, IPEN will make technical information available to interested parties.

• Philippines •

URANIUM EXPLORATION

Recent and Ongoing Activities

During 1995 and 1996, the Philippine Nuclear Research Institute, formerly PAEC, conducted a reconnaissance and semi-detailed uranium geochemical exploration in Palawan Island. Available funds for this project amounted to US$ 60 000 for the two-year period. At least two prospective geochemical anomalies were identified in the San Vicente area. These uranium occurrences are related to granitic and metamorphic rocks (phyllite and schist).

For 1997, it is planned to conduct a modest (US$ 50 000) reconnaissance uranium geochemical exploration programme in southern Palawan.

URANIUM EXPLORATION EXPENDITURES

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES US$	30 000	30 000	30 000	50 000

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

There are no significant known uranium resources in the country. Minor occurrences have been identified in association with pyrometasomatic replacement and hydrothermal metalliferous deposits related to middle Miocene intrusives of acid-to intermediate composition.

Undiscovered Conventional Resources (EAR-II & SR)

No formal estimate of the amount of undiscovered resources has been made.

The northern part of Palawan island located southwest of Luzon was identified in the 1991-1992 period as a geologically favourable area for discovery of uranium resources. Northern Palawan is considered to be a rifted portion of a continental terrain where the oldest basement formations consist of folded sedimentary and metamorphic rocks. The age of the basement rock is thought to be Lower Paleozoic or older.

The basement rocks were intruded by Tertiary granitic bodies and ultramafics and are partly covered by Tertiary sedimentary formations. Major thrust faults separate these formations. Although the granitic intrusive bodies are thought to be prospective, the metamorphic formations near these intrusives are also considered to be geologically favourable for uranium mineralization.

URANIUM REQUIREMENTS

The Philippines has a 620 MWe PWR nuclear reactor, designated PNPP-1, which was built but never completed. There are plans to convert this facility to a fossil fuel fired power plant. There are therefore no uranium requirements for the foreseeable future.

NATIONAL POLICIES RELATING TO URANIUM

Uranium exploration and mining is open to private enterprise. These activities are subject to nuclear safety regulations and existing production sharing schemes being implemented by the Mines and Geosciences Bureau (formerly Bureau of Mines).

• Portugal •

URANIUM EXPLORATION

Historical Review

Uranium exploration first began in Portugal with the discovery in 1912 of the Urgeiriça deposit which contained radium and uranium. Radium was mined until 1944 and uranium has been mined since 1951. Between 1945 and 1962, a foreign privately-owned enterprise, Companhia Portuguesa de Radium Limitada (CPR) carried out radiometric surveys, detailed geological mapping, trenching and core drilling with gamma-ray logging in the granitic formations of the Beiras districts. In 1955 the Government started uranium exploration on a systematic basis using geological mapping, carborne and ground radiometric surveys, geophysics (resistivity surveys), trenching, diamond and percussion drilling. By 1961, the Junta de Energia Nuclear (JEN) had discovered about 100 deposits in the hercynian granitic or perigranitic zones in the districts of Beiras and Alto Alentejo. The Beiras areas with its numerous small deposits together with the Urgeiriça mill constitute an integrated uranium production district. The Alto Alentejo area would also support another production centre in the future. Since 1976 prospecting has been continued in the crystalline regions with known uranium resources.

Exploration in sedimentary regions started in 1971, employing geological, radiometric, geochemical, emanometric and drilling surveys in the western Meso-Cenozoic fringe of the Portuguese basin.

Responsibility for uranium mining and exploration activities were transferred respectively from JEN to the publicly-owned enterprise "Empresa Nacional de Urânio, S.A." (ENU), in 1977, and to the "Direcção-Geral de Geologia e Minas (DGGM)", in 1978. ENU carried out prospecting activities in areas adjacent to uranium deposits with their extensions.

Recent and Ongoing Activities

The Instituto Geológico e Mineiro (former Direcção-Geral de Geologia e Minas) has ceased all uranium exploration activities. A radiometric background map of Portugal (scale 1/200.000) is being prepared (three out of eight sheets have been produced) under contract with the General Directorate of the Environment. A rare earth exploration project is also being conducted.

ENU's exploration activities have remained at a very low level with a slight increase in 1995, related to the reappraisal of the Nisa project.

URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT – DOMESTIC

Currency reported: US$ 1000

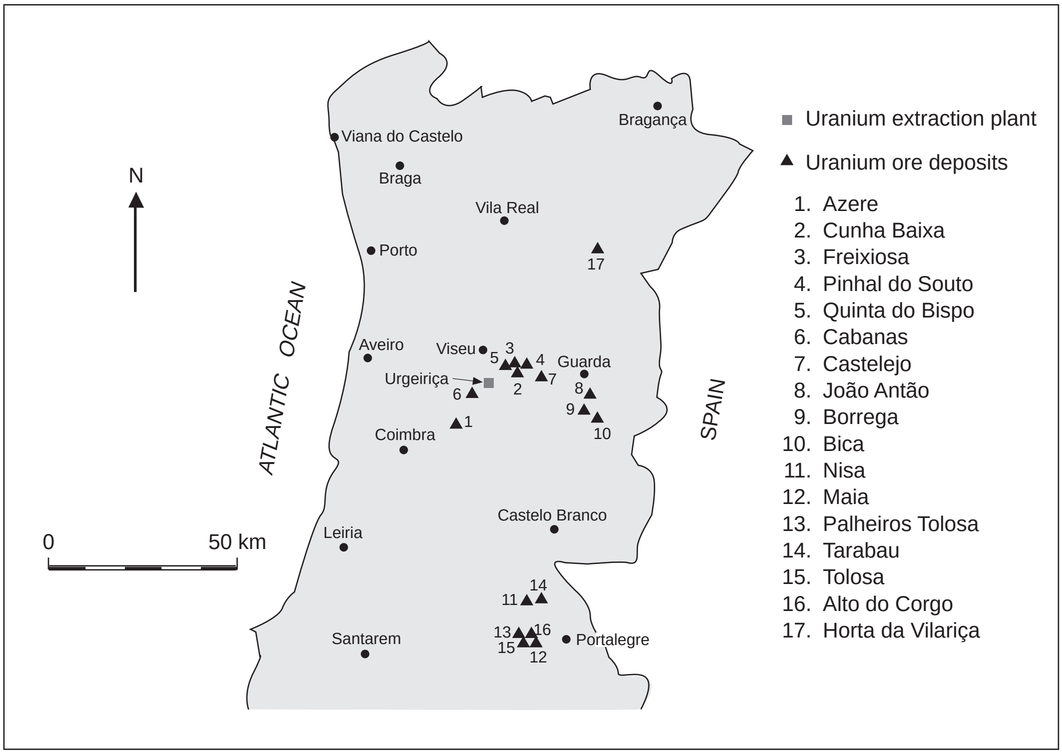
	1994	1995	1996	1997 Expected
Industry Expenditures	97	130	119	NA
Government Expenditures	9	0	0	0
TOTAL EXPENDITURES	106	130	119	NA
Industry Surface Drilling in Metres	3 040	2 855	4 416	5 000
Number of Industry Holes Drilled	69	85	108	NA

URANIUM RESOURCES

Known Conventional Resources (RAR and EAR-I)

Portugal reports total RAR of 8 900 tU recoverable at costs of $130/kgU or less. Of this total, 7 300 tU are recoverable at costs equal or below $80/kgU. Additionally, 1 450 tU are reported as EAR-I recoverable at costs equal or below $80/kgU.

Uranium deposits and occurrences in Portugal



URANIUM PRODUCTION

Historical Review

Between 1951 and 1962, the CPR produced a total of 1 123 tU from 22 concessions, of which 1 058 tU were milled at the Urgeiriça plant and 65 tU at mines by heap leaching. The uranium at that time was precipitated using magnesium oxide. During the period 1962 to 1977 the JEN took over the mining and milling activities from CPR, introducing organic solvent extraction. A total of 825 tU were produced from the Urgeiriça plant and the pilot plant at Senhora das Fontes. Between 1977 and 1994, ENU produced 1 651 tU.

Status of Production Capabilities

At present the Urgeiriça production mill, whose nominal production capacity is 170 tU/year, is operating at reduced capacity. The produced concentrate (25 tU/year) comes from low grade ore treatment by heap leaching and minor proportion from in situ leaching.

HISTORICAL URANIUM PRODUCTION
(Tonnes U contained in concentrate)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	Expected 1997
Conventional Mining						
• Open pit	1 246	–	–	–	1 246	
• Underground	1 881	–	–	–	1 881	
Subtotal	3 127	–	–	–	3 127	–
In situ Leaching	243	5	–	1	249	4
By-Product Production	–	–	–	–	–	–
Other Methods	230	19	18	14	281	13
TOTAL	3 600	24	18	15	3 657	17

Ownership Structure of the Uranium Industry

All mining and milling activities are entrusted to ENU, a fully state-owned company which also carried out uranium exploration activities in areas surrounding present and future mining sites by the end of 1992. Meanwhile the exploration permit has expired and all the exploration activities have ceased. ENU was integrated in 1992 into the Portuguese state mining holding, Empresa de Desenvolvimento Mineiro (EDM). A new development programme is expected after extensive manpower reduction and financing restructuring activities are completed.

DGGM/IGM ceased all exploration activities for uranium by the end of 1994 and the operating capacity has been allocated to other projects.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

	Centre # 1
Name of Production Centre	Urgeiriça
Production Centre Class	Existing
Operational Status	Operating
Start-up Date	1951
Source of Ore • Deposit Name • Deposit Type	 Bica, Castelejo, Quinta do Bispo Iberian
Mining Operation • Type (OP/UG/In situ) • Size (tonnes ore/day) • Average Mining Recovery (%)	 In situ and heap leaching
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Ore Recovery (%)	 IX/SX
Nominal Production Capacity (tU/year)	170

Future Production Centres

The Nisa project (south of Portugal) is planned to yield 100 tU/year, revised from 160 tU/year. The start of production is dependent on the evolution of the international uranium markets. Feasibility and environmental studies are ongoing.

Environmental Considerations

ENU has been monitoring several environmental parameters such as air quality, mining effluents (underground mine and surface drainage waters) and collecting data samples on soil, sediments and vegetation for further analysis on the following decommissioning mines: Urgeiriça, Castelejo and Cunha Baixa.

Every mine has wells and piezometers and the operation of analysing underground and surface drainage waters is being assessed along several monitoring sites upstream and downstream on every watercourse near the mines.

Underground waters are being monitorised at a distance of 300 to 400 metres beyond the tailings dam perimeter of Urgeiriça plant and the cleared waters are being monitorised downstream at a distance of 3 km.

On the radiological protection field, several analyses are being carried out to detect any radio elements in water.

Several studies are being carried out in order to characterise geochemical and hydrochemical aspects and establish the mitigation measures of negative effects the waste piles of the Cunha Baixa mine (decommissioning mine) and Quinta do Bispo mine (heap leaching mine) may have had on the environment.

Thus, alluvial and sediment samples are being collected upstream and downstream every water course near the site.

URANIUM REQUIREMENTS

No uranium requirements are presently envisaged.

NATIONAL POLICIES RELATING TO URANIUM

The national authority responsible for national policies concerning uranium are the State Secretariat of Energy and the General Directorate of Energy. All mining and milling activities are entrusted to the Empresa Nacional de Urânio, a fully state-owned company and now a subsidiary of Empresa de Desenvolvimento Mineiro, SA, a state holding for mining. Exploration is free and is granted by the Instituto Geológico e Mineiro, according with Portuguese mining law. ENU has the exclusive right for mining and milling under Decree 120/80, as of 15 May 1980.

• Romania •

URANIUM EXPLORATION

Historical Review[1]

Prospecting for uranium in Romania was initiated in the 1950s when a bilateral agreement between the Romanian and USSR governments (the Romanian-Soviet Joint Venture SOVROM-CUARTIT) was concluded. A series of radiometric surveys were then completed to identify uranium occurrences of industrial value.

Several uranium occurrences were discovered in 1952. The Bihor deposit (tabular sandstone deposit with pitchblende and chalcopyrite mineralization) and the Avram Iancu deposit (vein-type mineralization in schists consisting of pitchblende with associated Ni and Co sulphoarsenides and Cu, Pb, Zn minerals) were discovered in the Apuseni Mountains. In the Banat Mountains, the Ciudanovita deposit, followed by Dobrei and Natra deposits (tabular, sandstones with bituminous pitchblende mineralization) were discovered. It was then established that uranium deposits are of endogene origin and they occur in the Permian Formations (Bihor, Ciudanovita) or crystalline rocks (Avram Iancu). Airborne radiometric surveys of gamma radiation were completed over most of the Carpathian Mountain range.

Results of this work indicate both the Apuseni and west Banat Mountains are highly prospective for uranium while the potential of the Eastern and Middle Carpathians is low. Uranium bearing radioactive anomalies with an undefined economic potential have been identified at Dobrogea in the Middle Carpathians and in the Poiana Rusca Mountains. At the Gradistea de Munte deposit, uranium occurs as an accessory to Rare Earths, molybdenum and thorium ores.

In the first stage, between 1951 and 1957, various prospecting methods were used including both ground and airborne radiometric, and radon emanometric surveys.

Little additional exploration work was then conducted until the 1961-1962 period, when the study of the Eastern Carpathians started. The Crucea, Botusana and Tulghes deposits were discovered at that time. These deposits, consisting of vein-type pitchblende mineralization, occur in metamorphosed shales. During this period, the tabular Padis deposit was also discovered in the Apuseni Mountains. It consists of pitchblende and other uranium mineralization in sandstones of Permian age.

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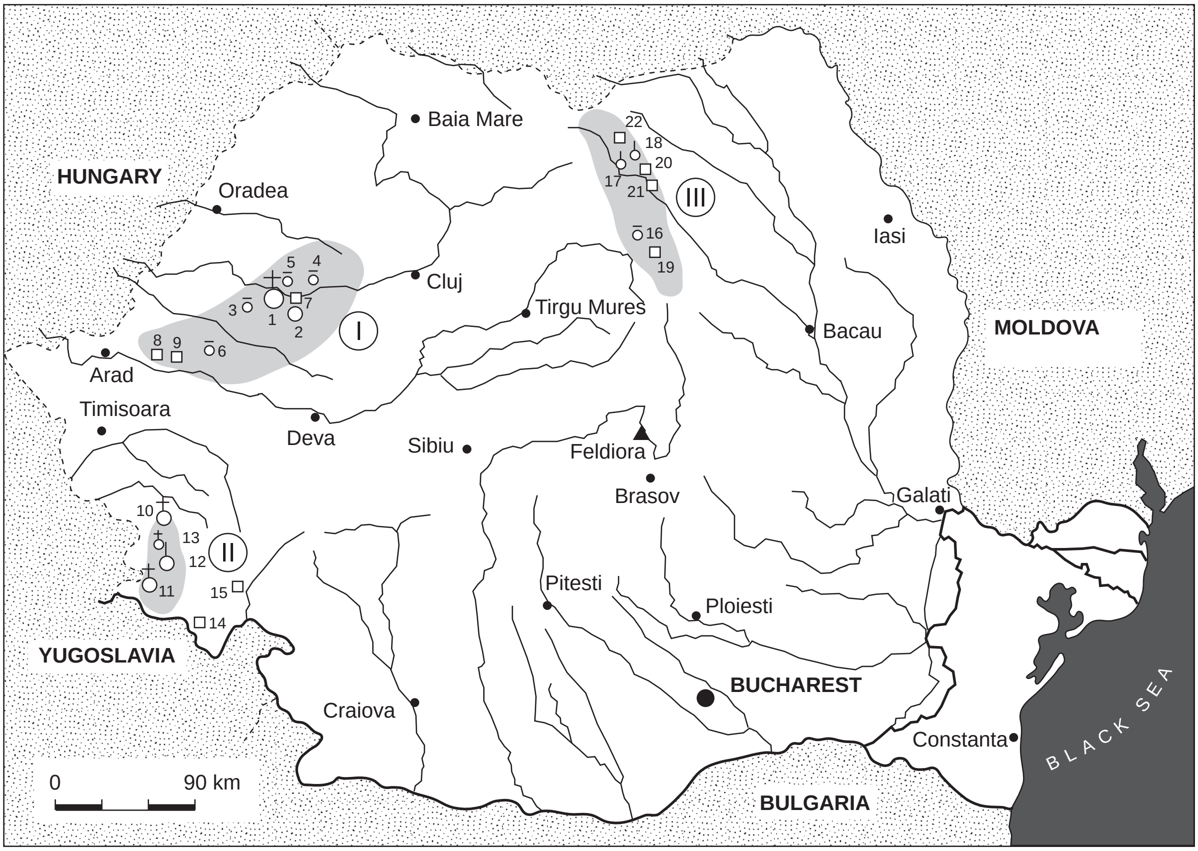
1. Additional information is available from the 1993 edition of this publication.

Uranium deposits in Romania



I. APUSENI MOUNTAINS

Deposits
1. Baita Bihor
2. Avram Iancu
3. Ranusa
4. Rachitele
5. Budureasa
6. Paiuseni

Occurrences
7. Arieseni
8. Milova
9. Conop

II. BANAT MOUNTAINS

Deposits
10. Ciudanovita
11. Natra
12. Dobrei South
13. Dobrei North

Occurrences
14. Ilisova
15. Mehadia

III. EASTERN CARPATHIANS

Deposits
16. Tulghes
17. Crucea
18. Botusana

Occurrences
19. Bicazul Ardelean
20. Piriul Lesu
21. Holdita
22. Hojda

▲ Uranium processing plant – Feldiora
Uranium provinces
Ⓘ Western Carpathians
Ⓘⓘ Banat Mountains
ⒾⒾⒾ Eastern Carpathians

○ Large deposits: > 20 000 t metal
○ Medium deposits: 5 000–20 000 t metal
○ Small deposits: < 5 000 t metal

Ore deposits depleted
Ore deposits in exploitation
Ore deposits in exploration
□ Mineralisation in exploration

During this same time period exploration started at the Ranusa deposit. This molybdenum and uranium mineralization forms a tabular occurrence in meta-rhyolites. The Milova deposit, consisting of vein mineralization in Hercynian age granites, and the tabular Arieseni deposit in Permian sandstones, were also discovered.

Mine production started in 1952 at the Bihor and Ciudanovita deposits, in 1962 at the Avram Iancu and in 1983 at the Crucea and Botusana deposits. Other deposits including the Tulghes, Ranusa, Padis, Arieseni, and Milova have been explored in detail to establish their full potential.

With the exception of the Banat Mountains deposits, where open pit mining was used, underground mining technology has been used in all of the deposits mined. Since 1978 all of the produced ores have been processed at the Feldiora mill.

Recent and Ongoing Uranium Exploration Activities

The amount of work planned for 1997 is being reduced because of decreasing budgets.

In Romania all uranium related activities are carried out by state-owned companies. No exploration is conducted outside the country.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES				
Lei (x 1000)	4 707 000	4 707 000	5 361 000	9 500 000
US$ (x 1000)	2 998	2 448	1 861	2 423
Government Surface Drilling in Metres	6 485	15 850	9 285	11 000

URANIUM RESOURCES

Known Conventional Uranium Resources (RAR & EAR-I)

A total of 18 000 tU are reported with an average grade of 0.11 per cent U. This includes 6 900 tU RAR with a production cost of less than $130/kgU. No resources with lower production costs are reported. EAR-I include 8 950 tU with a production cost of less than $130/kgU. Total RAR and EAR-I in this cost category are 15 850 tU.

REASONABLY ASSURED RESOURCES (RAR)

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	–	6 900

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	–	8 950

Undiscovered Conventional Resources (EAR-Category II and Speculative Resources)

A total of 4 970 tU of Undiscovered Resources are reported. This includes 1 970 tU of EAR-II in the less than $130/kgU production cost category and 3 000 tU of Speculative Resources in the same cost category.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	–	1 970

SPECULATIVE RESOURCES

(Tonnes U)

Cost Ranges		
<$40/kgU	Unassigned	<$130/kgU
–	–	3 000

URANIUM PRODUCTION

Historical Review

From 1950 until 1960, all uranium operations were carried out by the Romanian-Soviet Joint Venture SOVROM-CUARTIT. Uranium production in Romania started in 1952. During the 1952 to 1961 period, all uranium production was conducted for the Soviet Union. As no ore processing plant existed in Romania, the ore was shipped to foreign locations for processing. The uranium concentrate was then shipped to the Soviet Union.

The high grade Baita-Bihor deposit averaging 1.13–1.26 per cent U, was the first deposit to be mined in 1952. Mining started before the deposit was fully evaluated. The ore was sorted and shipped to the Sillimae ore processing plant in Estonia. The Baita-Bihor deposit is now depleted.

In 1961 the joint venture with the Soviet Union was dissolved and all uranium production was stopped. From 1956 to 1977, all uranium ores produced were stockpiled at the mines. The production of uranium concentrate was resumed in 1978 when the Feldiora hydrometallurgical plant became operational. he Feldiora plant is located 21 km north of Brasov in central Romania. Part of the production obtained was sent to FCN Pitesti nuclear fuel plant as uranium and sodium diuranate.

The Ciudanovita deposit was mined by underground methods from 1956 until January 1993, when the resources were depleted. The Dobrei North and Natra deposits, located in the same district, were also mined and are now reported as depleted. In 1980, mining of one deposit in the Eastern Carpathian district started.

In 1985 the circuit of the Feldiora plant was extended to include a refining section capable of producing uranium dioxide. The oxide is used in fabrication of fuel for the Candu type reactors at Cernavoda.

Status of Production Capability

Three mining plants are now in operation: E.M. Banat, E.M. Bihor and E.M. Crucea. The Feldiora hydrometallurgical plant uses a pressure alkaline leach circuit with recovery by ion exchange to produce sodium diuranate. This product is then further processed at the plant to produce uranium dioxide powder that may be sintered to produce fuel pellets. This process is conducted in the “R” mill at Feldiora.

A second production unit was planned at the Feldiora plant. Construction was about 50 per cent complete when it was suspended because of the lack of funds. Completion of this facility would increase capacity to 600 tU of UO_2 concentrate.

The planned development of a mine at the Tulghes deposit has also been suspended.

Ownership Structure of the Uranium Industry

In Romania all uranium exploration, research, exploitation and processing activity is conducted by the state.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

Name of Production Centre	Feldiora mill, fed from 3 mines
Production Centre Class	Existing
Operational Status	Operating
Start-up Date	1978
Source of Ore • Deposit Names • Deposit Type	 Banat, Bihor and Crucea Hydrothermal
Mining Operation • Type • Size (tonnes ore/year) • Average Mining Recovery (%)	(Three mines) Underground 150 000 80
Processing Plant • Type • Size (tonnes ore/year) • Average Processing Recovery (%)	Feldiora ALKPL/IX 150 000 80
Nominal Production Capacity (tU/year)	300
Plans for expansion (tU/year)	150

Employment in the Uranium Industry

EMPLOYMENT IN EXISTING PRODUCTION CENTRES
(Persons-Years)

1994	1995	1996	Expected 1997
6 500	6 000	5 000	4 550

Environmental Considerations

The Romanian uranium industry has a systematic programme for protection of the environment. Potential sources of the environmental impacts during uranium exploration, exploitation and milling activities include:

- mine and mill effluents containing natural radioactive elements above the maximum admissible concentration;
- waste rock from mining operations;
- low grade ore with a uranium content of 0.02-0.05 per cent, which at present is not processed, but stored at the mine site;
- tailings, from processing activities, stored in the dewatering ponds at the Feldiora mill; and
- metal and wooden wastes contaminated with radioactivity during exploitation and processing of radioactive minerals.

The installations and equipment required for the prevention of environmental contamination include:

- construction and enlargement of the water treatment plants for treating effluents at the following deposits: Carpates Orientals, Montagnes Apuseni and Banat;
- increased capacity of tailings impoundments;
- processing and closing of ore storage areas at various mines; and
- long-term stabilization, reclamation and revegetation of waste dumps and surrounding areas.

The following general activities are planned:

- rehabilitation of the entire rail car park;
- implementation of a ventilation system using filters at the mill and ore shipping stations; and
- equipping all uranium production sites and facilities with environmental monitoring systems.

URANIUM REQUIREMENTS

Based on the known uranium requirements of the CNE-Cernavoda nuclear power plant no problems are expected in supplying the required fuel.

INSTALLED NUCLEAR GENERATING CAPACITY
(MWe)

1996	1997	1998	2000	2005		2010		2015	
				Low	*High*	*Low*	*High*	*Low*	*High*
650	650	650	650	1 950	1 950	2 560	3 250	3 250	3 250

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS
(Tonnes U)

1996	1997	2000	2005		2010		2015	
			Low	*High*	*Low*	*High*	*Low*	*High*
100	100	100	300	300	400	500	500	500

Supply and Procurement Strategy

The Ministry of Electrical Energy is constructing five nuclear power plants of the PHWR type (Candu) at the Cernavoda site. Construction of the five units started between 1980 and 1986. The installed nuclear electricity generating capacity of each of these units will be 650 MWe net. The first Unit of CNE Cernavoda nuclear power plant was connected to the grid and started commercial generation in 1996. The second unit is scheduled to start operation in 2001.

The construction of the 3 remaining units at Cernavoda depends on the interest of the foreign investors, the availability of heavy water for the units and the electrical needs of Romania.

The fuel supply strategy will be developed coincident with the plans for constructing and commissioning the 5 units of the CNE Cernavoda nuclear power plant.

URANIUM STOCKPILES

Romania does not maintain a stockpile of uranium.

• Russian Federation •

This is the first official report from the Russian Federation providing a complete description of Russian uranium resources and production-related activities.

URANIUM EXPLORATION

Historical Review

Uranium exploration has been carried out in the Russian Federation since 1944. The full range of geological, geophysical and geochemical methods are applied for prospecting, exploration and ore delineation. Within this period about 10 ore-bearing districts have been discovered and delineated in the eastern part of Siberia. In addition, 4 were discovered in the European part of the Russian Federation. Four of the Siberian districts (Transurals, West Siberia, Vitimsky and Streltsovsky) have uranium resources in the <$40/kgU cost category. The European districts include: Stavropolsky, Onezhsky, Ladozhsky and Ergeninsky. The Stavropolsky deposit has been completely mined out, and production has stopped. The other deposits have resources in the >$80/kgU category.

Recent and Ongoing Uranium Exploration Activities

During 1995-1996 all of the reconnaissance and prospecting activity took place in the Kalmynya, Streltsovsky, Ladozhsky, Transurals, West Siberia and Far East regions. In 1997, exploration is planned for the Transurals, West Siberia and Vitimsky deposits. New production projects utilising ISL technology are planned for these deposits.

Annual uranium exploration expenditures were between US$ 4 197 million and US$ 5 581 million in 1994 to 1996. They are expected to increase by more than 2 times to about US$ 11 300 million in 1997. The exploration programme included drilling of 235, 485 and 240 holes, respectively in 1994, 1995 and 1996. A total of 31 681, 62 000 and 29 000 metres were drilled respectively in 1994, 1995 and 1996. A total of 485 holes comprising 62 000 metres are planned in 1997.

All uranium exploration activities are conducted by government organisations. There were no exploration expenditures made outside the Russian Federation territory during the 1994-1997 period.

URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT

	1994	1995	1996	1997 (Expected)
Industry Expenditures (Roubles x 1000)	0	0	0	0
Government Expenditures (Roubles x 1000)	7 575 555	28 352 000	21 400 000	62 300 000
TOTAL EXPENDITURES (Roubles x 1000)	7 575 555	28 352 000	21 400 000	62 300 000
TOTAL EXPENDITURES (US$ x 1000)	4 197	5 581	4 271	11 307
Industry Surface Drilling in Metres	0	0	0	0
Number of Industry Holes Drilled				
Government Surface Drilling (Metres)	31 681	62 000	29 000	62 000
Number of Government Holes Drilled	235	485	240	485
TOTAL SURFACE DRILLING	31 681	62 000	29 000	62 000
TOTAL HOLES DRILLED	235	485	240	485

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

The Russian Federation has one uranium producing district located near Krasnokamensk, in the Chita region. The district consists of the volcanic-type Streltsovsky deposits[1]. From 1994 to 1996 the resources were depleted by nearly 3 000 tU. Exploration in the region led to the discovery of some additional resources. Production took place from resources with a cost of <$40/kgU. Most of the remaining resources are in the $80-$130 cost category.

Exploration of the Dolmatovskoye deposit located in Transurals, was completed. A total of 10 200 tU RAR in the <$80/kg category have been defined[2].

Additional RAR and EAR-I resources in the <$80/kgU category amounting to about 52 600 tU were defined in the Vitimsky region.

A new deposit has been discovered in the West Siberian region. The deposit is now under exploration. The total RAR and EAR-I resources of the region are estimated to be 20 000 tU.

Speculative resources in the region are 180 000 tU.

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1. Details of the geology of the Streltsovsky deposits are reported in: ISCHUKOVA, A.P., “The Streltsovskoye uranium district”. Changes and events in uranium deposit development, exploration, resources, production and the world supply-demand relationship, IAEA-TECDOC-961, IAEA, Vienna, 1997, 237.

2. Details of the Dolmatovskoye and other similar deposits are reported in OECD/NEA-IAEA, “Uranium 1993 – Resources, Production and Demand”, OECD, Paris, 1994.

INSERT MAP OF **RUSSIAN FEDERATION** HERE

As of 1 January 1997, the RAR at a production cost of <$40/kgU, total 66 100 tU. RAR in the $40 to $80/kgU class total 78 900 tU.

EAR-I in the <$40/kgU are 17 200 tU, while there are 19 300 tU in the >$40/kgU to <$80/kgU class.

The total RAR and EAR-I resources at <$80/kgU are 181 500 tU.

REASONABLY ASSURED RESOURCES*
(Tonnes U)

Country	Cost Ranges	
Russian Federation	<$40/kgU	<$80/kgU
	66 100	145 000

* As in situ resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*
(Tonnes U)

Country	Cost Ranges	
Russian Federation	<$40/kgU	<$80/kgU
	17 200	36 500

* As in situ resources.

An assessment has not been made within the last 5 years for either the RAR or EAR-I resources.

Availability of "Known" (RAR & EAR-I) Resources

Eighty-eight per cent of the RAR in the <$40/kgU production cost category are contributory to existing production centres. Twelve per cent of the EAR-I in the <$40/kgU production cost category are contributory to existing production centres. A total of 86 per cent of the RAR in the <$80/kgU production cost category are tributory to existing production centres. A total of 14 per cent of the EAR-I in the <$80/kgU production cost category are contributory to existing production centres.

Undiscovered Conventional Resources (EAR-II & SR)

The estimation of EAR-II and SR of the Russian Federation has been completed. Most of the resources are located in the eastern part of the Russian Federation. These areas have no infrastructure which would increase the cost of producing these resources. The resources are classified in the over $80/kgU production cost category.

As of 1 January 1997, EAR-II include 56 300 tU in the <$80/kgU category, and 104 500 tU in the <$130/kgU category.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II*

(Tonnes U)

Country	Cost Ranges		
Russian Federation	<$40/kgU	<$80/kgU	<$130/kgU
	0	56 300	104 500

* As in situ resources.

As of 1 January 1997, the SR include 550 000 tU in the <$130/kgU category and 450 000 tU in the unassigned cost category.

SPECULATIVE RESOURCES

(Tonnes U)

Country	Cost Range <$130/kgU	Cost Range Unassigned	TOTAL
Russian Federation	550 000	450 000	1 000 000

* As in situ resources.

URANIUM PRODUCTION

Historical Review

Uranium ore mining and processing in the Russian Federation territory started in 1951 at the Beshtau and Bykogorskoye deposits, in the Stavropolsky region. Production was stopped in the late 1980s. The total uranium output was 5 685 tonnes, with 3 930 tonnes extracted by underground mining and 1 755 tonnes using in situ leach technology. In 1968-1980 the Sanarsk deposit was mined by the Malyshevsk Mining Administration. The uranium output over this period was 440 tU. Now only the Priargun Association is in production. This organisation has been producing uranium from the Streltsovsky uranium-ore region near Krasnokamensk since 1968. A total of 97 418 tU have been produced in the region through 1996. The average annual production over this period is nearly 3 500 tU. This high level of total production marks the volcanic-type Streltsovsky deposits as one of the outstanding uranium production districts worldwide.

Status of Production Capability

Uranium production in the Russian Federation fell from 2 697 tU in 1993 to 2 541 tU in 1994 and continued to decline to 2 160 tU in 1995. In 1996 production increased to 2 605 tU, a 21 per cent increase. Production in 1996 was 75 per cent by conventional underground mining, 3.6 per cent by open pit and 22.7 per cent by heap and in-stope leaching. Over the period 1993 to 1996 production by leaching increased while open pit mining is being phased out.

STATISTICAL DATA ON URANIUM PRODUCTION

(Tonnes U contained in concentrate)

Production Method	Pre-1993	1993	1994	1995	1996	Total to 1996
Conventional Mining						
• Open pit	37 889	262	294	110	100	38 655
• Underground	52 619	2 378	2 200	2 000	1 914	61 111
SUBTOTAL	90 508	2 640	2 494	2 110	2 014	99 766
Leaching	3 032	57	47	50	591	3 777
TOTAL	93 980	2 697	2 541	2 160	2 605	103 983

For the first time, the Russian Federation has reported total uranium production. Through 1996, the Russian Federation produced 103 983 tU. This places the Russian Federation as the fifth largest uranium producing country in the world.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)
Part 1: Existing and Operating

Name of Production Centre	"Priargun Mining and Chemical Production Association"
Production Centre Class	Existing
Operational Status	Operating
Start-up Date	1968
Source of Ore	15 deposits of Streltsovsky uranium-ore region
Mining Operations • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 OP, UG, HL, in-stope leaching 6 700 97
Processing Plant (acid) • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	 Ion exchange 4 700 95
Nominal Production (tU/year)	3 500

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
Part 2: Planned Centres

Name of Production Centre	Kurgan	Novosibirsk and Kemerovo	Buryatiya
Production Centre Class	Planned	Planned	Planned
Operational Status			
Start-up Date	~2010	~2010	~2010
Source of Ore • Deposit Names • Deposit Types	 Kurgan Sandstone	 Novosibirsk and Kemerovo Sandstone	 Buryatiya Sandstone
Mining Operation • Type • Size (tonnes ore/year) • Average Mining Recovery (%)	 ISL NA NA	 ISL NA NA	 ISL NA NA
Processing Plant • Type • Size (tonnes ore/day) • Average Ore Processing Recovery (%)	 IX NA NA	 IX NA NA	 IX NA NA
Nominal Production Capacity (tU/year)	1 700	2 000	2 300

Ownership Structure of the Uranium Industry

Ownership of all exploration and production activities have always been 100 per cent government owned. Uranium exploration is carried out under the State Concern "Geologorazvedka", a subsidy of the State Committee of Geology and Mineral Resources. Uranium production in the Strelsovsk District, Kransnokamenst is the responsibility of the State Concern "Priargun Mining and Chemical Production Association", Krasnokamensk, Chita Region. – The Share Capital is under State ownership.

In the past, mining was conducted by the state companies: Lermontov Mining and Chemical Production Association in the Stavropolsk Region, and by the Malyshevsk Mining Administration in the Sverdlovsk Region.

Employment in the Uranium Industry

In 1993, the Priargun Mining and Chemical Association had 15 900 employees. By 1996 the number of employees was reduced by 2 900 persons to a total of 13 000. The employment levels over the period 1993 to 1996 are shown below.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1993	1994	1995	1996
15 900	14 400	14 000	13 000

Short-Term Production Capability

The Russian Federation reports that its present production capability is based on the mine/mill complex operated by the Priargun Mining and Chemical Production Association, near Krasnokamensk. This organisation produces uranium from the volcanic-type Streltsovsk deposit complex. In 1996 the production came predominantly from underground mines which produced 2 014 tU. An additional 100 tU were produced by an open pit mine that is being phased out. A total of 591 tU were produced by in-stope and heap leaching. Use of this technology has been increasing since 1993 when 57 tU were produced by leaching.

The ore is processed in a conventional mill that started production in 1968. The mill uses acid leach technology, with a recovery of 97 per cent using ion exchange to recover the uranium. The nominal production capacity is 3 500 tU/year from 6 700 tonnes ore/day. Much of the recent production was from ore with a production cost of <$40/kgU. Most of the remaining ore has an associated cost of $80 to $130/kgU.

REACTORS CONNECTED TO THE RUSSIAN GRID

PLANT NAME	UNIT	REACTOR TYPE	CAPACITY (MWe Net)	START-UP DATE
1. Beloyarsk	3	BN-600	560	08.04.1980
2. Bilibino	A	LWGR	11	12.01.1974
	B	LWGR	11	30.12.1974
	C	LWGR	11	22.12.1974
	D	LWGR	11	27.12.1976
3. Balakovo	1	WWER-100	950	28.12.1985
	2	WWER-100	950	08.10.1987
	3	WWER-100	950	24.12.1988
	4	WWER-100	950	11.10.1993
4. Kalinin	1	WWER-100	950	09.05.1984
	2	WWER-100	950	24.12.1986
5. Kola	1	WWER-440	411	29.06.1973
	2	WWER-440	411	09.12.1974
	3	WWER-440	411	24.03.1981
	4	WWER-440	411	11.10.1984
6. Kursk	1	RBMK-1000	925	12.12.1976
	2	RBMK-1000	925	28.01.1979
	3	RBMK-1000	925	17.10.1983
	4	RBMK-1000	925	02.12.1985
7. Leningrad	1	RBMK-1000	925	21.12.1973
	2	RBMK-1000	925	11.07.1975
	3	RBMK-1000	925	07.12.1979
	4	RBMK-1000	925	09.02.1981
8. Novovoronezh	3	WWER-440	385	12.12.1971
	4	WWER-440	385	28.12.1972
	5	WWER-440	385	31.05.1980
9. Smolensk	1	RBMK-1000	925	09.12.1982
	2	RBMK-1000	925	31.05.1985
	3	RBMK-1000	925	17.01.1990
		TOTAL	19 843	

Future Production Centres

By 2010 the Russian Federation plans to expand its uranium production capability to 10 000 tU/annum by developing three new production centres based on ISL technology. The centres are to be located in the: Transurals (Kurgan region) with the maximum output of about 1 700 tonnes; West Siberia (Novosibirsk and Kemerovo regions) with the maximum output of about 2 000 tonnes; and Vitimsky (Buryatiya) with the maximum uranium output of about 2 300 tonnes (see Production Table, Part 2, and map).

URANIUM DEMAND

In July 1996, 29 industrial power units at 9 nuclear power plants were operating in the Russian Federation, with a total gross installed capacity of 21 242 MWe (net 19 843 MWe). This includes 13 water cooled, water moderated, pressure vessel-type WWER reactors (6 WWER-440 units and 7 WWER-1000 units), 15 uranium-graphite channel-type reactors (11 RBMK 1000 units and 4 EGP units with a capacity of 12 MWe each), and 1 fast breeder reactor (BN-600) unit. The reactors and their generating capacities are given in the preceding table.

These power plants have an annual fuel requirement of about 3 600 tU. Another 2 200 tU are needed to supply fuel for Russian design power plants located in Eastern Europe. The fuel for these plants is enriched and fabricated in the Russian Federation. Thus, the total uranium requirement for 1996 is estimated to be 5 800 tonnes.

• Slovak Republic •

URANIUM RESOURCES

Prior to the dissolution of the Czech and Slovak Republic, the uranium potential of all of the region which was to become the Slovak territory was investigated. Based on the results of the evaluation, it was concluded the Slovak Republic has no known uranium resources.

URANIUM PRODUCTION

In the 1960s and 1970s, small quantities of uranium ore were mined in Eastern Slovakia. Production was stopped due to inefficiency and the low grade of the ore.

URANIUM REQUIREMENTS

The Slovak Republic has one nuclear power plant (NPP) located at Bohunice. The plant has four units in operation and another four units under construction. The units are of the VVER 440 type with a rated capacity of 408 MWe net each. The annual fuel requirement is 14 tonnes of enriched uranium or 110 tonnes natural uranium per unit.

Four additional VVER units with a capacity of 388 MWe net are under construction at Mochovce in the Slovak Republic. The expected date of commissioning of the first of the four units is the middle of 1998.

The plans are for the first two Bohunice units to continue operation through 2001 or 2002, and then decommissioning will begin.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
1 588	1 588	2 364	1 592	3 140	1 592	3 140	1 592	2 368

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1996	**1997**	**2000**	**2005**		**2010**		**2015**	
			Low	*High*	*Low*	*High*	*Low*	*High*
440	770	495	330	660	330	660	330	495

SUPPLY AND PROCUREMENT STRATEGY

Up to the present time, all fuel required for the Slovak nuclear power plants has been procured from abroad in the form of fuel assemblies. This same procurement strategy is expected to continue, although the possibility of diversifying the supply is under consideration.

NATIONAL POLICIES RELATING TO URANIUM

As there is no uranium production in the Slovak Republic, the fuel assemblies are purchased from the Russian Federation. The present contractual arrangement with the Russian Federation is valid through 1997. Because of the assured supply of fuel, there is no need for sizeable emergency stocks.

URANIUM STOCKS

At present only a small amount of enriched uranium is stockpiled at the Bohunice nuclear power plant. The 28 tU enriched uranium is present as fuel assemblies.

TOTAL URANIUM STOCKS

(Tonnes U natural equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Total
Government	0	0	0
Utility	0	220*	220*
TOTAL	0	220	220

* Stock in the form of the fuel assemblies include about 28 tonnes of enriched uranium or about 220 tU natural equivalent.

• Slovenia •

URANIUM EXPLORATION

Historical Review

Exploration of the Zirovski vrh area began in 1961. In 1968 the P-10 tunnel was developed giving access to the orebody. Mining began at Zirovski vrh in 1982. Uranium concentrate production (as yellow cake) began in 1985.

Recent and Ongoing Activities

Expenditures for exploration ended in 1990. There are no recent or ongoing uranium exploration activities in Slovenia.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

The staff of the uranium mine Zirovski vrh carried out the most recent resource assessment of the deposit in 1994. RAR are estimated to be 2 200 tU in ore with an average grade of 0.14 per cent U. These resources are in the below $80/kgU category. EAR-I of 5 000 tU in the under $80/kgU category and 10 000 tU in the below $130/kgU category are reported. The average grade of these resources is 0.13 per cent U. The resources are recoverable resources adjusted for 35 per cent mining and 10 per cent processing losses.

The deposit occurs in the grey sandstone of the Permian Groeden formation. The orebodies occur as linear arrays of elongated lenses within folded sandstone.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	2 200	2 200

* As recoverable resources in the Zirovski vrh deposit.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
–	5 000	10 000

* As recoverable resources.

Undiscovered Conventional Resources (EAR-II & SR)

The 1994 estimate of resources includes EAR-II of 1 060 tU in the under $130/kgU class. They are reported as recoverable resources adjusted for estimated mining and processing losses of 35 per cent and 10 per cent, respectively.

URANIUM PRODUCTION

Historical Review

The Zirovski vrh uranium mine was the only uranium producer in Slovenia. It is located 20 km Southwest of Škofja Loka.

Ore production in the Zirovski vrh mine started in 1982. The ore processing plant located at the mine began operation in 1984 to treat the previously stockpiled ore. The annual production capability of the mill was 102 tU. The ore was mined using a conventional underground operation with a haulage tunnel and ventilation shaft. The ore occurs in numerous small bodies in the mineralised coarse grained sandstone. It was mined selectively using room and pillar, and cut and fill methods. In 1990, the operation was terminated and placed on temporary standby. The total cumulative production from this production centre amounted to 382 tU.

Status of Production Capability

In 1992, the decision for final closure and subsequent decommissioning was made. Since 1992, there has been no production from the Zirovski vrh mine and mill.

In 1994, the plan for the decommissioning of the centre was accepted by the Slovenian Government Authorities.

Ownership Structure of the Uranium Industry

No changes in ownership have occurred since 1988. The uranium mine Zirovski vrh is owned by the Republic of Slovenia.

Environmental Considerations

The decommissioning plan for the Zirovski vrh production centre provides for the following steps:

- Permanent protection of the biosphere against the consequences of the mining operation. This includes permanent protection of the surface against displacement and subsidence, sealing of the shaft and tunnels against surface waters, airtight sealing of the shaft and tunnels, as well as the provision of an unobstructed run-off for mine waters.

- Permanent remediation of the ore processing plant site is planned in such a way that the remaining facilities can be used for other industrial purposes.

- Permanent rehabilitation of the mine waste and mill tailing areas. This includes the stabilisation of the disposal sites including the prevention of the infiltration of precipitation, as well as erosion. Additional measures are being taken to prevent the solution and transport of harmful chemicals into ground and surface waters, and to control contamination by radon.

Remediation of the Zirovski vrh mine production site will take 2 to 3 years.

URANIUM REQUIREMENTS

The short-term nuclear generating capacity of Slovenia is based on the 632 MWe PWR at Krsko which started commercial operation in January 1983. The power plant is owned 50 per cent each by Slovenia and Croatia. The Secretariat estimates the installed nuclear generating capacity will remain at 632 MWe, through 2015. The annual reactor-related uranium requirements are estimated at 102 tU.

There is a moratorium against the construction of additional nuclear power plants in Slovenia.

NATIONAL POLICIES RELATING TO URANIUM

The company that owns and operates the Krsko plant will import uranium to cover the future reactor related uranium requirements.

• South Africa •

URANIUM EXPLORATION

Historical Review

Uranium exploration in South Africa commenced in the late 1940s when a worldwide investigation of uranium resources focused attention on the uranium content of the Witwatersrand quartz-pebble conglomerates. Uranium exploration in the Witwatersrand Basin was always conducted as an adjunct to gold exploration, until the oil crisis in the early 1970s. At that time the price of uranium soared. This resulted in an intensification of uranium exploration activities and in 1982 South Africa's first primary uranium producer, the Beisa Mine commenced production.

The crash in the uranium market in the early 1980s caused a substantially reduced interest in uranium exploration, and by the mid-1980s all exploration in the Witwatersrand Basin was directed exclusively at gold, which continued at high levels until the early 1990s. A spin-off of these activities was the incidental discovery of new uranium resources because of the ubiquitous presence of uranium in the quartz-pebble conglomerates. In the early 1990s the static gold price resulted in a substantial curtailment of gold exploration activities.

Until the late 1960s uranium exploration was confined to the Witwatersrand Basin as an adjunct to gold exploration. The discovery of uranium in the Karoo sediments during oil exploration resulted in a diversification of uranium exploration activities. Work in the Karoo was at a low level until the advent of the oil crisis in the early 1970s when exploration activities boomed

This however was relatively short-lived because of the Three Mile Island incident in 1979 which sent the overheated uranium market crashing in the early 1980s. Uranium exploration in the Karoo declined rapidly and finally ceased in the mid-1980s. Since then low key re-evaluations of identified deposits are virtually the only activities which have taken place. In 1991 the Atomic Energy Corporation of South Africa launched a programme aimed at researching the fundamental characteristics of the Karoo sandstone uranium deposits with a view to defining exploration criteria which may be applied to finding new deposits should market forces cause a renewed interest in the Karoo uranium province.

Outside of the Witwatersrand and Karoo Basins, exploration activities have been directed at the discovery of other types of uranium deposits including unconformity-related, calcrete, alaskitic, breccia, Olympic Dam-type, and marine phosphate deposits. These activities were always on a lower key than in the two main uranium-bearing basins, and reached a peak in the late 1970s and early 1980s when the uranium market peaked. They were met with only very limited success, and declined rapidly after the crash in the uranium market in the early 1980s.

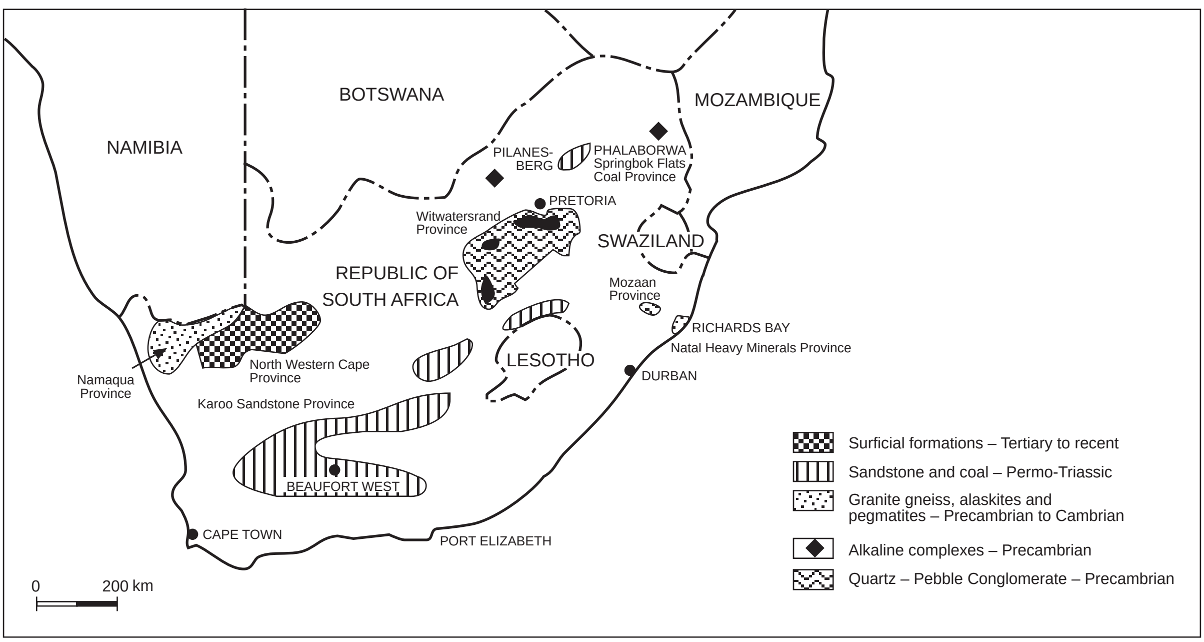
Recent and Ongoing Uranium Exploration Activities

No exploration activities aimed at discovering primary uranium resources took place during 1995-1996. Exploration activities in the Witwatersrand Basin were targeted on gold and the depressed gold market severely limited these activities.

Commercial interest in the Karoo Basin was almost non-existent. No field work was carried out. The data from some of the larger and higher grade uranium deposits was, however, re-evaluated to establish the economic viability of establishing mining operations. The Karoo research project initiated by the Atomic Energy Corporation in 1991 was completed in 1994. The work identified a number of fundamental controls of the uranium mineralization in the Karoo sandstones. The study indicated that significant potential exists for the discovery of further uranium deposits within the main Karoo Basin.

No exploration work for uranium took place outside the Witwatersrand and Karoo Basins during 1995-1996.

Localities of uranium provinces in South Africa



URANIUM RESOURCES

Known Conventional Uranium Resources (RAR & EAR-I)

No exploration has been carried out in South Africa during 1995 and 1996 for uranium as a primary product. As a result no new discoveries have been made, although minor increases have occurred as extensions to existing resources. A large proportion of South Africa's uranium resources occur as a by-product of gold in the Witwatersrand quartz-pebble conglomerates. Consequently uranium is discovered during gold exploration. The gold industry in South Africa has been undergoing difficult business conditions and as a result, exploration has been severely curtailed. Therefore, this source has added little to South Africa's uranium resource base.

No exploration has been carried out in the Karoo rocks for some years now, but the AEC conducted a research programme aimed at identifying mineralization controls. This study revealed areas where the true potential for uranium mineralization has not been recognised previously. Palaeontological markers for stratigraphic control were also identified which would be of considerable assistance in any future exploration activities.

The major influences on the South Africa's uranium resources are the gold price, mining working costs, the dollar/rand exchange rate, and the uranium price. The spot market uranium price has doubled over the last two years, but as the revenue derived by uranium from a tonne of Witwatersrand ore is only about 10 per cent of the total revenue, the influence of this rise is of minor importance with respect to the other factors involved. The dollar gold price has fallen marginally over the same period. The working cost per tonne ore milled on the Witwatersrand gold mines has increased by 21 per cent in the last two years. The combination of these factors should have resulted in a decline in South Africa's uranium resources. However the dollar/rand exchange rate has declined substantially giving increased gold and uranium prices in rand terms.

For the purposes of this exercise a dollar/rand exchange rate of R4.70 to the dollar and a gold price of $370/oz have been used.

The positive and negative effects of the factors discussed above have largely cancelled each other out and the “known” resources as of 1 January 1997 (i.e. RAR and EAR-I recoverable at costs less than $80/kgU) have increased only marginally by 9.2 per cent since the 1995 estimates.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
110 500	218 300	269 800

* As recoverable resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
44 400	66 100	87 800

* As recoverable resources.

Undiscovered Conventional Resources (EAR-II & SR)

The depressed state of exploration for both gold and uranium has resulted in little or no work being carried out to identify new areas where uranium deposits may potentially be discovered. Limited efforts have been made to identify subsidiary Witwatersrand-type basins outside of the currently known limits of the main basin. The lack of exploration funding for this speculative type of work has, however, hindered the achievement of any meaningful results.

EAR-II at a production cost of less than $80/kgU are 34 900 tU as of 1 January 1997. This is an increase of 6 000 tU from the 1 January 1995 estimate. There is no change in the Speculative Resources which total 1 113 510 tU with no cost range assigned.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
28 740	34 900	113 000

* As recoverable resources.

"Availability" of "Known" (RAR and EAR-I) Resources

A large proportion of South Africa's RAR and EAR-I resources, recoverable at $80/kg or less, is tributary to existing gold production centres and are mined for their gold content. However only a small proportion of the uranium is actually extracted; the rest ends up in the gold mine tailings dams. The availability of these resources in the tailings dams depends on the degree of dilution by non-uraniferous tailings and the possible usage of the tailings to backfill old mined out areas.

URANIUM PRODUCTION

Historical Review

South African uranium production commenced in 1952 when a uranium plant was commissioned at the West Rand Consolidated Mine which exploited quartz-pebble conglomerates of the Witwatersrand Supergroup. This was closely followed by the commissioning of four more uranium plants at various centres in 1953. Production accelerated until 1959 when 26 mines around the Witwatersrand Basin were feeding 17 uranium plants for a total production of 4 954 tU. Production subsequently declined to 2 262 tU in 1965.

In 1971 Palabora Mining Company became the first non-Witwatersrand uranium producer in South Africa. This company produced uranium as a by-product of copper at its open pit mining operation in the Northern Province.

The world oil crisis in the 1970s stimulated interest in uranium as an energy source and South African uranium producers responded by almost trebling production to 6 143 tU in 1980.

Many decades of gold mining and milling generated vast amounts of tailings around the Witwatersrand Basin which contained substantial reserves of gold and uranium. The boom in the uranium market lead to the establishment of tailings reprocessing plants at Welkom (Joint Metallurgical Scheme – 1977), in the East Rand (ERGO – 1978), and at Klerksdorp (Chemwes - 1979).

The collapse of the uranium market in the early 1980s had serious repercussions in the South African uranium industry which resulted in the closure of 14 uranium plants since 1980. At the end of 1996 only four mines were producing uranium from five plants.

HISTORICAL URANIUM PRODUCTION

(Tonnes U contained in concentrate)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	1997 (Expected)
By-product production	144 979	1 671	1 421	1 436	149 507	1 450

Status of Production Capability

The four mines which were producing uranium at the end of 1996 were Hartebeestfontein and Vaal Reefs at Klerksdorp, Western Areas on the West Rand, and Palabora in the Northern Province (previously Northern Transvaal). All these produce uranium as a by-product, gold being the primary product in the first three, and copper in the last.

Hartebeestfontein has one uranium plant which has a capacity to treat 3 200 000 tonnes of ore per annum. The plant operates on a reverse leach cycle which enhances the gold production. For the last few years the plant has operated at a recovery factor of 65 per cent which optimises the recovery costs of the uranium. Losses are made on the production of uranium, but the significant increase in gold recovery enhances the overall profitability of the operation.

Vaal Reefs has two uranium plants, the third having been closed recently. One plant is operating at 100 per cent capacity, while the second is operating at 50 per cent capacity. The three plants between them have a capacity to treat 9 000 000 tonnes of ore per annum, but during 1996 only 5 500 000 tonnes of ore were treated.

Western Areas is the highest grade uranium producer of the Witwatersrand and has one plant which has the capacity to treat 650 000 tonnes of ore per annum. In 1993-94 the mine's gold operations returned to profitability, but uranium continues to make an important contribution to the mine's total profit.

Palabora is a large open-pit copper producer which produces uranium as a by-product. The uranium ore mineral uranothorianite is first concentrated in a gravity separation plant, along with other heavy minerals. The uranium is then recovered using an acid leach and solvent extraction process. The uranium plant has an annual capacity of 2 000 000 tonnes of gravity concentrate.

Major reductions in production capacity in the Witwatersrand took place in the late 80s and early 90s, but the situation has stabilised in recent years and in the 1995-1996 period no plant closures took place. Unless the uranium market improves before the turn of the century it is expected that production will decline to about 1 000 tonnes U by that time.

The status of plants where uranium production has stopped may be summarised. The nine uranium production plants which have been shut down and are being dismantled include: Beisa, Blyvooruitzicht, Buffelsfontein, Dreifontein, Ergo, Freegold, Harmony (Merriespruit), Stilfontein and West Rand Consolidated. Uranium production could not be restarted at these plants without completely rebuilding them. The Randfontein (Cooke) uranium plant was converted for the extraction of gold.

The status of operational uranium plants is summarized below.

Ownership Structure of the Uranium Industry

The uranium producers are all owned by various private sector companies. As these are companies quoted on various stock exchanges, it is impossible to determine the proportion of domestic and foreign ownership. No significant changes have taken place in the ownership of individual uranium producers since 1990. There is no State participation in any uranium mining activities.

Employment in the Uranium Industry

Uranium is only produced as a by-product and therefore no exact employment figures are available for uranium production.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of Production Centre	Hartebeestfontein	Vaal Reefs	Western Areas	Palabora
Production Centre Class	Existing	Existing (2 plants)	Existing	Existing
Operational Status	Operating	Operating (100%, 50%)	Operating	Operating
Start-up Date	1956	1956, 1977	1982	1979
Source of Ore • Deposit Names • Deposit Types	Vaal Reef, Quartz-pebble conglomerate	Vaal Reef, Quartz-pebble conglomerate	Elsburg Reefs, Quartz-pebble conglomerate	Palabora, Intrusive deposit
Mining Operation • Type • Size (tonnes ore/day) • Average Mining Recovery (%)	Underground 9-10 000 Variable	Underground 24-31 000 Variable	Underground 3-3 300 Variable	Open pit 80 000 Variable
Processing Plant • Type • Size (tonnes ore/day) • Average Processing Recovery (%)	AL/SX 9-10 000 Variable	AL/SX 9-10 000 Variable	AL/SX 9-10 000 Variable	AL/SX 10 000 Variable
Nominal Production Capacity (tU/year)	200-500	1 000-2 000	200-300	100-250
Plans for expansion	None	None	None	None

Future Production Centres

There are no committed or planned uranium production centres in South Africa. The by-product nature of the majority of uranium resources in South Africa make it impossible to predict whether prospective production centres could be supported by the existing known resources in the RAR and EAR-I categories recoverable at costs of $80/kgU. The cost categorisation of a great part of South African uranium resources is based on the associated gold values, working costs and dollar rand exchange rate, which have little to do with the uranium market. Given favourable conditions in all these variables South Africa would be able to return to the production levels achieved during the late 1970s and early 1980s, that is to say, in excess of 6 000 tU per annum. If the gold price and, more importantly, the uranium price do not improve substantially, then this level of uranium production will not be attainable.

Obviously a lead time would be necessary in order to reconstruct uranium plants at previous production centres where production was stopped in the past, or construct plants at new production centres. In addition to this the Karoo sandstone and coal-hosted deposits would probably be able to support production levels of about 2 000 tU per annum.

Environmental Aspects

South Africa has areas of mine land which have been contaminated by radioactivity, particularly where existing or previously existing uranium plants are or were located. If development takes place on former mine land, the area is radiometrically surveyed and, where necessary, cleanup is conducted. The South African Council for Nuclear Safety is the regulatory body responsible for the implementation of nuclear legislation related to these activities, and the standards conform to international norms. Vast areas around the gold/uranium mines are covered with slimes dams and rock dumps. South Africa has, however, a strict environmental legislation which ensures that these areas are suitably rehabilitated. Environmental issues relating to gold/uranium mining on the Witwatersrand are dust pollution, surface and groundwater contamination and residual radioactivity. Old gold-uranium plants are being decommissioned. Scrap materials from these operations are decontaminated to internationally acceptable levels and then sold.

URANIUM REQUIREMENTS

South Africa has one nuclear power plant designated Koeberg. This plant includes two reactors: Koeberg-I, commissioned in 1984, and Koeberg-II which came on stream in 1985. Together they consume 200 tU per annum.

Supply and Procurement Strategy

South Africa's internal uranium requirements are met from South African mines.

Installed Nuclear Generating Capacity to 2010

Koeberg has an installed capacity of 1 842 MWe. Sites for further nuclear stations have been identified but no plans for future construction have been made because of current over-capacity in conventional coal-fired power stations.

Annual Reactor-Related Requirements to 2010

Koeberg reactor uranium requirements are expected to remain constant at 200 tU per annum. The South African requirements are expected to remain at this level until 2010 because no further nuclear stations are planned.

NATIONAL POLICIES RELATING TO URANIUM

South Africa's national policies affecting the production and export of uranium are given expression in the Nuclear Energy Act, 1993, as amended. No person may prospect or mine for uranium without the permission of the Minister of Mineral and Energy Affairs. Such permission may be withheld only if the Minister is satisfied that the security of the State could be endangered if the applicant were given permission to proceed.

There are no restrictions on foreign participation in uranium prospecting and mining, and foreign-based operations are subject to the same legal requirements as domestic companies. In a practical sense, uranium prospecting and mining are subject to the same mining laws and regulations generally applicable.

The State does not actively undertake prospecting operations, but limits its activities to general research, national resource assessment, geological mapping, airborne surveys and regional hydro-geological, geochemical and geophysical investigations.

The Nuclear Energy Act also provides that no person may dispose of uranium or export it from South Africa, except under the authority of the Minister. In exercising this control, the Minister is required to consult the Atomic Corporation of South Africa Limited (AEC), the members of which represent various national interests, including the uranium mining industry. In practice, the Minister's functions are exercised by the chairman of the AEC.

• Spain •

URANIUM EXPLORATION

Historical Review

Uranium exploration started in 1951 and was conducted by the Junta de Energía Nuclear (JEN). Initial targets were the hercynian granites of western Spain. In 1957 and 1958, the first occurrences in precambrian-cambrian schists were discovered, including the Fe deposit, located in the Salamanca province. In 1965, exploration was started in sedimentary rocks and the Mazarete deposit in the Guadalajara province was discovered. Exploration activities by the Empresa Nacional del Uranio, S.A. (ENUSA) ended in 1992. Exploration through joint ventures between ENUSA and other companies continued until the end of 1994. During this period, most of the Spanish territory had been surveyed using a variety of exploration methods, adapted to different stages. An ample coverage of airborne and ground radiometrics on the most interesting areas has been achieved.

Recent and Ongoing Uranium Exploration Activities

Throughout 1995 and 1996, activities were limited to close spacing development drilling in extensions of ENUSA's mina Fe deposit in the Salamanca province. These activities were terminated by the end of 1996.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

From 1993 to 1996, the Empresa Nacional del Uranio (ENUSA) made a substantial effort to update the data on uranium deposits in the Salamanca Province (Ciudad Rodrigo area).

This task was carried out by means of both an intensification of the close-spaced development drilling, with more than 100 000 metres being drilled each year, and an update of the feasibility studies and mining projects of the more important orebodies in the area.

In order to achieve this, a full update of the data processing capabilities with new data acquisition systems, grade estimation, open pit optimisation and design programmes was implemented in 1992-1993. As a result, new figures are being obtained for the recoverable resources in the RAR and EAR-1 categories. The RAR resources are the result of economic open pit optimisation at different price levels, carried out during the update of the mining project.

In the EAR-I category, where no detailed mining project is available, recoverable resources have been estimated as ratios for each cost from the in situ resources. All the known uranium resources recoverable at cost below $80/kgU are tributary to existing production centres.

Undiscovered Conventional Resources (EAR-II & SR)

No resources within these categories have been estimated.

URANIUM PRODUCTION

Historical Review

Production started in 1958 at the Andujar Plant (Jaen province), and continued until 1980. The Don Benito Plant (Badajoz province) remained in operation from 1983 to 1990. Production at the FE deposit (Salamanca province) started in 1975 with heap leaching. A new dynamic leaching plant started production in 1993.

Status of Production Capability

The production capability at the FE deposit in Salamanca province is 800 tU/year.

HISTORICAL URANIUM PRODUCTION

(Tonnes U contained in concentrate)

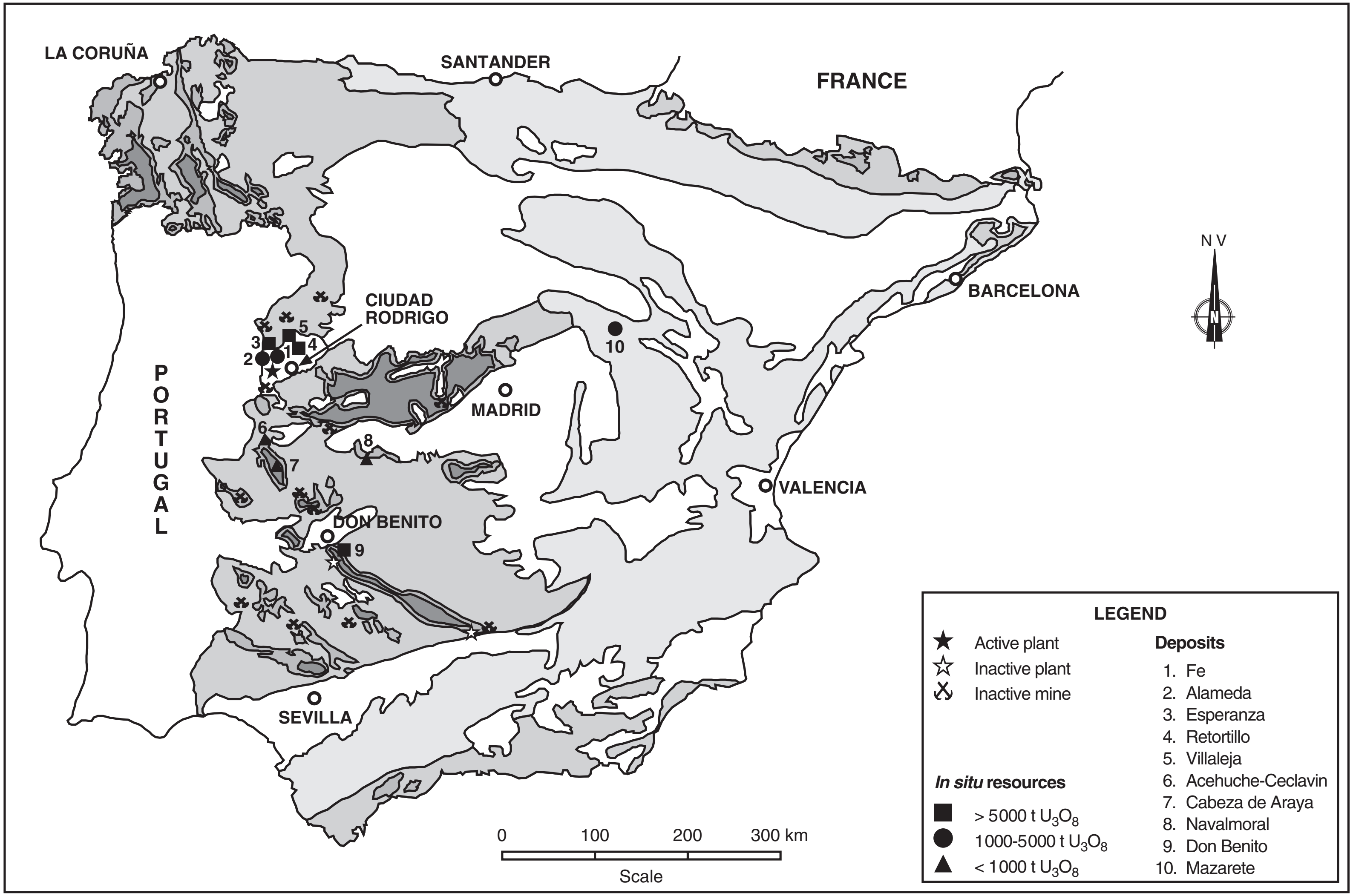
Production Method	Pre-1994	1994	1995	1996	Total to 1996	Expected 1997
Conventional Mining						
• Open pit	3 175	256	255	255	3 941	255
Other Methods (a)	781				781	
TOTAL	3 956	256	255	255	4 722	255

(a) Includes production from a variety of sources by the Junta de Energía Nuclear (JEN), before 1975.

Ownership Structure of the Uranium Industry

The only active production centre in Spain belongs to the Empresa Nacional del Uranio (ENUSA), a private company, sixty per cent owned by the Sociedad Estatal de Participaciones Industriales (SEPI) and forty per cent by the Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT).

Uranium deposits in Spain



URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

	Centre # 1
Name of Production Centre	Saelices El Chico
Production Centre Class	Existing
Operational Status	Operating
Start-up Date	1975
Source of Ore • Deposit Name • Deposit Type	 FE, D Vein (Iberian type)
Mining Operation • Type (OP/UG/In situ) • Size (tonnes ore/day) • Average Mining Recovery (%)	 OP 2 600 (a)
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) • Average Processing Ore Recovery (%)	 AL/SX 5 000 (b) 70 (c)
Nominal Production Capacity (tU/year)	800
Plans for expansion	None
Other remarks	Plant works intermittently

(a) Mining losses negligible due to type of open pit operation.
(b) Ore capacity depends on particle size, reaching 10 000t/day for 10 per cent of particles less than 1 mm.
(c) Includes heap leaching on 24 per cent of the ore.

Employment in the Uranium Industry

The number of employees at the FE mine was 178 at the end of 1996.

Future Production Centres

No new centres are being considered.

ENVIRONMENTAL CONSIDERATIONS

In March 1995, the dismantlement and restoration of the old Andujar uranium concentrate plant were completed. This work was carried out by the "Empresa Nacional de Residuos Radiactivos, S.A." (ENRESA). The Andujar Plant was in operation between November 1959 and July 1981. A ten-year supervision programme, which is a pre-requisite established by the Spanish Nuclear Safety Council for the issuing of the final declaration of closure, was initiated in 1995 once the dismantlement and restoration were completed.

Decommissioning of the waste dump and processing plant at ENUSA's La Haba production centre (Badajoz province) was authorised in November 1995. Dismantling and restoration of the site were carried out during 1996 and were scheduled to be completed in the first half of 1997. The materials have been placed in the tailings dam that has been capped with a 3-8 metre thick layer of high clay content waste material and finally with soil. The open pit was decommissioned during 1995, including revegetation.

After completion of the dismantling and closure operation at La Haba, a five-year supervision programme will be established so as to verify the fulfilment of the design and construction criteria imposed by the Spanish Nuclear Safety Council.

At the Saelices Mining Centre (Salamanca province), a project for decommissioning the old Elefante treatment plant and another project for the heaps from the old heap leaching operation, were presented to the Nuclear Safety Council and are pending authorisation.

The Nuclear Safety Council and the Ministry of Industry and Energy have approved a plan for the restoration of twenty-two old uranium mines, operated by the former "Junta de Energía Nuclear" (JEN) between the early fifties and 1981. They were active either as trial or production mines, and the ore was treated at the Andujar plant. Out of the twenty-two mines, sixteen are in the Extremadura autonomous region, five in Andalucía and one in the Castilla-La Mancha region. In March 1997, the Extremadura autonomous government approved the decommissioning project for the mines located in this region and the work was due to start by mid-1997.

STATISTICAL DATA ON URANIUM PRODUCTION

Long-Term Capability

No plans for new production centres are being considered at present. Production can be expected to continue at the only active mining centre at Saelices, Salamanca province, drawing from Spain's RAR and EAR reserves.

URANIUM REQUIREMENTS

Uranium Requirements

There are nine reactors operating in Spain, with a total net capacity of a little more than 7 GWe. Additional nuclear reactors which were in moratorium have been definitely cancelled and no new reactors are expected to be ordered within the period ending in the year 2000.

Supply and Procurement Strategy

The strategy is to maintain the same level of domestic production until the year 2000 and beyond if the market situation makes that advisable; otherwise, procurement will be based mainly on imports, with a diversified portfolio of contracts.

NATIONAL POLICIES RELATING TO URANIUM

The uranium import policy provides for diversification of supply sources. The Spanish legislation leaves uranium exploration and production open to national and foreign companies.

• Sweden •

URANIUM EXPLORATION

Historical Review

Uranium exploration was carried out during the period 1950-1985. However, at the end of 1985, exploration activities were stopped due to good availability of uranium and low prices in the world market.

There are four main uranium provinces in Sweden. The first is in the Upper Cambrium and Lower Ordovicium sediments in southern Sweden and along the border of the Caledonian mountain range in central Sweden. The uranium occurrences are stratiform, in black (alum) shale. Billingen (Västergötland), where the Ranstad deposit is located, covers an area of more than 500 km^2.

The second uranium province, Arjeplog-Arvidsjaur-Sorsele, is immediately south of the Arctic Circle. It comprises one deposit, Pleutajokk, and a group of more than 20 occurrences. The individual occurrences are discordant, of a vein or impregnation type, associated with soda-metasomatism.

A third province is located north of Östersund in central Sweden. Several discordant mineralizations have been discovered in, or adjacent to, a window of Precambrium basement within the metamorphic Caledonides.

A fourth province is located near Åsele in northern Sweden.

Recent and Ongoing Exploration Activities

There are no ongoing uranium exploration activities in Sweden.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

There are small resources in granitic rocks (vein deposits) in Sweden. There are also larger resources in alum shale. However, these deposits are very low grade and the cost of recovery is above $130/kgU, which means that they are not included in the tables in this report.

Undiscovered Conventional Resources (EAR-II & SR)

There are no estimates on EAR-II or SR in Sweden.

URANIUM PRODUCTION

Historical Review

In the 1960s, 200 tU were produced from the alum shale deposit in Ranstad. This mine is now being restored to protect the environment.

Status of Production Capability

There is no uranium production in Sweden and there are no plans for such production.

ENVIRONMENTAL CONSIDERATIONS

The Ranstad mine was rehabilitated in the 1990s. The open pit was transformed into a lake and the tailings area was covered with a multilayer top to prevent the formation of acid from sulphur in the shale tailings. An environmental monitoring programme is now being carried out.

URANIUM REQUIREMENTS

The Swedish uranium requirements are around 1 500-1 600 tU per year. This amount will decrease by 100 tU in 1998 and another 100 tU in 2001 due to the premature closure of the two reactors at Barsebäck.

Supply and Procurement Strategy

The utilities are free to negotiate their own purchases.

NATIONAL POLICIES RELATING TO URANIUM

Sweden has joined the Euratom Treaty and adjusted its policy accordingly.

URANIUM STOCKS

With a stockpile of low enriched uranium corresponding to 35 TWh of electricity, nuclear fuel in fabrication and at the reactors should enable the reactors to operate twenty-two months if import ceases.

URANIUM PRICES

The average cost of nuclear fuel to the Swedish utilities, including spent fuel disposal, was 0.038 SEK/kWh electricity in 1994. The part of this cost that corresponds to natural uranium, included in the cost above, was 0.007 SEK/kWh electricity.

• Switzerland[1] •

URANIUM EXPLORATION

Background

In June 1979, the Federal Government decided to encourage uranium exploration by awarding a grant of 1.5 million francs divided between the years 1980 to 1984. During 1980 and 1981 about 1 000 metres of galleries were excavated for prospection by a private company in the Hercynian Massif of Aiguilles Rouges and the surrounding gneisses. The limited work so far has not allowed a clear picture of the factors controlling the mineralization which is of low grade and disseminated in an area which is geologically very complex.

In 1982 the Federal Government supported surface prospecting to the South of Iserables and drilling at Naters (Valais). Between 1982 and 1984, in the framework of the five-year programme financed by the Federal Government, uranium exploration was carried out in the rugged region of the Penninic Bernhard nappe, in the western Valais. The radiometric and chemical investigations concentrated mainly on the detrital deposits of Permo-carboniferous and schists of older age (series of Nendaz and the underlying series of Siviez). Owing to strong alpine tectonism, the uranium is generally irregularly disseminated in the rock. Radioactive anomalies seem to be bound to the carbonatic and chloritic facies of the Nendaz series, but their practical value could not be confirmed.

Recent and Ongoing Activities

Since 1985 all domestic exploration activities have been halted. Private industry, however, has engaged in uranium exploration in the USA (i.e., the Arizona Strip) since 1983.

URANIUM RESOURCES

No uranium resources have been reported for Switzerland.

1. The information in this report was drawn mainly from the 1991 Red Book response.

URANIUM PRODUCTION

Status of Production Capability

Switzerland does not produce uranium.

Future Production Centres

No future production centres in Switzerland are envisaged in the short term.

URANIUM REQUIREMENTS

Uranium Requirements

Switzerland has five operating nuclear power stations located at Beznau (Units 1 & 2), Muehleberg, Goesgen and Leibstadt. In 1996, total installed net nuclear capacity was 3 055 MWe. In September 1990, a national referendum was held and the Swiss rejected an initiative to phase out the use of nuclear energy as soon as possible. This was the third time in ten years that the Swiss had voted against a phase-out of nuclear power. However, at the same time, the electorate did approve a ten-year moratorium on the construction and operation of new plants.

Supply and Procurement Strategy

Switzerland reported that uranium is currently procured from one or several of the following sources:

- Partnership/Joint Venture production.
- Long-Term contracts.
- Spot Market contracts.

INSTALLED NUCLEAR GENERATING CAPACITY TO 2015

(MWe Net)

1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2005**	**2010**	**2015**
3 055	3 055	3 117	3 179	3 179	3 179	3 179	3 179	3 179

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS TO 2015

(Tonnes U)

1995	1996	1997	1998	1999	2000	2005	2010	2015
481	537	499	452	430	479	470	470	581

URANIUM POLICIES

No changes to Swiss uranium policy were reported for this edition of the Red Book. Switzerland does not produce uranium and does not export uranium. There is no official import policy as procurement is handled by private companies entirely. Regarding uranium stocks, it is the policy of nuclear plant operating companies to maintain a stockpile of fresh fuel assemblies at the reactor site equivalent to the fuel requirement for one to two years.

URANIUM STOCKS

Switzerland reported a one-year requirement in the form of finished fuel assemblies.

• Thailand •

URANIUM EXPLORATION

Historical Review

Uranium exploration was carried out in the early 1970s by the Royal Thai Department of Mineral Resources (DMR). Uranium occurrences were found in diverse geological environments, including sandstone and granite environments. Sandstone-type mineralization occurs in the Phu Wiang district of the Khon Kaen province, northeastern Thailand. This area had been independently investigated by DMR, as well as in co-operation with foreign organisations. Granite hosted uranium occurrences associated with fluorite were discovered in the Doi Toa district, Chiang Mai province and the Muang district of Tak province, northern Thailand. These occurrences have received the most attention.

The most important uranium exploration activity carried out in Thailand is the nationwide airborne geophysical survey completed between 1985 and 1987. The survey was conducted by Kenting Sciences International Limited Canada, as contractor to the Canadian International Development Agency (CIDA).

Recent and Ongoing Activities

Uranium exploration expenditures in 1994 and 1995 were US$ 115 900 and US$ 119 200 respectively. No government agencies or companies have been involved in uranium exploration activities in 1996, and none is expected for 1997.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

A small uranium occurrence found in Jurassic sandstones in the Phu Wiang district is estimated to contain about 1.5 tU based on a cut-off grade of 0.04 per cent U. This estimate is classified as RAR recoverable under $130/kgU.

Granitic areas in the Doi Toa and Om Koi districts (Chiang Mai province) in northern Thailand are considered to have some uranium potential. Uranium minerals have been identified in fluorite veins. Uranium assays yielded values between 0.02 and 0.25 per cent U. The estimate of EAR-I is about 2.0 tU in the cost category below $130/kgU with a cut-off grade of 0.05 per cent U.

Undiscovered Conventional Resources (EAR-II & SR)

No undiscovered conventional resources are reported.

• Turkey •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Turkey began in 1956-1957 and was directed towards the discovery of vein-type deposits in crystalline terrain, such as acidic igneous rocks and metamorphics. As a result of these activities, some pitchblende mineralizations were found but they did not form economic deposits. Since 1960, studies have been conducted in sedimentary rocks which surround the crystalline rocks and some small orebodies containing autunite and torbernite mineralizations have been found in different parts of the country. In the mid-1970s, the first hidden uranium deposit with black ore below the water table was found in the Köprübasi area. As a result of recent exploration activities, uranium mineralization has been found in Neogene sediments in the Yozgat-Sorgun region of Central Anatolia.

Recent and Ongoing Activities

Prospecting in north-western Anatolia will continue, and airborne survey in the eastern Black Sea region will begin in June 1997.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Salihli-Köprübasi: 2 852 tU in 10 orebodies and at grades of 0.04 - 0.05 per cent U_3O_8 in fluviatile Neogene sediments.

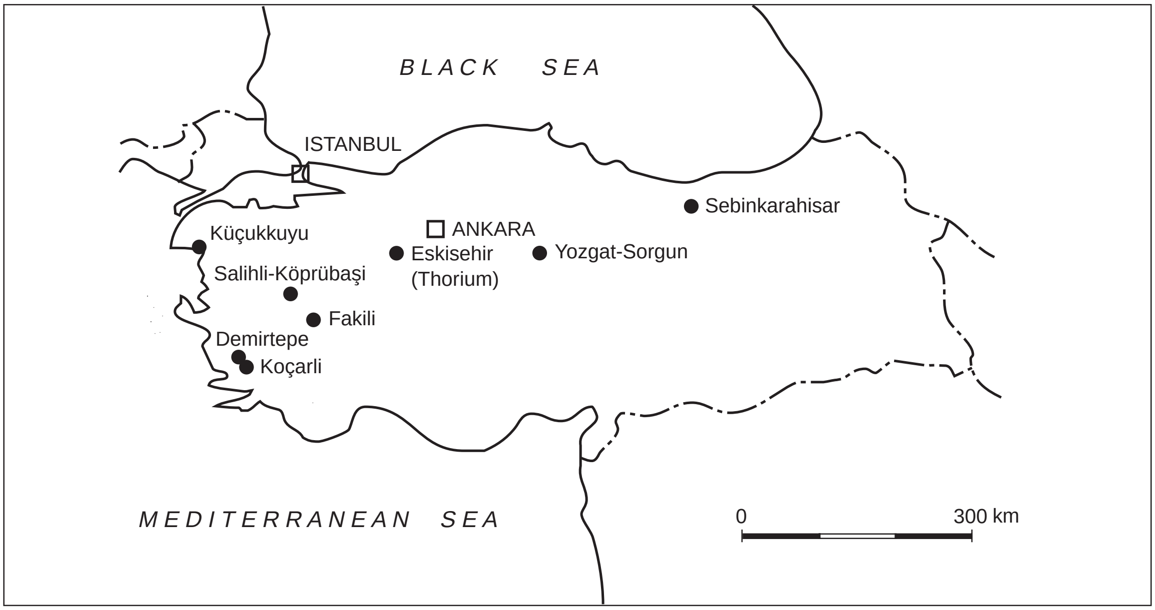
Fakili: 490 tU at 0.05 per cent U_3O_8 in Neogene lacustrine.

Koçarli (Küçükçavdar): 208 tU at 0.05 per cent U_3O_8 in Neogene sediments.

Demirtepe: 1 729 tU at 0.08 per cent U_3O_8 in fracture zones in gneiss.

Yozgat-Sorgun: 3 850 tU at 0.1 per cent U_3O_8 in Eocene deltic lagoonal sediments.

Uranium deposits and occurrences in Turkey



• Ukraine •

URANIUM EXPLORATION

Historical Review

The exploration for commercial uranium deposits started in Ukraine in 1944. Exploration began with radiometric surveys of museum samples, drill core, and accessible mine workings. Under a special government resolution, drillholes throughout the country were logged using gamma survey equipment. These activities lead to the discovery of the Pervomayskoye deposit in 1945 and the Zheltorechenskoye deposit in 1946. These deposits are associated with alkaline metasomatism of the ferruginous rocks of the Krivoi Rog basin. Deposits of other types were also identified, including small deposits in the sedimentary cover of the Ukrainian shield as well as deposits in bitumens and pegmatites. The sedimentary hosted deposits were amenable to in situ leach mining.

The first commercial uranium deposit (Michurinskoye) was discovered in 1964. It is associated with alkaline metasomatism and fault zones in a granite-gneiss complex of the Ukrainian shield. Further exploration for this new type of deposit led to the discovery of the Kirovograd uranium district.

In the early years, the State Geological Enterprise “Kirovgeology” was established and made responsible for uranium exploration and development. Initially, Kirovgeology's geological prospecting units conducted specialised exploration within the most prospective areas which were primarily defined based on their similarity with known world uranium deposits.

Subsequently, scientific geological organisations of the Ukraine and the former USSR selected the most favourable areas for further evaluation. Special radiometric, general geophysical, radio-hydrogeological and drilling methods were used for uranium exploration.

The uranium deposits discovered in the Ukraine have large dimensions. These characteristics are favourable for the deposit development and mining. The average uranium content of these deposits is 0.2 per cent or less.

Recent and Ongoing Activities

At present, specialised maps at a scale 1 : 50 000 are being prepared for areas thought to have good potential for new discoveries. These include areas of the Ukrainian shield covered by younger sediments with a thickness of 20-100 metres or more. This initial evaluation of the more prospective areas includes geophysical surveys (gravity, magnetic and electric prospecting as well as isotope surveys) and extensive parametric drilling. Kirovgeology begins direct exploratory drilling after the construction of a geological-structural diagram of the prospective area. This system is found to be the most effective under the present conditions.

In 1995-1997, exploration focused on targets with low production costs. This includes deposits with higher ore grades and complex uranium-rare metal mineralization. The activity is primarily conducted in crystalline and metamorphic rocks of the Ukrainian shield.

In 1996-1997, exploration for iron ore in the north Krivoy-Rog basin delineated uranium mineralization containing up to 1.2 per cent U over a thickness of 6.7 metres. The mineralization occurs in veins in a metasomatised schist-quartzite host rock The State Geological Enterprise Kirovgeology is carrying out an evaluation of this area.

Exploration drilling activities have been in the range of 153 820 to 155 000 metres over the period 1994 to 1996. The same level of activity is planned for 1997. The number of holes drilled has decreased from 1 670 in 1994 to around 1 300 in 1996, with 1 300 planned for 1997.

URANIUM EXPLORATION DRILLING EFFORT – DOMESTIC

	1994	1995	1996	1997 (Expected)
Government Surface Drilling (Metres)	153 820	154 000	155 000	155 000
Number of Government Holes Drilled	1 670	1 250	1 300	1 300

Known Conventional Resources (RAR & EAR-I)

As compared with the previous report, only minor changes occurred in RAR and EAR-I estimates as of 1 January 1997. RAR as of 1 January 1997 total 84 000 tU recoverable at costs below $130/kgU, of which 45 600 tU are classified as being recoverable at $80/kgU or less. This is an increase of 3 000 tU in the RAR $80/kgU or lower class. The resource estimates are expressed as in situ resources.

EAR-I amount to 47 000 tU recoverable at $130/kgU or less, of which 17 000 t are recoverable at $80/kgU or below. These estimates represent decreases from the previous estimates amounting to 3 000 tU in both the $130 and $80/kgU cost categories. The resource estimates are expressed as in situ resources. Estimates of the $40/kgU class RAR and EAR-I have not been prepared for Ukraine.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	45 600	84 000

* As in situ resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
0	17 000	47 000

* As in situ resources.

The table that follows entitled "Identified Uranium Deposits of Ukraine" does not provide information on the class of resource in each deposit. While the total resources do not match the RAR and EAR-I listed above, it is included to provide information on the type of deposits in Ukraine.

According to the table, 76 per cent of the resources which total 135 500 tU, are hosted in the albitite-type Vatutinskoye, Severinskoye and Michurinskoye deposits; 11 per cent in pegmatite deposits; 7.5 per cent in sandstone-type deposits amenable to ISL technology; and the remaining 6 per cent in conglomerate, bitumen and Riphean deposit types.

IDENTIFIED URANIUM DEPOSITS OF UKRAINE

Deposit Name	Operating Mines	Deposit Type	Resources* (1000 tU)
1. Vatutinskoye	Vatutinskii mine	Albitite	25.5
2. Severinskoye		Albitite	50.0
3. Michurinskoye	Ingul'skii mine	Albitite	27.0
4. Zheltorechenskoye		Albitite	0**
5. Pervomaysskoye		Albitite	0**
6. Lozovatskoye		Pegmatite	2.3
7. Kalinovskoye		Pegmatite	7.6
8. Yuzhnoye		Pegmatite	5.1
9. Nikolokozelskoye		Conglomerate	2.1
10. Nikolayevskoye		Riphean***	1.8
11. Berekskoye		Bitumen	0.7
12. Krasnooskolskoye		Bitumen	0.7
13. Adamovskoye		Bitumen	2.7
14. Sadovokonstantinovskoye		Sandstone	0.7
15. Bratskoye		Sandstone	0**
16. Safonovskoye		Sandstone	3.5
17. Devladovskoye		Sandstone	0**
18. Novoguryevskoye		Sandstone	1.7
19. Surskoye		Sandstone	1.1
20. Chervonoyarskoye		Sandstone	0.5
21. Markovskoye		Sandstone	2.5

* Undefined as to resource category.
** Deposit mined out.
*** Riphean is equivalent to the most recent era of the Precambrian.

Undiscovered Conventional Resources (EAR-II & SR)

Undiscovered resources (EAR-II and SR) total 241 000 tU as compared to 235 000 tU published in the previous Red Book. Of the 241 000 tU, only 10 000 tU are classified as EAR-II recoverable at costs below $130/kgU, while 231 000 tU are reported as SR unassigned to any cost category.

The largest portion of the undiscovered resources are postulated to occur in the following types of deposits: albitite (133 500 tU), pegmatite (15 000 tU), bitumen (16 500 tU), and sedimentary cover of the Ukrainian Shield (20 000 tU), proposed unconformity-related deposits (20 000 tU) and stockwork-vein-type (30 000 tU). Exact information is not available on the assignment of the remaining 6 000 tU undiscovered resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	NA	10 000

* As in situ resources.

SPECULATIVE RESOURCES*

(Tonnes U)

Cost Range <$130/kgU	Cost Range Unassigned	TOTAL
NA	231 000	231 000

* As in situ resources.

URANIUM PRODUCTION

Historical Review

The uranium mining and milling industry of the Ukraine was established in 1946 by a special decree of the Soviet Council of People's Deputies. Since then a total of 21 uranium deposits were discovered and evaluated (shown on map). The most important were Vatutinskoye, Severinskoye and Michurinskoye. However, uranium production in Ukraine first took place in association with the iron ore mines in the vicinity of the present city of Zheltiye Vody.

Two large production centres were established to produce uranium. They include the Eastern Mining and Concentrating Mill at Zheltiye Vody (named VostGOK) and the “Prednieprovskiy Chemical Plant” (designated P.Ch.Z.). VostGOK currently operates underground mines near Kirovograds and Smolino in Kirovograd Province.

The Prednieprovskiy Chemical Plant is located at Dnieprodzerzhinsk in Dnieprovsk Province. This plant produced uranium from 1947 to 1990. Today it is producing other metals for the nuclear industry, as well as materials and chemicals. Before uranium production was suspended in 1990, the plant had produced more than 33 million tonnes of tailings[1]. It was initially established to process uranium ores shipped from central Europe and subsequently processed ores mined in Ukraine.

1. Rudy, C., Ukrainian proposals for environmental restoration projects in regions of uranium milling and mining activities, (Status Report and Project Proposals for RER/9/022 Planning Meeting, Vienna, 24-28 April 1995) Ministry for Environmental Protection and Nuclear Safety of Ukraine, Special Advisor to the Minister on Nuclear and Radiation Safety Issues.

Initial production in Ukraine from mines developed solely for uranium started in 1959 using underground mining. In the same year, the Zheltiye Vody hydrometallurgical plant was brought into production. In situ leach (ISL) uranium mining was started in the mid-1960s using wells developed from the surface.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

Name of Production Centre	Zheltiye Vody
Production Centre Class	Existing
Operational Status	Operating
Start-up Date	1959
Source of Ore Deposit Name Deposit Type	 90% Ingul'skii mine/Michurinskoye deposit 10% Vatutinskii mine/Vatutinskoye deposit Albitite
Mining Operation • Type (OP/UG/In Situ) • Size (t ore/day) • Average Mining Recovery (%)	 UG NA NA
Processing Plant • Type (IX/SX/AL) • Size (t ore/day) • Average Processing Recovery (%)	Zheltiye Vody AL/IX and SX NA 95
Nominal Production Capacity (tU/y)	1 000
Plans for Expansion	Doubling the capacity to 2 000 tU/y is planned

Uranium Mining

At present two mines are producing uranium ore (i.e. Ingul'skii and Vatutinskii). A third mine is planned to be developed on the Severinskoye deposit for production after 2000. About 90 per cent of the current uranium production is coming from the Ingul'skii mine developed on the Michurinskoye orebody. The remaining 10 per cent of production is from the Vatutinskii mine located near Smolino. Mining was previously conducted at the Pervomaysskoye albitite-type deposit near Kirovograd. The mine was closed when the ore was exhausted. In situ leach mining was also previously conducted at three sites (i.e. Devladove, Bratske and Safonovskoye) discussed below.

Michurinskoye Orebody

The Michurinskoye orebody was discovered in 1964 during water well drilling. Kirovgeology conducted exploration in 1965 and began development of the Ingul'skii mine in 1967.

The uranium deposits occur in a major tectonic zone that extends for hundreds of kilometres and is about 10 kilometres wide, striking northwest-southeast. Much movement and deformation has taken place in the tectonic zone. The ore occurs in a heterogeneous mixture of gneiss, granite and metasomatic albitite.

The ore bearing zone is about 10 metres thick by 1 km long and extending 1.5 km deep. The ore grade decreases with depth and the best grades occur between 90 and 150 metres below the surface. Sixty per cent of the uranium occurs in brannerite, with the oxides nasturnum and uraninite contributing most of the rest. Uranophane and coffinite are also present in minor amounts. The temperature of ore formation was 200°C to 400°C and the age of mineralization is 1.65 to 1.70 billion years.

Ingul'skii Mine

The Michurinskoye orebody is mined by the Ingul'skii mine. The main shaft is located 2 kilometres from Kirovograd.

Current production is less than 1 million tonnes ore/year. The initial plan was for 1 million t/year with a 25 year life based on resources of 19.1 million tonnes of ore. Mine production started in 1971. It reached the target level of 1 million t/year in 1976 and continued at this level to 1989.

The ore occurs in about 30 zones. Original planned reserves of 19.1 million tonnes ore, were increased after 1967 by delineation of an additional 7 million tonnes of ore. On 1 January 1995 the reserve was about 13 million tU, using a cut-off grade of 0.03 per cent U. The in-place grade is about 0.1 per cent U. Dilution during mining is about 29 per cent. The grade is increased to between 0.1 and 0.2 per cent U using radiometric ore sorting of mine-car sized lots conducted within the mine.

Access to the mine is through two 7 metre diameter shafts, designated North and South. Ore is hoisted at the North shaft using two 11 tonne capacity skips. The South shaft is for hoisting workers, supplies and for technical access. A ventilation shaft provides 480 m^3 air/second. The principal mine levels are developed at about 60 to 70 metre intervals, designated 90, 150, 210, 280, and 350.

Ore is mined using conventional drill and blast operations with backfill. The mine is operated by 3 shifts with a total staff of about 850. Large ore blocks are sub-divided into 10 to 12 metre high blocks for mining. A ring of test holes is drilled every 4 to 5 metres. Following blasting the ore is moved to loading pockets for transfer to the sub-level tracked haulage. The ore is transported by electric powered trams to the main shaft where it is crushed prior to hoisting to the surface.

Severinskoye Deposit

The Severinskoye deposit, located about 20 km from the Michurinskoye deposit, has been evaluated for future mining after 2000. It is in the largest deposit class with RAR and EAR-I of 68 400 tU and an average grade of about 0.1 per cent U. These resources are in the \$80 to \$130/kgU cost class. Twenty per cent is in the C2 class, with 80 per cent in A, B, and C1 classes. The deposit was explored from 1974 to 1980 by more than 40 kilometres of drilling. It has been left undeveloped.

Zheltiye Vody Hydrometallurgical Plant

The Zheltiye Vody Hydrometallurgical Plant (or Mill) is operated by VostGOK. Construction was started in 1958 and the mill came into production in January 1959. The design capacity of the mill is 1 million tonne ore/year. In recent years the mill has been operating at about half capacity. A total of 30 to 35 persons/shift operate the mill.

Ore is hauled to the mill by dedicated train from the 2 mines Ingul'skii and Vatutinskii, one at Kirovograd (100 km west) and the other at Smolino, near Beriozovka (150 km west). Ninety per cent of the ore is produced at Kirovograd. Following grinding and spiral classification ore is leached in autoclaves using sulphuric acid. Leaching conditions are at 150 to 200°C under 20 atmospheres pressure with a 4 hour residence time. Acid consumption is 80 kg/tonne ore.

In-pulp ion exchange resin is used to recover uranium. Following elution with a mixture of sulfuric and nitric acid, the uranium bearing solution is further concentrated and purified using solvent extraction technology. Ammonia gas is used for precipitation. The dewatered precipitate is calcined at 800°C to give a dark coloured product. By 1994 the large Zheltiye Vody plant had produced 41.1 million tonnes of tailings from its uranium processing operations (Rudy, ibid).

VostGOK operates a sulfuric acid plant located at Zolty Vody with an annual capacity of 1 million tonnes. The acid is used for uranium production as well as for manufacturing phosphate fertilisers for agriculture. In mid-1995 the plant was producing about 400 000 tonnes acid per year. VostGOK has a joint venture with a foreign partner to produce by-product scandium occurring in association with uranium.

In Situ Leach Mining

In situ leach (ISL) uranium mining was conducted at the Devladove, Bratske, and Safonovskoye sites[2]. The mining took place from 1966 to 1983 using acid leach technology. Uranium was recovered from sandstone hosted deposits occurring at depths of about 100 metres. Additional information is available in the previous edition of this report.

Ownership Structure of the Uranium Industry

All activities related to the nuclear fuel cycle in Ukraine are organised and owned by the state. Prior to 1997, all related activities were conducted under the State Committee for Utilisation of Nuclear Energy (GASCOMATOM). In 1997, a new Ministry of Energy of Ukraine was given the responsibility for uranium mining and production. The geological department of the uranium industry is also being reformed.

The State Geological Enterprise "Kirovgeology" is responsible for all uranium exploration and development activities leading up to full scale production. The organisation is a subsidiary of the State Committee of Geology and Utilization of Natural Resources. The headquarters of Kirovgeology

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2. Bakarjiev, A.Ch., O.F. Makivchuk and N.I. Popov, The industrial types of uranium deposits of Ukraine and their resources, paper presented at the Technical Committee Meeting on Recent Changes and Events in Uranium Deposit Development, Exploration, Resources, and the Supply/Demand Relationship, Kiev, Ukraine, 22-26 May 1995.

are in Kiev. The organisation has six district offices, or “Expeditions”, for conducting uranium exploration throughout prospective areas in Ukraine.

VostGOK, a subsidiary of the Ministry of Energy, is the organisation responsible for uranium mining and milling in Ukraine. In support of its mining and milling activities, VostGOK operates a large sulphuric acid plant, manages the energy and electrical supply, has a rail transport division, two geological expeditions, and produces mining equipment and spare parts.

Environmental Aspects

The accumulation of waste associated with uranium production in Ukraine have a negative impact upon the environment. The impact is primarily related to the tailing disposal areas where wastes from the hydrometallurgical processing are located. Additional impacts may also be associated with waste rock, low grade ores and tails from radiometric ore concentration within the areas of uranium mining. At present, no mines are being decommissioned in Ukraine.

In 1996 Ukraine enacted a new constitution which provides a new legislative base to conduct rehabilitation activities. The new laws provide for regulation of :

1. Utilisation of nuclear energy and radiation safety;

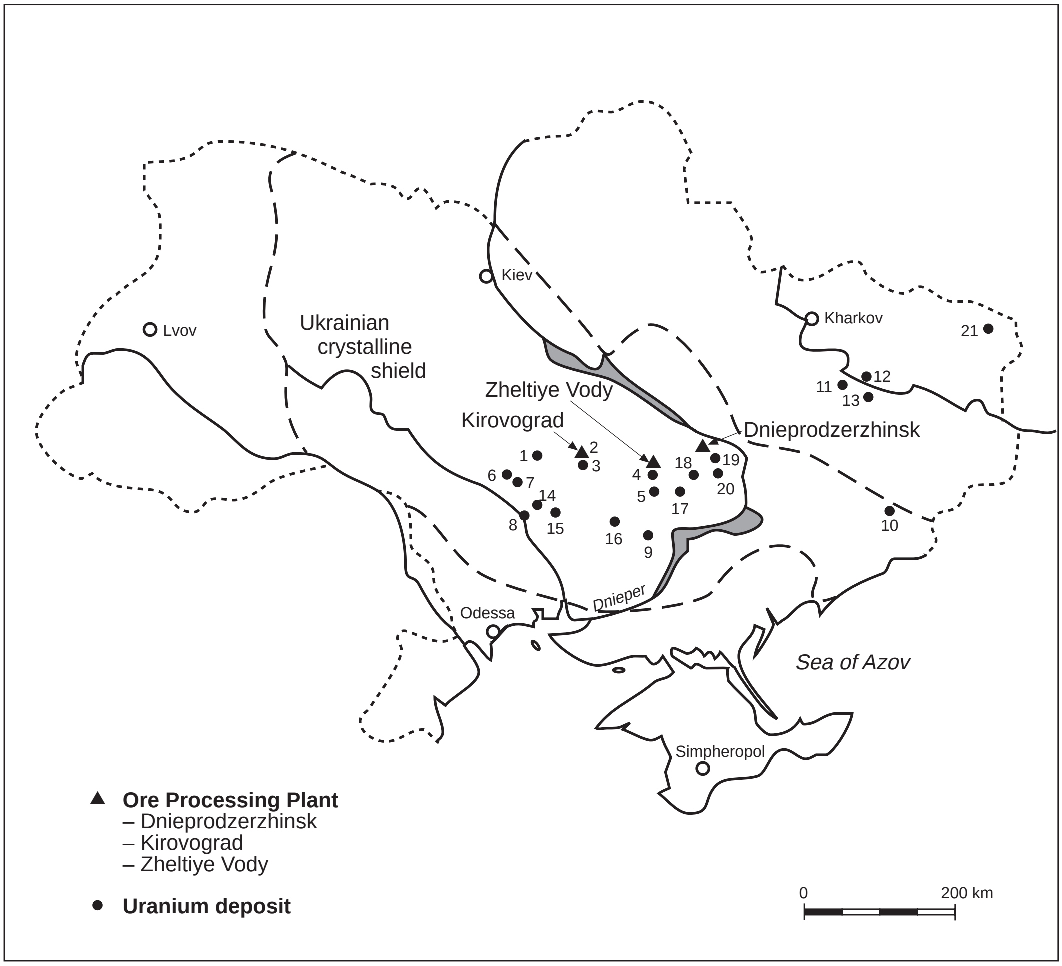
2. Radioactive waste management; and

3. Sanitation related to liquidation and closing, changing of direction of industrial activity and permanent closing of enterprises mining, processing and operating with radioactive ores (SP-LKP-91).

A programme is being conducted by VostGOK to clean up and rehabilitate sites in Zheltiye Vody, contaminated by uranium mill tailings. This programme was established by the Council of Ministers of Ukraine on 8 July 1995. It is the basis for cleaning and liquidation of contaminated land, decreasing the concentration of radon in houses, and implementing environmental monitoring in the city.

A State Programme for Improvement of Radiation Protection at Facilities of the Atomic Industry of Ukraine has also been established. This programme, covering all sites and environmental issues of uranium mining and milling in Ukraine has a budget of US$ 360 million. It provides for: decontamination of contaminated lands, environmental monitoring, installing personnel monitoring systems where required, and for improving technology for treatment of effluents, uranium bearing waste rock and contaminated equipment and land. It also provides for improving national regulations, scientific and design support for the programme, and liaison with international organisations regarding the programme.

Uranium deposits of Ukraine



1. Vatutinskoye
2. Severinskoye
3. Michurinskoye
4. Zheltorechenskoye
5. Pervomaysskoye
6. Lozovatskoye
7. Kalinovskoye
8. Yuzhnoye
9. Nikolokozelskoye
10. Nikolayevskoye
11. Berekskoye
12. Krasnooskoiskoye
13. Adamovskoye
14. Sadovokonstantinovskoye
15. Bratskoye
16. Safonovskoye
17. Deviadovskoye
18. Novoguryevskoye
19. Surskoye
20. Chervonoyarskoye
21. Markovskoye

URANIUM REQUIREMENTS

Reactor-related uranium requirements for Ukraine are based upon an installed nuclear generating capacity of 12 880 MWe in 1995 and gradually increasing to 15 880 MWe in the year 2010. Information on 2015 is not available.

Correspondingly, annual uranium requirements are expected to increase from 2 310 tU in 1995 and 2 640 t in 1997 to 2 790 t in 2010.

INSTALLED NUCLEAR GENERATING CAPACITY

(MWe Net)

1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2005**	**2010**
12 880	13 880	13 880	14 880	15 880	15 880	15 880	15 880

ANNUAL REACTOR-RELATED URANIUM REQUIREMENTS

(Tonnes U)

1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2005**	**2010**
2 310	2 490	2 640	2 350	2 790	2 820	2 890	2 790

SUPPLY AND PROCUREMENT STRATEGY

Ukraine’s operating uranium production facilities provide 50 per cent of its reactor requirements. All uranium concentrate is shipped to the Russian Federation for conversion, enrichment and fuel fabrication. The shortfall of uranium is met through purchases from the Russian Federation.

Ukraine plans to increase its uranium supply capability to meet 100 per cent of its requirements. This programme requires substantial increases of activities ranging from uranium exploration to production.

In addition, the Ukrainian government announced a programme for the establishment of a complete fuel cycle in Ukraine by 2010. This includes establishing its own fuel fabrication capabilities.

URANIUM STOCKS

There are no uranium stocks in Ukraine.

• United Kingdom •

URANIUM EXPLORATION

Recent and Ongoing Activities

Despite some earlier systematic exploration, no significant uranium reserves are known to exist in the United Kingdom. Since 1983, all domestic exploration activities have been halted. Exploration in overseas countries is carried out by private companies operating through autonomous subsidiary or affiliate organisations established in the country concerned (e.g. members of the Rio Tinto group of companies). There were no industry expenditures reported for domestic exploration from 1988 to the end of 1996, nor were any government expenditures reported for exploration either domestic or abroad.

URANIUM RESOURCES

Despite some sideline mining of uranium in Cornwall during the 1800s in association with tin extraction, no uranium deposits have been located in the United Kingdom. Two districts, the metalliferous mining region of SW England, and the north of Scotland, however, are believed to contain some uranium resources. The reader is referred to the 1989 Red Book for more information on uranium resources in the United Kingdom. There has been no geological reappraisal of UK uranium resources since 1980 and no significant discoveries have occurred since that time. The Reasonably Assured Resources (RAR)and Estimated Additional Resources – Category I (EAR-I) are essentially zero. There are small quantities of in situ Estimated Additional Resources – Category II (EAR-II) and Speculative Resources (SR).

URANIUM PRODUCTION

Status of Production Capability

The United Kingdom is not a uranium producer and is unlikely to become a uranium exporter in the foreseeable future.

URANIUM REQUIREMENTS

At the end of 1996, the 35 operating reactors in the United Kingdom had a combined net power capacity of 12.8 MWe. During 1996, these reactors produced nearly 86 TWh of electricity, some 6 per cent more than in 1995 and just over one quarter of the total electricity used in the United Kingdom.

INSERT MAP OF **THE UNITED KINGDOM** HERE

The BNFL Thorp reprocessing complex is building up to full operation and is now in the process of moving from its active commissioning phase toward full operational status. All parts of the plant have been tested under active conditions of operation and all major fuel types have been reprocessed. BNFL applied for final consent to operate on 18 December 1996.

Adjacent to Thorp, the construction of the Sellafield Mixed Oxide Fuel Plant, which will manufacture fuel from recycled uranium and plutonium, is progressing and is due for completion by the end of 1997. Building and civil engineering work is complete and the installation of major plant items is now underway.

Urenco, the UK based centrifuge enricher, which has been making deliveries since 1975, delivered its 30 millionth SWU in 1996. In order to meet increased delivery orders Urenco is expanding capacity at its Capenhurst site, which when complete, will increase site capacity by around 30 per cent. The first phase of the development is scheduled to be completed at the end of 1997 with full installation by early 1999.

The public enquiry into Nirex's application for planning permission to construct an underground rock characterisation facility ended in February 1996. The facility would have been the next stage of Nirex's investigation into the suitability of a site adjacent to BNFL's Sellafield works for its proposed deep repository for low and intermediate level radioactive wastes. But in March 1997 the then Secretary of State for the Environment announced that permission would not be granted for construction of the facility at the site adjacent to Sellafield. The situation is currently being assessed.

Supply and Procurement Strategy

The previous Government's review of the nuclear industry, “The prospects for Nuclear Power in the United Kingdom” published in May 1995, concluded inter alia that the United Kingdom's Advanced Gas-cooled Reactors (AGRs)and Pressurised-Water Reactor (PWR)should be transferred to the private sector in 1996. It further concluded that the Magnox power stations should remain in the public sector.

The nuclear generating industry was formally restructured on 31 March 1996 in preparation for privatisation. A holding company, British Energy plc (BE), and two subsidiary companies were created. The subsidiaries are Nuclear Electric Ltd, operating the PWR and five AGR stations in England and Wales, and Scottish Nuclear Ltd, operating two AGR stations in Scotland.

The six Magnox power stations remaining in public ownership are operated by Magnox Electric plc. Magnox is decommissioning a further three stations which have reached the end of their useful economic lives. The Nuclear Review proposed eventual integration of Magnox with BNFL and work on this is proceeding.

In September 1996, the Government successfully completed the privatisation of AEA Technology plc, the former commercial arm of the United Kingdom Atomic Energy Authority (UKAEA). Following the privatisation, the ownership and responsibility for the safe management of UKAEA's nuclear liabilities, as well as certain other functions more appropriate to Government, including fusion research, remain in the public sector.

From April 1996 BNFL assumed procurement responsibility for Scottish Nuclear Ltd. BNFL Uranium Asset Management Company Ltd. (UAM) was formed to manage and develop a range of uranic business initiatives on BNFL's behalf, including procurement responsibility for Scottish Nuclear and BNFL. UAM is a 100 per cent subsidiary of BNFL. Nuclear Electric Ltd will continue to be responsible for its own uranium procurement arrangements.

The present UK Government was elected in May 1997 on a manifesto that saw no economic case for the building of new nuclear power stations, and currently sees no justification for using public funds for that purpose. The option to build new nuclear stations remains but it will be for the private sector to decide on commercial grounds whether or not to proceed with new stations.

Supply and procurement strategy continues to be to utilise excess stocks where they exist and to seek a measure of supply diversity whilst maintaining the lowest cost of supply possible.

URANIUM POLICIES

No changes to uranium policy were reported in the United Kingdom. As regards the current policy on participation of private and foreign companies, the UK Atomic Energy Act 1946 gives the Secretary of State (for Trade and Industry) wide-ranging powers in relation to uranium resources in the United Kingdom, in particular to obtain information (section 4), to acquire rights to work minerals without compensation (section 7), to acquire uranium mined in the United Kingdom on payment of compensation (section 8), and to introduce a licensing procedure to control or condition the working of uranium (section 12A).

There are no specific policies relating to restrictions on foreign and private participation in uranium exploration, production, marketing and procurement in the United Kingdom nor exploration activities in foreign countries. There is no national stockpile policy in the UK. Utilities are free to develop their own policy.

Exports of uranium are subject to the Export of Goods (Control) Order 1970 (SI No.1288), as amended, made under the Import, Export and Customs Powers (Defence) Act 1939.

URANIUM STOCKS

As mentioned above, the UK stockpile practices are the responsibility of the individual bodies concerned. Actual stock levels are commercially confidential.

URANIUM PRICES

Uranium prices are commercially confidential in the United Kingdom.

• United States •

URANIUM EXPLORATION

Historical Review

From 1947 through 1970, the development of a private-sector uranium exploration and production industry in the United States was fostered by the US Atomic Energy Commission (AEC) to procure uranium for the US Government, continue development of atomic energy for military uses, and to promote research and development of peaceful applications of atomic energy. In late 1957, when private-industry exploration was increasing and new deposits were being brought into production, the AEC ended its uranium exploration efforts. The Government has continued a programme to monitor private-sector uranium exploration and development activities and to periodically assess uranium reserves and resources commensurate with requirements for Federal policy option evaluations and for basic information.

Exploration by the domestic industry increased rapidly in the 1970s in response to rising uranium prices and the projected large demand for uranium to fuel an increasing number of nuclear reactors being built or planned for civilian electric power stations. The peak total surface drilling (exploration and development) was reached in 1978, when 14 700 km of bore hole drilling were completed. During the period from 1966 through 1982, US surface drilling totalled some 116 400 km in the search for new uranium deposits. From 1983 through 1996, industry has completed an additional 8 380 km of surface drilling. Surface drilling is the primary method of delineating uranium deposits, and the annual drilling total has proved to be a reliable indicator of overall exploration activity.

In the United States, exploration has been primarily for sandstone-hosted deposits in districts such as the Grants Mineral Belt and Uravan Mineral Belt of the Colorado Plateau region and in the Wyoming Basins and Texas Gulf Coastal Plain regions. Vein-type and other structure-controlled deposits were developed in the Front Range of Colorado, near Marysvale in Utah, and in north-eastern Washington State. Since 1980, large sandstone-hosted deposits have been mined in north-western Nebraska, and additional relatively high-grade deposits associated with breccia-pipe structures have been mined in northern Arizona. A large deposit was discovered in southern Virginia in the early 1980s, but a moratorium on uranium mining by the State has pre-empted its exploitation.

Recent and Ongoing Activities

Total US surface drilling (exploration and development) completed during 1996 was 928 kilometres, an increase of 126 per cent above the 1995 total. The 1996 total does not include drilling completed for uranium production control at in situ leach, underground, and open pit mine projects.

In 1996, US industry companies reported exploration expenditures of just under US$ 10.1 million, a 67 per cent increase above the level reported for 1995. Of the total expenditures, "other exploration" accounted for US$ 2.50 million (25 per cent), "surface drilling" for US$ 7.15 million (71 per cent), and "land acquisition" activities for US$ 0.40 million (4 per cent). There were no exploration expenditures by the US Government during 1996. Foreign participation in US exploration accounted for US$ 4.42 million, or about 44 per cent of total exploration expenditures.

The total area of land held for uranium exploration in the United States by domestic and foreign companies was about 1 166 km^2 at the end of 1996. Companies acquired about 146 km^2 for exploration during 1996, a nearly fivefold increase over the total for land acquired in 1995. The US Government does not reserve land for uranium exploration and does not provide financial assistance for that purpose.

URANIUM EXPLORATION EXPENDITURES AND DRILLING EFFORT – DOMESTIC

	1994	1995	1996	1997 (Expected)
Industry Expenditures	3 654	6 009	10 054	NA
Government Expenditures	675	0	0	–
TOTAL EXPENDITURES (US$ x 1 000)	4 329	6 009	10 054	NA
Industry Surface Drilling in Metres*	200	411	928	NA
Number of Industry Holes Drilled	996	2 312	4 695	NA
Government Surface Drilling in Metres	–	–	–	–
Number of Government Holes Drilled	–	–	–	–
TOTAL SURFACE DRILLING (Metres)	200	411	928	NA
TOTAL HOLES DRILLED	996	2 312	4 695	NA

* Rounded to nearest thousand metres.

NA = Not available.

URANIUM RESOURCES

Known Conventional Resources (RAR)

The estimate of RAR for the $80/kgU category for the United States as at 1 January 1997, was 110 000 tU, a decrease of about 2 000 tU below the level reported for the same resource category in the 1995 Red Book. The estimate of RAR for the $130/kgU at year-end 1996 was 361 000 tU, a decrease of about 3 000 tU below the level reported for 1995.

For 1996, active uranium mine properties and other selected properties were re-evaluated to account for annual production and to incorporate updated costs and mining technology information. The result was a reduction in identified resources for each cost category. The 1996 RAR estimates have been adjusted to account for mining dilution and processing losses.

Undiscovered Conventional Resources (EAR & SR)

Estimates of EAR for 1 January 1997, in the $80/kgU and $130/kgU categories were 839 000 tU and 1 270 000 tU, respectively. The estimate of SR at $260/kgU was 1 340 000 tU for 1 January 1997. These estimates have been revised marginally downward from previous estimates to reflect annual changes in the values of economic indexes used in the estimation methodology. EAR and SR estimates are derived by the Energy Information Administration by using estimates of uranium endowment prepared by the US Geological Survey.

(*Note*: The United States does not separate EAR as EAR-I and EAR-II.)

URANIUM PRODUCTION

Historical Review

Following the passage of the Atomic Energy Act of 1946, designed to meet the US Government's uranium procurement needs, the Atomic Energy Commission (AEC) from 1947 through 1970 fostered development of a domestic uranium industry, chiefly in the western United States, through incentive programmes for exploration, development, and production. To assure that the supply of uranium ore would be sufficient to meet future needs, the AEC in April 1948 announced a domestic ore procurement programme designed to stimulate prospecting and to build a domestic uranium mining industry. The AEC also negotiated concentrate procurement contracts, pursuant to the Atomic Energy Acts of 1946 and 1954, with guaranteed prices for source materials delivered within specified times. Contracts were structured to allow milling companies that built and operated mills the opportunity to amortise plant costs during their procurement-contract period. By 1961, 27 privately-owned mills had been constructed and 23 of these were in operation in the western United States. Overall, 32 conventional mills and several pilot plants, concentrators, up graders, heap-leach, and solution-mining facilities were operated at various times. The AEC, as the sole Government purchasing agent, provided the only US market for uranium. Many of the mills were closed soon after completing deliveries scheduled under AEC purchase contracts, though several mills continued to produce concentrate for the commercial market after fulfilling their AEC commitments. The Atomic Energy Act of 1954 made lawful the private ownership of nuclear reactors for commercial electricity generation. By late 1957, domestic ore reserves and milling capacity were sufficient to meet the Government's needs. In 1958, the AEC's procurement programmes were reduced in scope, and, in order to foster utilisation of atomic energy for peaceful purposes, domestic producers of ore and concentrate were allowed to sell uranium to private domestic and foreign buyers. The first US commercial-market contract was finalised in 1966. The AEC announced in 1962 a "stretch out" of its procurement programme that committed the Government to take only set annual quantities of uranium for 1967 through 1970: this also assisted in sustaining a viable domestic uranium industry. The US Government's natural uranium procurement programme was ended on 31 December 1970, and the industry became a private-sector, commercial enterprise with no Government purchases.

Since 1970, domestic uranium production has supported the commercial market. After achieving peak production of 16 800 metric tU in 1980, the US industry experienced generally declining annual production between 1981 and 1993. From 1994 through 1996, US uranium concentrate production has increased each year. In 1996 production was 2 431 metric tU, which was nearly 5 per cent above the level reported for 1995. In situ leach mining and other non-conventional technologies for uranium recovery have dominated US production since 1991. Non-conventional production in 1996, some 2 100 metric tU, was largely from five in situ leach plants in Nebraska, Texas, and Wyoming. Uranium was recovered also in 1996 from mine water (one mill, New Mexico) and from site cleanup materials (one mill, Washington). One conventional mill in Utah, which had resumed production in 1995 from stockpiled ore, was again placed on standby status late in 1996.

Status of Production Capability

At the end of 1996, no conventional uranium mills were being operated in the United States: six mills with a combined capacity of 13 060 tonnes of ore per day were on standby. At year end, the status of the 14 non-conventional plants (combined capacity 4 180 metric tU/year) in the United States was as follows: 5 in situ leach plants (combined capacity 2 290 metric tU/year) and 2 by-product plants (combined capacity 450 metric tU/year) were being operated, the remaining plants (5 in situ leach and 2 by-product) were being maintained in standby mode.

Ownership Structure of the Uranium Industry

Domestic privately-held firms accounted for the larger part of the total US uranium concentrate production in 1996; firms controlled by foreign governments and by foreign privately-held firms accounted for the remainder.

US 1996 uranium production attributed according to the percentages of ownership for firms that owned and operated production facilities is shown below:

US private ownership:	49 per cent;
Foreign government ownership:	36 per cent;
Foreign private ownership:	16 per cent.

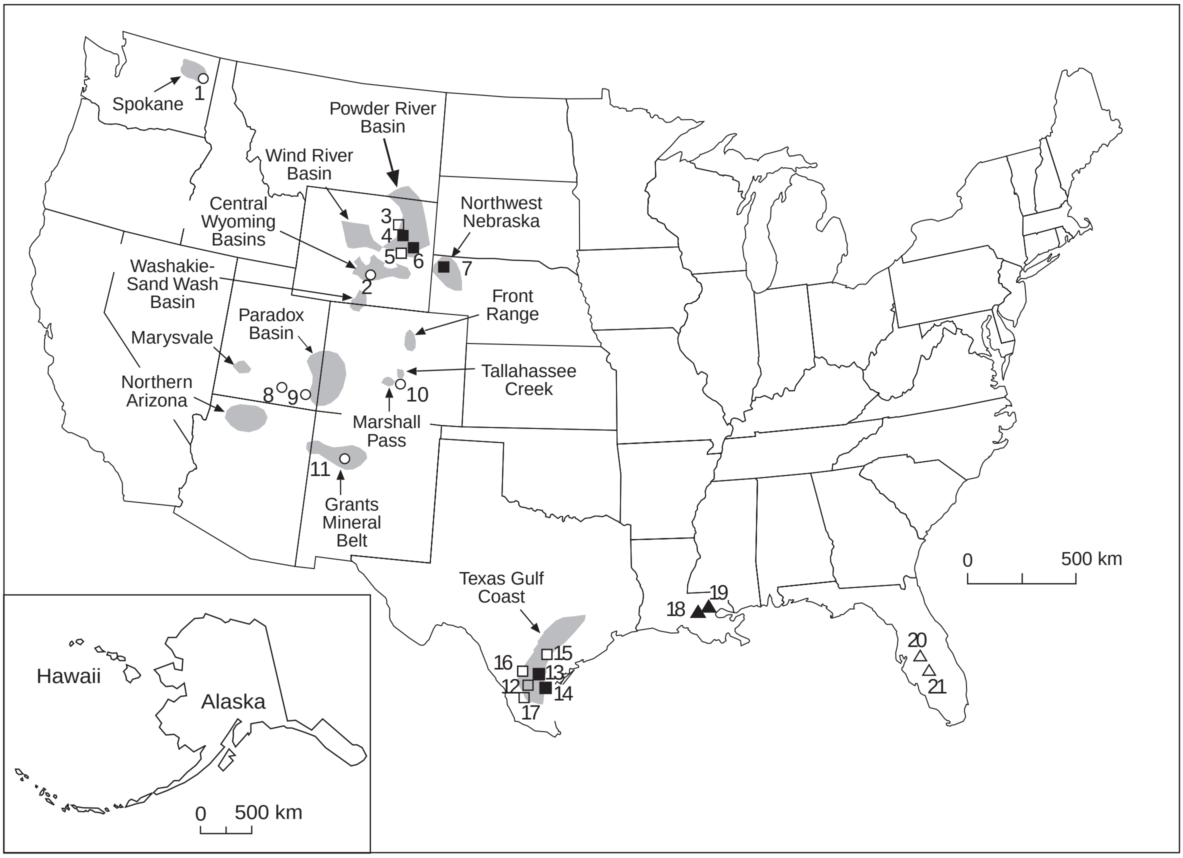
Employment in the Uranium Industry

In the United States uranium raw materials industry, employment (persons-years expended) has increased each year in the period 1993-1996, following the generally declining annual employment reported for 1988 through 1992. Total employment for combined “exploration-mining-milling-processing” activities increased from 535 persons-years in 1995 to 689 persons-years in 1996, an upturn of 29 per cent. Reclamation activities decreased 25 per cent over that same time-period, from 573 persons-years in 1995 to 429 persons-years in 1996.

Future Production Centres

In 1992, Rio Algom's Smith Ranch in situ leach property in Wyoming was licensed for commercial operation. The property is on standby status and no production start-up date has been announced. In 1993, Pathfinder Mines was granted a commercial uranium production license for its North Butte-Ruth in situ leach project in Wyoming; a start-up date for that project has not been announced.

Major uranium reserve areas and status of mills and plants, December 31, 1996



Active at the end of 1996

4. Malapai Resources, Christensen Ranch
6. Converse County Mining Venture, Highland
7. Crow Butte Resources, Crow Butte
13. Uranium Resources, Rosita
14. Uranium Resources, Kingsville Dome
18. IMC-Agrico, Sunshine Bridge
19. IMCAgrico, Uncle Sam

Uranium production centers

Active	Inactive	
●	○	Conventional mill
■	□	In situ leach plant
▲	△	By-product from phosphate processing
		Major uranium reserve areas[f]

Inactive at the end of 1996

1. Dawn Mining, Ford[a]
2. Green Mountain Mining Venture, Sweetwater
3. Malapai Resources, Irigaray[b]
5. Rio Algom Mining, Smith Ranch[b]
8. U.S. Energy, Shootaring
9. Energy Fuels Nuclear, White Mesa[c, e]
10. Cotter Corp., Canon City
11. Rio Algom Mining, Ambrosia[d]
12. Malapai Resources, Holiday-El Mesquite[b, e]
15. Everest Minerals, Hobson
16. COGEMA Mining, West Cole[b]
17. Malapai Resources, O'Hem[b]
20. IMC-Agrico, Plant City
21. IMC-Agrico, New Wales

a. Recovered uranium by processing water treatment plant sludge by-product.
b. Recovered uranium by processing water from in situ leach well field ground-water restoration.
c. Recovered uranium by processing ore and other materials.
d. Recovered uranium by processing water from conventional mines.
e. Facility was operated for less than the full year.
f. Major areas containing reasonably assured resources at $130-per-kg U or less.

Sources: Based on U.S. Department of Energy, Grand Junction Project Office (GJPO), *National Uranium Resource Evaluation*, *Interim Report* (June 1979) Figure 3.2; GJPO data files; Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1996); and site visits by staff of the Analysis and Systems Division, Office of Coal, Nuclear, Electric and Alternate Fuels.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS

(as of 1 January 1997)

	Centre # 1	Centre # 2	Centre # 3	Centre # 4
Name of Production Centre	Ambrosia Lake	Canon City	Christensen Ranch	Crow Butte
Production Centre Class	Existing	Existing	Existing	Existing
Operational Status	Standby	Standby	In operation	In operation
Start-up Date	1958	1979	1989	1991
Source of Ore • Deposit Names • Deposit Types	 Various Sandstone	 Schwaltzwalder Vein	 Christensen Ranch, Irigaray Sandstone	 Crow Butte Sandstone
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average Mining Recovery (%)	 UG NA NA	 UG NA NA	 ISL NA NA	 ISL NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average Processing Ore Recovery (%)	 AL/SX 6 350 7 000 NA	 AL/SX 1 090 1 200 NA	 ISL NA NA NA	 ISL NA NA NA
Nominal Production Capacity (tU/year) (ST U_3O_8/year)	3 300 4 290	620 810	250 330	380 500
Plans for expansion	Unknown	Unknown	Unknown	Unknown

	Centre # 5	Centre # 6	Centre # 7	Centre # 8
Name of Production Centre	Converse Co. Mining Vent.	Ford	Hobson	Holiday- El Mesquite
Production Centre Class	Existing	Existing	Existing	Existing
Operational Status	In operation	Standby	Standby	Standby
Start-up Date	1988	1957	1979	1979
Source of Ore • Deposit Names • Deposit Types	 Converse Co. Mining Vent. Sandstone	 Midnite Vein, Disseminate	 Various Sandstone	 Various, El Mesquite Sandstone
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average Mining Recovery (%)	 ISL NA NA	 OP NA NA	 ISL NA NA	 ISL NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average Processing Ore Recovery (%)	 IX NA NA NA	 AL/SX 410 450 NA	 IX NA NA NA	 IX NA NA NA
Nominal Production Capacity (tU/year) (ST U_3O_8/year)	770 1 000	200 260	380 500	230 320
Plans for expansion	Unknown	Unknown	Unknown	Unknown

	Centre # 9	Centre # 10	Centre # 11	Centre # 12
Name of Production Centre	Irigaray	Kingsville Dome	New Wales	Plant City
Production Centre Class	Existing	Existing	Existing	Existing
Operational Status	Standby	In operation	Standby	Standby
Start-up Date	1978	1988	1980	1981
Source of Ore • Deposit Names • Deposit Types	 Irigaray Sandstone	 Kingsville Dome Sandstone	 NA Phosphorite	 NA Phosphorite
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average Mining Recovery (%)	 ISL NA NA	 ISL NA NA	 OP NA NA	 OP NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average Processing Ore Recovery (%)	 IX NA NA NA	 IX NA NA NA	 DEPA/TOPO NA NA NA	 DEPA/TOPO NA NA NA
Nominal Production Capacity (tU/year) (ST U_3O_8/year)	130 180	500 650	290 380	230 300
Plans for expansion	Unknown	Unknown	Unknown	Unknown

	Centre # 13	Centre # 14	Centre # 15	Centre # 16
Name of Production Centre	Rosita	Shootering	Smith Ranch	Sunshine Bridge
Production Centre Class	Existing	Existing	Planned	Existing
Operational Status	In operation	Standby	Pilot Plant	In operation
Start-up Date	1990	NA	1986	1981
Source of Ore • Deposit Names • Deposit Types	 Rosita (Rogers) Sandstone	 Various Sandstone	 Smith Ranch Sandstone	 NA Phosphorite
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average Mining Recovery (%)	 ISL NA NA	 UG NA NA	 ISL NA NA	 OP NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average Processing Ore Recovery (%)	 IX NA NA NA	 AL/SX 680 1 000 NA	 IX NA NA NA	 DEPA/TOPO NA NA NA
Nominal Production Capacity (tU/year) (ST U_3O_8/year)	380 500	380 –	100 130	160 210
Plans for expansion	Unknown	Unknown	Unknown	Unknown

	Centre # 17	Centre # 18	Centre # 19	Centre # 20
Name of Production Centre	Sweetwater	Uncle Sam	West Cole	White Mesa
Production Centre Class	Existing	Existing	Existing	Existing
Operational Status	Standby	In Operation	Standby	Standby
Start-up Date	1981	1978	1981	1980
Source of Ore • Deposit Names • Deposit Types	 Various Sandstone	 NA Phosphorite	 Various Sandstone	 Various Sandstone
Mining Operation • Type (OP/UG/ISL) • Size (tonnes ore/day) • Average Mining Recovery (%)	 OP/UG NA NA	 OP NA NA	 ISL NA NA	 UG NA NA
Processing Plant • Type (IX/SX/AL) • Size (tonnes ore/day) (ST ore/day) • Average Processing Ore Recovery (%)	 AL/SX 2 720 3 000 NA	 DEPA/TOPO NA NA NA	 IX NA NA NA	 AL/SX 1 810 2 000 NA
Nominal Production Capacity (tU/year) (ST U_3O_8/year)	350 –	290 380	80 100	1 650 2 140
Plans for expansion	Unknown	Unknown	Unknown	Unknown

Notes: Conversion factors: 1 short ton U_3O_8 = 0.769 metric tU.

UG:	Underground mine(s)
OP:	Open-pit mine(s)
AL/SX:	Acid Leach/Solution Exchange
ISL:	In situ leach mine(s)
DEPA:	Di (2-ethyl-hexyl) phosphoric acid
TOPO:	Tri octyl phosphine oxide
NA:	Not Available
t ore/day:	Tonnes of ore per day, rounded to nearest 10 tonnes
ST ore/day:	Short tons of ore per day, rounded to nearest 10 tons
tU/year:	Tonnes U per year, rounded to nearest 10 tonnes
ST U_3O_8/day:	Short tons of U_3O_8 per year, rounded to nearest 10 tons
–:	Not applicable. Original value in SI units.

ENVIRONMENTAL CONSIDERATIONS

One conventional mill (1 810 tonnes of ore per day capacity) in the United States that processed uranium ore during 1996 was returned to standby status late in the year. At year end 1996, six mills (13 060 combined tonnes of ore per day) remained in standby status.

Title X of the Energy Policy Act of 1992 (Public Law 102-486) gave the US Department of Energy (DOE) responsibility for reimbursing licensees of active uranium or thorium processing sites for remedial-action costs attributable to by-product materials (mill tailings) generated as an incident of uranium or thorium concentrate sales to the United States. Specifically, qualified licensees can receive up to US$ 5.50 per dry short ton (US$ 4.99 per dry metric ton of tailings) of Federally-related tailings generated. In 1996, the limit for the total reimbursement amount for qualified uranium licensees combined was increased to US$ 350 million from US$ 270 million, and the maximum allowable reimbursement to a single eligible thorium licensee was increased to US$ 65 million from US$ 40 million.

URANIUM REQUIREMENTS

In 1994, The Tennessee Valley Authority (TVA) announced it would not complete Bellefonte-1 and 2 and Watts Bar-2 nuclear plants. TVA is evaluating conversion to non-nuclear fuel or full cancellation . The Watts Bar-1 plant was completed and came on line early in 1996.

Annual US uranium requirements for the period through 2010 are projected to peak at 21 300 metric tU (1997) and to then decline to 18 000 metric tU (2010). By 2015, annual requirements are projected to decrease to 8 500 metric tU, given the anticipated closures of plants for which operating license renewals would not be sought (all requirements quoted are for the reference case of the 1996 DOE/EIA Projections).

Supply and Procurement Strategy

There is no United States national policy on uranium supply or on uranium procurement. Decisions about uranium production, supply, and sales and purchases are made solely in the private sector by firms involved in the domestic uranium mining and nuclear power industries.

NATIONAL POLICIES RELATING TO URANIUM

In the United States, activities for uranium exploration, production, and marketing are conducted within the private sector by domestic- and foreign-owned firms, and there are no Federal restrictions on these activities. Both privately-held foreign firms and foreign nationally affiliated firms currently have various financial and ownership interests in the US uranium industry. The Federal policy situation relating to importation of uranium is described below.

Uranium enrichment services were provided by the US Government for all customers to 1 July 1993, when the Government's uranium enrichment business was transferred to the US Enrichment Corporation (USEC), established by the Energy Policy Act of 1992. The USEC is chartered to operate as a business enterprise in providing enrichment services to its customers on an efficient and profitable basis. Eventually, the USEC is to be fully privatised through its sale to private sector entities pending review and approval of sale arrangements by the Congress and the President.

Other programmes provided for in the Energy Policy Act of 1992 are: (a) remedial action for active uranium and thorium processing sites; (b) revitalisation of the US uranium industry; (c) licensing and regulation of uranium enrichment plants by the US Nuclear Regulatory Commission; and (d) establishment of a Uranium Enrichment Decontamination and Decommissioning Fund.

The Energy Information Administration published "The Role of Thorium in Nuclear Energy" in the *Uranium Industry Annual 1996*.

Policy on Activities in Foreign Countries

The US Government has no policies restricting uranium exploration and production by US firms in foreign countries.

Uranium Export Policy

A specific US Nuclear Regulatory Commission license is required for exportation of natural or enriched uranium materials. Export license criteria include that the export not be inimical to US common defence and security and that the export, when intended for eventual nuclear use, be pursuant to the terms and conditions of an agreement for co-operation, including that nuclear materials safeguards be applied. Except as specifically provided in an agreement for co-operation, no uranium exported from the United States, without prior US approval, may be : (1) altered in form or content by enrichment or reprocessing, or (2) retransferred from one agreement for co-operation to another agreement for co-operation.

Uranium Import Policy

Beginning in 1991, the United States committed to limit the impact on the domestic nuclear fuel industry caused by uranium imports from the former Soviet Union (FSU) republics. Then in 1994 and 1995, the initial suspension agreements signed in 1992 with Kazakhstan, the Russian Federation, and Uzbekistan were amended to provide for more realistic access to US markets and established different quotas for each country. The amended agreements with Kazakhstan and Uzbekistan addressed the so-called “enrichment bypass option” and created matched sales requirements for Russian imports. The enrichment bypass option is exercised when uranium, mined either in Kazakhstan or Uzbekistan, is third-country enriched to LEU before being imported into the United States. In the original suspension agreements, the enrichment country had been considered to be the country of origin for an enriched product, rather than the origin country of the U_3O_8 feed. The 1994 and 1995 amendments now provide that uranium mined in Kazakhstan or Uzbekistan for sale in the United States will count directly against each country’s quota, notwithstanding whether the material is imported as natural uranium or as feed component in a third-country-enriched product. The amendment with the Russian Federation requires that under the specified quota, an import of the Russian Federation-origin uranium or separative work units (SWU) in a US market transaction must be matched with an equal quantity of newly produced US origin uranium or SWU.

HEU Agreement

In 1992, the US and Russian governments agreed to the purchase by the United States of HEU derived from dismantled FSU nuclear weapons. A 1993 framework clarification called for the HEU to be blended down in the Russian Federation into LEU and then shipped to the United States. Use of this LEU must minimize uranium-market disruptions and maximise economic benefits for the agreement parties.

In 1994, US and Russian officials signed a final agreement whereby the United States Enrichment Corporation will fund transfer to the United States of the LEU derived from Russian HEU. The 20-year agreement calls for the United States to pay US$ 11.9 billion (unadjusted 1993 US dollars) to the Russian Federation in exchange for at least 500 metric tons HEU that will be blended with LEU of a 1.5 per cent ^{235}U assay to yield enriched product of 4.4 per cent ^{235}U. The down blending will yield an estimated 15 259 metric tons LEU. This would equal about 153 100 metric tons of natural uranium and 92 million SWU, if an enrichment tails assay of 0.30 per cent ^{235}U is assumed. An additional 50 metric tons HEU obtained from dismantled Ukrainian nuclear weapons also is a part of the US purchase agreement.

In January 1994, the President of the United States and the President of the Russian Federation issued a “Joint Statement Between the United States and the Russian Federation on Non-proliferation of Weapons of Mass Destruction and the Means for Their Delivery”. US non-proliferation efforts in this regard are five-fold: (1) to secure nuclear materials in the former Soviet Union; (2) to assure safe, secure, long-term storage and disposition of surplus weapons-useable fissile materials; (3) to establish transparent and irreversible nuclear arms reductions; (4) to strengthen the nuclear non-proliferation regime; and (5) to control nuclear exports. To demonstrate the United States’ commitment to these objectives, the President announced in March 1995 that approximately 200 metric tons of US origin weapons-usable fissile materials, consisting of approximately 162 metric tons HEU and 38 metric tons weapons-grade plutonium, had been declared excess to the United States defence needs. The Secretary of Energy has announced that the United States has about 213 metric tons of surplus fissile materials (174.3 metric tons HEU and 38.2 metric tons weapons-grade plutonium), including the 200 metric tons above. During 1995, the United States continued to develop and evaluate various proposals for achieving the safe and secure storage and disposition of its excess weapons-usable HEU and plutonium materials.

Uranium Stockpile Policy

The Energy Policy Act of 1992 (EPA 1992) established a National Strategic Uranium Reserve under the direction of the Secretary of Energy. The Reserve consists of natural uranium and uranium equivalent materials currently held for defence purposes. Its use, including the enriched uranium stockpile, is to be restricted to military and government research for a period of six years from the date of passage of the EPA 1992.

URANIUM STOCKS

At year-end 1996, total US commercial stocks of uranium (equivalent uranium) were 31 200 metric tU, an increase of 12 per cent above the total stocks at year-end 1995. Utility held stocks at year-end 1996 were about 26 000 metric tU, up by 15 per cent from year-end 1995, and supplier held stocks were about 5 300 metric tU, down by less than 1 per cent over the same period. Enriched uranium stocks at year-end 1996 held by suppliers were about 300 metric tU, 37 per cent above 1995, while those held by utilities were about 9 700 metric tons, 44 per cent above the 1995 level. Combined US Government and US Enrichment Corporation uranium stocks at the end of 1996 were about 41 400 metric tU (3 per cent below 1995 year end levels) and included 31 700 metric tU natural uranium and 9 700 metric tU enriched uranium, 12 per cent below the 1995 level.

URANIUM PRICES

Average US Uranium Prices, 1990-1996 (US Dollars per Kilogram U Equivalent)		
Year	Domestic Utilities from Domestic Suppliers	Domestic Utilities/Suppliers from Foreign Suppliers
1996	35.91	34.19
1995	28.89	26.52
1994	26.79	23.27
1993	34.17	27.37
1992	34.96	29.48
1991	35.52	40.43
1990	40.82	32.63

Prices shown are quantity-weighted averages (nominal US dollars) for all primary transactions (domestic- and foreign-origin uranium) for which prices were reported. The transactions can include US-origin as well as foreign-origin uranium.

• Uzbekistan[1] •

URANIUM EXPLORATION

Historical Review

Uranium exploration in Uzbekistan pre-dates the 1952 start-up of the uranium mine at the Taboshar deposit, in the Fergana valley of eastern Uzbekistan. Exploration, including airborne geophysical surveys, ground radiometry, and underground workings, etc., conducted during the late 1950s over the remote Kyzylkum desert in central Uzbekistan, led to the discovery of the uranium in the Uchkuduk area. Drilling confirmed the initial discovery, and development of the first open pit mine began in 1961.

Following the development of a model for uranium deposits hosted by unconsolidated oxidised Meso-Cenozoic sediments, core drilling and a range of geophysical bore hole logging methods became the main exploration tools for exploring the sedimentary environment. Based on the knowledge of the deposit characteristics and using the improved drilling techniques, large areas in the Karakata depression located in the Bukinai area and the southern rim of the Zirabulak-Ziaetdin mountains were explored. This led to the discovery of major sandstone uranium deposits including Bukinai, Sabyrsai, Yuzhny Bukinai, Sugraly, Lavlakan, and Ketmenchi. In addition, exploration for uranium deposits in metamorphic schists in the Auminza-Beltau and Altyntau areas started in 1961. This resulted in the discovery of the Rudnoye and Koscheka U-V-Mo deposits.

The development of the in situ leach (ISL) mining technique for the recovery of uranium from sandstone-type deposits in the beginning of the 1970s led to a re-evaluation of those previously ignored deposits including Lavlakan and Ketmenchi, and to an increase of exploration efforts in the sedimentary environments of the Central Kyzylkum desert.

Exploration concentrated upon the north-west portion of the Nurata mountains, as well as upon the south-eastern part of the Zirabulak-Ziaetdin mountains. The discoveries made in these areas include the Alendy, Severny (North) and Yuzhny (South) Kanimekh deposits (Nurata mountains) and the Shark and Maizak deposits (Zirabulak-Ziaetdin mountains).

One of the main technical achievements at this time was the recognition of the polymetallic nature of the sandstone-type uranium deposits. This led to the recovery of the by-products selenium, molybdenum, rhenium and scandium.

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1. This report provides a complete update for the Republic of Uzbekistan based on the response to the 1997 Red Book Questionnaire.

Uranium exploration was organised so, that exploration in and around known deposits was the responsibility of the geological division of the production company. Exploration in new areas became the mandate of the Krasnokholms Exploration Organisation.

Since the beginning of the 1990s, drilling has been limited to the delineation of known deposits and to the search for the extension of known deposits.

Recent and Ongoing Activities

Since 1994, all uranium exploration activities have been funded by the Navoi Mining and Metallurgical Complex (NMMC). These activities include both the exploration in and around known deposits and the search for new deposits, carried out by the Krasnokholms Exploration Organisation and later by its successor, the State Geological Company Kyzyltepageologia.

In 1995-1996, Kyzyltepageologia developed the known resources of the Severny (North) Kanimekh, Alendy, Kendykijube and Tokhumbet deposits. In addition, assessments of undiscovered resources were done in the Kyzylkum, the Bukhara-Khiva and Fergana provinces.

Plans for 1997 include the continuation of the drilling programme and ore reserve estimation at the Kendykijube and Tokhumbet deposits. In the prospective areas of the Kyzylkum and Bukhara-Khiva provinces the assessment of undiscovered uranium resources will continue.

The following table provides statistical data on uranium exploration done between 1994 and 1997. It includes the activities and expenditures of both the industrial organisation NMMC and the government exploration branch Kyzyltepageologia.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
Industry Expenditures (soum 1000)	8 204	24 748	49 655	78 905
Government Expenditures (soum 1000)	9 742	137 000	204 000	398 000
Total Expenditures (soum 1000)	17 946	161 748	253 655	476 905
TOTAL EXPENDITURES (US$ 1000)	427	6 197	7 026	8 671
Industry Surface Drilling in Metres	119 293	65 939	40 537	54 000
Number of Industry Holes Drilled	576	271	116	155
Government Surface Drilling in Metres	103 970	127 715	114 768	119 090
Number of Government Holes Drilled	447	740	639	650
TOTAL SURFACE DRILLING (Metres)	223 263	193 654	155 305	173 090
TOTAL HOLES DRILLED	1 023	1 011	755	805

It is reported that the decrease in industry surface drilling (by NMMC) is mainly due to the adjustment of exploration activities to the planned uranium production. It is envisaged that NMMC's drilling will increase again as indicated by the projections for 1997.

URANIUM RESOURCES

Uzbekistan's uranium resources occur in a large number of uranium deposits, some of which have been depleted. All of the significant resources are in the Central Kyzylkum area, comprising a 125 km wide belt extending over a distance of about 400 km from Uchkuduk in the north-west, to Nurabad in the south-east. The deposits are located in four districts: Bukantausky or Uchkuduk, Auminza-Beltausky or Zarafshan, West-Nuratinsky or Zafarabad, and Zirabulak-Ziaetdinsky or Nurabad.

Uranium occurs in two deposit types, referred to as sandstone-type and “breccia-complex type”. The sandstone-type occurs in Mesozoic-Cenozoic depressions filled with up to 1 000 metres of clastic sediments of Cretaceous, Paleogene and Neogene age. The mineralization consists of pitchblende with some occasional coffinite. The average ore grades vary between 0.026 and 0.18 per cent U. Associated elements include selenium, vanadium, molybdenum, rhenium, scandium and lanthanides in commercial concentrations. The depth of the orebodies is between 50 and 610 metres. Twenty-five uranium deposits belonging to this type are reported (see Map), and many are amenable to ISL extraction techniques.

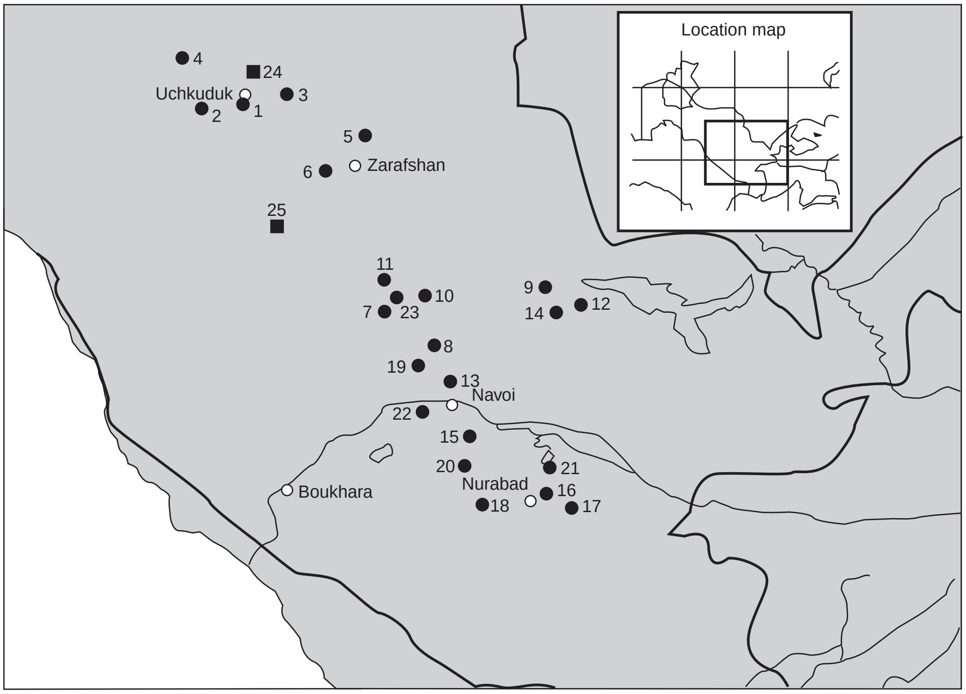
The “breccia complex type” deposits are hosted by black carbonaceous and siliceous schists of Precambrian to Lower Paleozoic age. The mineralization includes uranium-vanadium-phosphate ores. The average uranium grade is between 0.06 and 0.132 per cent, associated with up to 0.024 per cent Mo, 0.1-0.8 per cent V, 6–8 g Y/t and 0.1–0.2 g Au/t. The orebodies occur at depths ranging from 20 to 450 metres. The known deposits of this type are Rudnoye and Koscheka (see Map). Production from “breccia complex type” deposits was by open pit and subsequent heap leaching.

Known Conventional Resources (RAR & EAR-I)

For the first time in this publication Uzbekistan reports uranium resources following the standards developed by NEA-IAEA. The resource estimates provided for the previous Red Book are therefore not directly comparable.

As of 1 January 1997, the known uranium resources (RAR + EAR-I) recoverable at costs below $130/kgU total 130 200 tU as recoverable resources adjusted for depletion. This includes 83 700 tU RAR recoverable below $130/kgU. Of this, 66 210 t, or nearly 80 per cent, are recoverable at costs below $40/kgU. Resources of the EAR-I category amount to 46 500 tU recoverable below $130/kgU, of which 39 360 t, or 85 per cent, are recoverable at costs below $40/kgU.

Uranium deposits of Uzbekistan



Deposits in sandy-argillaceous sediments

1. Uchkuduk
2. Meylisai
3. Kendykijube
4. Bakhaly
5. Aktau
6. Sugraly
7. Severny Bukinai
8. Yuzhny Bukinai
9. Beshkak
10. Alendy
11. Aulbek
12. Terekuduk
13. Yuzhny Kanimekh
14. Varadzhan
15. Sabyrsaj
16. Ketmenchi
17. Shark
18. Agron
19. Severny Kanimekh
20. Tutly
21. Nagornoe
22. Severny Maizak
23. Tokhumbet

Deposits in crystalline basement

24. Altyntau ore field
25. Auminza-Beltau ore field

REASONABLY ASSURED RESOURCES*
(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
66 210	66 210	83 700

* As recoverable resources adjusted for depletion.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*
(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
39 360	39 360	46 500

* As recoverable resources adjusted for depletion.

Of the known resources recoverable at costs below $40/kgU, a total of 65 per cent are tributary to existing and operating production centres.

The known conventional resources recoverable at costs below $130/kgU are summarised in the following table by uranium district and deposit type. It shows the significance of the sandstone-type deposits, with a combined resource base of 97 290 tU corresponding to about 75 per cent of the total.

KNOWN CONVENTIONAL RESOURCES BY DISTRICT AND DEPOSIT TYPE
(Tonnes U)*

Uranium District	Deposit Type	Known Resources
Bukantausky (Uchkuduk)	Sandstone type Breccia complex	14 890 23 190
TOTAL Bukantausky		**38 080**
Auminza-Beltausky (Zarafshan)	Sandstone type Breccia complex	31 930 9 740
TOTAL Auminza-Beltausky		**41 670**
West-Nuratinsky (Zafarabad)	Sandstone type Breccia complex	41 310 0
TOTAL West-Nuratinsky		**41 310**
Zirabulak-Ziaetdinsky (Nurabad)	Sandstone type Breccia complex	9 140 0
TOTAL Zirabulak-Ziaetdinsky		**9 140**
SUBTOTAL	Sandstone type Breccia complex	97 290 32 910
TOTAL		**130 200**

* As recoverable resources.

Undiscovered Conventional Uranium Resources (EAR-II & SR)

Total undiscovered resources amount to 174 170 tU, of which 72 570 tonnes are EAR-II recoverable at costs of $130/kgU, while the remaining 101 600 tonnes are SR unassigned to any cost category. Both estimates are expressed as recoverable resources adjusted for mining and milling losses. Of the total undiscovered resources, the nearly 80 per cent assigned to sandstone-type uranium deposits are nearly equally divided among the four uranium districts: Bukantausky (Uchkuduk), Auminza-Beltausky (Zarafshan), West-Nuratinsky (Zafarabad) and Zirabulak-Ziaetdinsky (Nurabad). The best potential for breccia complex deposits is thought to be in the Auminza-Beltausky (Zarafshan) district.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY II*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
52 510	52 510	72 570

* As recoverable resources.

SPECULATIVE URANIUM RESOURCES*

(Tonnes U)

Cost Ranges		
<$130/kgU	Cost Range Unassigned	TOTAL
–	101 600	101 600

* As recoverable resources.

URANIUM PRODUCTION

Historical Review

Uranium production in Uzbekistan began in 1952 at the Taboshar deposit in the Fergana valley. The mine is no longer in operation and the deposit is depleted.

Commercial uranium mining began at Uchkuduk in 1958 with the development of both open pit and underground mines. The ore was stockpiled until the completion in 1964 of the hydrometallurgical uranium processing plant in Navoi, located some 300 km south-east of Uchkuduk. The mill and all mines have been operated by the Navoi Mining and Metallurgical Complex (NMMC). ISL experiments conducted at this deposit started as early as 1963, leading to the commercial application of ISL in 1965.

Conventional underground mining operations started at the Sabyrsaj and Sugraly deposits in 1966 and 1977, respectively. In 1975 the ISL technique began to replace the underground mining of the Sabyrsaj mine. Conventional underground mining at the Sabyrsaj mine was stopped completely in 1983. The Ketmenchi ISL plant began operation in 1978. In 1994 the reduction of uranium demand led to the closure of the open pit Uchkuduk mine as well as both the underground and ISL Sugraly mines.

Uranium production in the Kyzylkum area peaked in the 1980s when 3 700 to 3 800 tU/year were produced.

HISTORICAL URANIUM PRODUCTION

(Tonnes U in concentrates)

Production Method	Pre-1994	1994	1995	1996	Total to 1996	1997 (Expected)
Conventional Mining						
• Open pit	35 979	270	0	0	36 249	0
• Underground	19 609	110	0	0	19 719	0
SUBTOTAL	55 588	380	0	0	55 968	0
In situ Leaching	27 175	1 635	1 644	1 459	30 454	2 050
TOTAL	82 763	2 015	1 644	1 459	86 422	2 050

Status of Production Capability

Since 1994, NMMC has been producing uranium using only ISL technology. Facilities are located at the Uchkuduk, Sabyrsaj, Ketmenchi, North Bukinai, Beshkak, and since 1995 Kendykijube deposits. These ISL centres are organised in three divisions of NMMC. They are referred to as: “Northern Mining Division”, located in Uchkuduk, with the Uchkuduk and Kendykijube centres; “Southern Mining Division” in Zafarabad with Sabyrsaj and Ketmenchi; and “Mining Division No. 5” in Nurabad with North Bukinai, South Bukinai and Beshkak.

The production of the three mining divisions is transported by rail to the central metallurgical plant located at Navoi. The plant has a nominal production capacity of 3 000 tU/year.

The available technical details of the production centres of the three active mining divisions as well as those of the inactive Eastern Mining Division, are summarised in the following table.

URANIUM PRODUCTION CENTRE TECHNICAL DETAILS
(as of 1 January 1997)

Name of Production Centre	Northern Mining Division	Southern Mining Division	Mining Division No. 5	Eastern Mining Division
Production Centre Class	Existing	Existing	Existing	Existing
Operational Status	Operating	Operating	Operating	Mothballed
Start-up Date	1964	1966	1968	1977
Source of Ore Deposit Names Deposit Type	 Uchkuduk Kendykijube Sandstone	 Sabyrsaj Ketmenchi Sandstone	 North Bukinai South Bukinai Beshkak Sandstone	 Sugraly Sandstone
Mining Operation • Type • Size • Average Mining Recovery (%)	 ISL NA 70	 ISL NA 75	 ISL NA 80	 NA NA NA
Processing Plant • Type • Size • Average Process Recovery (%)	Navoi SX NA 99.5			
Nominal Production Capacity (tU/year)	3 000			

Ownership Structure of the Uranium Industry

NMMC is part of the government holding company Kyzylkumredmetzeloto. Consequently, the entire uranium production of NMMC is owned by the Government of Uzbekistan.

Employment in the Uranium Industry

Five towns were constructed on the basis of the uranium production activities: Uchkuduk, Zarafshan, Zafarabad, Nurabad and Navoi. Those towns provide the required infrastructure for a combined population of 500 000 persons, including roads, railway and electricity. This population is the source of NMMC's stable and highly skilled work force.

EMPLOYMENT IN EXISTING PRODUCTION CENTRES

(Persons-Years)

1994	1995	1996	Expected 1997
6 688	7 378	8 201	8 200

Future Production Centres

The future uranium production of Uzbekistan will come entirely from ISL operations. There is no information as to the expected life time of the operating ISL plants. However, it is reported that a new ISL facility at the North Kanimekh deposit will be in operation in the near future. It is also reported that Uzbekistan plans to continue uranium production through 2040 at a rate of about 3 000 t/year.

SHORT-TERM PRODUCTION CAPABILITY

(Tonnes U/year)

1997				1998				2000			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 050	2 050	2 050	2 050	2 050	2 050	2 500	2 500	2 050	2 050	3 000	3 000

2005				2010				2015			
A-I	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**	**A-I**	**B-I**	**A-II**	**B-II**
2 050	2 050	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000

Environmental Considerations

More than 30 years of uranium production-related activities by NMMC have impacted Uzbekistan's natural environment. This includes the areas affected by conventional mining and processing of uranium ores, as well as the operation of in situ leach facilities. In addition to the areas directly affected by these activities, there are surface accumulations comprising an estimated 2 420 000 m^3 of sub-economic uranium bearing material. The uranium content of this material is estimated to be 2-5 mg/kg (0.002 to 0.005 per cent U). This is in addition to the 60 million tonnes of tailings located near the Navoi Hydrometallurgical Plant Number 1, and ground water impacted by in situ leach mining. The total area impacted by ISL mining is 13 000 000 m^2. The related contaminated material recovered from the surface of these operations is about 3 500 000 m^3.

In order to fully evaluate the extent of any contamination and develop a programme for reclamation and restoration, NMMC is working with Uzbekistan's leading experts, specialists from the Commonwealth of Independent States, as well as with international organisations.

The results of radiation monitoring of NMMC's uranium mining and processing activities indicate that the average annual effective equivalent radiation dose of the critical population group living in these regions does not exceed 1 mSv/year, relative to a sum of all radiation-hazard factors.

NMMC has developed an environmental policy regarding its uranium production activities. The policy is to:

- Provide for the ecological safety for all NMMC objects by using the most ecologically acceptable and cleanest in situ leach mining method;

- Close those mining and processing enterprises that are economically and environmentally less effective;

- Isolate and properly dispose of all accumulated radioactive wastes, and;

- Reclaim land disturbed by the enterprise's uranium activities.

To realise these objectives, NMMC has been developing and carrying out a step-by-step programme for evaluating and, where necessary, reclaiming the environment which may have been impacted over more than thirty years of its uranium production operations.

At Navoi's hydrometallurgical plant a system of wells has been installed to monitor and control potential ground water contamination from the tailings impoundment. Recovered waters are returned to the plant for use in processing. An investigation is underway to obtain the data necessary for the selection and development of a tailings impoundment burial system. Following radioactive decontamination and reclamation of any contaminated lands surrounding the impoundment including the pipeline route from the plant to the impoundment, plans are being made for covering the tailings sites in the 2000 to 2005 period.

Long-Term Production Capability

Internal plans include the continuation of uranium production through the year 2040 at a level of approximately 3 000 tU/y. An increase of production above this level is not foreseen.

NATIONAL POLICIES RELATED TO URANIUM

As a member of the IAEA, the Republic of Uzbekistan complies with all international agreements related to the peaceful use of the uranium produced on its territory.

The uranium production is owned by the Republic of Uzbekistan, and private entities, including domestic and foreign companies and individuals are not permitted by law to become active in uranium exploration and production.

• Viet Nam •

URANIUM EXPLORATION

Historical Review

Uranium exploration in selected areas of Viet Nam has been carried out, starting in 1955. Since 1978, a systematic regional exploration programme has been underway throughout the entire country.

About 300 000 km^2, equivalent to 95 per cent of the country, have been surveyed at the 1:200 000 scale using surface radiometric methods combined with geological observations. Nearly 25 000 km^2 or 7 per cent of the country has been covered by an airborne radiometric/magnetic survey at the 1:25 000 scale. Selected occurrences and anomalies have been investigated in more detail by 75 000 metres of drilling and underground exploration works.

Recent and Ongoing Activities

Uranium exploration is being undertaken by Geological Division No. 10 and the Geophysical Division of the Geological Department of the Ministry of Heavy Industry. The total staff employed in uranium exploration activities ranges from 300 to 500, working from several regional offices.

In 1995 and 1996, exploration concentrated on further evaluation of the uranium potential of the Nong Son Basin, Quang Nam Province. Exploration activities have focused on two projects:

- Exploration of sandstone terrains in the Tabhing area, in the western part of the Nong Son Basin.
- Exploration of the An Diem area where uranium occurrences are present in a volcanic environment.

The following table presents exploration expenditures and drilling statistics for the 1994-1997 period.

URANIUM EXPLORATION EXPENDITURES AND DRILLING STATISTICS

	1994	1995	1996	1997 (Expected)
GOVERNMENT EXPENDITURES US$ (x 1000)	136	160	208	227
Government Surface Drilling in Metres	0	0	800	NA
Number of Surface Holes by Government Organisations	0	0	NA	NA

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

RAR producible at $130/kgU or less as in situ resources are newly reported in amount of 1 337 tU in Khe Hoa-Khe Cao deposit. Estimated Additional Resources – Category I (EAR-I) as of 1 January 1997 have increased to 6 744 from 544 tU in 1995. The increases of RAR and EAR-I result from the continuing exploration of the Khe Hoa-Khe Cao deposit in the Nong Son Basin.

REASONABLY ASSURED RESOURCES*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	NA	1 337

* As in situ resources.

ESTIMATED ADDITIONAL RESOURCES – CATEGORY I*

(Tonnes U)

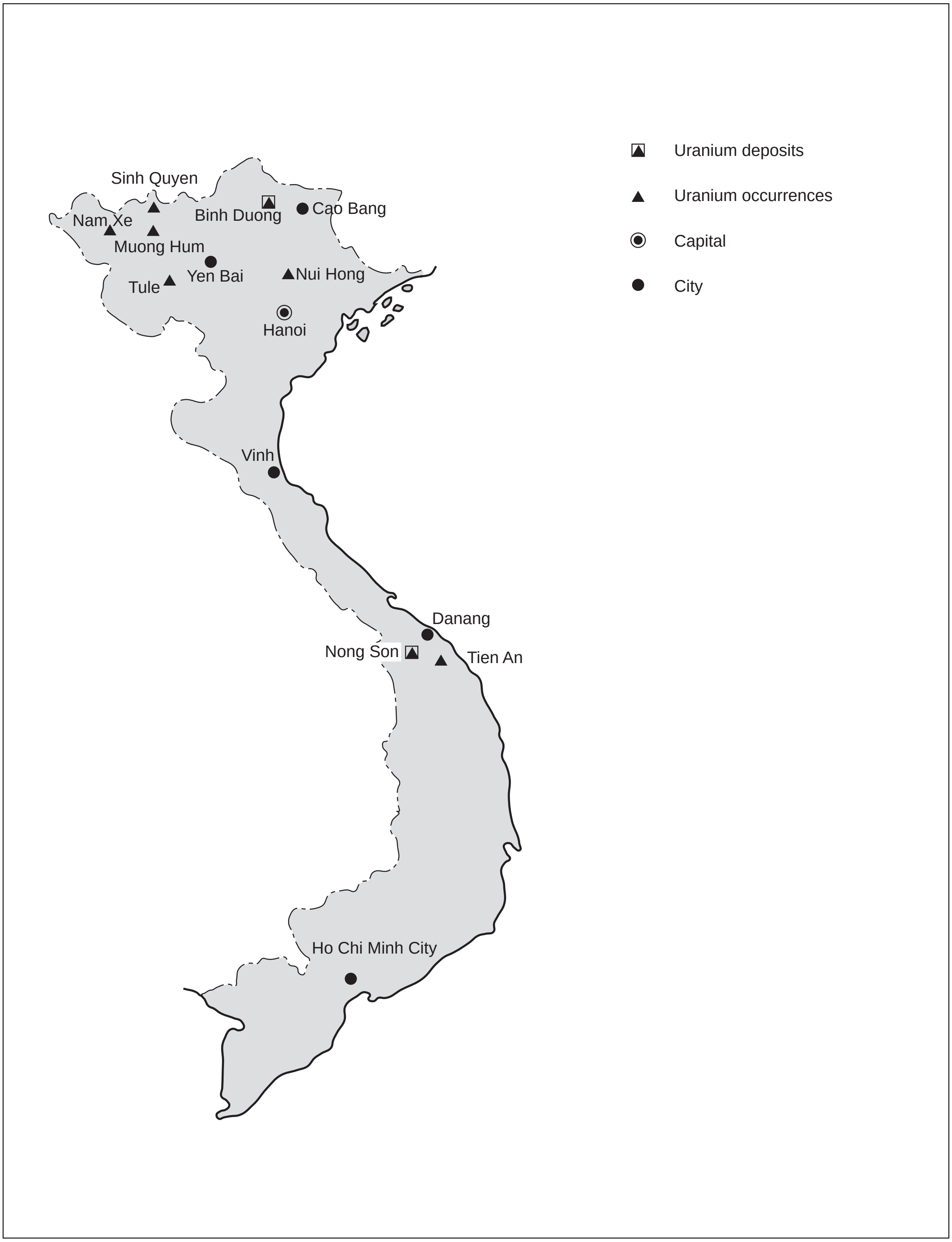
Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	491	6 744

* As in situ resources.

Undiscovered Conventional Resources (EAR-II & SR)

Both the EAR-II and Speculative Resources remain the same as reported in the 1995 Red Book. The EAR-II recoverable at costs below $130/kgU consist mainly of the 5 000 tU in the Tabhing occurrence of the Nong Son basin.

Principal uranium deposits and occurrences in Viet Nam



ESTIMATED ADDITIONAL RESOURCES – CATEGORY II*

(Tonnes U)

Cost Ranges		
<$40/kgU	<$80/kgU	<$130/kgU
NA	NA	5 700

* As in situ resources.

The Speculative Resources are estimated at 230 000 tU as of 1 January 1997, of which 130 000 tU are not assigned to any cost category (see table).

SPECULATIVE RESOURCES*

(Tonnes U)

Cost Ranges		Total
<$130/kgU	Unassigned	
100 000	130 000	230 000

* As in situ resources.

Unconventional and By-Product Resources

Unconventional resources are reported to occur in the coal deposits of the Nong Son Basin, in rare earth deposits, in the sedimentary Binh Duong phosphate deposit, as well as in the Tien An graphite deposit.

NATIONAL POLICIES RELATING TO URANIUM

Viet Nam is a country with few fossil fuels. Therefore in its new energy policy for the next century, the Government includes nuclear power as one of the alternatives. The Government is planning to construct a nuclear power plant before 2015. However, no long-term plans for developing a domestic uranium supply have been established.

• Zambia •

URANIUM EXPLORATION

Recent and Ongoing Activities

The uranium assessment project initiated in about 1990 is continuing. Uranium geochemical maps are under preparation. Uranium exploration expenditures in 1994 were 3 million Kwachas (US$ 4 380). Information is not available for 1995 and 1996.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

Zambia does not report any known uranium resources.

Undiscovered Conventional Resources

Results of the compilation of uranium geochemical maps led to the definition of two new metallogenic provinces with uranium potential. They are defined based on the presence of anomalous uranium values in stream sediments. These metallogenic provinces include the Bangweulu block in Northern Zambia and the Kabwe-Mkushi area in Central Zambia. In addition, there are known uranium occurrences in the Copperbelt and in the Mid-Zambezi Valley.

The Bangweulu block is a cratonic unit composed of crystalline basement, acid metavolcanics and granitoids formed between 2 000 and 1 800 million years. The Kabwe-Mkushi area is underlain by metasediments of the Katanga Group deposited between 1 300 million years ± 40 million years and 620 million years ± 20 million years.

The uranium potential of these two provinces have been estimated at 22 000 tU EAR-II recoverable at costs of below $130/kgU. Of the total potential, 3 000 tU are judged to occur in vein-type deposits, and the remaining 19 000 tU in sandstone-type deposits.

There have been no changes in Zambia’s uranium resources in the last two years.

NATIONAL POLICIES RELATING TO URANIUM

Exploration for uranium will be done by the Geological Survey Department of Zambia. However, due to limited funding, no exploration is being undertaken.

• Zimbabwe •

URANIUM EXPLORATION

Historical Review

Modern uranium exploration in Zimbabwe started in 1981 when a gamma-spectrometric airborne survey was flown over the entire Zambezi Valley using fixed wing aircraft. The purpose of the survey was to evaluate the potential of the sedimentary rocks of the Karoo System. To verify and screen anomalies identified in the airborne survey, a follow-up heliborne and ground based survey was conducted in 1982. From 1983 to 1987 additional work was completed on all verified anomalies. Following discovery of the Kayemba-1 deposit a detailed evaluation was initiated. Between 1985 and 1990, exploration and delineation drilling as well as technical studies including hydrogeology, rock mechanics, ore processing, mining, and others, were completed. A prefeasibility study was also completed using this information.

Exploration activities for the Kayemba-1 deposit were completed by the end of 1991. During 1991 and 1992 a technical feasibility study was completed for the deposit. The Environmental Impact Study was started, including the collection of baseline data on hydrogeology, radon flux, dosimetry and micro-meteorology of the area.

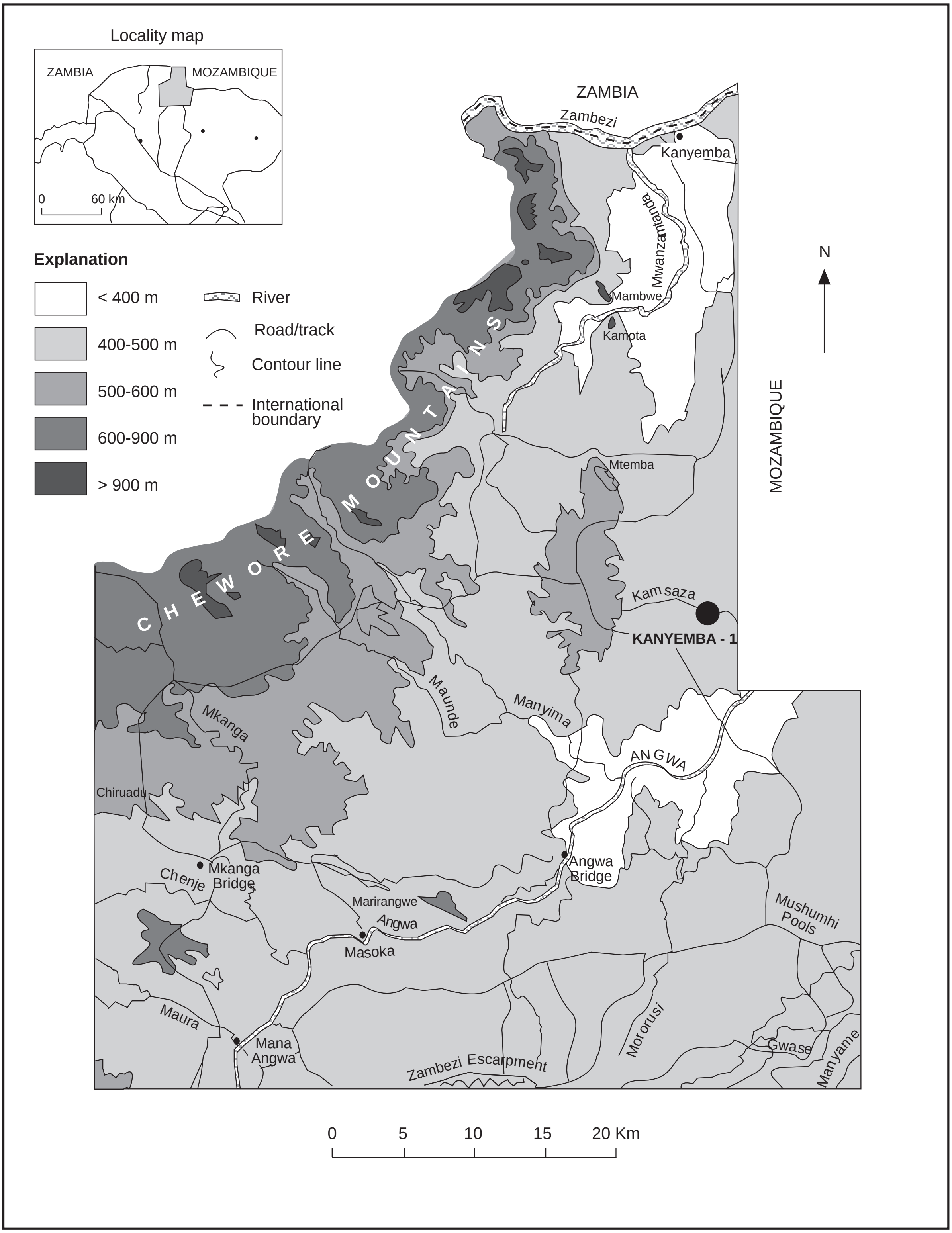
Due to the depressed international uranium market which negatively impacts the feasibility of the Kayemba project, all activities were terminated at the end of 1992. No exploration expenditures were made through 1996. None are planned for 1997.

URANIUM RESOURCES

Known Conventional Resources (RAR & EAR-I)

The known conventional resources of Zimbabwe are 1 800 tU with a recoverable cost of up to $80/kgU and an average grade of 0.6 per cent. The resources are associated with the Kanyemba-1 deposit located in the northern part of the country, near the boundary with Mozambique. The deposit consists of several lens shaped bodies, 0.20-3 metres thick, 20-100 metres wide and up to 600 metres long. It is a tabular deposit occurring in sandstones of the Upper Pebbly Arkose Formation, Upper Triassic, of the Upper Karoo System. The sandstone host rock was deposited by a meandering fluvial system.

Location of Kanyemba-1 uranium deposit, Zimbabwe



Undiscovered Conventional Resources (EAR-II & SR)

Zimbabwe does not report any estimates of EAR-II. However, it does report SR of 25 000 tU recoverable at $\$ \leq 130$/kgU. This is associated with sedimentary rocks of the Permian-lower Jurassic Karoo System.

URANIUM PRODUCTION

The Kanyemba I deposit, with its known resources of 1 800 tU in the below $80/kgU cost category, could under favourable market conditions, support a production centre. Tentative plans provide for the construction of such a centre with a production capability of 350 tU/year. Additional details are not available.

NATIONAL POLICIES RELATING TO URANIUM

Exploration for uranium may be carried out in Zimbabwe by both domestic and foreign companies. The exploration is administrated and monitored by the Ministry of Mines and must meet the same requirements as exploration for base and precious metals. National policies regarding the production and marketing of uranium in Zimbabwe have not yet been formulated.

Annex 1

MEMBERS OF THE NEA-IAEA URANIUM GROUP

Argentina	Mr. A. CASTILLO	Comisión Nacional de Energía Atómica Unidad de Proyectos Especiales de Suministros Nucleares, Buenos Aires
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Czech Republic	Mr. J. ŠURÁN **(Vice-Chairman)** Mr. J. BADAR Mr. J. MAKOVICKA	DIAMO s.p. Stráz pod Ralskem

Czech Republic *(contd.)*	Mr. R. MAYER	Ministry of Industry and Trade Prague
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Germany	Dr. F. BARTHEL **(Chairman)**	Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover
Greece	Mr. D.A.M. GALANOS	Institute of Geology and Mineral Exploration, Athens
Hungary	Mr. G. ÉRDI-KRAUSZ	Mecsekuran Ltd. Pécs
India	Dr. C.K. GUPTA	Bhabha Atomic Research Centre Mumbai, Bombay
	Mr. K.K. DWIVEDY	Atomic Minerals Division Department of Atomic Energy Hyderabad
Iran	Mr. A.G. GARANKANI Mr. S.M.R. AYATOLLAHI Mr. M.H. MASHAYEKHI	Atomic Energy Organisation of Iran Tehran
Japan	Mr. H. MIYADA	Geotechnics Development Section Tono Geoscience Centre Power Reactor and Nuclear Fuel Development Corp. (PNC), Toki-shi Tokyo

Japan *(contd.)*	Mr. K. NORITAKE	PNC Paris Office, Paris
Jordan	Mr. S. AL-BASHIR	Jordan Phosphate Mines Company Amman
Kazakhstan	Mr. G.V. FYODOROV	Atomic Energy Agency of Kazakhstan Almaty
Lithuania	Mr. K. ZILYS	Acting Resident Representative of Lithuania, Vienna, Austria
Mongolia	Mr. T. BATBOLD	Uranium Co., Ltd. Ulaanbaatar
Morocco	Mr. D. MSATEF	Centre d'Études et de Recherches des Phosphates Minéraux, Casablanca
Namibia	Mr. H. ROESENER	Geological Survey Ministry of Mines and Energy Windhoek
Netherlands	Mr. J.N. HOUDIJK	Ministry of Economic Affairs The Hague
Pakistan	Mr. M.Y. MOGHAL	Atomic Energy Minerals Centre Lahore
Philippines	Ms. P.P. GARCIA	Philippine Embassy Pretoria
Portugal	Mr. R. DA COSTA	Instituto Geologico e Mineiro Lisbon

Russian Federation	Mr. A.V. BOITSOV	All-Russian Research Institute of Chemical Technology, Moscow
	Mr. S.S. NAUMOV	Geologorazvedka Moscow
	Mr. A.V. TARKHANOV	Ministry of the Russian Federation on Atomic Energy, Moscow
South Africa	Mr. B.B. HAMBLETON-JONES **(Vice-Chairman)** Mr. L.C. AINSLIE Mr. R.G. HEARD	Atomic Energy Corporation of South Africa Ltd. Pretoria
Spain (ENUSA)	Mr. J. ARNÁIZ DE GUEZALA	Empresa Nacional del Uranio S.A. Madrid
Sweden	Dr. I. LINDHOLM	Swedish Nuclear Fuel & Waste Management Co., Stockholm
Switzerland	Mr. R.W. STRATTON	Nordostschweizerische (NOK) Kraftwerke AG Baden
Turkey	Mr. Z. ERDEMIR	Turkish Electricity Generation Ankara
Ukraine	Mr. A.Ch. BAKHARZHIIEV	The State Geological Enterprise “Kirovgeology”, Kiev
	Mr. A.P. CHERNOV	The Ukrainian State Committee on Nuclear Power Utilisation, (Goscomatom) Kiev
	Mr. B.V. SUKHOVAROV-JORNOVYI	Scientific, Technological and Energy Centre Kiev
United Kingdom	Mr. N. JONES	Rio Tinto Mineral Services Ltd. London

United States	Mr. J. GEIDL **(Vice-Chairman)**	Energy Information Administration US Department of Energy Washington
	Mr. W. FINCH	US Geological Survey Denver
Uzbekistan	Mr. N.S. BOBONOROV	State Committee on Geology and Mineral Resources of the Republic of Uzbekistan Tashkent
	Mr. S.B. INOZEMTSEV	Navoi Mining and Metallurgy Combinat Navoi
European Commission	Mr. J-P. LEHMANN	Directorate General XVII (Energy) Nuclear Energy Brussels, Belgium
IAEA	Dr. D.H. UNDERHILL **(Scientific Secretary)**	Division of Nuclear Fuel Cycle and Waste Technology Vienna, Austria
OECD/NEA	Dr. I. VERA **(Scientific Secretary)**	Nuclear Development Division Paris

Annex 2

LIST OF REPORTING ORGANISATIONS

Argentina	Comisión Nacional de Energía Atómica, Unidad de Proyectos Especiales de Suministros Nucleares, Avenida del Libertador 8250, 1156 Buenos Aires
Australia	Department of Primary Industries and Energy, GPO Box 858, Canberra, ACT 2601
Belgium	Ministère des Affaires Économiques, Administration de l'Énergie, Service de l'Énergie Nucléaire, 154 Boulevard Emile Jacqmain, B-1210 Brussels
Brazil	Commissão Nacional de Energia Nuclear, Rua General Severiano, 90, 22294-900, Botafogo, Rio de Janeiro
Bulgaria	Committee of Energy, 8, Triaditza Street, Sofia
Canada	Uranium and Radioactive Waste Division, Energy Resources Branch, Natural Resources Canada, 580 Booth Street, Ottawa, Ontario K1A OE4
Chile	Comisión Chilena de Energía Nuclear, Departamento de Materiales Nucleares, Amunategui No. 95, Santiago
China	Bureau of Mining and Metallurgy, China National Nuclear Corporation, P.O. Box 2102-9, Beijing 100822
	Bureau of Geology, China National Nuclear Corporation, P.O. Box 762, Beijing 100013
Colombia	INEA, Dirección General, Avenida El Dorado Carrera 50, Santafé de Bogotá
Cuba	Ministerio de Ciencias, Tecnología y Medio Ambiente, Centro de Estudios Aplicados al Desarrollo Nuclear, Calle 30 # 502 esq. 5ta Ave. Miramar, Municipio Playa, Ciudad de La Habana
Czech Republic	DIAMO s.p., 471 27 Stráz pod Ralskem
	CEZ, a.s., Nuclear Fuel Cycle Section, Jungmannova 29, 111 48 Praha 1
Denmark	Ministry of Environment and Energy, Mineral Resources Administration for Greenland, Slotholmsgade 1, 4th floor, DK-1216 Copenhagen K
Egypt	Nuclear Materials Authority, P.O. Box 530, El Maadi, Cairo

Estonia	Ministry of Environment, Toompuiestee 24, 0100 Tallinn
Finland	Ministry of Trade and Industry, Energy Department, P.O. Box 37, SF-0131 Helsinki
France	Commissariat à l'Énergie Atomique, Centre d'Études de Saclay, F-91191-Gif-sur-Yvette Cédex
Gabon	Compagnie des Mines d’Uranium de Franceville (COMUF), B.P. 260, Libreville
	Ministère des Mines, de l’Energie et du Pétrole, B.P. 874 et 576, Libreville
Germany	Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-30655 Hannover
Greece	Institute of Geology and Mineral Exploration (I.G.M.E.), 70, Messogion Street, GR-115 27 Athens
Hungary	Mecsekurán Ltd., P.O. Box 65, H-7614 Pécs
India	Atomic Minerals Division, Department of Atomic Energy, 1-10-153-156, Begumpet, Hyderabad 500 016
	Uranium Corporation of India Ltd., Jaduguda Mines P.O., Bihar, Singhbhum (East), India 832 102
Indonesia	Nuclear Minerals Development Centre, National Atomic Energy Agency (BATAN), Jl. Cinere Pasar Jumat, P.O. Box 6010 Kbyb, Jakarta 12060
Iran	Atomic Energy Organisation of Iran, P.O. Box 14155-1339, Tehran
Ireland	Nuclear Safety Division, Dept. of Transport, Energy and Communications, 44 Kildare Street, Dublin 2
Italy	Italian Delegation to the OECD, 50, rue de Varenne, F-75007 Paris
Japan	Science and Technology Agency, 2-1 Kasumigaseki, 2-chome, Chiyoda-ku, Tokyo 100
Jordan	Natural Resources Authority, P.O. Box 7, Amman
	Jordan Phosphate Mines Co., P.O. Box 30, Amman
Kazakhstan	Atomic Energy Agency of the Republic of Kazakhstan (KAEA), 13 Republic Square, Almaty, 480013

Korea, Rep. of	Atomic Energy International Co-operation Division, Ministry of Science and Technology, Government Complex Building II, Gwachun, Rep. of Korea 427-760
Lithuania	Ministry of National Economy, Gedimino pr. 38/2, 2600 Vilnius
Malaysia	Geological Survey of Malaysia, 19th-21st Floor, Bangunan Luth, Jalan Tun Razak, 50736 Kuala Lumpur
Mexico	Comisión Nacional de Seguridad Nuclear y Salvaguardias, Dr. Barragan No. 779, Col. Narvarte, 03202 Mexico, D.F.
Mongolia	Uran Co. Ltd., Baga troiru-6, Ulan Bator
Morocco	Centre d’Études et de Recherches des phosphates minéraux, Casablanca
Namibia	Geological Survey of Namibia, Ministry of Mines and Energy, P.O. Box 2168, Windhoek
Netherlands	Ministry of Economic Affairs, Coal and Nuclear Energy Division, P.B. 20101, NL-2500 EC The Hague
Niger	Ministère des Mines, Direction des Mines, B.P. 11700, Niamey
Norway	Norwegian Radiation Protection Authority, P.O. Box 55, N-1345 Østeraas
Pakistan	Atomic Energy Minerals Centre, Ferozepur Road, P.O. Box 658, Lahore - 16
Peru	Instituto Peruano de Energía Nuclear, Avenida Canada 1470, San Borja
Philippines	Philippine Nuclear Research Institute, Don Mariano Marcos Avenue, Diliman, Quezon City
Portugal	Ministério da Indústria e Energia, Instituto Geológico e Mineiro, Rua Almirante Barroso, 38, P-1000 Lisbon
Romania	Regie Autonome for Rare and Radioactive Metals, 68, Dionisie Lupu Street, Bucharest
Russian Federation	Ministry for the Russian Federation of Atomic Energy, JSK “Atomredmetzoloto”, Bolshaya Ordynka st. 24/26, Moscow, 109017
	Concern “Geologorazvedka”, Marshala Rybalko 4, Moscow, 123436
Slovak Republic	Nuclear Regulatory Authority of the Slovak Republic, Bajkalská 27, P.O. Box 24, 820 07 Bratislava 27
Slovenia	Rudnik Zirovski vrh, p.o., Todraz 1, 4224 Gorenja Vas

South Africa	Atomic Energy Corporation of South Africa Limited, P.O. Box 582, Pretoria 0001
Spain	Departamento de Materiales, División de Uranio, ENUSA, Santiago Rusiñol, 12, E-28040 Madrid
Sweden	Swedish Nuclear Fuel and Waste Management Co., Box 5864, S-102 40 Stockholm
Switzerland	Nordostschweizerische Kraftwerke AG, Parkstrasse 23, CH-5401 Baden
Thailand	Department of Mineral Resources, Economic Geology Division, Rama IV Road, Bangkok 10400
Turkey	Turkish Atomic Energy Authority, Alaçam Sokak No. 9, Çankaya, Ankara
Ukraine	The State Committee of Ukraine on Geology and Utilization of Mineral Resources, The State Geological Enterprise “Kirovgeology”, 8 Kikvidze Street, 252103 Kiev
United Kingdom	Department of Trade and Industry, London SW1H OET
	Nuclear Electric plc, Barnett Way, Barnwood, Gloucester GL4 7RS
	British Nuclear Fuels plc (BNFL), Risley, Warrington, Cheshire WA3 6AS
	Scottish Nuclear, 3 Redwood Crescent, Peel Park, East Kilbride, Scotland, G74 5PR
United States	Energy Information Administration, Coal, Nuclear, Electric and Alternate Fuels (EI- 50), U.S. Department of Energy, Washington, D.C. 20585
Uzbekistan	The State Committee of the Republic of Uzbekistan on Geology and Mineral Resources, 11 Shevchenko st., 700060 GSP, Tashkent
	The State Geological Enterprise “Kyzyltepageologia”, Tashkent, 7a Navoi st., 700000 Tashkent
	The Navoi Mining and Metallurgical Complex, 27 Navoi st., 706800 Navoi
Viet Nam	Viet Nam Atomic Energy Commission, 59 Ly Thuong Kiet, Hanoi
Zambia	Geological Survey Department, P.O. Box 50135, 15101 Lusaka
Zimbabwe	Zimbabwe Geological Survey Department, P.O. Box CY 210, Causeway, Harare

Annex 3

GEOLOGIC SETTING OF URANIUM DEPOSITS[1]

The uranium resources of the world can be assigned on the basis of their geological setting to the following fifteen main categories of uranium ore deposit types arranged according to their approximate economic significance:

1. Unconformity-related deposits;
2. Sandstone deposits;
3. Quartz-pebble conglomerate deposits;
4. Vein deposits;
5. Breccia complex deposits;
6. Intrusive deposits;
7. Phosphorite deposits;
8. Collapse breccia pipe deposits;
9. Volcanic deposits;
10. Surficial deposits;
11. Metasomatite deposits;
12. Metamorphic deposits;
13. Lignite;
14. Black shale deposits;
15. Other types of deposits.

The main features of these deposits are described below:

1. Unconformity-related deposits

Deposits of the unconformity-related type occur spatially close to major unconformities. Such deposits most commonly developed in intracratonic basins during the period about 1 800-800 million years ago, but also during Phanerozoic time. Type examples are the ore bodies at Cluff Lake, Key Lake and Rabbit Lake in northern Saskatchewan, Canada, and those in the Alligator Rivers area in northern Australia.

2. Sandstone deposits

Most of the ore deposits of this type are contained in rocks that were deposited under fluvial or marginal marine conditions. Lacustrine and eolian sandstones are also mineralised, but uranium deposits are much less common in these rocks. The host rocks are almost always medium to

1. This classification was developed by the IAEA in 1988-89 and replaces the classification defined and used in the Red Books 1986, 1988, 1990 and 1992.

coarse-grained poorly sorted sandstones containing pyrite and organic matter of plant origin. The sediments are commonly associated with tuffs. Unoxidised deposits of this type consist of pitchblende and coffinite in arkosic and quartzitic sandstones. Upon weathering, secondary minerals such as carnotite, tuyamunite and uranophane are formed.

The Tertiary, Jurassic and Triassic sandstones of the Western Cordillera of the United States account for most of the uranium production in that country. Cretaceous and Permian sandstones are important host rocks in Argentina. Other important uranium deposits are found in Carboniferous deltaic sandstones in Niger; in Permian lacustrine siltstones in France; and in Permian sandstones of the Alpine region. The deposits in Precambrian marginal marine sandstones in Gabon have also been classified as sandstone deposits.

3. Quartz-pebble conglomerate deposits

Known quartz-pebble conglomerate ores are restricted to a specific period of geologic time. They occur in basal Lower Proterozoic beds unconformably situated above Archaean basement rocks composed of granitic and metamorphic strata. Commercial deposits are located in Canada and South Africa, and sub-economic occurrences are reported in Brazil and India.

4. Vein deposits

The vein deposits of uranium are those in which uranium minerals fill cavities such as cracks, fissures, pore spaces, breccias and stockworks. The dimensions of the openings have a wide range, from the massive veins of pitchblende at Jachymov (Czech Republic), Shinkolobwe (Democratic Republic of the Congo) and Port Radium (Canada) to the narrow pitchblende filled cracks, faults and fissures in some of the ore bodies in Europe, Canada and Australia.

5. Breccia complex deposits

Deposits of this group were developed in Proterozoic continental regimes during anorogenic periods. The host rocks include felsic volcanoclastics and sedimentary rocks. The uranium mineralisation occurs in rock sequences immediately overlying granitoid basement complexes. The ores generally contain two phases of mineralisation, an earlier stratabound and a later transgressive one. The main representative of this type is the Olympic Dam deposit in South Australia. Deposits in Zambia, Democratic Republic of the Congo and the Aillik Group in Labrador, Canada, may also belong to this category.

6. Intrusive deposits

Deposits included in this type are those associated with intrusive or anatectic rocks of different chemical composition (alaskite, granite, monzonite, peralkaline syenite, carbonatite and pegmatite). Examples include the Rössing deposit in Namibia, the uranium occurrences in the porphyry copper deposits such as Bingham Canyon and Twin Butte in USA, the Ilimaussaq deposit in Greenland, Palabora in South Africa as well as the deposits in the Bancroft area, Canada.

7. Phosphorite deposits

Sedimentary phosphorites contain low concentrations of uranium in fine grained apatite. For the purpose of this report uranium of this type is considered an unconventional resource. Examples include the deposits in Florida, USA, where uranium is recovered as a by-product, and the large deposits in North African and Middle-Eastern countries.

8. Collapse breccia pipe deposits

Deposits in this grouping occur in circular, vertical pipes filled with down-dropped fragments. Uranium is concentrated in the permeable breccia matrix and in the accurate fracture zones enclosing the pipe. Type examples are the deposits in the Arizona Strip in Arizona, USA.

9. Volcanic deposits

Uranium deposits of this type are stratabound and structurebound concentrations in acid volcanic rocks. Uranium is commonly associated with molybdenum, fluorine, etc. Type examples are the uranium deposits Michelin in Canada, Nopal I in Chihuahua, Mexico, Macusani in Peru and numerous deposits in China and the CIS.

10. Surficial deposits

Uraniferous surficial deposits may be broadly defined as uraniferous sediments, usually of Tertiary to Recent age which have not been subjected to deep burial and may or may not have been calcified to some degree. The uranium deposits, associated with calcrete, which occur in Australia, Namibia and Somalia in semi-arid areas where water movement is chiefly subterranean are included in this type. Additional environments for uranium deposition include peat and bog, karst caverns as well as pedogenic and structural fills.

11. Metasomatite deposits

Included in this grouping are uranium deposits in alkali metasomatites (albitites, aegirinites, alkali-amphibole rocks) commonly intruded by microcline granite. Type examples are the deposits Espinharas in Brazil, Ross Adams in Alaska, USA, as weIl as the Zheltye Vody deposit in Krivoy Rog area, Ukraine.

12. Metamorphic deposits

Uranium deposits belonging to this class occur in metasediments and/or metavolcanics generally without direct evidence of post-metamorphic mineralisation. Examples include the deposits at Forstau, Austria.

13. Lignite

Deposits of this type, generally classified as unconventional uranium resources occur in lignite and in clay and/or sandstone immediately adjacent to lignite. Examples are uraniferous deposits in the Serres Basin, Greece, North and South Dakota, USA and Melovoe, in the CIS.

14. Black shale deposits

Low concentrations of uranium occur in carbonaceous marine shales. Also these resources are considered unconventional resources for the purpose of this report. Examples include the uraniferous alum shale in Sweden, the Chatanooga Shale in the USA, but also the Chanziping deposit of the "argillaceous-carbonaceous-siliceous-pelitic rocks" type in the Guangxi Autonomous Region in China and the deposit of Gera-Ronneburg, in the eastern portion of Germany.

15. Other deposits

Included in this grouping are those deposits which cannot be classified with the deposit types already mentioned. These include the uranium deposits in the Jurassic Todilto Limestone in the Grants district, New Mexico, USA.

Annex 4

INDEX OF NATIONAL REPORTS IN RED BOOKS 1965-1997

The following index lists all national reports and the year in which these reports were published in the Red Books. A detailed listing of all Red Book editions is shown at the end of this Index.

Algeria						1975	1977	1979	1982								
Argentina		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Australia		1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Austria							1977										
Bangladesh											1986	1988					
Belgium									1982	1983	1986	1988	1990	1992	1994	1996	1998
Benin													1990				
Bolivia							1977	1979	1982	1983	1986						
Botswana								1979		1983	1986	1988					
Brazil				1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998
Bulgaria													1990	1992	1994	1996	1998

Cameroon							1977		1982	1983							
Canada	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Central African Republic				1970	1973		1977	1979			1986						
Chile							1977	1979	1982	1983	1986	1988		1992	1994	1996	1998
China													1990	1992	1994	1996	1998
Colombia							1977	1979	1982	1983	1986	1988	1990			1996	1998
Costa Rica									1982	1983	1986	1988	1990				
Ivory Coast									1982								
Cuba												1988		1992		1996	1998
Czech Republic															1994	1996	1998
Czech & Slovak Federal Rep.													1990				
Denmark (Greenland)	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986		1990	1992		1996	1998
Dominican Republic									1982								
Ecuador							1977		1982	1983	1986	1988					
Egypt							1977	1979			1986	1988	1990	1992	1994	1996	1998
El Salvador										1983	1986						
Estonia																	1998
Ethiopia								1979		1983	1986						
Finland					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
France	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Gabon		1967		1970	1973				1982	1983	1986					1996	1998
Germany				1970		1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998

Ghana							1977			1983							
Greece							1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Guatemala											1986	1988					
Guyana								1979	1982	1983	1986						
Hungary														1992	1994	1996	1998
India	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986		1990	1992	1994	1996	1998
Indonesia							1977				1986	1988	1990	1992	1994	1996	1998
Iran							1977										1998
Ireland								1979	1982	1983	1986			1992			1998
Italy		1967		1970	1973	1975	1977	1979	1982	1983	1986	1988		1992	1994	1996	1998
Jamaica									1982	1983							
Japan	1965	1967		1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Jordan							1977				1986	1988	1990	1992	1994	1996	1998
Kazakhstan															1994	1996	1998
Korea, Republic of						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Kyrgyzstan																1996	1998
Lesotho												1988					
Liberia							1977			1983							
Libyan Arab Jamahirya										1983							
Lithuania															1994	1996	1998
Madagascar						1975	1977	1979	1982	1983	1986	1988					
Malaysia										1983	1986	1988	1990	1992	1994	1996	1998

Mali											1986	1988					
Mauritania													1990				
Mexico				1970	1973	1975	1977	1979	1982		1986		1990	1992	1994	1996	1998
Mongolia															1994	1996	1998
Morocco	1965	1967				1975	1977	1979	1982	1983	1986	1988	1990				
Namibia								1979	1982	1983	1986	1988	1990			1996	1998
Netherlands									1982	1983	1986		1990	1992	1994	1996	1998
New Zealand		1967					1977	1979									
Niger		1967		1970	1973		1977				1986	1988	1990	1992	1994	1996	1998
Nigeria								1979									
Norway								1979	1982	1983				1992		1996	1998
Pakistan		1967															1998
Panama										1983		1988					
Paraguay										1983	1986						
Peru							1977	1979		1983	1986	1988	1990	1992	1994	1996	1998
Philippines							1977		1982	1983	1986		1990		1994	1996	1998
Portugal	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Romania														1992	1994	1996	1998
Russian Federation															1994		1998
Rwanda											1986						
Senegal									1982								
Slovak Republic															1994	1996	1998

Slovenia															1994	1996	1998
Somalia							1977	1979									
South Africa	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986			1992	1994	1996	1998
Spain	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Sri Lanka							1977		1982	1983	1986	1988					
Sudan							1977										
Surinam									1982	1983							
Sweden	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Switzerland						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Syrian Arab Republic									1982	1983	1986	1988	1990		1994		
Tanzania													1990				
Thailand							1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Togo								1979									
Turkey					1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Ukraine															1994	1996	1998
United Kingdom						1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
United States	1965	1967	1969	1970	1973	1975	1977	1979	1982	1983	1986	1988	1990	1992	1994	1996	1998
Uruguay							1977		1982	1983	1986	1988	1990				
USSR														1992			
Uzbekistan															1994	1996	1998
Venezuela											1986	1988					

Viet Nam														1992	1994	1996	1998
Yugoslavia														1992			
Zaire		1967			1973		1977					1988					
Zambia											1986	1988	1990	1992	1994	1996	1998
Zimbabwe									1982			1988		1992	1994	1996	1998

SUCCESSIVE RED BOOK EDITIONS SINCE 1965

OECD/ENEA:	World Uranium and Thorium Resources, Paris, 1965;
OECD/ENEA:	Uranium Resources, Revised Estimates, Paris, 1967;
OECD/ENEA-IAEA:	Uranium Production and Short-Term Demand, Paris, 1969;
OECD/ENEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1970;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1973;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1975;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1977;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1979;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1982;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1983;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1986;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1988;
OECD/NEA-IAEA:	Uranium Resources, Production and Demand, Paris, 1990;
OECD/NEA-IAEA:	Uranium 1991: Resources, Production and Demand, Paris, 1992;
OECD/NEA-IAEA:	Uranium 1993: Resources, Production and Demand, Paris, 1994;
OECD/NEA-IAEA:	Uranium 1995: Resources, Production and Demand, Paris, 1996;
OECD/NEA-IAEA:	Uranium 1997 : Resources, Production and Demand, Paris, 1998.

Annex 5

ENERGY CONVERSION FACTORS

The need to establish a set of factors to convert quantities of uranium into common units of energy appeared during recent years with the increasing frequency of requests for such factors applying to the various reactor types.

The NEA has therefore asked organisations of its member countries to provide such factors to be published in this report.

The contributions of these organisations are presented in the following table.

ENERGY VALUES FOR URANIUM USED IN VARIOUS REACTOR TYPES[(1)]

COUNTRY	CANADA	FRANCE	GERMANY		JAPAN		RUSSIAN FEDERATION		SWEDEN		UNITED KINGDOM		UNITED STATES	
REACTOR TYPE	CANDU	N4 PWR	BWR	PWR	BWR	PWR	WWER-1000	RBMK-1000	BWR	PWR	MAGNOX	AGR	BWR	PWR
Burnup [MWday/tU]														
a) Natural Uranium or National Uranium Equivalent	7 770	5 848	5 665	5 230	5 532	4 694	4 855	4 707	6 250	5 780	5 900	NA	4 996	4 888
b) Enriched Uranium	–	42 500	40 000	42 000	33 000	43 400	42 000	22 000	40 000	42 000	–	24 000	33 000	40 000
Uranium Enrichment [% ^{235}U]	NA	3.60	3.20	3.60	3.00	4.10	4.23	2.40	3.20	3.60	–	2.90	3.02	3.66
Tails Assay [%^{235}U]	NA	0.25	0.30	0.30	0.25	0.30	0.25	0.25	0.25	0.25	–	0.30	0.30	0.30
Efficiency of Converting Thermal Energy into Electricity	30%	34.60%	33.50%	34.20%	33%	34%	33.30%	31.20%	34.00%	34.50%	26%	40%	32%	32%
Thermal Energy Equivalent of 1 Tonne Natural Uranium [in 10^{15} Joules] [(2)]	0.671	0.505	0.490	0.452	0.478	0.406	0.419	0.406	0.540	0.500	0.512	0.360	0.432	0.422
Electrical Energy Equivalent of 1 Tonne Natural Uranium [in 10^{15} Joules] [(2)]	0.201	0.175	0.164	0.155	0.158	0.140	0.139	0.127	0.184	0.173	0.133	0.144	0.138	0.135

(1) Does not include Pu and U recycled. Does not take into account the requirement of an initial core load which would reduce the equivalence by about 6 per cent, if based on a plant life of about 30 years with a 70 per cent capacity factor.

(2) Does not take into account the energy consumed for 235U enrichment in LWR and AGR fuel. The factor to be applied to the energy equivalent under the condition of 3 per cent 235U enrichment and 0.2 per cent tails assay should be multiplied by 0.95

NA Data not available.

Conversion factors and energy equivalences for fossil fuel

(for comparison)

1 cal	=	4.1868 J
1 J	=	0.239 cal
1 tonne of oil equivalent (net, LHV)	=	42 GJ[1] = 1 TOE
1 tonne of coal equivalent (standard, LHV)	=	29.3 GJ[1] = 1 TCE
1 000 m^3 of natural gas (standard, LHV)	=	36 GJ
1 tonne of LNG	=	46 GJ
1 000 kWh (primary energy)	=	9.36 GJ
1 TOE	=	10 034 Mcal
1 TCE	=	7 000 Mcal
1 000 m^3 natural gas	=	8 600 Mcal
1 tonne LNG	=	11 000 Mcal
1 000 kWh (primary energy)	=	2 236 Mcal[2]
1 TCE	=	0.697 TOE
1 000 m^3 natural gas	=	0.857 TOE
1 tonne LNG	=	1.096 TOE
1 000 kWh (primary energy)	=	0.223 TOE
1 tonne of fuelwood	=	0.380 TOE
1 tonne of uranium: light water reactors	=	10 000 - 16 000 TOE
open cycle	=	14 000 - 23 000 TCE

1. World Energy Council standards conversion factors (from Standards Circular No. 1, 11/83).
2. With 1 000 kWh (final consumption) = 860 Mcal as WEC conversion factor.

Annex 6

CURRENCY EXCHANGE RATES*

(In National Currency Units per US$)

COUNTRY (currency abbreviation)	June 1994	June 1995	June 1996	January 1997
Argentina (ARS)	0.998	0.998	0.998	0.998
Australia (AUD)	1.360	1.390	1.260	1.260
Austria (ATS)	11.700	9.600	10.900	10.900
Belgium (BEF)	33.900	28.300	31.500	32.000
Brazil (BRE)	2 150.000	0.900	0.987	1.045
Bulgaria (BGL)	53.900	65.800	135.000	500.000
Canada (CAD)	1.380	1.360	1.370	1.360
Chile (CLP)	425.000	375.000	405.000	420.000
China (CNY)	8.510	8.410	8.280	8.280
Colombia (COP)	820.000	867.000	1 050.000	994.000
Costa Rica (CRC)	153.000	171.000	201.000	213.000
Cuba (CUB$)	0.740	0.740	1.000	1.000
Czech Republic (CZK)	27.800	26.200	27.300	27.400
Denmark (Greenland) (DKK)	6.470	5.400	5.920	5.950
Egypt (EGP)	3.390	3.370	3.370	3.370
Finland (FIM)	5.410	4.240	4.730	4.650
France (FRF)	5.630	4.890	5.200	5.250
Gabon (GBF)	563.000	489.000	520.000	525.000
Germany (DEM)	1.650	1.390	1.530	1.550
Greece (GRD)	237.000	226.000	243.000	241.000
Hungary (HUF)	104.000	120.000	146.000	159.000
India (INR)	31.200	31.200	34.000	35.500
Indonesia (IDR)	2 144.000	2 220.000	2 330.000	2 330.000
Italy (ITL)	1 590.000	1 650.000	1 560.000	1 530.000
Japan (JPY)	104.000	83.000	107.000	115.800
Jordan (JOD)	0.702	0.688	0.708	0.708

* *Source*: The Department of Finance of the United Nations Development Programme, New York.

COUNTRY (currency abbreviation)	June 1994	June 1995	June 1996	January 1997
Kazakhstan (KZR)	31.000	62.000	66.000	72.500
Korea (Republic of) (KRW)	786.000	762.000	785.000	839.000
Lithuania (LTL)	4.000	4.000	4.000	4.000
Malaysia (MYR)	2.710	2.450	2.500	2.500
Mauritania (MRO)	124.000	129.000	136.000	140.000
Mexico (MXP)	3.300	5.800	7.350	7.800
Mongolia (MNT)	408.000	448.000	495.000	689.000
Morocco (MAD)	9.450	8.480	8.610	8.810
Namibia (NMR)	3.600	3.670	4.340	4.670
Netherlands (NLG)	1.850	1.540	1.710	1.750
Niger (XOF)	563.000	489.000	520.000	525.000
Norway (NOK)	7.150	6.190	6.550	6.450
Peru (PEN)	2.170	2.250	2.350	2.580
Philippines (PHP)	27.300	25.700	25.900	26.200
Portugal (PTE)	171.000	145.000	158.000	155.000
Romania (ROL)	1 570.000	1 920.000	2 880.000	3 920.000
Russian Federation (SUR)	1 805.000	5 080.000	5 010.000	5 510.000
Slovak Republic (SKK)	32.700	29.100	30.100	30.800
Slovenia (SLT)	129.000	111.000	130.000	138.000
South Africa (ZAR)	3.600	3.670	4.340	4.670
Spain (ESP)	137.000	121.000	129.000	131.000
Sweden (SEK)	7.480	7.260	6.750	6.870
Switzerland (CHF)	1.430	1.140	1.260	1.350
Syria (SYP)	26.600	26.600	26.600	26.600
Thailand (THB)	25.300	24.700	25.100	25.400
Turkey (TRL)	33 000.000	44 100.000	77 050.000	105 000.000
Ukraine (UKK)	45 800.000	153 000.000	189 000.000	1.830
United Kingdom (GBP)	0.645	0.620	0.650	0.594
United States (USD)	1.000	1.000	1.000	1.000
Uruguay (UYP)	4.840	6.120	7.710	8.610
Uzbekistan (UZS)	3 800.000	26.100	36.100	55.000
Viet Nam (VND)	11 000.000	11 000.000	11 000.000	11 130.000
Yugoslavia (YUP)	NA	1.390	5.050	5.120
Zambia (ZMK)	685.000	853.000	1 240.000	1 280.000
Zimbabwe (ZWD)	7.890	8.250	9.800	10.500

Annex 7

GROUPING OF COUNTRIES AND AREAS*WITH URANIUM RELATED ACTIVITIES

The countries and geographical areas included in each grouping are listed below.

1. North America

Canada	Mexico	United States of America

2. Central and South America

Argentina	Bolivia	Brazil
Chile	Colombia	Costa Rica
Cuba	Dominican Republic	Ecuador
El Salvador	Guatemala	Guyana
Panama	Paraguay	Peru
Uruguay	Venezuela	

3. Western Europe and Scandinavia

Austria	Belgium	Denmark
Finland	France	Germany
Ireland	Italy	Netherlands
Norway	Portugal	Spain
Sweden	Switzerland	United Kingdom

4. Central and Eastern Europe

Armenia	Belarus	Bulgaria
Croatia	Czech Republic	Estonia
Greece	Hungary	Lithuania
Poland	Romania	Russian Federation
Slovak Republic	Slovenia	Turkey
Ukraine	Yugoslavia	

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* This list has been compiled to describe countries on a geographical basis.

5. Africa

Algeria	Botswana	Cameroon
Central African Republic	Democratic Republic of the Congo (formerly Zaire)	Egypt
Ethiopia	Gabon	Ghana
Ivory Coast	Lesotho	Liberia
Libyan Arab Jamahiriya	Madagascar	Mali
Mauritania	Morocco	Namibia
Niger	Nigeria	Rwanda
Senegal	Somalia	South Africa
Sudan	Togo	Zambia
Zimbabwe		

6. Middle East, Central and South Asia

Bangladesh	India	Iran, Islamic Republic of
Jordan	Kazakhstan	Kyrgyzstan
Pakistan	Sri Lanka	Syrian Arab Republic
Uzbekistan		

7. South East Asia

Indonesia	Malaysia	Philippines
Thailand	Viet Nam	

8. Pacific

Australia	New Zealand

9. East Asia[2]

China	Democratic People's Republic of Korea	Japan
Korea, Republic of	Mongolia	

2. Includes Chinese Taipei.

Annex 8

TECHNICAL TERMS

The following abbreviations for technical terms in mining and ore processing were used in some tables:

	Type	Abbreviation
Mining Operation	Open Pit Underground	OP UG
Processing	a) Feed Preparation Crush-Wet Grind Semi-Autogenous Grind	 CWG SAG
	b) Sorting and Preconcentration Radiometric Sorting Density Separation Magnetic Separation Flotation	 Rad-Sort Dens-Sep Mag-Sep Flot.
	c) Leaching Acid Leaching Two-stage Acid Leaching Alkaline Pressure Leaching In Situ Leaching In Place Leaching Heap Leaching Percolation Leaching	 AL 2 AL ALKPL ISL IPL HL Perc L
	d) Extraction Ion Exchange Solvent Extraction	 IX SX

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