• South Africa •

URANIUM EXPLORATION

Historical review

The world-wide search for uranium resources in the early 1940s resulted in the commencement of uranium exploration in South Africa during 1944. Attention at the time was focused on the occurrence of uranium in the gold bearing quartz-pebble conglomerates of the Witwatersrand Supergroup. Exploration for uranium in the Witwatersrand Basin was always a consequence of gold exploration until the oil crisis emerged in 1973. With the price of uranium increasing more than five times in a short space of time, uranium exploration activities intensified leading to the establishment of South Africa's first primary uranium producer at Beisa Mine in 1981.

However, the crash in the uranium market shortly thereafter not only resulted in the closure of the Beisa's uranium production facility in 1985, but also had a detrimental effect on uranium exploration in general. Incidental discoveries of new uranium resources were nevertheless made during the exploration for gold due to the ubiquity of uranium in the quartz-pebble conglomerates. The static gold price in the 1990s furthermore led to a substantial curtailment of gold exploration activities within the Witwatersrand Basin.

The discovery of uranium in the Karoo Basin whilst drilling for oil in the early 1970s, resulted in a diversification of uranium exploration activities in South Africa. Although initially at a modest level, exploration activities increased until the incident at Three Mile Island in 1979, which sent the overheated uranium market plummeting. Exploration activities in the Karoo Basin declined rapidly thereafter and finally ceased in the mid 1980s.

Exploration for uranium outside of these two geological basins resulted in the discovery of uranium deposits associated with coal seams, carbonatites, granites, marine phosphates as well as surface deposits. Such exploration has always been undertaken on a low-key basis and rendered very limited success in terms of additional uranium resources.

Recent and ongoing uranium exploration and mine development activities

Exploration for uranium as a primary commodity was last experienced in 1988 during exploration activities on the Springbok Flats in the Limpopo Province. The upsurge in the price of uranium from 2005 onwards prompted a closer look at the Witwatersrand gold reefs where uranium comprises a more substantial income contributor with gold a useful windfall. This led to the establishment of a new Canadian registered mining group, Uranium One, which will become the only primary South African uranium producer.

An increase in the gold price from below USD 400 towards the end of 2003 to more than USD600/troy ounce at the end of 2006 stimulated a renewed interest in exploration for this precious metal at several locations along the limb of the Witwatersrand Basin, while the much higher uranium price encouraged some gold mining groups to revert to a routine of recording the uranium concentrations within the reefs during their ore outlining, development and mining activities. Some mining companies have also drilled and assayed slimes dams to determine their uranium and gold content for possible future exploitation. Renewed interest in uranium occurrences in the Karoo Basin has also been experienced in recent years.

Although no new discoveries of uranium in South Africa have been reported lately, significant additional resources of uranium have been delineated by Uranium One at its new mine NW of Klerksdorp in the North West Province.

No exploration for uranium by South African based companies outside of South Africa has been undertaken.

The statutory responsibility for uranium exploration and development has been transferred from the Atomic Energy Corporation of South Africa Limited to the South African Nuclear Energy Corporation Limited and National Nuclear Regulator in 1999, whilst the responsibility for updating the Red Book information had since taken place under the guidance of the Council for Geoscience.

URANIUM RESOURCES

Identified Resources (RAR & Inferred)

By far the largest portion (about 67%) of South Africa's Identified Resources comprises low-grade concentrations within the gold-bearing Witwatersrand quartz-pebble conglomerates. Where uranium is recovered as a by-product of gold operations, it generally accounts for less than 10% of the total revenue from the ore mined.

The low level of exploration for gold experienced in recent years made way for increased exploration activities fuelled by an increase in the gold price to above USD 600/troy ounce in 2006 and fast diminishing known ore reserves. Two of the three operating gold mines which closed down during 2005 have been reopened resulting in their uranium resources potentially becoming exploitable again.

The exploration for uranium as a primary commodity as reflected in an almost exponential increase in the exploration and development expenditure in 2006, resulted in a substantial increase in the resources figure for RAR recoverable at a cost of <USD40/kgU.

As uranium is presently only produced as a by-product of gold mining, the gold and uranium prices, rand/USD exchange rate, as well as the mining and processing costs have a significant effect on South Africa's uranium resource figures and cost category allocations.

The majority (about 73%) of South Africa's identified *in situ* uranium resources recoverable at less than USD 80/kgU is likewise associated with gold resources within the Witwatersrand Supergroup. However, since only one mine, Vaal River Operations, has a uranium recovery plant in operation, large amounts of uranium are presently being discarded in tailing dams. Recovery of uranium from this source will depend to a large extent on the degree of dilution by non-uraniferous tailings and the possible use of such tailings as backfill in mined-out areas.

Less than ten percent (9%) of the total South African identified uranium resources recoverable at less than USD 40/kgU and 13% of the Identified Resources recoverable at less than USD 80/kgU are associated with South Africa's only uranium recovery facility.

Undiscovered Resources (Prognosticated & SR)

Little exploration for uranium deposits outside of the Witwatersrand Basin is presently undertaken. More than thirty applications for uranium prospecting permits associated with previously discovered deposits within the Karoo Basin have, however, been issued during 2006.

Limited efforts to identify Witwatersrand-type basins outside of the currently known limits of the main basin have rendered discouraging results. The lack of funding for speculative type of exploration has further precluded the chances of any meaningful outcome.

Uranium resources in the Prognosticated Resources category which can be produced at a cost of less than USD 80/kg U, as well as the estimate for Speculative Resources with no cost range assigned, remained unchanged from previous estimates.

Unconventional Resources and other materials

No Unconventional Resources have been identified.

Availability of Identified (RAR & Inferred) Resources

Sixty-one percent of South Africa's RAR plus Inferred Resources recoverable at USD 40/kgU or less are in existing and committed production centres.

Forty-two percent of South Africa's RAR plus Inferred Resources recoverable at USD 80/kgU or less are in existing and committed production centres.

URANIUM PRODUCTION

Historical review

Uranium production in South Africa commenced in 1952 with the commissioning of a plant at the West Rand Consolidated Mine to extract uranium from quartz-pebble conglomerates of the Witwatersrand Basin.

During 1953 a further four plants came into production at various centres. Total uranium production peaked in 1959 when 4 957 tU was produced from 17 plants being fed from 26 mines within the Witwatersrand Basin. Production thereafter declined to 2 263 tU in 1965.

The world oil crisis which emerged in 1973 stimulated the demand for uranium as an alternative source of energy. The large uranium containing tailings stockpiles which accumulated over many decades at the time became a readily available source of uranium. These stockpiles were reprocessed at Welkom (Joint Metallurgical Scheme – 1977), on the East Rand (ERGO – 1978) and at Klerksdorp (Chemwes – 1979) which culminated in a record uranium production of 6 028 tU in 1980.

In 1967 there were seven producers (2 585 tU); this number increased to 14 in 1983 (5 880 tU). Since 1983 there was a steady decline in the number of producers with only three remaining in 1994 (1 550 tU). The Phalabora Mining Company which commenced uranium production in 1994 outside of the Witwatersrand Basin as a by-product of copper mining, ceased production in 2002, leaving the Vaal River Operations as the sole producer of uranium in South Africa at present.

Status of production capability

Uranium is mined at Vaal River Operations near Klerksdorp as a by-product of gold. Uranium rich slurries are collected from two mines and transported to Nufcor for processing into a uranium oxide concentrate.

Nufcor presently has two processing plants capable of producing ca. 4 000 t U_30_8 (3 392 tU). A heightened interest in uranium production is being experienced in the industry since 2006 mainly due to a significant rise in the uranium price. Several mining companies are now investigating the possibility of producing uranium rich slurries in the future. Nufcor may decide to treat such material on a toll-treatment basis.

Ownership structure of the uranium industry

In 1998 Nufcor became a wholly owned subsidiary of AngloGold Ashanti Limited, a public company listed, amongst others, on the New York and London Stock Exchanges and the Johannesburg Securities Exchange.

The South African Government is not associated with any uranium production activities.

Employment in the uranium industry

Vaal River Operations employs a total of 100 persons (apportioned on a full time basis) associated with its uranium operation. An additional 55 workers are employed at Nufcor.

Future production centres

Since the uranium resources in South Africa occur mainly as a by-product of gold, it is difficult to predict whether any prospective operator, other than the existing and committed production centres, could be supported by existing Identified Resources in the Reasonably Assured and Inferred Resources categories recoverable at a cost of <USD 80/kgU. The cost of producing uranium is to a large degree determined by the gold content of the ore, the gold price, working costs as well as the SA rand/USD exchange rate.

Given favourable conditions in respect of these variables and the current uranium price in excess of 100 USD per pound U_3O_8, it is not inconceivable for South Africa to achieve uranium production levels of more than 6 000 tU per annum (last experienced in 1980) within the next decade. South Africa further has significant quantities of uranium contained in mine tailings, which could be extracted given stable and predictable long-term sales contracts.

Exploration for uranium as a primary commodity which was undertaken since 2003 and gained momentum during 2006 yielded good results. Uranium One's committed processing plant with a design capacity of 1 460 tU per annum is expected to operate at full capacity by 2010.

Employment in existing production centres

Vaal River Operations employs a total of 100 persons at the slurry collection operation with an additional 55 individuals employed at Nufcor.

Uranium production centre technical details
(as of 1 January 2007)

	Centre #1	Centre #2
Name of production centre	Vaal River Operations	Uranium One
Production centre classification	Existing	committed
Start-up date	1977	2007
Source of ore: • Deposit name • Deposit type • Resources (tU) • Grade (% U)	 Vaal Reef quartz-pebble conglomerate NA	 Dominium & Rietkuil quartz-pebble conglomerate NA
Mining operation: • Type (OP/UG/ISL) • Size (t ore/day) • Average mining recovery (%)	 UG Variable	 UG NA NA
Processing plant (acid/alkaline): • Type (IX/SX/AL) • Size (t ore/day) for ISL (L/day or L/h) • Average process recovery (%)	 AL/SX Variable	 SX NA NA
Nominal production capacity (tU/year)	3 400	1 460
Plans for expansion	under surveillance	feasibility study
Other remarks	None	none

NA Not available.

Secondary sources of uranium

Production and use of mixed-oxide fuel

South Africa has never produced or utilised mixed-oxide fuels and has no plans to do so in future.

Production and use of re-enriched tails

South Africa decommissioned and dismantled its uranium enrichment plant at Pelindaba in the period 1997-1998 and does not undertake enrichment activities at present.

Production and use of reprocessed uranium

No reprocessed uranium is produced or utilised in South Africa.

ENVIRONMENTAL ACTIVITIES AND SOCIAL CULTURAL ISSUES

Within South Africa mine related land exists which has been contaminated by radioactivity, particularly where existing and previous uranium plants are or were located. If development takes place on former mine land, the area is radiometrically surveyed and, where necessary, decontaminated. The National Nuclear Regulator is the body responsible for the implementation of nuclear legislation related to these activities, and the standards conform to international norms. Large areas around gold/uranium mines are covered with slimes dams and rock dumps. South Africa has strict environmental legislation, which ensures that such areas are suitably rehabilitated after closure.

Environmental issues relating to gold/uranium mining within Witwatersrand Basin are dust pollution, surface and ground water contamination and residual radioactivity. Scrap materials from decommissioned plants may only be sold after these have been decontaminated to internationally acceptable standards.

The by-product status of uranium production in South Africa makes it impossible to establish what portion of the total expenditure on environmental related activities specifically pertain to uranium. The South African mining industry, however, allocates considerable resources for environmental rehabilitation from the exploration stage, through to mining and finally mill closure.

URANIUM REQUIREMENTS

South Africa has only one nuclear power plant, Koeberg, which has two reactors. Koeberg I was commissioned in 1984 and Koeberg II in 1985. They have a combined installed capacity of 1 840 MW electricity and collectively consume *ca.* 292 tU per annum.

Eskom, South Africa's national electricity generating utility, intends to have *ca.* 20 000 MW nuclear electricity generating capacity by 2025. Due to practical considerations the first additional nuclear generating capacity is unlikely to come on stream before 2015. Eskom's ambitious expansion plans will result in an almost ten times increase in uranium fuel requirements by 2025.

Nuclear fuel will also be required for the commission of a Pebble Bed Modular Reactor (PBMR) demonstration plant to be constructed at Koeberg. The demonstration PBMR is designed to produce 165 MWe consuming *ca.* 2 tU per annum. The Environmental Impact Assessment process is at present still ongoing, a prerequisite for the issuing of a licence by the National Nuclear Regulator. It is believed that construction of the demonstration plant should start in 2009. Commercial PBMR reactors will likewise produce electricity each, and to maximise the sharing of support systems it is believed that it will be most economical to build it in a 4-pack configuration. The intention is to have a local installed capacity from PBMR of between 4 000 and 5 000 MW electricity by 2025. As many as 80 reactors could also be exported from South Africa between 2020 and 2030 once the technology has been demonstrated successfully.

Supply and procurement strategy

Fuel for the Koeberg nuclear power plant used to be manufactured at Pelindaba near Pretoria prior to 1997. Subsequently Eskom sources its uranium from the international market, including from secondary sources, provided that the country of origin is a signatory to the IAEA NPT treaty and that the supply is in accordance with applicable legislation, safeguard treaties and policies. The anticipated expansion of South Africa's nuclear programme and changes in the world uranium market of late would most likely necessitate an adjustment of the utility's uranium procurement strategy to a more long-term relationship focused strategy. Fuel for the demonstration PBMR plant will be manufactured at Pelindaba from radioactive material to be imported. The issuing of a licence by the National Nuclear Regulator for this facility is awaited.

NATIONAL POLICIES RELATING TO URANIUM

The Nuclear Energy Act No. 131 of 1993, as amended, provided expression to South Africa's national policies relating the prospecting for and mining of uranium, foreign participation in such activities, the State's role in this regard, as well as the export of uranium and the disposal of spent nuclear fuel.

This Act has been replaced by the Nuclear Energy Act No. 46 of 1999 and the National Nuclear Regulator Act No. 47 of 1999. The former act provides for the establishment of the South African Nuclear Energy Corporation Limited (NECSA) to replace Atomic Energy Corporation of South Africa Limited, a public company wholly owned by the State to, *inter alia*, regulate the acquisition and possession of nuclear fuel, the import and export of such fuel and to prescribe measures regarding the discarding of radioactive waste and the storage of irradiated nuclear material. The latter Act provides for the establishment of a National Nuclear Regulator to regulate nuclear activities, to provide for safety standards and regulatory practices for protection of persons, property and the environment against nuclear damage.

URANIUM STOCKS

Uranium fuel stock levels are dependent on market and contractual conditions and it is conceivable that Eskom might increase its strategic stock levels to mitigate the current supply/demand imbalance.

URANIUM PRICES

Confidential information**.**

Uranium exploration and development expenditures and drilling effort – domestic

Expenses in million ZAR	2004	2005	2006	2007 (expected)
Industry exploration expenditures	1 472	9 000	158 750	7 000
Government exploration expenditures	0	0	0	NA
Industry development expenditures	4 360	1 559	2 772	99 000
Government development expenditures	0	0	0	NA
Total expenditures	5 832	10 559	161 522	106 000
Industry exploration drilling (metres)	NA	10 300	91 621	21 269
Number of industry exploration holes drilled	9	52	164	855
Government exploration drilling (metres)	0	0	0	NA
Number of government exploration holes drilled	0	0	0	NA
Industry development drilling (metres)	NA	5 624	NA	95 346
Number of development exploration holes drilled	50	70	56	243
Government development drilling (metres)	0	0	0	NA
Number of development exploration holes drilled	0	0	0	NA
Subtotal exploration drilling (metres)	1 472	9 000	158 750	7 000
Subtotal exploration holes	9	52	164	855
Subtotal development drilling (metres)	4 360	1 559	2 772	99 000
Subtotal development holes	50	70	56	243
Total drilling (metres)	NA	15 924	91 621	116 615
Total number of holes	59	122	220	1 098

NA Not available.

Reasonably Assured Resources*
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Recovery factor (%)
Underground mining	93 977	136 117	193 665	NA
Open-pit mining	1 643	22 543	24 938	NA
In situ leaching	0	0	0	0
Heap leaching	0	0	0	0
In-place leaching (stope/block leaching)	0	0	0	0
Co-product and by-product	0	0	0	0
Unspecified	19 248	47 272	65 775	NA
Total	114 868	205 932	284 378	NA

* Recoverable resources, but depletion is not considered.

Reasonably Assured Resources by deposit type
(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unconformity-related	0	0	0
Sandstone	1 643	22 543	24 938
Hematite breccia complex	0	0	0
Quartz-pebble conglomerate	88 135	126 380	163 632
Vein	0	0	0
Intrusive	1 351	1 351	1 351
Volcanic and caldera-related	0	0	0
Metasomatite	0	0	0
Other	23 739	55 658	94 457
Total	114 868	205 932	284 378

Inferred Resources
(tonnes U)

Production method	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU	Recovery factor (%)
Underground mining	114 877	124 260	130 322	NA
Open-pit mining	2 974	7 376	7 894	NA
In situ leaching	0	0	0	
Heap leaching	0	0	0	
In-place leaching (stope/block leaching)	0	0	0	
Co-product and by-product	0	0	0	
Unspecified	1 906	5 676	12 495	NA
Total	119 757	137 312	150 711	NA

Inferred Resources by deposit type
(tonnes U)

Deposit type	<USD 40/kgU	<USD 80/kgU	<USD 130/kgU
Unconformity-related	0	0	0
Sandstone	2 974	7 376	7 894
Hematite breccia complex	0	0	0
Quartz-pebble conglomerate	113 702	123 085	129 147
Vein	0	0	0
Intrusive	1 175	1 175	1 175
Volcanic and caldera-related	0	0	0
Metasomatite	0	0	0
Other	1 906	5 676	12 495
Total	119 757	137 312	150 711

Prognosticated Resources
(tonnes U)

Cost ranges	
<USD 80/kgU	<USD 130/kgU
34 901	110 310

Speculative Resources
(tonnes U)

Cost ranges	
<USD 130/kgU	Unassigned
–	1 112 900

Historical uranium production
(tonnes U in concentrate)

Production method	Total through end of 2003	2004	2005	2006	Total through end of 2006	2007 (expected)
Open-pit mining[1]	0	0	0	0	0	0
Underground mining[1]	0	0	0	0	0	0
In situ leaching	0	0	0	0	0	0
Heap leaching	0	0	0	0	0	0
In-place leaching*	153 253	747	673	534	155 207	750
Co-product/by-product	0	0	0	0	0	0
U recovered from phosphates	0	0	0	0	0	0
Other methods**	0	0	0	0	0	0
Total	153 253	747	673	534	155 207	750

(1) Pre-2004 totals may include uranium recovered by heap and in-place leaching.
* Also known as stope leaching or block leaching.
** Includes mine water treatment and environmental restoration.

Ownership of uranium production in 2006

Domestic				Foreign				Totals	
Government		Private		Government		Private			
[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]	[tU]	[%]
0	0	534	100	0	0	0	0	534	100

Uranium industry employment at existing production centres
(person-years)

	2004	**2005**	**2006**	**2007** (expected)
Total employment related to existing production centres	150	150	150	150
Employment directly related to uranium production	60	60	65	65

Short-term production capability
(tonnes U/year)

2007				**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
4 860	4 860	0	0	4 860	4 860	0	0	4 860	6 320	0	0

2020				**2025**				**2030**			
A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II	A-I	B-I	A-II	B-II
4 860	6 320	0	0	4 860	6 320	0	0	4 860	6 320	0	0

Net nuclear electricity generation

	2005	**2006**
Nuclear electricity generated (TWh net)	1 800	1 800

Installed nuclear generating capacity to 2030
(MWe net)

2006	**2007**	**2010**		**2015**	
		Low	*High*	*Low*	*High*
1 800	1 840	1 840	1 840	2 005	8 420

2020		**2025**		**2030**	
Low	*High*	*Low*	*High*	*Low*	*High*
10 500	15 340	16 000	25 000	20 000	25 000

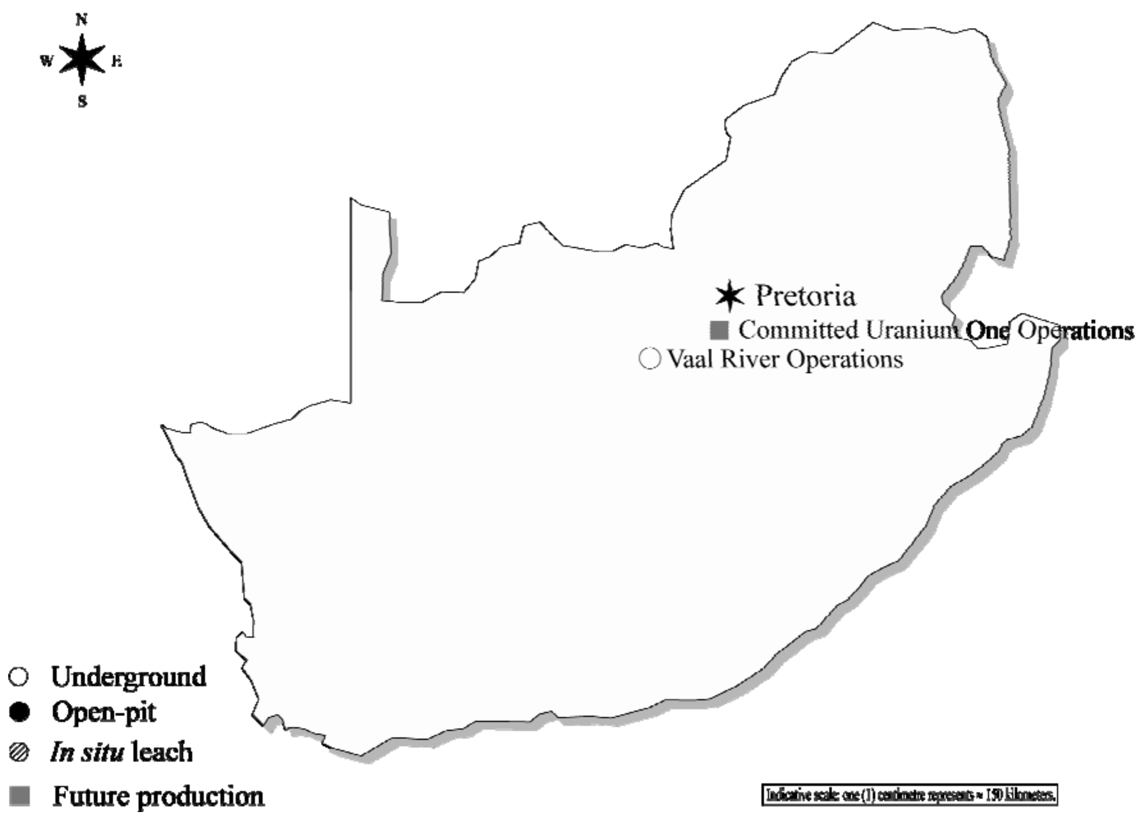
Annual reactor-related uranium requirements to 2030 (excluding MOX)
(tonnes U)

2006	2007	2010		2015	
		Low	*High*	*Low*	*High*
282	292	292	292	294	1 312

2020		2025		2030	
Low	*High*	*Low*	*High*	*Low*	*High*
1 569	2 144	2 099	3 235	3 175	3 235

Total uranium stocks
(tonnes natural U-equivalent)

Holder	Natural uranium stocks in concentrates	Enriched uranium stocks	Depleted uranium stocks	Reprocessed uranium stocks	Total
Government	0	0	0	0	NA
Producer	Unknown	0	0	0	NA
Utility	0	0	Unknown	0	NA
Total	NA	0	NA	0	NA



Appendix 4

GLOSSARY OF DEFINITIONS AND TERMINOLOGY

UNITS

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

1 short ton U_3O_8	= 0.769 tU
1 percent U_3O_8	= 0.848 percent U
1 USD/lb U_3O_8	= USD 2.6/kg U
1 tonne	= 1 metric ton

RESOURCE TERMINOLOGY

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.

a) Definitions of resource categories

Uranium resources are broadly classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is a primary product, co-product or an important by-product (e.g., from the mining of copper and gold). Very low-grade resources or those from which uranium is only recoverable as a minor by-product are considered unconventional resources.

Conventional resources are further divided, according to different confidence levels of occurrence, into four categories. The correlation between these resource categories and those used in selected national resource classification systems is shown in Figure A.

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. Unless otherwise noted, RAR are expressed in terms of quantities of uranium recoverable from mineable ore (see Recoverable Resources).

Inferred Resources refers to uranium, in addition to RAR, that is inferred to occur based on 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 deposit's 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. Unless otherwise noted, Inferred Resources are expressed in terms of quantities of uranium recoverable from mineable ore (see Recoverable Resources).

Figure A. **Approximate Correlation of Terms used in Major Resources Classification Systems**

<table>
<tr><th></th><th colspan="3">IDENTIFIED RESOURCES</th><th colspan="3">UNDISCOVERED RESOURCES</th></tr>
<tr><td>NEA/IAEA</td><td colspan="2">REASONABLY ASSURED</td><td>INFERRED</td><td>PROGNOSTICATED</td><td colspan="2">SPECULATIVE</td></tr>
<tr><td rowspan="2">Australia</td><td colspan="2">DEMONSTRATED</td><td rowspan="2">INFERRED</td><td colspan="3" rowspan="2">UNDISCOVERED</td></tr>
<tr><td>MEASURED</td><td>INDICATED</td></tr>
<tr><td>Canada (NRCan)</td><td>MEASURED</td><td>INDICATED</td><td>INFERRED</td><td>PROGNOSTICATED</td><td colspan="2">SPECULATIVE</td></tr>
<tr><td>United States (DOE)</td><td colspan="2">REASONABLY ASSURED</td><td colspan="2">ESTIMATED ADDITIONAL</td><td colspan="2">SPECULATIVE</td></tr>
<tr><td>Russian Federation, Kazakhstan, Ukraine, Uzbekistan</td><td>A + B</td><td>C 1</td><td>C 2</td><td>P1</td><td>P2</td><td>P3</td></tr>
<tr><td>UNFC*</td><td colspan="2">G1 + G2</td><td>G3</td><td>G4</td><td colspan="2">G4</td></tr>
</table>

* United Nations Framework Classification correlation with NEA/IAEA and national classification systems is still under consideration.

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.

Prognosticated Resources refers to uranium, in addition to Inferred Resources, 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 mineralisation 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 Inferred Resources. Prognosticated Resources are normally expressed in terms of uranium contained in mineable ore, i.e., *in situ* quantities.

Speculative Resources (SR) refers to uranium, in addition to Prognosticated Resources, 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. SR are normally expressed in terms of uranium contained in mineable ore, i.e., *in situ* quantities.

b) Cost categories

The cost categories, in United States dollars (USD), used in this report are defined as: <USD 40/kgU, <USD 80/kgU, and <USD 130/kgU. All resource categories are defined in terms of costs of uranium recovered at the ore processing plant

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

Conversion of costs from other currencies into USD is done using an average exchange rate for the month of June in that year except for the projected costs for the year of the report, which uses the exchange rate of 1 January 2007 (Appendix 8).

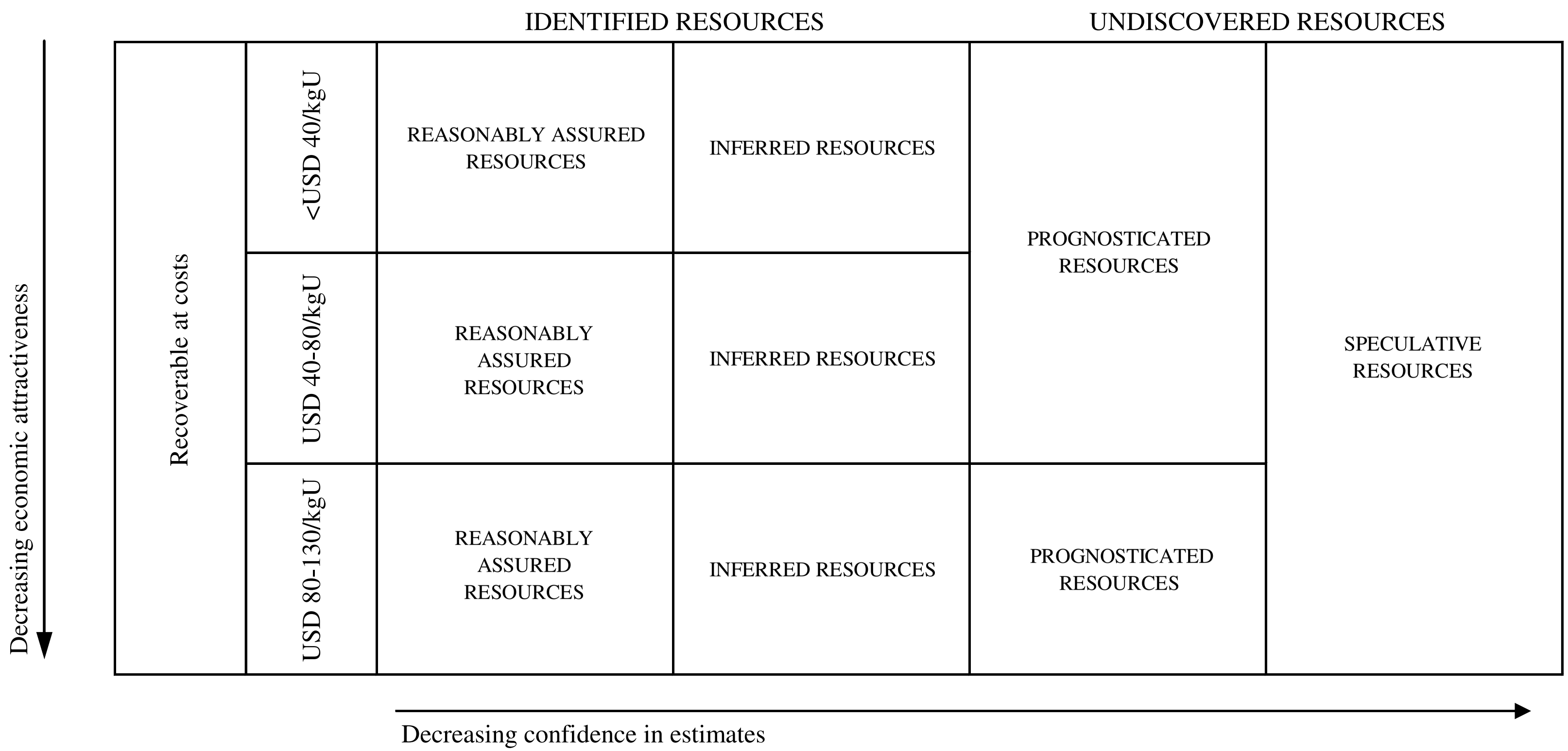
When estimating the cost of production for assigning resources within these cost categories, account has been taken of the following costs:

- 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 that remain non-amortised.
- 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 are not normally taken into consideration.

c) Relationship between resource categories

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

Figure B. **NEA/IAEA Classification Scheme for Uranium Resources**



d) Recoverable resources

RAR and Inferred 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*, i.e., not taking into account mining and milling losses. Therefore both expected mining and ore processing losses have been deducted in most cases. If a country reports its resources as *in situ* and the country does not provide a recovery factor, the Secretariat assigns a recovery factor to those resources based on geology and projected mining and processing methods to determine recoverable resources. The recovery factors that have been applied are:

Mining and milling method	**Overall recovery factor** (%)
Open-pit mining with conventional milling	80
Underground mining with conventional milling	80
ISL (acid)	75
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SECONDARY SOURCES OF URANIUM TERMINOLOGY

a) Mixed-oxide fuel (MOX): MOX is the abbreviation for a fuel for nuclear power plants that consists of a mixture of uranium oxide and plutonium oxide. Current practice is to use a mixture of depleted uranium oxide and plutonium oxide.

b) Depleted uranium: Uranium where the ^{235}U assay is below the naturally occurring 0.7110%. (Natural uranium is a mixture of three isotopes, ^{238}U – accounting for 99.2836%, ^{235}U – 0.7110%, and ^{234}U – 0.0054%). Depleted uranium is a by-product of the enrichment process, where enriched uranium is produced from initial natural uranium feed material.

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 uranium resources that are tributary to these facilities. For the purpose of describing production centres, they have been divided into four classes, as follows:

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

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 Inferred, i.e., "Identified 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 practices.

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. The projection is presented based on those resources recoverable at costs <USD 80/kgU.

Production: Denotes the amount of uranium output, in tonnes U contained in concentrate, from an ore processing plant or production centre (with milling losses deducted).

c) Mining and milling

***In situ* leaching (ISL)**: The extraction of uranium from sandstone using chemical solutions and the recovery of uranium at the surface. ISL extraction is conducted by injecting a suitable uranium-dissolving leach solution (acid or alkaline) into the ore zone below the water table thereby oxidising, complexing, and mobilising the uranium; then recovering the pregnant solutions through production wells, and finally pumping the uranium bearing solution to the surface for further processing.

Heap leaching (HL): Heaps of ore are formed over a collecting system underlain by an impervious membrane. Dilute sulphuric acid solutions are distributed over the top surface of the ore. As the solutions seep down through the heap, they dissolve a significant (50-75%) amount of the uranium in the ore. The uranium is recovered from the heap leach product liquor by ion exchange or solvent extraction.

In place leaching (IPL): involves leaching of broken ore without removing it from an underground mine. This is also sometimes referred to as stope leaching or block leaching.

Co-product: Uranium is a co-product when it is one of two commodities that must be produced to make a mine economic. Both commodities influence output, for example, uranium and copper are co-produced at Olympic Dam in Australia. Co-product uranium is produced using either the open-pit or underground mining methods.

By-product: Uranium is considered a by-product when it is a secondary or additional product. By-product uranium can be produced in association with a main product or with co-products, e.g., uranium recovered from the Palabora copper mining operations in South Africa. By-product uranium is produced using either the open-pit or underground mining methods.

Uranium from phosphates: Uranium has been recovered as a by-product of phosphoric acid production. Uranium is separated from phosphoric acid by a solvent extraction process. The most frequently used reagent is a synergetic mixture of Tri-m-Octyl Phosphine Oxide (TOPO) and Di 2-Ethylhexyl Phosphoric Acid (DEPA).

Ion exchange (IX): Reversible exchange of ions contained in a host material for different ions in solution without destruction of the host material or disturbance of electrical neutrality. The process is accomplished by diffusion and occurs typically in crystals possessing – one or two – dimensional channels where ions are weakly bonded. It also occurs in resins consisting of three-dimensional hydrocarbon networks to which are attached many ionisable groups. Ion exchange is used for recovering uranium from leaching solutions.

Solvent extraction (SX): A method of separation in which a generally aqueous solution is mixed with an immiscible solvent to transfer one or more components into the solvent. This method is used to recover uranium from leaching solutions.

DEMAND TERMINOLOGY

a) Reactor-related requirements: Refers to natural uranium acquisitions *not* necessarily consumption during a calendar year.

ENVIRONMENTAL TERMINOLOGY[2]

a) Close-out: In the context of uranium mill tailings impoundment, the operational, regulatory and administrative actions required to place a tailings impoundment into long-term conditions such that little or no future surveillance and maintenance are required.

b) Decommissioning: Actions taken at the end of the operating life of a uranium mill or other uranium facility in retiring it from service with adequate regard for the health and safety of workers and members of the public and protection of the environment. The time period to achieve decommissioning may range from a few to several hundred years.

c) Decontamination: The removal or reduction of radioactive or toxic chemical contamination using physical, chemical, or biological processes.

d) Dismantling: The disassembly and removal of any structure, system or component during decommissioning. Dismantling may be performed immediately after permanent retirement of a mine or mill facility or may be deferred.

2. Definitions based on those published in OECD (2002), *Environmental Remediation of Uranium Production Facilities*, Paris.

e) Environmental restoration: Cleanup and restoration, according to predefined criteria, of sites contaminated with radioactive and/or hazardous substances during past uranium production activities.

f) Environmental impact statement: A set of documents recording the results of an evaluation of the physical, ecological, cultural and socio-economic effects of a planned installation, facility, or technology.

g) Groundwater restoration: The process of returning affected groundwater to acceptable quality and quantity levels for future use.

h) Reclamation: The process of restoring a site to predefined conditions, which allows new uses.

i) Restricted release (or use): A designation, by the regulatory body of a country, that restricts the release or use of equipment, buildings, materials or the site because of its potential radiological or other hazards.

j) Tailings: The remaining portion of a metal-bearing ore consisting of finely ground rock and process liquids after some or all of the metal, such as uranium, has been extracted.

k) Tailings impoundment: A structure in which the tailings are deposited to prevent their release into the environment.

l) Unrestricted release (or use): A designation, by the regulatory body of a country, that enables the release or use of equipment, buildings, materials or the site without any restriction.

GEOLOGICAL TERMINOLOGY

a) Uranium occurrence: A naturally occurring, anomalous concentration of uranium.

b) Uranium deposit: A mass of naturally occurring mineral from which uranium could be exploited at present or in the future.

c) Geologic types of uranium deposits[3]

Uranium resources can be assigned on the basis of their geological setting to the following categories of uranium ore deposit types (arranged according to their approximate economic significance):

1. Unconformity-related deposits.
2. Sandstone deposits.
3. Hematite breccia complex deposits.
4. Quartz-pebble conglomerate deposits.
5. Vein deposits.
6. Intrusive deposits.
7. Volcanic and caldera-related deposits.
8. Metasomatite deposits.
9. Surficial deposits.
10. Collapse breccia pipe deposits.
11. Phosphorite deposits.
12. Other types of deposits.
13. Rock types with elevated uranium content.

3. This classification of the geological types of uranium deposits was developed by the IAEA in 1988-89 and updated for use in the Red Book.

1. **Unconformity-related deposits**: Unconformity-related deposits are associated with and occur immediately below and above an unconformable contact that separates a crystalline basement intensively altered from overlying clastic sediments of either Proterozoic or Phanerozoic age.

   The unconformity-related deposits include the following sub-types:

   - *Unconformity contact*
     i. Fracture bound deposits occur in metasediments immediately below the unconformity. Mineralisation is monometallic and of medium grade. Examples include Rabbit Lake and Dominique Peter in the Athabasca Basin, Canada.
     ii. Clay-bound deposits occur associated with clay at the base of the sedimentary cover directly above the unconformity. Mineralisation is commonly polymetallic and of high to very high grade. An example is Cigar Lake in the Athabasca Basin, Canada

   - *Sub-unconformity-post-metamorphic deposits*
     Deposits are strata-structure bound in metasediments below the unconformity on which clastic sediments rest. These deposits can have large resources, at low to medium grade. Examples are Jabiluka and Ranger in Australia.

2. **Sandstone deposits:** Sandstone uranium deposits occur in medium to coarse-grained sandstones deposited in a continental fluvial or marginal marine sedimentary environment. Uranium is precipitated under reducing conditions caused by a variety of reducing agents within the sandstone, for example, carbonaceous material, sulphides (pyrite), hydrocarbons and ferro-magnesium minerals (chlorite), etc. Sandstone uranium deposits can be divided into four main sub-types:

   - *Roll-front deposits*: The mineralised zones are convex down the hydrologic gradient. They display diffuse boundaries with reduced sandstone on the down-gradient side and sharp contacts with oxidised sandstone on the up-gradient side. The mineralised zones are elongate and sinuous approximately parallel to the strike, and perpendicular to the direction of deposition and groundwater flow. Resources can range from a few hundred tonnes to several thousands of tonnes of uranium, at grades averaging 0.05-0.25%. Examples are Moynkum, Inkay and Mynkuduk (Kazakhstan); Crow Butte and Smith Ranch (United States) and Bukinay, Sugraly and Uchkuduk (Uzbekistan).

   - *Tabular deposits* consist of uranium matrix impregnations that form irregularly shaped lenticular masses within reduced sediments. The mineralised zones are largely oriented parallel to the depositional trend. Individual deposits can contain several hundreds of tonnes up to 150 000 tonnes of uranium, at average grades ranging from 0.05-0.5%, occasionally up to 1%. Examples of deposits include Westmoreland (Australia), Nuhetting (China), Hamr-Stráz (Czech Republic), Akouta, Arlit, Imouraren (Niger) and Colorado Plateau (United States).

   - *Basal channel deposits*: Paleodrainage systems consist of several hundred metres wide channels filled with thick permeable alluvial-fluvial sediments. Here, the uranium is predominantly associated with detrital plant debris in ore bodies that display, in a plan-view, an elongated lens or ribbon-like configuration and, in a section-view, a lenticular or, more rarely, a roll shape. Individual deposits can range from several hundreds to 20 000 tonnes uranium, at grades ranging from 0.01-3%. Examples are the deposits of Dalmatovskoye (Transural Region), Malinovskoye (West Siberia), Khiagdinskoye (Vitim district) in Russia and Beverley in Australia.

- *Tectonic/lithologic deposits* occur in sandstone related to a permeable zone. Uranium is precipitated in open zones related to tectonic extension. Individual deposits contain a few hundred tonnes up to 5 000 tonnes of uranium at average grades ranging from 0.1-0.5%. Examples include the deposits of Mas Laveyre (France) and Mikouloungou (Gabon).

3. **Hematite breccia complex deposits:** Deposits of this group occur in hematite-rich breccias and contain uranium in association with copper, gold, silver and rare earths. The main representative of this type of deposit is the Olympic Dam deposit in South Australia. Significant deposits and prospects of this type occur in the same region, including Prominent Hill, Wirrda Well, Acropolis and Oak Dam as well as some younger breccia-hosted deposits in the Mount Painter area.

4. **Quartz-pebble conglomerate deposits:** Detrital uranium oxide ores are found in quartz-pebble conglomerates deposited as basal units in fluvial to lacustrine braided stream systems older than 2.3-2.4 Ga. The conglomerate matrix is pyritiferous, and gold, as well as other oxide and sulphide detrital minerals are often present in minor amounts. Examples include deposits found in the Witwatersrand Basin where uranium is mined as a by-product of gold. Uranium deposits of this type were mined in the Blind River/Elliot Lake area of Canada.

5. **Vein deposits:** In vein deposits, the major part of the mineralisation fills fractures with highly variable thickness, but generally important extension along strike. The veins consist mainly of gangue material (e.g. carbonates, quartz) and ore material, mainly pitchblende. Typical examples range from the thick and massive pitchblende veins of Pribram (Czech Republic), Schlema-Alberoda (Germany) and Shinkolobwe (Democratic Republic of Congo), to the stockworks and episyenite columns of Bernardan (France) and Gunnar (Canada), to the narrow cracks in granite or metamorphic rocks, also filled with pitchblende of Mina Fe (Spain) and Singhbhum (India).

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 Rossing and Trekkopje deposits (Namibia), the uranium occurrences in the porphyry copper deposits such as Bingham Canyon and Twin Butte (United States), the Ilimaussaq deposit (Greenland), Palabora (South Africa), as well as the deposits in the Bancroft area (Canada).

7. **Volcanic and caldera-related deposits**: Uranium deposits of this type are located within and nearby volcanic caldera filled by mafic to felsic volcanic complexes and intercalated clastic sediments. Mineralisation is largely controlled by structures (minor stratabound), occurs at several stratigraphic levels of the volcanic and sedimentary units and extends into the basement where it is found in fractured granite and in metamorphites. Uranium minerals are commonly associated with molybdenum, other sulphides, violet fluorine and quartz. Most significant commercial deposits are located within Streltsovsk caldera in the Russian Federation. Examples are known in China, Mongolia (Dornot deposit), Canada (Michelin deposit) and Mexico (Nopal deposit).

8. **Metasomatite deposits**: Deposits of this type are confined to the areas of tectono-magmatic activity of the Precambrian shields and are related to near-fault alkali metasomatites, developed upon different basement rocks: granites, migmatites, gneisses and ferruginous quartzites with production of albitites, aegirinites, alkali-amphibolic and carbonaceous-ferruginous rocks. Ore lenses and stocks are a few metres to tens of metres thick and a few hundred metres long. Vertical extent of ore mineralisation can be up to 1.5 km. Ores are uraninite-brannerite by composition and belong to ordinary grade. The reserves are usually medium scale or large. Examples include Michurinskoye, Vatutinskoye, Severinskoye, Zheltorechenskoye and Pervomayskoye deposits (Ukraine), Lagoa Real, Itataia and Espinharas (Brazil), the Valhalla deposit (Australia) and deposits of the Arjeplog region in the north of Sweden.

9. **Surficial deposits:** Surficial uranium deposits are broadly defined as young (Tertiary to Recent) near-surface uranium concentrations in sediments and soils. The largest of the surficial uranium deposits are in calcrete (calcium and magnesium carbonates), and they have been found in Australia (Yeelirrie deposit), Namibia (Langer Heinrich deposit) and Somalia. These calcrete-hosted deposits are associated with deeply weathered uranium-rich granites. They also can occur in valley-fill sediments along Tertiary drainage channels and in playa lake sediments (e.g., Lake Maitland, Australia). Surficial deposits also can occur in peat bogs and soils.

10. **Collapse breccia pipe deposits:** Deposits in this group occur in circular, vertical pipes filled with down-dropped fragments. The uranium is concentrated as primary uranium ore, generally uraninite, in the permeable breccia matrix, and in the arcuate, ring-fracture zone surrounding the pipe. Type examples are the deposits in the Arizona Strip north of the Grand Canyon and those immediately south of the Grand Canyon in the United States.

11. **Phosphorite deposits**: Phosphorite deposits consist of marine phosphorite of continental-shelf origin containing syn-sedimentary stratiform, disseminated uranium in fine-grained apatite. Phosphorite deposits constitute large uranium resources, but at a very low grade. Uranium can be recovered as a by-product of phosphate production. Examples include New Wales Florida (pebble phosphate) and Uncle Sam (United States), Gantour (Morocco) and Al-Abiad (Jordan). Other type of phosphorite deposits consists of organic phosphate, including argillaceous marine sediments enriched in fish remains that are uraniferous (Melovoe deposit, Kazakhstan).

12. **Other deposits**

Metamorphic deposits: In metamorphic uranium deposits, the uranium concentration directly results from metamorphic processes. The temperature and pressure conditions, and age of the uranium deposition have to be similar to those of the metamorphism of the enclosing rocks. Examples include the Forstau deposit (Austria) and Mary Kathleen (Australia).

Limestone deposits: This includes uranium mineralisation in the Jurassic Todilto Limestone in the Grants district (United States). Uraninite occurs in intra-formational folds and fractures as introduced mineralisation.

Uranium coal deposits: Elevated uranium contents occur in lignite/coal, and in clay and sandstone immediately adjacent to lignite. Examples are uranium in the Serres Basin (Greece), in North and South Dakota (United States), Koldjat and Nizhne Iliyskoe (Kazakhstan) and Freital (Germany). Uranium grades are very low and average less than 50 ppm U.

13. **Rock types with elevated uranium contents:** Elevated uranium contents have been observed in different rock types such as pegmatite, granites and black shale. In the past no economic deposits have been mined commercially in these types of rocks. Their grades are very low, and it is unlikely that they will be economic in the foreseeable future.

    Rare metal pegmatites: These pegmatites contain Sn, Ta, Nb and Li mineralisation. They have variable U, Th and rare earth elements contents. Examples include Greenbushes and Wodgina pegmatites (Western Australia). The Greenbushes pegmatites commonly have 6-20 ppm U and 3-25 ppm Th.

    Granites: A small proportion of un-mineralised granitic rocks have elevated uranium contents. These "high heat producing" granites are potassium feldspar-rich. Roughly 1% of the total number of granitic rocks analysed in Australia have uranium-contents above 50 ppm.

    Black Shale: Black shale-related uranium mineralisation consists of marine organic-rich shale or coal-rich pyritic shale, containing syn-sedimentary disseminated uranium adsorbed onto organic material. Examples include the uraniferous alum shale in Sweden and Estonia, the Chatanooga shale (United States), the Chanziping deposit (China), and the Gera-Ronneburg deposit (Germany).

Appendix 5

ACRONYM LIST

AGR	Advanced gas-cooled reactor
AL	Acid leaching
ALKAL	Alkaline atmospheric leaching
BWR	Boiling water reactor
CANDU	***Can***adian ***d***euterium ***u***ranium
CWG	Crush-wet grind
DOE	Department of Energy (United States)
EC	European Commission
EIA	U.S. Energy Information Administration
EU	European Union
EUP	Enriched uranium product
FLOT	Flotation
Ga	Giga-years
GDR	German Democratic Republic
GIF	Generation IV International Forum
GNSS	Global Nuclear Services and Supply
GWe	Gigawatt electric
HEU	Highly enriched uranium
HL	Heap leaching
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
INPRO	International project on innovative nuclear reactors and fuel cycles
IPL	In-place leaching
ISL	*In situ* leaching
IX	Ion exchange
kg	Kilograms
km	Kilometre
LEU	Low enriched uranium
LWR	Light water reactor
MAGNOX	Magnesium oxide
MOX	Mixed oxide fuel
MWe	Megawatt electric

NEA	Nuclear Energy Agency
OECD	Organisation for Economic Co-operation and Development
OP	Open-pit
ppm	Part per million
Pu	Plutonium
PHWR	Pressurised heavy-water reactor
PWR	Pressurised water reactor
RAR	Reasonably assured resources
RBMK	Water-cooled, graphite-moderated reactor (Russian acronym)
SWU	Separative work unit
SX	Solvent extraction
t	Tonnes (metric tons)
Th	Thorium
tHM	Tonnes heavy metal
TOE	Tonnes oil equivalent
tU	Tonnes uranium
TVA	Tennessee Valley Administration
TWh	Terrawatt-hour
U	Uranium
UG	Underground mining
USSR	Union of Soviet Socialist Republics
VVER	Water-cooled, water-moderated reactor (Russian acronym)

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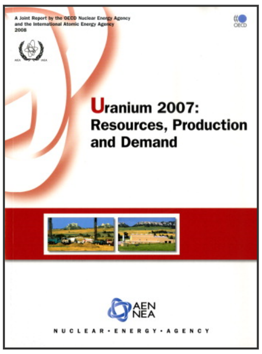

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