# Uranium Deposits of the World

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Total world uranium production in 1996 is estimated to be in the order of 36 600 tonnes U. An increase of around 2 600 tonnes U from the 1995 production. This, however, is still about 25 400 tonnes, or 41%, short of the world uranium demand to fuel existing nuclear power reactors. The gap is being filled with the remaining inventory and individual stockpiles. These sources are soon to be exhausted. Contribution from the Highly Enriched Uranium (HEU) from the dismantled nuclear warheads is expected to supplement part of the unfilled demand in the near future. Regardless, there will still be a large gap that has to be met through new production. It is more likely that new production will come from countries with low cost uranium deposits, such as the unconformity-related and the sandstone types. Only sandstone uranium deposits that are amenable to in-situ leach method of production are expected to play an important role.

The International Atomic Energy Agency (IAEA) recently published an atlas "World Distribution of Uranium Deposits" at the scale of 1:30 000 000. It is the most comprehensive compilation of such an information ever published. The atlas is accompanied by a guidebook with brief descriptions of the deposits, their districts or provinces, and their geological characteristics. The map used the Geological Survey of Canada digital Generalized Geology of the World as a base. Plotted on this map are 582 uranium deposits occurring in 48 countries that meet the minimum criteria set for the production of the world map. Each of the deposits (except as noted) have average grades of 0.3% U or more, and contain uranium resources of at least 500 tonnes. For practical purposes, the 14 deposit types noted in the database were compressed into 11 classes. They are plotted in designated coloured symbols of different sizes in accordance to their types and contained resources. Of the 582 deposits, 167 (29%) are in North America, 158 (27%) are in Europe (excluding Russia), 111 (19%) in Asia of which 78 (12%) are in Central Asia (mainly Kazakhstan and Uzbekistan), 62 (11%) in Africa, 34 (6%) in Australia, and only 18 (3%) in South America. Russia, with a large land area, is listed separately with 32 (5%) deposits. The geographical distribution of the deposit types is given in Table 1.

As can be expected, the distribution of uranium deposits is confined to distinct geological environments. Despite the existence of apparently similar geological environments in other parts of the world, the Proterozoic unconformity-related deposits are with one exception, confined to two restricted areas: the Athabasca basin of Northern Saskatchewan, Canada, and the Pine Creek geosyncline of the Northern Territory, Australia. In contrast, sandstone type deposits are much more widespread. They are most common in sedimentary basins of Cenozoic and Mesozoic ages. However, outside of Kazakhstan and Uzbekistan, this type of deposit is little known in Asia. This deposit type is not known in Canada. Because of its very specific depositional environment, the quartz-pebble conglomerate type is found only in the Lower Proterozoic rocks of Elliot Lake, Canada, and the Witwatersrand of South Africa. Europe accounts for about 60% of the world's known vein deposits. In this case, the well-documented association with Hercynian granites is the controlling factor.

The less well-known volcanic type deposits, with important associated uranium production, include the large tonnage deposits of the Chita Region of Siberia, Russia, and similar deposits of Northern Mongolia. The distribution of this deposit type, although small in number, is relatively widespread. Certain types of unique deposits are of economic interest. Among these are the breccia complex, or Olympic Dam type, found only in South Australia; the collapse breccia pipe deposits, confined to Arizona, USA; and the intrusive-alaskite, or Rössing type, of Namibia. Surficial deposits, with their specific depositional environments, are confined to the desert regions of Africa (primarily Namibia) and Western Australia.

As shown in Table 2, another significant relationship is the preferential association of many of these deposit types with specific geological time periods. For example, three important types of uranium deposits — unconformity-related (with one exception), quartz-pebble conglomerate and breccia complex (Olympic Dam) — are found only in rocks of Proterozoic and older ages. Because of the close association with the Hercynian orogeny, a large percentage of vein deposits are found in rocks of Paleozoic age. Specific ages are also associated with deposits of the metasomatite (Proterozoic and older), black shale (Paleozoic) and surficial (Cenozoic) types and, to a certain degree, with the phosphorite and intrusive types.

From Table 3 it may be seen that Europe and Australia have the most productive geological environments, while South America and Russia are among the least productive regions. The relatively high endowment for Asia is due to the large amount of resources in the Central Asian countries (i.e., including Kazakhstan, Kyrgystan, Mongolia, Tajikistan and Uzbekistan). Excluding these countries, the endowment for Asia is only 0.0124 tonne U/km$^2$, which is even lower than for South America, the region with the smallest endowment. These differences probably

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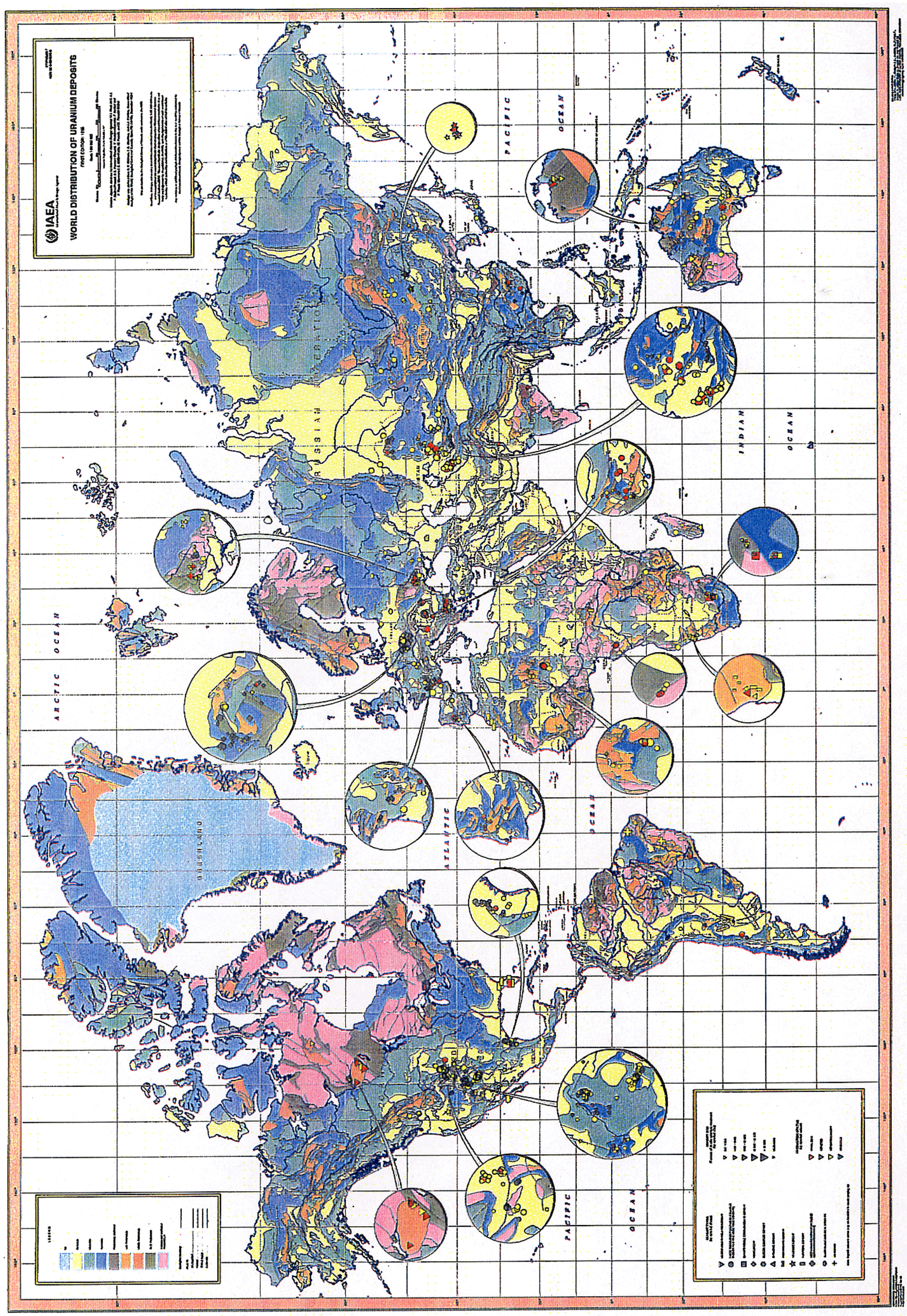


**Figure 1:** *Uranium deposits of the world.*

**Table 1:** ***Numbers of different types of uranium deposits and their regional distribution.***

| Deposit types | Africa | America, North | America, South | Asia | Australia | Europe | Russia | Total |
|---|---|---|---|---|---|---|---|---|
| 01. Unconformity-related | - | 13 | - | 1 | 8 | 1 | - | 23 |
| 02. Sandstone | 20 | 110 | 7 | 48 | 11 | 41 | 13 | 250 |
| 03. Quartz-pebble conglomerate | 17 | 4 | - | 1 | - | - | - | 22 |
| 04. Veins | 7 | 9 | 3 | 28 | 3 | 83 | 5 | 138 |
| 05. Breccia complex | - | - | - | - | 1 | - | - | 1 |
| 06. Intrusive | 6 | 3 | - | - | - | 4 | - | 13 |
| 07. Phosphorite | 4 | 6 | - | - | - | - | - | 10 |
| 08. Collapse breccia pipe | - | 10 | - | - | - | - | - | 10 |
| 09. Volcanic | - | 10 | 3 | 16 | 3 | 2 | 9 | 43 |
| 10. Surficial | 7 | - | 1 | 1 | 5 | 2 | - | 16 |
| 11. Metasomatite | 1 | 1 | 3 | - | 2 | 5 | 1 | 12 |
| 12. Coal | - | - | - | 3 | 1 | 16 | 2 | 22 |
| 13. Black shale | - | - | - | 5 | - | 4 | - | 9 |
| 14. Others: - Limestone | - | 1 | 1 | 3 | - | - | - | 5 |
| - Bony detritus | - | - | - | 5 | - | - | 2 | 7 |
| - Dolomite | - | - | - | - | - | - | - | 1 |
| Total | 62 | 167 | 18 | 111 | 34 | 158 | 32 | 582 |
| % of total | 11 | 29 | 3 | 19 | 6 | 27 | 5 | 100 |

**Table 2:** ***Numbers and distribution of uranium deposit types grouped by geological age of the host rocks.***

| Deposit types | Cenozoic | Mesozoic | Paleozoic | Proterozoic + Archean | Age not reported | Total | % of total |
|---|---|---|---|---|---|---|---|
| 01. Unconformity-related | - | - | 1 | 22 | - | 23 | 4.0 |
| 02. Sandstone | 104 | 101 | 35 | 5 | 5 | 250 | 42.0 |
| 03. Quartz-pebble conglomerate | - | - | - | 22 | - | 22 | 3.8 |
| 04. Veins | 6 | 9 | 86 | 36 | 1 | 138 | 23.7 |
| 05. Breccia complex | - | - | - | 1 | - | 1 | 0.2 |
| 06. Intrusive | - | 1 | 3 | 9 | - | 13 | 2.2 |
| 07. Phosphorite | 6 | 4 | - | - | - | 10 | 1.7 |
| 08. Collapse breccia pipe | - | - | 10 | - | - | 10 | 1.7 |
| 09. Volcanic | 9 | 19 | 8 | 4 | 3 | 43 | 7.4 |
| 10. Surficial | 14 | - | - | 1 | 1 | 16 | 2.7 |
| 11. Metasomatite | - | - | 1 | 11 | - | 12 | 2.1 |
| 12. Coal | 10 | 2 | 8 | - | 2 | 22 | 3.8 |
| 13. Black shale | - | - | 8 | - | 1 | 9 | 1.5 |
| 14. Others: - Limestone | 4 | 1 | - | - | - | 5 | 0.9 |
| - Bony detritus | 7 | - | - | - | - | 7 | 1.2 |
| - Dolomite | - | - | 1 | - | - | 1 | 0.2 |
| Total | 160 | 137 | 161 | 111 | 13 | 582 | 100.0 |
| % of total | 27 | 24 | 28 | 19 | 2 | 100 | |

cannot be solely attributed to the favourability or lack of favourability of the geological environments of these continents. The low intensity of exploration efforts and relative difficulty of accessing the remote areas that comprise significant parts of South America and Asia are probably more important factors.

Information on past uranium exploration expenditures is very incomplete as historic data are not available for most countries in eastern Europe, Russia, Central Asia and China. Regardless, looking at the available information, it is apparent exploration activities in North America and western Europe have been very intensive, for at least the last four decades (Table 4). Despite its small area, the high level of past exploration activities conducted in western Europe resulted in the discovery of more resources than in South America and Asia. These are two regions where much less uranium exploration has been conducted.

**Table 3:** ***Estimated total world cumulative uranium produced plus remaining uranium resources.[1]***

| Continent | Total resources in t U | Amount of known resources in t U/km² |
|---|---|---|
| Africa | 1 118 450 | 0.0372 |
| America, North | 1 441 110 | 0.676 |
| America, South | 278 560 | 0.0156 |
| Asia [2] | 1 594 730 | 0.0498 |
| Australia | 962 690 | 0.1252 |
| Europe [3] | 897 480 | 0.1407 |
| Russia | 385 100 | 0.0226 |
| Total | 6 678 120 | |

1. Includes amounts of uranium that have been mined and processed.
2. Includes Kazakhstan, Kyrgystan, Mongolia, Tajikistan and Uzbekistan.
3. Not including Russia.

**Table 4:** ***Relation between exploration expenditures and known uranium resources of selected regions.***

| Regions (reporting countries) | Area in km² | Total exploration expenditures through 1994 in US $ (000s) | Exploration expenditures ($/km²) | Total resources [1] in t U |
|---|---|---|---|---|
| Africa (17) | 30 100 000 | 544 267 | 18 | 1 118 450 |
| America, North (3) | 21 311 808 | 3 727 828 | 174 | 1 441 110 |
| America, South [2] (12) | 18 327 814 | 313 290 | 17 | 278 560 |
| Asia [3] (13) | 10 022 151 | 282 327 | 28 | 120 697 |
| Australia (1) | 7 686 848 | 444 337 | 57 | 962 690 |
| Europe, Western (14) | 4 035 328 | 1 373 102 | 340 | 435 004 |

Sources of information on exploration expenditures: NEA/OECD-IAEA, "Uranium 1995 — Resources, Production and Demand," OECD, Paris (1996).

1. Includes uranium that has been mined and processed.
2. Includes Central American countries.
3. Not including Central Asian countries, China and Mongolia.