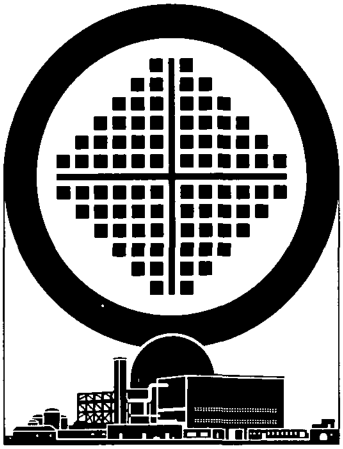

Uranium Resources and Supply

by James Cameron,

The future supply of uranium has to be considered against a background of forecasts of uranium demand over the next decades which show increases of a spectacular nature. It is not necessary to detail these forecasts, they are well known. A world survey by the Joint NEA/IAEA Working Party on "Uranium Resources, Production and Demand", completed this summer, indicates that from a present production level of just over 19,000 tonnes uranium per year, the demand will rise to the equivalent of an annual production requirement of 50,000 tonnes uranium by 1980, 100,000 by 1985 and 180,000 by 1990. Few, if any, mineral production industries have been called upon to plan for a near tenfold increase in production in a space of about 15 years as these forecasts imply. This might possibly mean that, perhaps, ten times the present number of uranium mines will have to be planned and engineered by 1990.

The NEA/IAEA study shows that present "Reasonably Assured Resources" in the less than US$ 10/lb U_3O_8 category (which are equivalent to **Reserves** in the mining sense) amounted to 866,000 tonnes uranium at mid-1973. The geographical distribution of these reserves and of the "Estimated Additional Resources" and the resources in the US$ 10-15/lb U_3O_8 price range is given in Table No. 1.

If all the present low cost reserves (i.e. 866,000 tonnes) could be used up in the time, (which is improbable), they would be just sufficient to provide fuel up to approximately 1987, but if a forward reserve equivalent to eight years consumption is maintained to assure supply at the projected rate, a satisfactory reserve situation would only be maintained up to around 1979.

Since a substantial portion of the world reserves are in countries (e.g. South Africa) where the reserves could not be produced in that time-frame, but rather over a period of 20 years or more, the eight-year reserve position **worldwide** is likely to be inadequate to provide needed production levels. Furthermore, if no new exploration efforts were undertaken until 1979, the annual discovery rates for new reserves would then have to be rather high, of the order of 150,000 tonnes U. Such discontinuity in exploration activities should certainly be avoided and a desirable reserve position resulting from a smooth increase of the mean discovery rate of recent years (some 65,000 tonnes U per year) to a rate of 230,000 tonnes U per year in 1990 should be the objective of the uranium exploration industry. If discoveries would follow such a curve, an eight-year forward reserve would still be maintained in 1990.

Present world reserves are mainly in five countries – Australia, Canada, France (and associated African countries), South Africa and the USA. In the United States, which has the largest listed reserves, about 96% of the reasonably assured resources are in irregular, stratiform deposits and in "roll" deposits in sandstone. In South Africa, which has the next greatest listing, the reserves are principally in the gold/uranium bearing

TABLE 1*. ESTIMATED WORLD RESOURCES OF URANIUM (Data available January 1973)

Country	Price Range < $[1] 10/lb U_3O_8		Price Range $ 10-15/lb U_3O_8	
	Reasonably Assured Resources	Estimated Additional Resources	Reasonably Assured Resources	Estimated Additional Resources
Argentina	9.2	14	7.7	23
Australia	71	78.5	29.5	29
Brazil	-	2.5[2]	0.7	-
Canada	185	190	122	219
Central African Republic	8	8	-	-
Denmark (Greenland)	5.6	10	-	-
Finland	-	-	1.3	-
France	34.2	19.3	10	20
Gabon	20	5	-	5
India	-	-	(2.3)	(0.8)
Italy	1.2	-	-	-
Japan	2.8	-	4.2	-
Mexico	1.0	-	0.9	-
Niger	40	20	10	10
Portugal (Europe)	7.4	5.9	-	10
(Angola)	-	-	-	13
South Africa	202	8	62	26
Spain	8.5	-	7.7	-
Sweden	-	-	270	40
Turkey	2.2	-	0.5	-
USA	259	538[3]	141	231
Yougoslavia	6	10	-	-
Zaïre	1.7	1	-	-
TOTAL (rounded)	865	911	670	627

[1] $ Value of March 1973: 1 $ = 0.829 EMA u/a = 0.829 SDR (Special Drawing Rights). This $ value corresponds to $42.22 per fine ounce of gold.

[2] Plus 70,000 tonnes U by-product from phosphates.

[3] Plus 70,000 tonnes U by-product from phosphate and copper production.

* From Joint NEA/IAEA Working Party Report "Uranium Resources, Production and Demand", August 1973.

quartz-pebble conglomerates of the Witwatersrand and production of uranium from this source is principally as a by-product of gold production. The third largest reserve is in Canada where 80% of the resources are in the quartz-pebble conglomerates of the Elliot Lake and Agnew Lake areas. France and associated African countries have the fourth largest reserves, those in France being mainly in vein-type deposits and those in Niger and Gabon in sedimentary formations. The most recent developments have been in Australia where active exploration over the last few years has brought Australia to being the fifth greatest uranium reserve country, and there seems to be some possibility that continuing exploration will further increase reserves. The reserves are distributed in several types of geological environments but are mainly in Pre-Cambrian rocks.

Approximately 94% of the total low cost reserves are concentrated in these seven countries. Fifteen other countries report lesser quantities or higher cost uranium reserves, and there are many other countries which on geological grounds have considerable potential for future resources.

The present distribution of low cost reserves into four geological ore types is shown on Table II.

TABLE II. REASONABLY ASSURED RESOURCES $ 10/lb U_3O_8

Geological Ore Types	% of total
Sandstones	38.9
Quartz-pebble conglomerates	34.9
Vein and related types	17.6
Others	8.6
	100.0

The major part of the estimated additional resources, as well as the higher priced resources, is contained in sandstones (mostly located in the U.S.A.).

Because of the physical nature of ore bodies and dependance on production of other metals (e.g. gold in South Africa, and copper and phosphate in the United States) not all the presently known reserves could be made available by 1987. In view of the market situation it is also probable that little effort will be made to develop existing reserves in the higher cost range in time for production before 1987, and this will further limit the availability of these resources. Availability will, however, depend on the evolution of prices and the related growth of production in the intervening period.

Other potential sources of uranium can be drawn upon in addition to known reserves, for example, an estimated 70,000 tonnes of uranium could be recovered in the United States as a by-product of phosphate and copper production by the end of this century. The 680,000 tonnes uranium estimated in the $ 10-15/lb U_3O_8 reasonably assured category would also be available if the price of uranium were to increase into this range. However, nearly half of this higher cost material is in Swedish black shales and, according to Swedish authorities, production from this source will be restricted to helping meet only Sweden's needs.

Uranium at costs up to $ 15 per pound U_3O_8 or more, may well be economically competitive in water reactors, but the effort to develop the capability to produce the quantities of low-grade ore equivalent to such a price will not begin until there is positive indication of a market at that price. The uranium content of $ 15 resources is generally very much lower than for $ 10 resources, therefore, an equivalently greater tonnage of ore must be mined and processed to produce the same amount of uranium. In effect, a possible doubling of the industry would be required just to maintain the existing production capability.

Further caution is needed regarding estimates of low-grade resources. A high proportion of the high-cost resources are in the same deposits as the lower cost material. So long as mining continues at the cutoff appropriate for lower costs, much of the higher cost material will be lost entirely or become even more costly for later recovery. On the other hand, it is recognized that the estimates of $ 15 uranium are probably conservative for lack of data because industry's effort has, up to now, been directed to the development of higher grade ore.

Because of the long lead time needed to develop any large low-grade deposit, and the prevailing low prices which will probably not exceed $ 10 for the next decade, substantial production cannot be expected from such sources during the next 20 years when requirements will be the largest. The effect on the environment of developing very large tonnage near surface deposits also raises many problems and may ultimately restrict production from such deposits. Discovery of new low-cost resources appears to be the only reasonable alternative to meeting future requirements.

Fortunately, there are extensive, apparently favourable areas that have not yet been prospected. Although many of these are remote, the obstacles to exploration can probably be surmounted in much the same manner as they have been in the development of the Niger deposits. Undoubtedly, future exploration will continue to focus on Africa, parts of Asia and on Australia where many important new finds have recently been made.

The question is how to achieve the required increase in the rate of discovery of uranium to satisfy the most likely demand forecasts. The present exploration effort throughout the world is not increasing sufficiently to attain this objective. This situation is directly related to the present over-supply of uranium and the consequently depressed state of the market. Not only is there unused production capacity, but the uranium output in recent years has exceeded demand, causing a build-up of stockpiles and inventories.

Although this situation of oversupply is periodically encountered in the mineral industries, it is hard to draw a parallel with the uranium case when confronted with an exceptionally high growth in which a doubling of annual uranium requirements in five years is forecast. The magnitude of this challenge is brought more clearly into focus when viewed in the context of the lead times necessary for exploration and subsequent preparation of new production facilities.

In summary, no shortages of uranium supply are to be expected in the 1970s. However, the rapid growth in demand in the coming decade cannot be satisfied on the basis of existing uranium exploration levels. Given the necessity of a lead time of about eight years between discovery and actual production, it is therefore essential that steps be taken to increase the rate of exploration for uranium so that an adequate forward reserve may be maintained.

References

1. "Uranium Resources, Production and Demand" A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, August 1973.

2. "Uranium Reserves and Requirements" R.D. Nininger, U.S.A.E.C., Atomic Industrial Forum, March 1973.