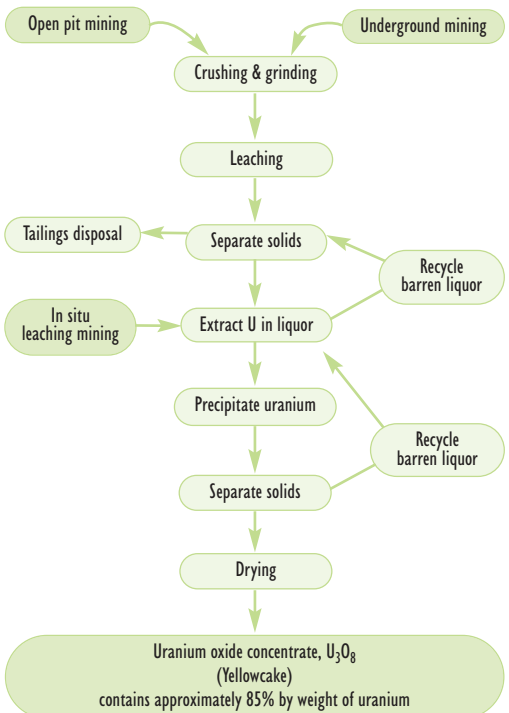
MILLING

Simplified flow chart of uranium ore processing from mining to the production of concentrate. These processes are commonly known as milling and the product – uranium oxide concentrate – is the raw material for nuclear fuel fabrication.



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URANIUM PRODUCTION AND RESOURCES

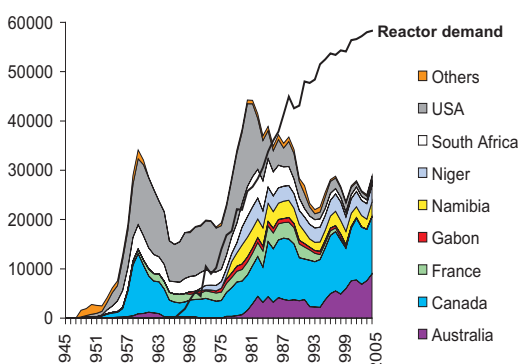
Country or area	2007 Production (tU)	Capacity (tU) at 31.12.07	Uranium resources (tU)* <US$80/kg
Australia	8611	9550	714 000
Brazil	299	400	157 400
Canada	9476	11 810	329 200
China †	712	1000	44 300
Czech Rep	306	440	600
India †	270	300	n/a
Kazakhstan	6637	7000	344 200
Namibia	2879	3850	145 100
Niger	3153	3500	44 300
Pakistan †	45	50	n/a
Romania †	77	100	n/a
Russia	3413	3500	172 400
South Africa	539	2000	205 900
Ukraine †	846	1000	126 500
USA	1654	2000	99 000
Uzbekistan	2320	2500	55 200
Other	42	0	n/a
Total	**41 279**	**49 000**	**2 438 100**

Sources: * OECD/NEA Reasonably Assured Resources Category
WNA † World Nuclear Association estimate
OECD/NEA NB Many other countires have also known uranium resources

URANIUM HISTORY

- In 1789 Martin Klaproth, a German chemist, isolated an oxide of uranium while analysing pitchblende samples from the Joachimsthal silver mines in Bohemia.
- For over 100 years uranium was mainly used as a colorant for ceramic glazes and for tinting in early photography. Uranium was produced in Bohemia, Cornwall, Portugal and Colorado and total production amounted to about 300-400 tonnes.
- The discovery of radium in 1898 by Marie Curie led to the construction of a number of radium extraction plants processing uranium ore (radium is a decay product of uranium).
- Prized for its use in cancer therapy, radium reached a price of 750 000 gold francs per gram in 1906 (US$10 million). It is estimated that 754 grams were produced worldwide between 1898 and 1928. Uranium itself was simply dumped as a waste material.
- With the discovery of nuclear fission in 1939, the uranium industry entered a new era. On 2 December 1942, the first controlled nuclear chain reaction was achieved in Chicago. The first nuclear explosion in 1945 demonstrated the enormous power potential of nuclear fission.
- From a small beginning in 1951, when four lightbulbs were lit with nuclear electricity, the nuclear power industry now supplies some 16% of world electricity.

WESTERN WORLD HISTORIC URANIUM PRODUCTION



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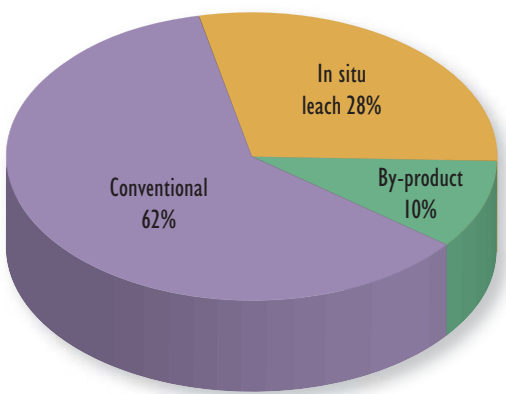
URANIUM FROM MINE TO MILL

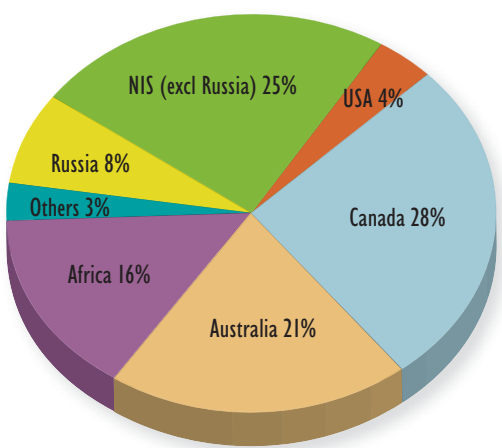


World uranium production by mining method, 2007

www.world-nuclear.org

TOP TEN URANIUM MINES IN 2006 - 2007

Mine	Country	Main owner	Mine type	Production (tU)		% of world production		Rank	
				2006	2007	2006	2007	2006	2007
McArthur River	Canada	Cameco	Conventional	7200	7199	18	17	1	1
Ranger	Australia	ERA (Rio Tinto 68%)	Conventional	4026	4589	10	11	2	2
Olympic Dam	Australia	BHP Billiton	By-product (copper)	2868	3388	7	8	5	3
Priargunsky	Russia	TVEL	Conventional	2900	3037	7	7	4	4
Rössing	Namibia	Rio Tinto (69%)	Conventional	3067	2583	8	6	3	5
Arlit	Niger	Areva/Onarem	Conventional	1565	1750	4	4	8	6
Rabbit Lake	Canada	Cameco	Conventional	1972	1544	5	4	6	7
Akouta	Niger	Areva/Onarem	Conventional	1869	1403	5	3	7	8
Akdala	Kazakhstan	Uranium One	ISL	1000	1000	3	2	9	9
Mining Utility#5	Uzbekistan	Navoi	ISL	900	900	2	2	10	10
World total from top ten mines				**27 367**	**27 392**	**69**	**66**		



World uranium production, 2007

LEADING URANIUM MINING COMPANIES

Company	2007 production	
	Actual (tU)	World share (%)
Cameco	7770	19
Rio Tinto	7172	17
Areva	6046	15
KazAtomProm	4795	12
TVEL	3413	8
BHP Billiton	3388	8
Navoi	2320	6
Uranium One	784	2
Sub total	35 688	87
World total	**41 279**	**100**

MINERALOGY AND ORE GRADE

- **Uraninite** is the most common primary uranium mineral: others of economic interest include coffinite and brannerite. The most common form of uraninite is **pitchblende**, which is sometimes associated with colourful secondary uranium minerals derived from weathering.
- The average abundance of uranium in the Earth's crust is 2.7 parts per million, making it more common than tin.
- The concentration of uranium needed to form an economic mineral deposit varies widely depending on its geological setting and physical location. Average ore grades at operating uranium mines range from 0.03% U to as high as 10% U, but are most frequently less than 1% U. These figures do not apply to by-product operations.

MINING METHODS

- **Open pit:** used to mine shallow deposits. Economics depend on the ratio of ore to waste, higher grade ores being able to produce higher ratios.
- **Underground:** used to mine deposits too deep for open pit mining. For mining to be viable, these deposits must be compara tively high grade.
- **In situ leach:** this method is applicable only to sandstone-hosted uranium deposits located below the water table in a confined aquifer. The uranium is dissolved in a mildly alkaline or acidic solution that is injected into and recovered from the aquifer by means of wells. The geology remains undisturbed.
- **By-product:** uranium often occurs in association with other minerals such as gold (Witwatersand), phosphate (United States and elsewhere) and copper (Australia).

PROCESSING AND EXTRACTION

- **Crushing and grinding:** breaks down the ore to sand/silt sized particles, thereby freeing the uranium minerals.
- **Leaching:** acid or alkali dissolves the freed uranium, allowing the uranium-bearing solution to be separated from the leached solids by solid-liquid separation device, resulting in a clarified uranium-bearing solution.
- **Extraction:** ion exchange or solvent extraction methods are used to separate the dissolved uranium from the aqueous solution.
- **Precipitation and drying:** uranium is precipitated from solution using one of several chemicals. Dewatering, filtration and drying complete the process. The final product is sometimes known as yellowcake, although it is typically khaki.