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 making nuclear fuel.



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Uranium production and resources

Country or area	2009 production (tV)	Capacity (tU) at 31.12.09	Uranium resources (tU)* <us\$80 kg<="" th=""></us\$80>		
Australia	7982	9550	714,000		
Brazil	345	400	157,400		
Canada	10,173	11,810	329,200		
China 🕇	750	1000	44,300		
Czech Republic	258	440	600		
India 🕇	290	300	n/a		
Kazakhstan	14,020	15,000	344,200		
Namibia	4626	5000	145,100		
Niger	3234	3500	44,300		
Pakistan †	50	50	n/a		
Romania +	75	100	n/a		
Russia	3564	3750	172,400		
South Africa	563	2000	205,900		
Ukraine	840	1000	126,500		
USA	1453	2000	99,000		
Uzbekistan	2429	2500	55,200		
Other	112	n/a	n/a		
Total	50,772	58,400	2,438,100		

Sources: WNA. OECD/NEA

* OECD/NEA Reasonably Assured Resources Category

WNA estimate

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 14% of world electricity.

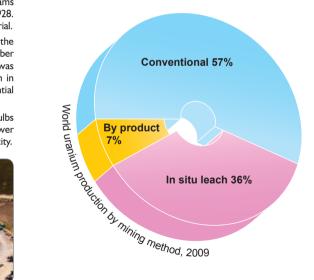


McArthur River – world's top producing uranium mine in 2009

2010 WNA Pocket Guide



URANIUM, FROM MINE TO MILL

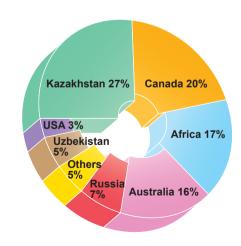


Top ten uranium mines in 2008 - 2009

Mine Country	C	Main annan	Mine tune	Production (tU)		% of world production		Rank	
	Main owner	Mine type	2008	2009	2008	2009	2008	2009	
McArthur River	Canada	Cameco	Conventional	6383	7339	15	15	I	I
Ranger	Australia	ERA (Rio Tinto 68%)	Conventional	4527	4444	10	9	2	2
Rössing	Namibia	Rio Tinto (69%)	Conventional	3449	3520	8	7	3	3
Priargunsky	Russia	ARMZ	Conventional	3050	3004	7	6	5	4
Olympic Dam	Australia	BHP Billiton	By-product (copper)	3344	2955	8	6	4	5
Tortkuduk	Kazakhstan	Areva/KazAtomProm	ISL	741	2272	2	4	-	6
Arlit	Niger	Areva	Conventional	1743	1808	4	4	6	7
Rabbit Lake	Canada	Cameco	Conventional	1368	1447	3	3	7	8
Akouta	Niger	Areva	Conventional	1289	1435	3	3	8	9
Budenovskoye 2	Kazakhstan	KazAtomProm	ISL	662	1415	I	3	-	10
World total from top ten mines		27,436	29,638	62	59				

Leading uranium mining companies

Compony	2009 production				
Company	Actual (tU)	World share (%)			
Areva	8623	17			
Cameco	8000	16			
Rio Tinto	7963	16			
KazAtomProm	7467	15			
ARMZ	4624	9			
BHP Billiton	2955	6			
Navoi	2429	5			
Uranium One	1368	3			
Paladin	1210	2			
General Atomics	583	l			
Sub total	45,222	89			
World total	50,772 100				



World uranium production, 2009



Yellowcake

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 24% 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 relatively 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 comparatively 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.

Western world historic uranium production

