**Uranium Mining**

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2007 uranium mining, by nationality. Data is taken from.



World Uranium production in 2005.

Uranium mining is the process of extraction of uranium ore from the ground. The worldwide production of uranium in 2009 amounted to 50,572 tonnes, of which 27% was mined in Kazakhstan. Kazakhstan, Canada, and Australia are the top three producers and together account for 63% of world uranium production. Other important uranium producing countries in excess of 1000 tonnes per year are Namibia, Russia, Niger, Uzbekistan, and the United States.

A prominent use of uranium from mining is as fuel for nuclear power plants. As of 2008, known uranium ore resources that can be mined at about current costs are estimated to be sufficient to produce fuel for about a century, based on current consumption rates.

After mining uranium ores, they are normally processed by grinding the ore materials to a uniform particle size and then treating the ore to extract the uranium by chemical leaching. The milling process commonly yields dry powder-form material consisting of natural uranium, "yellowcake," which is sold on the uranium market as U3O8.

**History**

Uranium minerals were noticed by miners for a long time prior to the discovery of uranium in 1789. The uranium mineral pitchblende, also known as uraninite, was reported from the Erzgebirge (Ore Mountains), Saxony, as early as 1565. Other early reports of pitchblende date from 1727 in Joachimsthal and 1763 in Schwarzwald.

In the early 19th century, uranium ore was recovered as a byproduct of mining in Saxony, Bohemia, and Cornwall. The first deliberate mining of radioactive ores took place in Jáchymov, also known by its German name Joachimsthal, a silver-mining city in what is now the Czech Republic. Marie Curie used pitchblende ore from Jáchymov to isolate the element radium, a decay product of uranium; her death was from aplastic anemia, almost certainly due to exposure to radioactivity. Until World War II uranium mining was done primarily for the radium content. Sources for radium, contained in the uranium ore, were sought for use as luminous paint for watch dials and other instruments, as well as for health-related applications, some of which in retrospect might have been harmful. The byproduct uranium was used mostly as a yellow pigment.

In the United States, the first radium/uranium ore was discovered in 1871 in gold mines near Central City, Colorado. This district produced about 50 tons of high grade ore between 1871 and 1895. However, most American uranium ore before World War II came from vanadium deposits on the Colorado Plateau of Utah and Colorado.

In Cornwall, the South Terras Mine near St. Stephen opened for uranium production in 1873, and produced about 175 tons of ore before 1900. Other early uranium mining occurred in Autunois in France's Massif Central, Oberpfalz in Bavaria, and Billingen in Sweden.

The Shinkolobwe deposit in Katanga, Belgian Congo now Shaba Province, Democratic Republic of the Congo (DRC) was discovered in 1913, and exploited by the Union Minière du Haut Katanga. Other important early deposits include Port Radium, near Great Bear Lake, Canada discovered in 1931, along with Beira Province, Portugal; Tyuya Muyun, Uzbekistan, and Radium Hill, Australia.

Because of the need for the uranium for bomb research during World War II, the Manhattan Project used a variety of sources for the element. The Manhattan Project initially purchased uranium ore from the Belgian Congo, through the Union Minière du Haut Katanga. Later the project contracted with vanadium mining companies in the American Southwest. Purchases were also made from the Eldorado Mining and Refining Limited company in Canada. This company had large stocks of uranium as waste from its radium refining activities.

American uranium ores mined in Colorado were mixed ores of vanadium and uranium, but because of wartime secrecy, the Manhattan Project would publicly admit only to purchasing the vanadium, and did not pay the uranium miners for the uranium content. In a much later lawsuit, many miners were able to reclaim lost profits from the U.S. government. American ores had much lower uranium concentrations than the ore from the Belgian Congo, but they were pursued vigorously to ensure nuclear self-sufficiency.

Similar efforts were undertaken in the Soviet Union, which did not have native stocks of uranium when it started developing its own atomic weapons program.

Intensive exploration for uranium started after the end of World War II as a result of the military and civilian demand for uranium. There were three separate periods of uranium exploration or "booms." These were from 1956 to 1960, 1967 to 1971, and from 1976 to 1982.

In the 20th century the United States was the world's largest uranium producer. Grants Uranium District in northwestern New Mexico was the largest United States uranium producer. The Gas Hills Uranium District, was the second largest uranium producer. The famous Lucky Mc Mine is located in the Gas Hills near Riverton, Wyoming. Canada has since surpassed the United States as the cumulative largest producer in the world.

**Types of uranium deposits**

Main article: Uranium ore deposits

Many different types of uranium deposits have been discovered and mined. There are mainly three types of uranium deposits including unconformity-type deposits, namely paleo placer deposits and sandstone-type also known as roll front type deposits.

**Uranium deposits in sedimentary rock**



A Uranium mine, near Moab, Utah. Note alternating red and white/green sandstone. This type of uranium deposit is easier and cheaper to mine than the other types because the uranium is found not far from the surface of the Crust. These deposits were formed when oxidized groundwater which had leached uranium from crust rocks flowed down into aquifers, where it was reduced to form precipitate uraninite, which is actually the main ore of uranium. This corresponds to oxidized and reduced conditions in groundwater redox chemistry. The rock forms in oxidizing conditions, and is then "bleached" to the white/green state when a reducing fluid passes through the rock. The reduced fluid can also carry Uranium-bearing minerals.

Uranium deposits in sedimentary rocks include those in sandstone (in Canada and the western US), Precambrian unconformities (in Canada), phosphate, Precambrian quartz-pebble conglomerate, collapse breccia pipes (see Arizona Breccia Pipe Uranium Mineralization), and calcrete.

Sandstone uranium deposits are generally of two types. Roll-front type deposits occur at the boundary between the up dip and oxidized part of a sandstone body and the deeper down dip reduced part of a sandstone body. Peneconcordant sandstone uranium deposits, also called **Colorado Plateau**-type deposits, most often occur within generally oxidized sandstone bodies, often in localized reduced zones, such as in association with carbonized wood in the sandstone.

Precambrian quartz-pebble conglomerate-type uranium deposits occur only in rocks older than two billion years old. The conglomerates also contain pyrite. These deposits have been mined in the Blind River-Elliot Lake district of Ontario, Canada, and from the gold-bearing Witwatersrand conglomerates of South Africa.

**Igneous or hydrothermal uranium deposits**

Hydrothermal uranium deposits encompass the vein-type uranium ores. Igneous deposits include nepheline syenite intrusive at Ilimaussaq, Greenland; the disseminated uranium deposit at Rossing, Namibia; and uranium-bearing pegmatites. Disseminated deposits are also found in the states of Washington and Alaska in the US.

**Exploration**

Uranium prospecting is similar to other forms of mineral exploration with the exception of some specialized instruments for detecting the presence of radioactive isotopes.

The Geiger counter was the original radiation detector, recording the total count rate from all energy levels of radiation. Ionization chambers and Geiger counters were first adapted for field use in the 1930s. The first transportable Geiger–Müller counter (weighing 25 kg) was constructed at the University of British Columbia in 1932. H.V. Ellsworth of the GSC built a lighter weight, more practical unit in 1934. Subsequent models were the principal instruments used for uranium prospecting for many years, until Geiger counters were replaced by scintillation counters.

The use of airborne detectors to prospect for radioactive minerals was first proposed by G.C. Ridland, a geophysicist working at Port Radium in 1943. In 1947, the earliest recorded trial of airborne radiation detectors (ionization chambers and Geiger counters) was conducted by Eldorado Mining and Refining Limited. (a Canadian Crown Corporation since sold to become Cameco Corporation). The first patent for a portable gamma-ray spectrometer was filed by Professors Pringle, Roulston & Brownell of the University of Manitoba in 1949, the same year as they tested the first portable scintillation counter on the ground and in the air in northern Saskatchewan.

Airborne gamma-ray spectrometry is now the accepted leading technique for uranium prospecting with worldwide applications for geological mapping, mineral exploration & environmental monitoring.

A deposit of uranium, discovered by geophysical techniques, is evaluated and sampled to determine the amounts of uranium materials that are extractable at specified costs from the deposit. Uranium reserves are the amounts of ore that are estimated to be recoverable at stated costs.

**Mining techniques**

As with other types of hard rock mining there are several methods of extraction. The main methods of mining are *box cut* mining, *open pit* mining and *In-situ leaching* (ISL).

**Open pit**



Rössing open pit uranium mine, Namibia

In open pit mining, overburden is removed by drilling and blasting to expose the ore body, which is then mined by blasting and excavation using loaders and dump trucks. Workers spend much time in enclosed cabins thus limiting exposure to radiation. Water is extensively used to suppress airborne dust levels.

**Underground uranium mining**

If the uranium is too far below the surface for open pit mining, an underground mine might be used with tunnels and shafts dug to access and remove uranium ore. There is less waste material removed from underground mines than open pit mines, however this type of mining exposes underground workers to the highest levels of radon gas.

Underground uranium mining is in principle no different to any other hard rock mining and other ores are often mined in association (e.g., copper, gold, silver). Once the ore body has been identified a shaft is sunk in the vicinity of the ore veins, and crosscuts are driven horizontally to the veins at various levels, usually every 100 to 150 meters. Similar tunnels, known as drifts, are driven along the ore veins from the crosscut. To extract the ore, the next step is to drive tunnels, known as raises when driven upwards and winzes when driven downwards through the deposit from level to level. Raises are subsequently used to develop the stopes where the ore is mined from the veins.

The stope, which is the workshop of the mine, is the excavation from which the ore is extracted. Two methods of stope mining are commonly used. In the "cut and fill" or open stopping method, the space remaining following removal of ore after blasting is filled with waste rock and cement. In the "shrinkage" method, only sufficient broken ore is removed via the chutes below to allow miners working from the top of the pile to drill and blast the next layer to be broken off, eventually leaving a large hole. Another method, known as room and pillar, is used for thinner, flatter ore bodies. In this method the ore body is first divided into blocks by intersecting drives, removing ore while so doing, and then systematically removing the blocks, leaving enough ore for roof support.

**Heap leaching**

Heap leaching is an extraction process by which chemicals (usually sulfuric acid) are used to extract the economic element from ore which has been mined and placed in piles on the surface. Heap leaching is generally only economically feasible only for oxide ore deposits. Oxidation of sulfide deposits occur during the geological process called weatherization. Therefore oxide ore deposits are typically found close to the surface. If there are no other economic elements within the ore a mine might choose to extract the uranium using a leaching agent, usually a low molar sulfuric acid.

If the economic and geological conditions are right, the mining company will level large areas of land with a small gradient, layering it with thick plastic (usually HDPE or LLDPE), sometimes with clay, silt or sand beneath the plastic liner. The extracted ore will typically be run through a crusher and placed in heaps atop the plastic. The leaching agent will then be sprayed on the ore for 30–90 days. As the leaching agent filters through the heap the uranium will break its bonds with the oxide rock and enter the solution. The solution will then filter along the gradient into collecting pools which will then be pumped to on-site plants for further processing. Only some of the uranium (commonly about 70%) is actually extracted.

The uranium concentrations within the solution are very important for the efficient separation of pure uranium from the acid. As different heaps will yield different concentrations the solution is pumped to a mixing plant that is carefully monitored. The properly balanced solution is then pumped into a processing plant where the Uranium is separated from the sulfuric acid.

Heap leach is significantly cheaper than traditional milling processes. The low costs allow for lower grade ore to be economically feasible (given that it is the right type of ore body). Environmental law requires that the surrounding ground water is continually monitored for possible contamination. The mine will also have to have continued monitoring even after the shutdown of the mine. In the past mining companies would sometimes go bankrupt, leaving the responsibility of mine reclamation to the public. Recent additions to the mining law require that companies set aside the money for reclamation before the beginning of the project. The money will be held by the public to insure adherence to environmental standards if the company were to ever go bankrupt.

Another very similar mining technique is called in situ, or in place mining where the ore doesn't even need extracting.

**Iran**



Trial well field for in-situ recovery at Honeymoon, South Australia

In-situ leaching (ISL), also known as solution mining, or in-situ recovery (ISR) in North America, involves leaving the ore where it is in the ground, and recovering the minerals from it by dissolving them and pumping the pregnant solution to the surface where the minerals can be recovered. Consequently there is little surface disturbance and no tailings or waste rock generated. However, the orebody needs to be permeable to the liquids used, and located so that they do not contaminate ground water away from the orebody.

Uranium ISL uses the native groundwater in the orebody which is fortified with a complexing agent and in most cases an oxidant. It is then pumped through the underground orebody to recover the minerals in it by leaching. Once the pregnant solution is returned to the surface, the uranium is recovered in much the same way as in any other uranium plant (mill).

In Australian ISL mines (Beverley and the soon to be opened Honeymoon Mine) the oxidant used is hydrogen peroxide and the complexing agent sulfuric acid. Kazakh ISL mines generally do not employ an oxidant but use much higher acid concentrations in the circulating solutions. ISL mines in the USA use an alkali leach due to the presence of significant quantities of acid-consuming minerals such as gypsum and limestone in the host aquifers. Any more than a few percent carbonate minerals means that alkali leach must be used in preference to the more efficient acid leach

The Australian government has published a best practice guide for in situ leach mining of uranium, which is being revised to take account of international differences.

**Recovery from seawater**

The uranium concentration of sea water is low, approximately 3.3 mg per cubic meter of seawater. But the quantity of this resource is gigantic and some scientists believe this resource is practically limitless with respect to world-wide demand. That is to say, if even a portion of the uranium in seawater could be used the entire world's nuclear power generation fuel could be provided over a long time period. Some anti-nuclear proponents claim this statistic is exaggerated. Although research and development for recovery of this low-concentration element by inorganic adsorbents such as titanium oxide compounds, has occurred since the 1960s in the United Kingdom, France, Germany, and Japan, this research was halted due to low recovery efficiency.

At the Takasaki Radiation Chemistry Research Establishment of the Japan Atomic Energy Research Institute (JAERI Takasaki Research Establishment), research and development has continued culminating in the production of adsorbent by irradiation of polymer fiber. Adsorbents have been synthesized that have a functional group (amidoxime group) that selectively adsorbs heavy metals, and the performance of such adsorbents has been improved. Uranium adsorption capacity of the polymer fiber adsorbent is high, approximately tenfold greater in comparison to the conventional titanium oxide adsorbent.

One method of extracting uranium from seawater is using a uranium-specific nonwoven fabric as an absorbent. The total amount of uranium recovered from three collection boxes containing 350 kg of fabric was >1 kg of yellowcake after 240 days of submersion in the ocean. According to the OECD, uranium may be extracted from seawater using this method for about $300/kg-U. The experiment by Seko *et al.* was repeated by Tamada et al. in 2006. They found that the cost varied from ¥15,000 to ¥88,000 (Yen) depending on assumptions and "The lowest cost attainable now is ¥25,000 with 4g-U/kg-adsorbent used in the sea area of Okinawa, with 18 repetition uses [sic]." With the May, 2008 exchange rate, this was about $240/kg-U.

**Uranium prices**

Main article: Uranium market

Since 1981 uranium prices and quantities in the US are reported by the Department of Energy. The import price dropped from 32.90 US$/lb-U3O8 in 1981 down to 12.55 in 1990 and to below 10 US$/lb-U3O8 in the year 2000. Prices paid for uranium during the 1970s were higher, 43 US$/lb-U3O8 is reported as the selling price for Australian uranium in 1978 by the Nuclear Information Centre.

Uranium prices reached an all-time low in 2001, costing US$7/lb, but has since rebounded strongly. In April 2007 the price of Uranium on the spot market rose to US$113.00/lb, This is very close to the all-time high (adjusted for inflation) in 1977. a high point of the uranium bubble of 2007. The higher price has spurred expansion of current mines, construction of new mines and reopening of old mines as well as new prospecting.

**Politics of uranium mining**

In the beginning of the Cold War, to ensure adequate supplies of uranium for national defense, the United States Congress passed the U.S. Atomic Energy Act of 1946, creating the Atomic Energy Commission (AEC) which had the power to withdraw prospective uranium mining land from public purchase, and also to manipulate the price of uranium to meet national needs. By setting a high price for uranium ore, the AEC created a uranium "boom" in the early 1950s, which attracted many prospectors to the Four Corners region of the country. Moab, Utah became known as the Uranium-capital of the world, when geologist Charles Steen discovered such an ore in 1952, even though American ore sources were considerably less potent than those in the Belgian Congo or South Africa.

In the 1950s methods for extracting diluted uranium and thorium, found in abundance in granite or seawater, were pursued. Scientists speculated that, used in a breeder reactor, these materials would potentially provide limitless source of energy.

American military requirements declined in the 1960s, and the government completed its uranium procurement program by the end of 1970. Simultaneously, a new market emerged: commercial nuclear power plants. However, in the U.S. this market virtually collapsed by the end of the 1970s as a result of industrial strains caused by the energy crisis, popular opposition, and finally the Three Mile Island nuclear accident in 1979, all of which led to a *de facto* moratorium on the development of new nuclear reactor power stations.

In Europe a mixed situation exists. Considerable nuclear power capacities have been developed, notably in Belgium, France, Germany, Spain, Sweden, Switzerland and the UK. In many countries development of nuclear power has been stopped and phased out by legal actions. In Italy the use of nuclear power was barred by a referendum in 1987, however this is now under revision. Ireland also has no plans to change its non-nuclear stance and pursue nuclear power in the future.

Opposition to uranium mining has been considerable in Australia, where notable anti-uranium activists have included Kevin Buzzacott, Jacqui Katona, Yvonne Margarula, and Jillian Marsh. Other notable anti-uranium activists include Manuel Pino (USA), JoAnn Tall (USA), and Sun Xiaodi (China).

**Health risks of uranium mining**

Main article: Uranium mining debate

**Lung cancer deaths**

See also: Health effects of radon, Uranium in the environment, and The Navajo People and Uranium Mining

Uranium ore emits radon gas. The health effects of high exposure to radon is a particular problem in the mining of uranium; significant excess lung cancer deaths have been identified in epidemiological studies of uranium miners employed in the 1940s and 1950s.

The first major studies with radon and health occurred in the context of uranium mining, first in the Joachimsthal region of Bohemia and then in the Southwestern United States during the early Cold War. Because radon is a product of the radioactive decay of uranium, underground uranium mines may have high concentrations of radon. Many uranium miners in the Four Corners region contracted lung cancer and other pathologies as a result of high levels of exposure to radon in the mid-1950s. The increased incidence of lung cancer was particularly pronounced among Native American and Mormon miners, because those groups normally have low rates of lung cancer. Safety standards requiring expensive ventilation were not widely implemented or policed during this period.

In studies of uranium miners, workers exposed to radon levels of 50 to 150 picocuries of radon per liter of air (2000–6000 Bq/m3) for about 10 years have shown an increased frequency of lung cancer. Statistically significant excesses in lung cancer deaths were present after cumulative exposures of less than 50 WLM. There is, however, unexplained heterogeneity in these results (whose confidence interval do not always overlap). The size of the radon-related increase in lung cancer risk varied by more than an order of magnitude between the different studies.

Since that time, ventilation and other measures have been used to reduce radon levels in most affected mines that continue to operate. In recent years, the average annual exposure of uranium miners has fallen to levels similar to the concentrations inhaled in some homes. This has reduced the risk of occupationally induced cancer from radon, although it still remains an issue both for those who are currently employed in affected mines and for those who have been employed in the past. The power to detect any excess risks in miners nowadays is likely to be small, exposures being much smaller than in the early years of mining.

**Clean-up efforts**

**United States**

Despite efforts made in cleaning up uranium sites, significant problems stemming from the legacy of uranium development still exist today on the Navajo Nation and in the states of Utah, Colorado, New Mexico, and Arizona. Hundreds of abandoned mines have not been cleaned up and present environmental and health risks in many communities. At the request of the U.S. House Committee on Oversight and Government Reform in October 2007, and in consultation with the Navajo Nation, the Environmental Protection Agency (EPA), along with the Bureau of Indian Affairs (BIA), the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), and the Indian Health Service (IHS), developed a coordinated Five-Year Plan to address uranium contamination. Similar interagency coordination efforts are beginning in the State of New Mexico as well.

**By territory**

See also: List of uranium mines and List of countries by uranium production

**Africa**

**Democratic Republic of the Congo (DRC)**

In the DRC uranium is being won. The uranium for the nuclear bombs which were used to bomb Japan at the end of the Second World War came from - then - Belgian Congo. The mining occurs in the mineral rich province of Katanga, for example in Shinkolobwe, Mindigi, Kalongwe, Kasompi, Samboa and the Emmanuel Depot in Kolwezi.Major player is Gécamines, the state mining company.

The french conglomerate Areva has an undisclosed contract with Gecamines which is reportedly allows the company to mine unlimited amounts of Uranium in the region

**Gabon**

In Gabon mining used to occur in Oklo, but the deposits are reported to be exhausted. In 1972, remains of a natural nuclear fission reactor were found at the Oklo deposits.

**Namibia**

Namibia produces uranium at Rossing deposit, where an igneous deposit is mined from one of the world's largest open pit mines. The mine is owned by a subsidiary of the Rio Tinto Group. The Langer Heinrich calcrete uranium deposit was discovered in 1973 and the open pit mine was officially opened in 2007.

**Niger**

Niger is Africa's leading uranium-producing nation. Uranium is produced from mines at Arlit owned by Areva NC.

In 2007, production in Niger had a total output of 3,720 tonnes U3O8 (8.2 million pounds) coming mainly from the Akouta (Cominak) and the Arlit (Somair) mines.

Niger's uranium came to world attention before the US invasion of Iraq, when it was asserted that Iraq had attempted to buy uranium from Niger (see *Niger uranium forgeries*).

**South Africa**

South Africa produces uranium from deposits in Precambrian quartz-pebble conglomerates of the Witwatersrand Basin, at Brakpan and Krugersdorp, Gauteng.

**Asia**

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**China**

China mined in 2007 636 tonnes of U3O8, a decrease of 17% of its production in 2006.

**India**

In Nalgonda District, the Rajiv Gandhi Tiger Reserve (the only tiger project in Andhra Pradesh) has been forced to surrender over 3,000 sq. kilometers to uranium mining following a directive from the Central Ministry of Environment and Forests.

In 2007, India was able to extract 229 tonnes of U3O8 from its soil. On July 19 of 2011, Indian officials announced that the Tumalapalli mine in Andhra Pradesh state of India could provide more than 170,000 tonnes of uranium, making it as the world's largest uranium mine. Production of the ore is slated to begin from next year.

As India vies for enriched uranium from the Nuclear Suppliers Group (NSG) members to get the raw material for its nuclear power plants, the scientists here have found massive uranium deposits in the mines of Tumalapalli in Andhra Pradesh. The site has the potential to emerge as the largest reserve of the key nuclear fuel in the world.

The Department of Atomic Energy (DAE) recently discovered that the upcoming mine in Tumalapalli has close to 49,000 tone uranium reserve. This could just be a shot in the arm for India's nuclear power aspirations as it is three times the original estimate of the area's deposits.

In fact, there were indications that the total quantity of uranium could go up to 1.5 lakh tonnes, which would make it among the largest uranium mines in the world.

The fact that Tumalapalli might have uranium reserves has been known for a while, but it took four years for the estimate to come to the present level.

**Jordan**

Jordan, the only Middle East country with confirmed uranium, is estimated to have around 140,000 tonnes in its uranium reserves plus a further 59,000 tonnes in phosphate deposits. Although no uranium has been mined yet, it was announced in 2008 that the Jordanian Government signed an agreement with the French Company AREVA to explore for uranium. This will benefit them on building a future nuclear plant in Jordan.

**CIS**

**Kazakhstan**

Kazakhstan produced some 7847 tU3O8 (17.3 million pounds) in 2007, much more than in 2006. Kazatomprom's four 100%-owned ISR mining groups (LLP Kazatomprom) combined produced half of the total output.

See also: Mineral industry of Kazakhstan#Uranium

**Russia**

The World Nuclear Associationstates that Russia has known uranium deposits of 500,000 tonnes and plans to mine 11,000 to 12,000 tonnes per year from deposits in the South Urals, Western Siberia, and Siberia east of Lake Baikal, by 2010.

The Russian nuclear industry has been undergoing an overall restructuring process during 2007. The production was high as almost 4 000 tU3O8 (8.8 million pounds) from three operating mines in 2007. Atomredmetzoloto reported that the Priargunsky mine yielded 7.8 million pounds in 2007, a slight decline from the 8.2 million pounds reported by TVEL in 2006. At the Dalur (Dolmatovskoye) and Khiagda ISR mines, production of 910 000 pounds and 68 000 pounds, respectively, was reached in 2007. Both ISR projects are expected to increase production steadily through 2015.

See also: Mineral industry of Russia#Uranium

**Ukraine**

Ukraine's VostGOK produced almost 1,000 tU3O8 (2.2 million pounds) from the Zhovti Vody mill in 2007, which was similar to the 2.1 million pounds produced in 2006. lSUQMY DILLL

**Uzbekistan**

In Uzbekistan, the Navoi Mining & Metallurgy Combinat reportedly produced 2,721 tonnes U3O8 or tU3O8 (6 million pounds) from its Nurabad, Uchkuduk and Zafarabad in-situ recovery facilities.

**Europe**



Origins of uranium delivered to EU utilities in 2009, from the 2009 Annual report of the Euratom Supply Agency

European uranium mining supplied just below 3% of the total EU needs, coming from the Czech Republic and Romania (a total of 526 tU). Production in the Rožňa mine was to be terminated in 2008, but the Czech Government decided in May 2007 to continue mining and extended the lifetime without time limit as long as it remains profitable.

**Bulgaria**

Bulgaria shut down its facilities for environmental reasons in 1992; terrains were re-cultivated but recently, there has been certain interest in resuming activities. Industrial mining first started in 1938 and was resumed after 1944 by a joint Soviet-Bulgarian mining company, reorganized in 1956 into the Redki Metali (Rare Metals) government-owned concern. At its peak, it had thirteen thousand employees, operated forty-eight uranium mines and two enrichment plants at Buhovo outside Sofia and Eleshnitsa near Bansko. Yearly production was estimated at 645 t that met about 55% of the needs of Kozloduy Nuclear Power Plant, which had six reactors with a total output of over 3600 MWe at its peak.

**Czech Republic**

The Czech Republic is the birthplace of industrial scale uranium mining. Uranium mining at Jáchymov (at that time named Joachimsthal and belonging to Austria-Hungary) started in the 1890s on an industrial scale, after the silver and cobalt production of the deposit declined. Uranium was first utilized to produce mainly yellow colors for glass and porcelain manufacture. After the Curies in France discovered the polonium and radium in tailings from Jáchymov, the town became the first place in the world for commercial radium production from uranium ore. Radioactive water from the mines was also used to set up a health resort still existing today for radon-treatments. Pre–Cold War production is estimated to be around 1,000 t of uranium. From 1947 on the Czech Republic started producing uranium for the Soviet Union. Early mining sites such as Jáchymov, Horní Slavkov and Příbram became known as parts of the "Czech Gulag". In the whole, the Czech Republic produced 110.000 t of uranium to 1992 from 64 uranium deposits. The largest deposit Příbram (vein style) produced about 50.000 t of uranium and was mined to a depth of over 1,800 m.

Today, the Rožná underground facility 55 km northwest of Brno is Europe's only operating uranium mine, continuously operating since 1957. It produces about 300 t of uranium annually. Since 2007, the Australian company Uran Ltd. is interested in participating in the operations at Rožná, as well as seeking permits with the Czech Ministry of Trade and Resources to open mines in the Czech Republic at other known locations, such as Brzkov, Jamné, Polná and Věžnice, through its Czech partner Timex Zdice and since 2008 through its subsidiary Urania Mining.

**Estonia**

See also: Oil shale in Estonia#Dictyonema argillite

During 1946–1952, the Dictyonema argillite (claystone) was mined and used for uranium production in Sillamäe.

**Finland**

In Uusimaa, Karelia and Lapland in Finland, presently (2009) uranium deposits are investigated.

In addition, Talvivaara Mining Company plc has announced in early 2010 the commencement of uranium recovery as a by-product out of its mine producing mainly nickel, copper, zinc and cobalt in Sotkamo, eastern Finland. Production is expected to be approximately 350 tons of yellowcake annually, making Finland almost self-sufficient in uranium, accounting for approximately 80% of annual demand. However, as Finland lacks the required reprocessing facilities to convert yellowcake into nuclear fuel, the mine's output will need to be sent abroad for reprocessing and enrichment.

**Germany**

The search for uranium ore intensified during the cold war, but only in East Germany was an extensive uranium mining industry established. Uranium was mined from 1947 to 1990 from mines in Saxony and Thuringia by the SDAG Wismut. All the uranium mines were closed after the German reunification for economic and environmental reasons. Total production in East Germany was 230,400 t of uranium, making it the third largest producer in history behind the USA and Canada. A minor production still takes place at the Königstein mine southeast of Dresden from cleaning of mine water. This production has been 38 t of uranium in 2007.

**Hungary**

In Hungary uranium mining began in the 1950s around Pécs to supply the country's first atomic plant in Paks. A whole district was built for the mining industry on the outskirt of Pécs, for which the name Uránváros (Uranium city) was given. After the fall of communism, uranium mining was gradually given up because of the high production costs. That caused serious economic problems and a rise of unemployment in Pécs. Recently an Australian company took up the challenge to search for uranium in the Mecsek.

**Portugal**

Portugal has some uranium exploration around the Northern Alentejo town of Nisa, although further exploration of this area is subject to resistance from environmental groups

**Romania**

Romania produced in 2008 around 250 tonnes of uranium., see SovRoms, Crucea - Botusana mine and Băiţa mine.

At the village Ciudanoviţa in the Banat region in the south west of Romania there are closed down mines which provided ore for 50 years but are now closed.

**Slovakia**

Uranium was formerly mined in the Novoveská Huta near Spišská Nová Ves from stratiform deposits. A mine for the extraction of uranium ore was established in the hills of Jahodna near the city of Košice. Tournigan Energy is mining Uranium at the Kuriskova mine, near to Košice. Several other uranium deposits are found in the Považský Inovec Mts. near Kálnica, in the area of Petrova Hora near Krompachy and in the Vikartovský chrbát in Kozie chrbty

The Australian Berkeley Resources Ltd. and Korea Electric Power mine Uranium in the Salamanca Province, near the city of Ciudad Rodrigo. Berkeley Resources is also active in the Cáceres (province), the Barcelona Province and the Guadualajara Province.

**Sweden**

In Sweden, uranium production took place at Ranstadsverket between 1965 and 1969 by mining of alum shale (kind of oil shale) deposits. The goal was to make Sweden self-supplying with uranium. The high operating costs of the pilot plant (heap leaching) due to the low concentration of uranium in the shale and the availability at that time of comparatively cheap uranium on the world market caused the mine to be closed, although a much cheaper and more efficient leaching process, using sulfur-consuming bacteria, had by then been developed. Since 2005 there have been investigations on opening new uranium mines in Sweden.

**United Kingdom**

The South Terras Mine in Cornwall was mined for uranium from 1873 to 1903.

Substantial uranium deposits were found on Orkney in the 1970s. When Margaret Thatcher proposed a uranium mine on Orkney a campaign followed which successfully argued that uranium mining would mean irreversible environmental, social and psychological damage.

**Oceania**

**Australia**



The Ranger Uranium Mine in Australia.

Main article: Uranium mining in Australia

Production in Australia rose significantly to 10,115 tU3O8 (22.3 million pounds) in 2007 from 19.7 million pounds in 2006, securing its position as the second largest uranium producing country, most of the production gain coming from increased operational performance and an increase in the grade of the ore mined.

Australia has the world's largest uranium reserves, 24% of the planet's known reserves. The majority of these reserves are located in South Australia with other important deposits in Queensland, Western Australia and the Northern Territory.

The Olympic Dam operation run by BHP Billiton in South Australia is combined with mining of copper, gold, and silver, and has reserves of global significance. There are currently three operating uranium mines in Australia, and several more have been proposed. The expansion of Australia's uranium mines is supported by the Federal Australian Labor Party (ALP) Government headed by Prime Minister Julia Gillard. The ALP abandoned its long-standing and controversial "no new uranium mines" policy in April 2007. One of the more controversial proposals was Jabiluka, to be built surrounded by the World Heritage listed Kakadu National Park. The existing Ranger Uranium Mine is also surrounded by the National Park, as the mine area was not included in the original listing of the Park.

Uranium mining and export and related nuclear issues have often been the subject of public debate, and the anti-nuclear movement in Australia has a long history.

See also: Uranium mining in Kakadu National Park

**North America**

**Canada**

Main article: Uranium mining in Canada

For many years Canada was the largest exporter of uranium ore, however in 2009 the top spot was taken over by Kazakhstan. The largest Canadian mines are located in the Athabasca Basin of northern Saskatchewan.

Canada's first uranium discovery was in the Alona Bay area, south of Lake Superior Provincial Park in Ontario, by Dr. John Le Conte in 1847. The Canadian uranium industry, however, really began with the 1932 discovery of pitchblende at Port Radium, Northwest Territories. The deposit was mined from 1933 to 1940, for radium, silver, copper, and cobalt. The mine shut down in 1940, but was reopened in 1942 by Eldorado Mining and Refining Limited to supply uranium to the Manhattan Project. The Canadian government expropriated the Port Radium mine and banned private claims taking and mining of radioactive minerals.

In 1947 the government lifted the ban on private uranium mining, and the industry boomed through the 1950s, spurred by high prices due to the nuclear weapons programs. Production peaked in 1959, when twenty-three mines in five different districts made uranium Canada's number-one export. That same year, however, the United Kingdom and the United States announced their intention to halt uranium purchases in 1963. By 1963, seven mines were left operating, a number that shrank to only three in 1972.

A price rise caused uranium to boom again in 1975 and 2005.

**Ontario**

In 1948, prospector Robert Campbell discovered pitchblende at **Theano Point**, in the area of Alona Bay, Ontario, and staked 30 claims. By November 1948 a rush had begun, and in the next three years, 5,000 claims would be staked in the area. A shaft and headframe were constructed, but abandoned before operations could begin; the mine proved unprofitable after uranium discoveries at Elliot Lake, Ontario.

The uranium-bearing pegmatite of Bancroft, Ontario began mining in 1952.

Uranium was discovered at Blind River-Elliot Lake area in 1949, and production began in 1955. The deposits are in Precambrian quartz-pebble conglomerates, similar to uranium deposits in Brazil and South Africa.

**Saskatchewan**



The headframe of the Gunnar mine, in Saskatchewan

Pitchblende veins were discovered near Beaverlodge Lake, Saskatchewan in 1935, and uranium mining started in 1953.

Today the Athabasca Basin in northern Saskatchewan hosts the largest high-grade uranium mines and deposits. Cameco, the world's largest low-cost uranium producer, which accounts for 18% of the world's uranium production, operates three mines and one dedicated mill in the region. Among the major mines are Cameco's flagship McArthur River mine, the developing Cigar Lake mine, the Rabbit Lake mine and mill complex, and the world's largest uranium mill at Key Lake. French-owned uranium syndicate Areva also operates the McClean Lake mill. Most of these mines are joint ventures between Cameco, Areva, and various other joint venture shareholders. Future mines currently in early development stages include Areva's Midwest Project (near McClean Lake), and Cameco's Millennium Project (near Key Lake). As of 2007, with uranium spot market prices well over the $100 USD/lb mark, Saskatchewan has become a hotbed of uranium exploration, with many junior exploration companies rushing to explore the highly valuable Athabasca basin.

**United States**



US Civilian Nuclear Power Reactors
2009 Sources of Uranium

Main article: Uranium mining in the United States

Most uranium ore in the United States comes from deposits in sandstone, which tend to be of lower grade than those of Australia and Canada. Because of the lower grade, many uranium deposits in the United States became uneconomic when the price of uranium declined sharply in the 1980s.

Regular production of uranium-bearing ore in the United States began in 1898 with the mining of carnotite-bearing sandstones of the Colorado Plateau in Colorado and Utah, for their vanadium content. The discovery of radium by Marie Curie, also in 1898, soon made the ore also valuable for radium. Uranium was a byproduct. By 1913, the Colorado Plateau uranium-vanadium province was supplying about half of the world supply of radium. Production declined sharply after 1923, when low-cost competition from radium from the Belgian Congo and vanadium from Peru made the Colorado Plateau ores uneconomic.

Mining revived in the 1930s with higher prices for vanadium. American uranium ores were in very high demand by the Manhattan Project during World War II, although the mining companies did not know that the by-product uranium was suddenly valuable. The late 1940s and early 1950s saw a boom in uranium mining in the western US, spurred by the fortunes made by prospectors such as Charlie Steen.

Uranium mining declined with the last open pit mine (Shirley Basin, Wyoming) shutting down in 1992. United States production occurred in the following states (in descending order): New Mexico, Wyoming, Colorado, Utah, Texas, Arizona, Florida, Washington, and South Dakota. The collapse of uranium prices caused all conventional mining to cease by 1992. In-situ leach mining has continued primarily in Wyoming and adjacent Nebraska as well has recently restarted in Texas. Rising uranium prices since 2003 have increased interest in uranium mining in the United States.

**Arizona**

On Wednesday 25 June 2008 the House Natural Resources Committee voted overwhelmingly to enact emergency protections from uranium mining for 1,000,000 acres (4,000 km2) of public lands around Grand Canyon National Park. This will mean the Secretary of the Interior has an obligation to protect public lands near the Grand Canyon from uranium extraction for three years. The Center for Biological Diversity, Sierra Club, and the Grand Canyon Trust recently won a court order against the Kaibab National Forest stopping uranium drilling near the national park until a thorough environmental analysis is conducted.

The Grand Canyon Watersheds Protection Act has been proposed. This bill would permanently ban uranium mining in the area. The impacts of uranium development have raised concerns of scientists and government officials alike. Due to increasing demand, uranium projects have been on the increase, raising concerns about water, public health, and fragile desert ecosystems.