



Australia's nuclear industry

Uranium mining in Australia

Scientists have discovered more than 150 uranium-bearing minerals. The most important are:

- uraninite (UO_2);
- pitchblende (a mixed oxide, usually U_3O_8);
- brannerite (a complex oxide of uranium, rare earths, iron and titanium); and
- coffinite (uranium silicate).

Most of the world's uranium is produced from pitchblende ores. One third of the world's uranium reserves are in Australia, which produces approximately 11% of the world's mined uranium.

Uranium has been mined in Australia since the 1950s. It was also produced as a by-product of radium mining in the 1930s. Australia currently has four operational mines with a fifth planned.

MINE	STATE	2013 PRODUCTION (tonnes U_3O_8)
Ranger	NT	2960
Olympic Dam	SA	4009
Beverley	SA	407
Honeymoon	SA	112
Four Mile	SA	planned

Six mines that were operational before 1988 are now closed (Radium Hill, Rum Jungle, Mary Kathleen, Moline, Rockhole and Nabarlek).

From 2000 to 2012, Australia exported almost 120 000 tonnes of uranium oxide concentrate valued at over A\$7.8 billion⁽¹⁾. Australian uranium is only exported to countries that meet strict safeguard requirements set by the government. These agreements have been developed to ensure uranium is used solely for production of electricity, not nuclear weapons. Australia does not currently generate electricity from nuclear power. However, as electricity production costs rise, nuclear energy may be required as a future source of energy.

Uranium is mined by three main methods⁽²⁾:

- Open-cut mining is used for deposits close to the Earth's surface (e.g. Ranger, Nabarlek, Mary Kathleen and Rum Jungle deposits).
- Underground mining is used for deeper ore bodies (e.g. Olympic Dam, Radium Hill and Moline).
- In-situ leaching is used where ore bodies lie in groundwater in porous unconsolidated material. Uranium minerals are removed without major ground disturbance by pumping an acidic or alkaline solution through the permeable ore body to dissolve uranium. Uranium is recovered from these solutions in a processing plant (e.g. Beverley and Honeymoon deposits).

Around 30% of the world's uranium comes from open-cut mines, 50% from underground mines and 20% from in-situ leaching.

Processing uranium ore

After mining, uranium ore is crushed and ground to a fine grain size. Grinding and mixing with water produces a slurry. Depending on the metallurgical characteristics of the ore, this slurry is then leached with either an acidic or an alkaline solution that dissolves uranium.

Residual solid materials, called 'tailings', separate from the uranium-rich liquid by settling. This liquid is then filtered to remove remaining solids. Uranium is recovered from solution through solvent extraction, ion exchange or direct precipitation.

Recovered uranium is in the form of a chemical precipitate. It is filtered and dried to produce a yellow powder known as 'yellowcake'. Yellowcake is heated to about 700 °C to produce a dark grey-green powder containing more than 98% uranium oxide (U_3O_8). The refined powder is stored in 200 L steel drums, ready for export. At a distance of one metre, a drum of freshly produced uranium oxide emits approximately half the radiation exposure that a passenger on a commercial aeroplane flight receives from cosmic rays emitted from space.

Radiation protection standards

The International Commission for Radiological Protection (ICRP) has established recommended standards of protection based on three principles.

- Exposure must be justified and must produce a net benefit.
- Risks should be kept as low as possible. Protection should be maximised and doses should be minimised.
- Dose limits should be allocated and enforced.

When it comes to safety, the majority of scientists, including international agencies such as the United Nations and the International Atomic Energy Agency, support the conservative 'no safe threshold' view. This assumes there is no safe threshold for nuclear radiation, and that any level of radiation carries the risk of causing irreparable mutations. Even so, there are some instances where radiation is unable to be controlled or where the benefits outweigh the risks. Examples include:

- natural background radiation which cannot be easily controlled,
- medical radiation where benefits usually outweigh the risks, and
- applications such as the use of radioactive americium-241 in smoke detectors.

Most scientists believe that no level of exposure to nuclear radiation is safe. However, some scientists think human cells can completely recover from very small amounts of radiation. They also believe that cells of organisms can benefit from nuclear radiation due to exposure to background radiation throughout their evolution.

Production of radioisotopes

Radioisotopes (radioactive isotopes) may exist in any form of matter, with solid materials comprising the largest group.

Radioisotopes can be produced in the following ways:

- neutron activation (bombardment),
- fission product separation, and
- particle acceleration (charged particle bombardment).

Neutron activation is the major method used to obtain industrially important radioisotopes. In this method atomic nuclei capture neutrons, which results in an excess of neutrons in nuclei (they are neutron-rich).

Australia's OPAL reactor, operated by the Australian Nuclear Science and Technology Organisation (ANSTO), was opened in 2007. It has significantly increased the quality, quantity and range of radioisotopes produced in Australia. OPAL uses low-enriched uranium fuel (manufactured in Argentina) and produces a relatively high neutron flux. Technetium-99m, molybdenum-99 and iridium-192 are typical radioisotopes produced at OPAL.

Some radioisotopes are manufactured by particle acceleration using a cyclotron. Particles are directed at high speeds towards a suitable target element to produce a nuclear reaction that creates a radioisotope. ANSTO operate a cyclotron at the Royal Prince Alfred Hospital in Sydney. It is used to make radiopharmaceuticals for diagnostic imaging. Isotopes produced in a cyclotron typically have shorter half-lives than isotopes produced in a reactor. This is why cyclotrons are often located in hospitals, close to the patients that require them.

In Australia, the production and delivery of radioisotopes is overseen by ANSTO Health, a government organisation⁽³⁾.

Uses of radioisotopes

Radioisotopes play an increasingly important part in Australian life⁽⁴⁾. They are used in many fields, including medicine, industry and the environment. Up to 200 radioisotopes are used on a regular basis in Australia, most requiring artificial production.

MEDICAL USES	INDUSTRIAL USES	SCIENTIFIC USES
nuclear imaging	mineral analysis	hydrogeology
diagnostic investigations	industrial radiology	environmental monitoring
therapeutic treatment	measurement	tracers
external radiotherapy	smoke detectors	
brachytherapy	food preservation	
biochemical analysis	tracers	
equipment sterilisation	mineral analysis	

Radiopharmaceuticals are used in nuclear medicine for direct treatment, pain relief, and to assist with diagnosing diseases through imaging techniques. Radiopharmaceuticals may be injected, inhaled or ingested. Over 80% of radioisotopes used in medical medical procedures worldwide come from reactors.

Importing radioisotopes

Australia needs to produce its own radio-pharmaceuticals due to reliability problems with overseas imports and regulations relating to transport of radioactive materials. Imported radiopharmaceutical products can 'miss' flights, or be delayed due to weather conditions. International air transport regulations prohibit radioactive materials of any type being carried in the same hold as live animals or food. There are also strict guidelines on the separation distance of passengers from radioactive materials.

The amount of radioactive material that can be carried on flights is subject to strict safety limits. Pilots can refuse to carry radioactive materials on their flights, and some airlines no longer carry radioactive materials at all. Transportation delays can result in partial or complete product decay.

References

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