

Petro genesis of Uranium Deposits

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1.Introduction

A. Petro genesis definition

The branch of petrology dealing with the origin and formation of rocks or the formation of rocks, especially igneous and metamorphic rocks.

B. Uranium ore

Uranium ore deposits are economically recoverable concentrations of uranium within the Earth's crust. Uranium is one of the more common elements in the Earth's crust, being 40 times more common than silver and 500 times more common than gold. It can be found almost everywhere in rock, soil, rivers, and oceans. The challenge is to find those areas where the concentrations are adequate to form an economically viable deposit.

Globally, the distribution of uranium ore deposits is widespread on all continents, with the largest deposits found in Australia, Kazakhstan, and Canada. To date, high-grade deposits are only found in the Athabasca Basin region of Canada.

Uranium deposits are generally classified based on host rocks, structural setting, and mineralogy of the deposit. The most widely used classification scheme was developed by the International Atomic Energy Agency (IAEA) and subdivides deposits into 15 categories.

2. Uranium

Uranium is a silvery-gray metallic weakly radioactive chemical element. It has the chemical symbol U and atomic number 92. The most common isotopes in natural uranium are ^{238}U (99.27%) and ^{235}U (0.72%). All uranium isotopes present in natural uranium are radioactive and fissionable, and ^{235}U is fissile (will support a neutron-mediated chain reaction). Uranium, thorium, and potassium are the main elements contributing to natural terrestrial radioactivity.

Uranium has the highest atomic weight of the naturally occurring elements and is approximately 70% denser than lead, but not as dense as tungsten, gold, platinum, iridium, or osmium. It is always found combined with other elements. Along with all elements having atomic weights higher than that of iron, it is only naturally formed in supernova explosions.

A. General Properties

Name, symbol	uranium, U
Appearance	silvery gray metallic; corrodes to a spalling black oxide coat in air

B. Uranium in the periodic table

Group, block	group n/a, f-block
Period	period 7
Element category	actinide
Standard atomic weight ($\pm$) (Ar)	238.02891(3)[1]
Electron configuration	[Rn] 5f ³ 6d ¹ 7s ²
per shell	2, 8, 18, 32, 21, 9, 2

C. Physical properties

Phase	solid
Melting point	1405.3 K (1132.2 °C, 2070 °F)
Boiling point	4404 K (4131 °C, 7468 °F)
Density near room temperature	19.1 g/cm ³
when liquid, at m.p.	17.3 g/cm ³
Heat of fusion	9.14 kJ/mol
Heat of vaporization	417.1 kJ/mol
Molar heat capacity	27.665 J/(mol·K)

Vapor pressure

P (Pa)	1	10	100	1000	10000	100000
at T (K)	2325	2564	2859	3234	3727	4402

D. Atomic properties

Oxidation states	6,5,4,3,[2]2,1 (a weakly basic oxide)
Electronegativity	Pauling scale: 1.38
Ionization energies	1st: 597.6 kJ/mol 2nd: 1420 kJ/mol
Atomic radius	empirical: 156 pm
Covalent radius	196±7 pm
Van der Waals radius	186 pm

E. History

Naming	after planet Uranus, itself named after Greek god of the sky Uranus
Discovery	Martin Heinrich Klaproth (1789)
First isolation	Eugène-Melchior Péligot (1841)

F. Miscellanea

Crystal structure	orthorhombic
Speed of sound thin rod	3155 m/s (at 20 °C)
Thermal expansion	13.9 $\mu\text{m}/(\text{m}\cdot\text{K})$ (at 25 °C)
Thermal conductivity	27.5 W/(m·K)
Electrical resistivity	0.280 $\mu\Omega\cdot\text{m}$ (at 0 °C)
Magnetic ordering	paramagnetic
Young's modulus	208 GPa
Shear modulus	111 GPa
Bulk modulus	100 GPa
Poisson ratio	0.23
Vickers hardness	1960–2500 MPa
Brinell hardness	2350–3850 MPa
CAS Number	7440-61-1

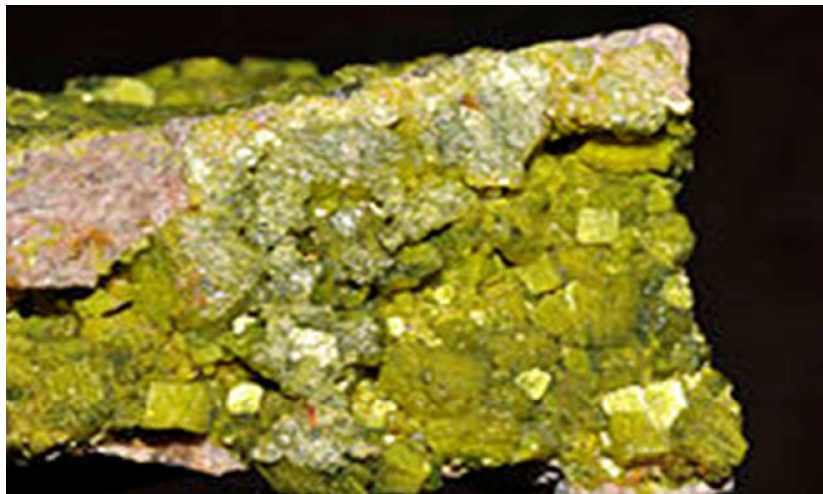
G. Most stable isotopes of uranium

iso	NA	half-life
²³² U	syn	68.9 y
²³³ U	trace	1.592×10 ⁵ y
²³⁴ U	0.005%	2.455×10 ⁵ y
²³⁵ U	0.720%	7.04×10 ⁸ y
²³⁶ U	trace	2.342×10 ⁷ y
²³⁸ U	99.274%	4.468×10 ⁹ y

3. Uranium Minerals



Uraninite, also known as pitchblende



Autunite, a secondary uranium mineral named after the town of Autun in France



Torbernite, an important secondary uranium mineral

The primary uranium ore mineral is uraninite (UO_2) or pitchblende. A range of other uranium minerals can be found in various deposits. These include carnotite, tyuyamunite, torbernite and autunite. The davidite-brannerite-absite type uranium titanates, and the euxenite-fergusonite-samarskite group are other uranium minerals.

A large variety of secondary uranium minerals are known, many of which are brilliantly coloured and fluorescent. The most common are gummite, autunite (with calcium), saleeite (magnesium) and torbernite (with copper); and hydrated uranium silicates such as coffinite, uranophane (with calcium) and sklodowskite (magnesium).

4. Ore Genesis

There are several themes of uranium ore deposit formation, which are caused by geological and chemical features of rocks and the element uranium. The basic themes of uranium ore genesis are host mineralogy, reduction-oxidation potential, and porosity.

Uranium is a highly soluble, as well as a radioactive, heavy metal. It can be easily dissolved, transported and precipitated within ground waters by subtle changes in oxidation conditions. Uranium also does not usually form very insoluble mineral species, which is a further factor in the wide variety of geological conditions and places in which uranium mineralization may accumulate.

Uranium is an incompatible element within magmas, and as such it tends to become accumulated within highly fractionated and evolved granite melts, particularly alkaline examples. These melts tend to become highly enriched in uranium, thorium and potassium, and may in turn create internal pegmatites or hydrothermal systems into which uranium may dissolve.

5. Classification schemes

IAEA Classification (1996)

The International Atomic Energy Agency (IAEA) assigns uranium deposits to 15 main categories of deposit types, according to their geological setting and genesis of mineralization, arranged according to their approximate economic significance.

1. Unconformity-related deposits
2. Sandstone deposits
3. Quartz-pebble conglomerate deposits
4. Breccia complex deposits
5. Vein deposits or Granite-related deposits
6. Intrusive deposits (Alaskites)
7. Phosphorite deposits
8. Collapse breccia pipe deposits
9. Volcanic deposits
10. Surficial deposits
11. Metasomatite deposits
12. Metamorphic deposits
13. Lignite
14. Black shale deposits
15. Other types of deposits

1. Unconformity-related deposits

Unconformity-related deposits arise from geological changes occurring close to major Proterozoic unconformities. Below the unconformity, the metasedimentary rocks which host the mineralisation are usually faulted and brecciated. The overlying younger Proterozoic sandstones are usually undeformed. Unconformity-related deposits constitute about one-third of the western world's uranium resources and they include some of the largest and richest deposits. Minerals are uraninite and pitchblende associated with strong quartz dissolution.

The main deposits occur in

- A. Canada (the Athabasca Basin,
- B. Saskatchewan and Thelon Basin, Northwest Territories); and
- C. Australia (the Alligator Rivers region in the Pine Creek Geosyncline, NT and Rudall River area, WA).

All of Canada's uranium production in Saskatchewan over the last 40 years is from unconformity-related deposits – Key Lake, Cluff Lake, Rabbit Lake, McClean Lake, McArthur River and Cigar Lake deposits – with some ore around 20% uranium. The deposits in the Athabasca Basin occur below, across and immediately above the unconformity, with the highest grade deposits situated at or just above the unconformity (e.g. Cigar Lake and McArthur River). In the Alligator Rivers region, the known deposits (Ranger, Jabiluka, Koongarra and Nabarlek) are basement-hosted below the unconformity and like their Canadian counterparts Eagle Point, Millennium, Triple R and Kiggavik, and the Kintyre deposit in the Rudall River area of Western Australia, are generally lower grade.

Strata-bound structure-controlled unconformity deposits include the low-grade Chitral and Lambapur deposits, **Cuddapah Basin, India.**

2. Sandstone deposits

Sandstone uranium deposits occur in medium- to coarse-grained sandstones deposited in a continental fluvial or marginal marine sedimentary environment. Impermeable shale/mudstone units are interbedded in the sedimentary sequence and often occur immediately above and below the mineralised sandstone. Uranium is precipitated under reducing conditions caused by a variety of reducing agents within the sandstone including: carbonaceous material (detrital plant debris, amorphous humate, marine algae), sulphides (pyrite, H_2S), hydrocarbons, and interbedded basic volcanic ash with abundant ferro-magnesian minerals (e.g. chlorite).

Five main sub-types of sandstone deposits, often mixed:

- **Basal channel deposits** – wide channels filled with permeable sediments. Examples are Dalur and Khiagda (Russia) and Beverley and Honeymoon (South Australia).
- **Tabular deposits** – irregular, elongate lenticular bodies parallel to the depositional trend, deposits commonly occur in palaeochannels incised into underlying basement rocks. Examples are Akouta, Arlit, and Imouraren (Niger), Hamr-Stráž pod Ralskem (Czech Rep) and those of the Colorado Plateau (USA).
- **Roll-front deposits** – arcuate bodies of mineralisation that crosscut sandstone bedding, often in palaeochannels. Examples are Budenovskoye, Tortkuduk, Moynkum, Inkai and Mynkuduk (Kazakhstan) and Crow Butte and Smith Ranch (USA).
- **Tectonic/ lithologic deposits** – occur in sandstones adjacent to a permeable fault zone. Examples are in the Lodève District (France) and the Franceville Basin (Gabon).
- **Mafic dykes or sills in Proterozoic sandstones** – Examples at Matoush (Canada) and Westmoreland (Australia).

Sandstone deposits constitute about 18% of world uranium resources and 41% of known deposits, and are of major economic importance in Kazakhstan, Uzbekistan, USA and Niger. Orebodies of this type are commonly low to medium grade (0.05 - 0.35% U) and individual orebodies are small to medium in size (ranging up to a maximum of 50,000 tU). Roll-front sub-types are mined by in situ leach (ISL) methods. Imouraren (Niger) and some Kazakh deposits are larger. The main primary U minerals are uraninite and coffinite.

The USA has large resources in sandstone deposits in the Western Cordillera region, and most of its uranium production has been from these deposits, recently by in situ leach (ISL) mining. The Powder River Basin in Wyoming, the Colorado Plateau and the Gulf Coast Plain in south Texas are major sandstone uranium provinces. Other large sandstone deposits occur in Niger, Gabon (Franceville Basin), and in the eastern part of Africa, in the Karoo Formation (Malawi, Tanzania, Zambia, South Africa).

3. Quartz-pebble conglomerate deposits

Detrital uranium occurs in some Archaean-early Palaeoproterozoic quartz-pebble conglomerates that unconformably overlie granitic and metamorphic basement. Quartz-pebble conglomerate uranium deposits occur in conglomerates deposited in the range 3070-2300 million years ago. Fluvial transport of detrital uraninite was possible at the time because of the prevailing anoxic atmosphere. Rare earths and thorium may be present.

Where uranium is recovered as a by-product of gold mining, such as at Witwatersrand in South Africa, the grade may be as low as 0.01%U. In uranium-dominant deposits such as at Elliot Lake in Canada average grades range as high as 0.15%U. Uranium is associated with rare earths.

4. Breccia complex deposits

Olympic Dam is the world's largest deposit of uranium, and accounts for the major part of Australia's uranium resources, though it is only recovered as a by-product with copper. Both it and Carrapateena occur in a hematite-rich granite breccia complex in the Gawler Craton, overlain by approximately 300 metres of flat-lying sedimentary rocks of the Stuart Shelf geological province.

The central core of the complex is barren hematite-quartz breccia, with several localised diatreme structures, flanked to the east and west by zones of intermingled hematite-rich breccias and granitic breccias. These zones are approximately one kilometre wide and extend almost 5 km in a northwest-southeast direction. Virtually all the economic copper-uranium mineralisation is hosted by these hematite-rich breccias. This broad zone is surrounded by granitic breccias extending up to 3 km beyond the outer limits of the hematite-rich breccias.

The deposit contains iron, copper, uranium, gold, silver, rare earth elements (mainly lanthanum and cerium) and fluorine. Only copper, uranium, gold, and silver are recovered. Uranium grades average from 0.07 to 0.035% U, the higher-grade mineralisation being pitchblende. Copper grades average 2.7% for proved reserves, 2.0% for probable reserves, and 1.1% for indicated resources.

Details of the origin of the deposit are still uncertain. However the principal mechanisms which formed the breccia complex are considered to have been hydraulic fracturing, tectonic faulting, chemical corrosion, and gravity collapse. Much of the brecciation occurred in near surface eruptive environment of a crater complex during eruptions caused by boiling and explosive interaction of water (from lake, sea or groundwater) with magma.

5. Vein deposits

Two sub-types: Endogranitic and Perigranitic. Includes many vein deposits in granite, deposits in adjacent meta-sedimentary rocks, and also disseminated mineralisation in granite. The dimensions of the openings have a wide range, from the massive veins of pitchblende at Jachymov deposit (Czech Republic), to the narrow pitchblende-filled cracks, faults and fissures in some of the ore bodies in Europe, Canada and Australia.

6. Intrusive deposits (Alaskites)

Included in this type are those associated with a variety of intrusive rocks including alaskite, granite, pegmatite, and monzonites. Major world deposits include Rössing and Husab (Namibia), Kvanefjeld (Greenland), Bancroft area (Canada), and Palabora (South Africa). In South Australia, Radium Hill was mined 1954-62, and large bodies of low-grade mineralisation occur in the Olary Province.

7. Phosphorite deposits

Sedimentary phosphorites of marine origin contain low concentrations of uranium in fine-grained apatite. Uranium concentrations are very low – 0.005-0.015%U. Very large phosphorite deposits occur in the USA (Florida and Idaho), Morocco, Jordan and other Middle Eastern countries and these are mined for phosphate. Where phosphoric acid is produced, uranium is sometimes extracted as a by-product, for example, in Florida. Continental phosphate deposits seldom have uranium, an exception is Bakouma (Central African Rep).

Estimates range to 22 million tonnes of uranium in these deposits, but most is subeconomic at present even as by-product of phosphate fertilizer production, unless new processes are deployed.

8. Collapse breccia pipe deposits

These occur in circular, vertical collapse structures filled with coarse fragments and a fine matrix of the penetrated sediments. The collapse pipes are 30-200 metres in diameter and up to 1000 metres deep. Uranium mineralisation is mostly within permeable sandstone breccias within the pipe. The principal uranium mineral is pitchblende. All examples of this type are near the Grand Canyon (USA), notably in the Arizona Strip.

9. Volcanic deposits

Uranium deposits of this type occur in and near volcanic calderas, in acid to intermediate volcanic rocks, and are related to faults and shear zones. Uranium occurs in veins or disseminated and is commonly associated with molybdenum and fluorite. Significant deposits of this type occur in China (Xiangshan), Kazakhstan, Mongolia (Dornod and Gurvanbulag), Russian Federation (Streltovska caldera, the major occurrence), Peru and Mexico. In Australia, they are minor – Ben Lomond and Maureen in Qld are the most significant.

10. Surficial deposits

Surficial uranium deposits are broadly defined as young (Tertiary to Recent) near-surface uranium concentrations in sediments or soils. These deposits usually have secondary cementing minerals including calcite, gypsum, dolomite, ferric oxide, and halite. Uranium deposits in calcrete are the largest of the surficial deposits. Uranium mineralisation is in fine-grained surficial sand and clay, cemented by calcium and magnesium carbonates. The uranium mineralisation is usually carnotite (hydrated potassium uranium vanadium oxide).

They formed where uranium-rich basement formations (granites, sandstones) were deeply weathered in a semi-arid to arid climate

and deposited in valley-fill sediments along Tertiary drainage channels, and in playa lake sediments. The Yeelirrie deposit in Western Australia is one of the world's largest surficial deposits. Other significant deposits in WA include Lake Way, Centipede, Thatcher Soak, and Lake Maitland. Calcrete uranium deposits also occur in the Central Namib Desert of Namibia, the largest being the Langer Heinrich deposit, also Trekkopje.

11. Metasomatite deposits

Metasomatite deposits consist of unevenly disseminated uranium in structurally deformed rocks that were affected by sodium and/or potassium metasomatism. Major examples of this type include Elkon district (Russia), the Lagoa Real-Caetite district (Brazil), Novokonstantinovskoye and those near Zheltye Vody (Ukraine), Valhalla and Skal (Australia), Michelin (Canada) and Lianshanguan (China).

12. Metamorphic deposits

Metamorphic-type uranium deposits occur in metasediments and/or metavolcanics unrelated to granite. Examples include the deposits at Forstau (Austria), Shinkolobwe deposit (DR Congo), Rozna (Czech Rep), Jaduguda (India), Kokshetau District (Kazakhstan) and Port Radium (Canada). In Australia the largest of this type was Mary Kathleen uranium/rare earth deposit near Mount Isa, Qld, which was mined 1958-63 and 1976-82. That orebody occurs in a zone of calcium-rich alteration within Proterozoic metamorphic rocks. The Itataia deposit in Brazil is marble-hosted phosphate.

13. Lignite

Uranium occurs in lignite or coal mixed with mineral detritus (silt, clay), and in immediately adjacent carbonaceous mud and silt/sandstone beds. Pyrite content is high. Examples include those in North and South Dakota (USA), Mulga Rock (Western Australia), Springbok Flats (South Africa), Nizhneylyiskoye (Kazakhstan), and Freital (Germany). Uranium has been adsorbed onto carbonaceous matter and consequently no discrete uranium minerals have formed.

There is estimated to be over 7 million tonnes of uranium in these deposits, but most is subeconomic at present.

14. Black shale deposits

Black shale-related uranium mineralisation consists of marine organic-rich shale or coal-rich pyritic shale, containing syngenetic disseminated uranium adsorbed onto organic material and clays. Examples include the uraniferous Alum shale in Sweden, the Rudnoye and Zapadno-Kokpatasskaya deposits in Uzbekistan, the Chatanooga shale in the USA, deposits in the Guangxi Autonomous Region, China, and the Gera-Ronneburg deposit, Germany.

Estimates range over 50 million tonnes of uranium in these deposits; they are mostly subeconomic at present.

15. Carbonate deposits

Deposits are hosted in limestone or dolomite, often related to karsts, fractures, faults and folds. Examples include the large strata-bound **Tummalapalle (India)**, Mailuu-Suu (Kyrgyzstan) and Bentou-Sanbaqi (China).

7. Uranium Deposit of India

Jaduguda in Singhbhum Thrust Belt (in the state of Jharkhand, formerly part of Bihar) is the first uranium deposit to be discovered in the country in 1951. The Singhbhum Thrust Belt (also known as Singhbhum Copper belt or Singhbhum shear Zone) is a zone of intense shearing and deep tectonization with less than 1km width and known for a number of copper deposits with associated nickel, molybdenum, bismuth, gold, silver etc. It extends in the shape of an arc for a length of about 160 km.

This discovery of uranium at Jaduguda in this belt paved the way for intensive exploration work and soon a few more deposits were brought to light in this area. Some of these deposits like Bhatin, Narwapahar and Turamdih are well known uranium mines of the country. Other deposits like Bagjata, Banduhurang and Mohuldih are being taken up for commercial mining operations. Some of the other areas like Garadih, Kanyaluka, Nimdih and Nandup in this belt are also known to contain limited reserves with poor grades.

Apart from discoveries in the Singhbhum Thrust Belt, several uranium occurrences have also been found in Cuddapah basin of Andhra Pradesh. These include Lambapur-Peddagattu, Chitral, Kuppunuru, Tumallapalle, Rachakuntapalle which have significantly contributed towards the uranium reserve base of India. In the Mahadek basin of Meghalaya in North-Eastern part of the country, sandsyone type uranium deposits like Domiasiat, Wakhyn,

Mawsynram provide near-surface flat orebodies amenable to commercial operations. Other areas in Rajsthan, Karnataka and Chattishgarh hold promise for developing into some major deposits. (Fig.1).

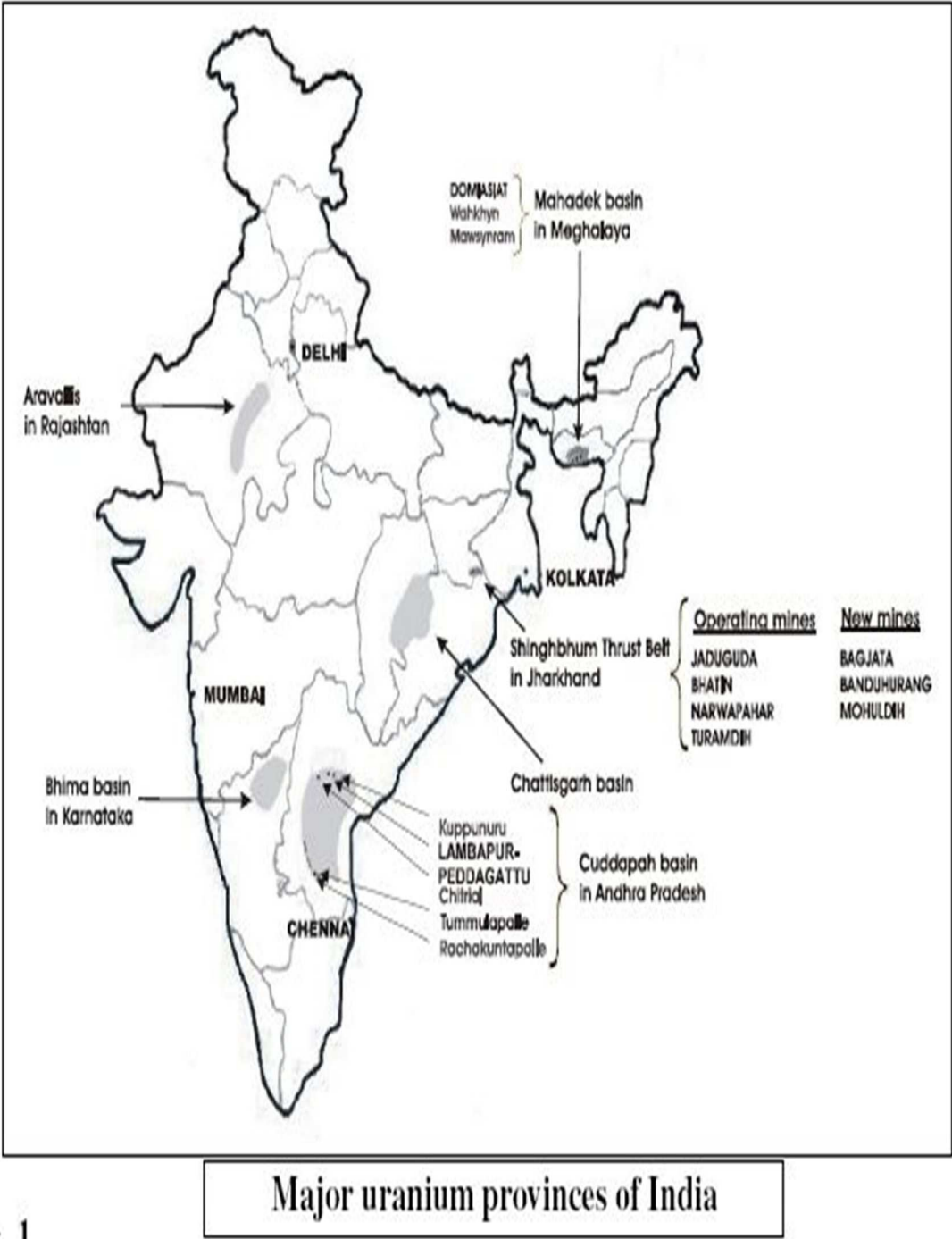


Fig. 1.

8. Uranium mining in India

The uranium mining in India made an exciting beginning with the formation of Uranium Corporation of India Ltd. in 1967 under the Department of Atomic Energy. Since then, the uranium industry of the country has recorded phenomenal growth in production and upgradation of technology. The corporation launched its operation with the commissioning of an underground mine and ore processing plant at Jaduguda (1968). Subsequently, underground mines at Bhatin (1987), Narwapahar (1995) and Turamdih (2003) were commissioned. All these units are within 25 km from Jaduguda in the state of Jharkhand. The process plant at Jaduguda was progressively expanded embracing newer technologies to treat additional ore generated from the new mines.

Keeping in view the nation's endeavour to expand nuclear energy infrastructure (20,000 MWe by 2020 AD from the present capacity of 2770 MWe), new uranium mines are being opened by UCIL not only in the Singhbhum Thrust Belt of Jharkhand but also in other parts of the country.

8.1. Operating mines

Jaduguda Mine: Jaduguda is the first mine in the country to produce uranium ore in a commercial scale. In this deposit, two parallel lodes extend from surface up to a depth of 905 m, which may also persist deeper. The mineralization is structurally controlled being confined to shears. The entry into the mine is through a vertical shaft of 640 m deep, which was sunk in two stages - from surface to 315 m and then from 315 m to 640 m. The mine has been further deepened by sinking an underground vertical shaft from a depth of 555 m to 905 m. Both the shafts are equipped with two tower mounted multi-rope friction winders – the Cage winder and the Skip winder. Double deck

cages are used for movement of men and material and for hoisting of waste rock. Skips with a payload of 5 tonne are used for hoisting of ore. Levels are generally developed at vertical intervals of 65 meters. The principal stoping method adopted in Jaduguda Mine is horizontal cut-and-fill using de-slimes mill tailing as the fill. Jaduguda mine is presently the deepest operating mine of the country.

Bhatin Mine: Bhatin is a small uranium deposit situated 3 km west of Jaduguda. Geological settings, mineral assemblages and other host rock characteristics in this deposit are similar to those of Jaduguda deposit. The mine is now 215 m deep. The entry into the mine is through adits. The lower levels are accessed by two principal winzes and are equipped with double drum winders with provision for man winding. The levels are developed at 50 m interval. The stoping method is similar to that of Jaduguda. As the ore body is narrow, only pneumatic equipment are used for stoping and development work. Ore from Bhatin mine is transported by road to Jaduguda for processing and the de-slimes tailings of Jaduguda mill is sent back for mine back-filling. Mine deepening at Bhatin has now been taken up to create additional production levels.

Narwapahar Mine: It is a large deposit located 12 km west of Jaduguda. This mine was commissioned in 1995. A 70 decline has been developed as entry to the mine in the footwall side of the ore body through which large machinery move underground. From the decline, ramps are developed as entry to the stopes at different elevations, which facilitates the movement of twin-boom drill jumbo, low-profile-dump-truck, service truck, passenger carrier, low profile grader, scissor-lift etc. This system of mining has effected early commissioning of the mine with high productivity and low mining cost. It has also provided the flexibility to adopt different stoping methods that becomes suitable due to the variations in width and

inclination of the ore lenses. Movement of men and hoisting of ore from deeper levels is done through a vertical shaft sunk up to a depth of 355 m. Cut-and-fill is the principal stoping method adopted in Narwapahar mine. Ore from this mine is sent to Jaduguda by road for processing. The de-slimed mill tailings of Jauguda mill and the waste generated from the mine are used as the filling material. The split ventilation system, microprocessor based bulk ore assaying system with automatic grade estimation and subsequent computation are some distinctive features in this mine.

Turamdih mine: Turamdih uranium deposit is located about 24 km west of Jaduguda. The entry into the mine has been established through a 80 decline which provides facilities for using trackless mining equipment like passenger carrier, drill jumbo, low-profile dump truck etc. At a depth of 70 m (first level), the ore body has been accessed from the decline by a cross-cut. Drives are being developed following the contacts of ore body. Ventilation shafts have been sunk in line with the requirement of adequate fresh air. The development faces are ventilated by auxiliary ventilation system using auxiliary fans and flexible ducts. A vertical shaft of 5 m diameter is being sunk from surface up to a depth 250 m with facilities for ore hoisting and movement of men and material. The ore from this mine will be processed in the new plant, which is under construction near the mine site at Turamdih.

8.2. New mines in the state of Jharkhand

Banduhurang mine: This deposit is the western extension of Turamdih mineralization, where part of the ore body outcrops at surface. It is a low-grade, large tonnage deposit. After the initial evaluation, the techniques of computerised ore body modeling and mine planning using SURPAC software was carried out. Open-pit

mining method has been considered as the most favourable option. The pit limits were optimised using WHITTLE software and the layout of the mine as been finalized with all finer details. The pit will attain the ultimate depth of 160 m with ore to overburden ratio of 1:2.7. Ultimate pit slope has been designed for 47° up to a depth of 120 m and 44° below 120 m. The proposed mining at Banduhurang will be a conventional opencast mine using excavator-dumper combination. Careful selection of earth moving equipment has been done to maintain ore benches of 6m height and over burden/waste benches of 6 m/12 m height. A code of practice has been formulated for control of run-off-mine quality for this low-grade deposit with the introduction of bio-informatics.

The pit will also undergo simultaneous back-filling with the overburden (Fig. 2). The work on development of this deposit will start soon. The ore of Banduhurang mine will be processed in the new plant at Turamdih.

Bagjata Mine: This deposit is about 30 km south-east of Jaduguda, where the ore body extends like a thin vein up to a depth of 600 m. This mine is being developed in the first stage up to 300 m. It will become operational soon with a 70° decline as the access into the mine.

The levels will be developed at 50 m interval. The method of stoping will be cut-and fill with cross-cuts/ramps from decline as the entry to stopes. Moderate level of mechanisation with the deployment of single-boom drill jumbo, LHD, LPDT etc is proposed in this mine. A vertical shaft initially up to a depth of 375 m will be sunk to provide access of men and material to deeper levels. The ore of Bagjata will be processed in Jaduguda plant and the de-slimed mill tailings from Jaduguda will be sent to Bagjata for back-filling.

Mohuldih Mine: This deposit is located about 27 km west of Jaduguda, about 3 km west of proposed Banduhurang open cast mine. The ore body extends like a thin vein up to a depth of 320 m. This deposit will also be opened with a decline as the access and a vertical shaft up to a depth of 355 m will be used for men and material transport. The levels will be developed at 50 m interval. Trackless equipment will be employed in this mine. The principal method of stoping will be cut-and-fill. The ore of Mohuldih will be treated in the Turamdih plant.

8.3. New mines in the state of Andhra Pradesh

Lambapur-Peddagattu mine: The deposits in this region fall along the unconformity contacts of underlying granites and overlying quartzites. The flat orebody with varying thickness is spread over five distinct blocks and occurring within a depth of 15 m to 60 m. Considering the nature and depth of occurrence of ore lenses, one opencast mine and three underground mines have been planned in this region. The open pit mine will extend only up to a depth of 15 m with ore to overburden ratio of 1:4.2. The underground mines will be about 70 m deep accessed by declines. Room-and-pillar stoping method will be followed using low profile drilling machine, LHD and LPDT. Ore will be hoisted to the surface through central conveyor and transported by road to the plant.

8.4. New mines in the state of Meghalaya

Domiasiat mine: This deposit with large and good grade uranium reserve is hosted in a thick pile of sandstone within a depth of about 40m with underlying granite. A small rivulet flowing in the area divides the deposit into two separate mining blocks. Both the blocks Killung and Rangam will be mined by open pit mining method up to a depth of 45 m with ore to overburden ratio of 1:6.7. The pit will be

concurrently backfilled with mill tailings and overburden. (Fig. 4) Since the deposit falls in a very high rainfall area, special measures are planned for mine dewatering and the safe disposal of water to the aquatic environment.

Tummalapalle uranium deposit: The large uranium reserve discovered in the Proterozoic Cuddapah basin in the state of Andhra Pradesh is hosted by carbonate rock formations. The strata bound ore body has been delineated up to a depth of 275 m extending like thin veins from surface. The orebody has fairly uniform dip and width. Underground exploratory mining work in this deposit has been completed confirming the configuration of ore body. The ore recovered from the exploratory mine is being used for various laboratory and pilot plant studies.

Rohili uranium deposit: This area in the state of Rajasthan is under advanced stage of detailed exploration. The steeply dipping ore body in the albitite host rock already identified up to a depth of 100 m holds the promise of a deep underground mine. Pre-project activities in this area will start soon.

9. REFERENCES

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