Uranium Mining and Processing in India

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Preamble

The paper explains, in brief, the purpose of the establishment of Uranium Corporation of India Limited (UCIL) by the Government of India, its significance, and its contribution to the implementation of the three-stage nuclear power programme of the country. It discusses the uranium deposits in different geographical locations within the country, the deposit types, and the potential of such deposits. The paper also discusses the history of individual mines and uranium ore processing plants opened in different states and the future expansion proposals to meet the growing demand for indigenous uranium for the PHWR reactors.

Introduction

The Uranium Corporation of India Limited (UCIL), a Public Sector Undertaking (PSU) under the Department of Atomic Energy (DAE), was incorporated on October 04, 1967, as a sequel to the formation of the Atomic Energy Commission in 1948. Owned fully by the Government of India, UCIL has the mandate to mine and process uranium ore in the country to meet the fuel requirements of the nuclear power programme of the country.

Dr Homi J. Bhabha (father of the atomic energy programme of the country) formulated a three-stage nuclear power programme for India to achieve self-reliance in atomic fuel production and the spirit of indigenization of the programme. The first stage is based on pressurized heavy water reactors (PHWR) fuelled by natural uranium. The second stage envisages the utilization of plutonium produced and re-processed from the spent fuel of the first stage. The third stage is based on thorium, for which R&D efforts are in progress. These three stages are discussed in an earlier chapter.

In the year 1944, Dr Homi Jahangir Bhabha (1909-1966) said, “When nuclear energy has been successfully applied for power production, in say a couple of decades from now,

India will not have to look abroad for its experts but will find them ready at home." Six decades later, India has the second largest number of nuclear power plants under construction in the world. India has a very ambitious and optimistic nuclear power programme, perhaps the largest and most unique among all the developing countries.

Fig.1: Dr. Homi J. Bhabha, visit to Jaduguda

UCIL shipped its first batch of uranium concentrate in 1968. Since then, the company has grown manifold, multiplying the uranium production by the opening of new mines and processing plants in the country. UCIL plays a very significant role in the nuclear power generation of the country by fulfilling the requirement for uranium for the Pressurized Heavy Water Reactors.

Uranium production in India has maintained a steady progressive trend. Uranium production from UCIL has its exclusive use in the indigenous nuclear programme of the country. Its role in the first stage PHWR reactors of the strategic three-stage nuclear power programme has a vital link to utilizing the large thorium resource of the country, paving the way for long-term energy security.

Uranium production, the front-end activity of the nuclear programme of the country, has always remained a challenging task considering the limited availability of good quality uranium resources in India. UCIL, over the years, has excelled on various fronts with technological advancements in all areas of its operations. The practices of uranium mining, processing, and waste management adopted by UCIL are under continuous up-gradation and are in line with eco-friendly global best practices. In the international arena, UCIL has received due recognition for its technology and practice of uranium mining and extraction.

Uranium deposits in the country

Only a small part of the land mass in the Indian subcontinent is assumed to be geologically favourable for hosting uranium deposits. Uranium exploration in our country, spanning over 70 years, has brought out the presence of five major types of uranium deposits (vein type, sandstone type, strata-bound type, fracture-controlled type,

and unconformity proximal type) in different geological settings. The major uranium deposits of the country occur in geological basins of the Singhbhum shear zone (Jharkhand), Cuddapah basin (Andhra Pradesh and Telangana), Mahadek basin (Meghalaya), Delhi Supergroup of rocks (Rajasthan) and Bhima basin (Karnataka). Of the total uranium (U_3O_8) resources identified in India, Jharkhand accounts for about 26%, Andhra Pradesh 49%, Meghalaya 9%, and the remaining in other states. However, most of these uranium deposits are small and of far lower grade compared to those in the leading uranium-producing countries in the world.

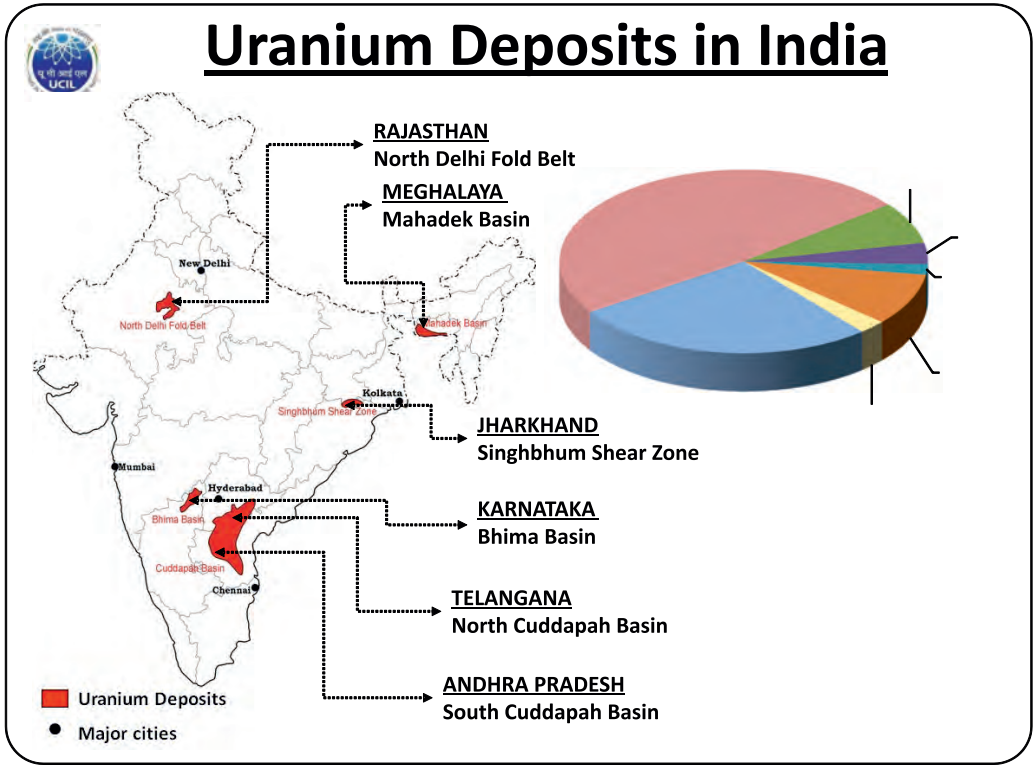

Fig.2: Uranium Deposits in India

Uranium production in the country

UCIL operates six underground mines (Bagjata, Jaduguda, Bhatin, Narwapahar, Turamdih, and Mohuldih) and one open pit mine (Banduhurang) in the Singbhum shear zone in the State of Jharkhand. Ore produced from these mines is processed in two processing plants located at Jaduguda and Turamdih in the same region.

Apart from this, UCIL operates a large underground mine and processing plant in the Proterozoic Cuddapah Basin at Tummalapalle, YSR District in Andhra Pradesh. This plant adopts a new indigenous alkaline leaching technology suitable for processing very low-grade uranium ore.

The uranium concentrate produced from these plants is sent to the Nuclear Fuel Complex, Hyderabad, for further purification, and fabrication of nuclear fuel rods.

Uranium production in the country - Jharkhand

Jaduguda mine

Jaduguda is the first mine in the country to produce uranium ore on a commercial scale. The main 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. The production levels of the mine are generally developed at vertical intervals of 65 meters. The principal stoping method adopted in Jaduguda Mine is horizontal cut-and-fill using de-slimed mill tailing as the fill. The broken ore in the stopes is mechanically handled using Load Haul Dump (LHD) equipment and is transferred to the ore transfer passes. Hauling of ore at levels is carried out using locomotives and side discharge Granby cars. Finally, the ore is dumped into the central ore pass through grizzlies. After primary crushing (~6" size) ore is hoisted through a skip and sent to the Jaduguda mill through a conveyor belt. Jaduguda mine is presently the second deepest operating mine in the country.

Fig. 3: Shaft of Jaduguda Mine

Bhatin mine

Bhatin is a small uranium deposit situated 3 km west of Jaduguda which was commissioned in 1987. 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 intervals. The stoping method is similar to that of Jaduguda. Ore from the Bhatin mine is transported by road to Jaduguda for processing and the de-slimed tailing from the Jaduguda mill is sent back for mine back-filling.

Fig.4: Adit Entry of Bhatin Mine

Narwapahar mine

It is a large deposit located 12 km west of Jaduguda which was commissioned in 1995. A 7° decline has been developed as an entry into the mine in the footwall side of the ore body through which tyre mounted underground diesel-hydraulic /electro-hydraulic machineries enter underground. From the decline, ramps ups /ramp downs are developed as entries into mineral blocks under extraction, called stopes, located at different elevations, which facilitates the movement of twin-boom drill jumbo, low-profile dump

Fig.5: Decline entry of Narwapahar Mine

truck, service truck, passenger carrier, low profile grader, scissor-lift etc. This system of mining has resulted in early commissioning of the mine with high productivity and low mining cost. It has also provided the flexibility to adopt different stoping methods suitable for different widths and inclinations of 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 method of stoping adopted in Narwapahar mine. Ore from this mine is sent to Jaduguda by road for processing. The de-slimed mill tailings from the Jaduguda mill and the waste generated from the mine are used as the filling material. The split ventilation system adopted in the Narwapahar mine facilitates the supply of clean air to all working places. The micro-processor-based bulk ore assaying system with automatic grade estimation and subsequent computation is a distinctive feature in this mine.

Bagjata mine

A small deposit is located at Bagjata which is about 30 km east of Jaduguda. This mine has been planned in line with the mine layout of Narwapahar employing trackless mining technology with a decline entry. It was commissioned in the year 2008. The ore from this mine is transported to the Jaduguda mill for processing.

Fig.6: Decline Entry of Bagjata Mine

Turamdih mine

Turamdih uranium deposit is located about 24 km west of Jaduguda. It was commissioned in 2003. The entry into the mine has been established through an 8° decline which provides facilities for using trackless mining equipment like passenger carriers, drill jumbo, low-profile dump trucks etc. The development faces are ventilated by auxiliary ventilation systems using auxiliary fans and flexible ducts. A vertical shaft of 5 m diameter has been sunk from the surface up to a depth of 260 m with facilities for ore hoisting and movement of men and material. The ore from this mine is processed in a plant constructed adjacent to the mine site at Turamdih.

Fig.7: Decline Entry of Turamdih Mine

Banduhurang mine

This deposit is the western extension of the Turamdih mine, where part of the ore body outcrops at the surface. It is a low-grade, large tonnage deposit. After the initial evaluation, the technique of computerized ore body modeling and mine planning using SURPAC software was applied. The first opencast uranium mine in the country was made operational at Banduhurang in 2007. 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. It is a conventional opencast mine using an excavator dumper combination. Careful selection of earth moving equipment has been done to maintain ore benches of 6 m height and overburden /waste benches of 6 m /12 m height with due emphasis on ROM quality as well as stripping requirements. The ore of this mine is sent by road to the Turamdih mill for processing.

Jaduguda processing plant

The first operating plant in the country at Jaduguda has been in operation since 1968 and it is based on acid leaching technology. The process know-how has been indigenously developed and upgraded time-to-time keeping pace with the global developments. The plant has been expanded twice; nearly doubling the original processing capacity to 2500 tonnes per day to treat the ore of Jaduguda, Bhatin, Bagjata and Narwapahar mines. In the Jaduguda plant, the ore of different sizes undergoes crushing followed by two stages of wet grinding. The ground ore in the form of slurry is thickened and leached in leaching pachucas under controlled pH and temperature conditions. The leached liquor is then filtered and undergoes ion exchange in which uranyl ions get absorbed in the resin. The final product of the Jaduguda plant is uranium peroxide, which is sent to Nuclear Fuel Complex, Hyderabad for further processing into nuclear-grade fuel.

Fig.8: Aerial view of Jaduguda Processing Plant

Turamdih processing plant

The ore processing plant at Turamdih has been set-up in 2007 with a processing capacity of 3,000 tonnes per day to treat the ore of Turamdih and Banduhurang mines. Later, ore from Mohuldih mine is also being fed in this mill. The plant follows the acid leaching process and a flow sheet similar to that of the Jaduguda plant. With several automated process control mechanisms and an online monitoring system, the practices adopted at the Turamdih plant are comparable with the best in similar industries anywhere in the world.

Fig.9: Aerial view of Turamdih Processing Plant

Uranium production in the country – Andhra Pradesh

Tummalapalle mine

A large mine of 3000 TPD capacity and plant at Tummalapalle, Andhra Pradesh in the southwestern parts of the Cuddapah Basin has been successfully commissioned. Present mining, over a strike length of 5.6 Km, has been taken up and is already in production through innovative mining technology with three declines in the apparent dip o direction (9°) and conveyor hoisting system. On either side of the decline, advance strike drives (ASDs) are driven in the strike direction at different levels connected by ramps within the ore body. The method of mining adopted in this mine is the Room & Pillar mining method with a combination of Cut and fill. The mined-out ore (ROM) is being transported to the processing plant at Tummalapalle through a conveyor belt.

Fig.10: Decline Entry of Tummalapalle Uranium Mine

Tummalapalle processing plant

The alkaline processing technology adopted for the plant at Tummalapalle is developed by a joint team of BARC, AMD and UCIL through pilot plant studies and has been adopted for the first time in the country. The processing plant has been in continuous operation since 2017 with the desired capacity of 3000 tonnes per day.

Fig.11: Aerial View of Tummalapalle Processing Plant.

Uranium production in the country - Upcoming projects

Further detailed exploration of the uranium resource within the existing leasehold areas has given some encouraging results and initiatives have been taken for expanding the capacity and extending the operational lives of these mines.

Keeping in view the growing demand for indigenous uranium for the PHWR reactors of the country under domestic safeguard which generate the required plutonium for the second stage fast breeder reactors; UCIL is also working to open up some new deposits discovered by the Atomic Minerals Directorate for Exploration and Research (AMD) in different parts of the country which are techno-economically viable for commercial exploitation.

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