A new approach to mining and processing of a low grade uranium deposit at Tummalapalle, Andhra Pradesh, India

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Introduction:

Meeting the challenge of quantitative demand of clean, secure and affordable electricity, is the thrust area for India's endeavor towards energy independence and accordingly an installed capacity of 20,000 MWe of nuclear power by 2020 AD has been set as the immediate goal. The country is on the preferred path of meeting this target with the production of indigenous uranium as the fuel. Expansion of existing units and development of new uranium production centers (mines and mill) have helped in meeting the requirement of fuel.

In order to expand the uranium production capability, the state owned Uranium Corporation of India Ltd is aggressively pursuing the action plan to mine and process all possible uranium reserves identified so far. A breakthrough has now been achieved through indigenous research to mine and process large low grade uranium deposits at Tummalapalle and adjoining areas.

Location:

Tummalapalle uranium deposit (14°18'36.6"N 14°20'20"N: 78°15'16.57"E 78°18"3.33"E) is located in the Cuddapah district of Andhra Pradesh, in the southern part of India. It is well connected to major cities of the country like Bangalore, Hyderabad and Chennai by road and rail.

General Geology:

Geologically, Tummalapalle area is in the south western part of the Cuddapah basin, close to the Archean basement. A thick pile of carbonate rock (Vempalle formation) is the host to uranium mineralization in this area. Lithologically, the Vempalle formation consists of purple shale, massive limestone, intraformational conglomerate, dolostone (uraniferous), shale and cherty limestone. The impersistent conglomerate and a purple shale band occurring immediately below and above the mineralized rock respectively, serve as the marker horizons. The general strike of the formation is WNW-ESE with the amount of dip varying between 15° to 17° due N22°E.

The ore body is fairly continuous over the entire strike length of 6.6 km and uniformly extending downdip upto a depth of 275m. Two parallel ore bands, designated as hangwall lode and footwall lode with average width of 3.2 m and 2.5 m respectively are tabular, stratabound and non-transgressive in nature with little variation in grade and thickness along strike as well as in dip direction. These two bands are separated by a lean zone of 1.5 m to 3 m width. The host rock is quite competent.

The radioactive minerals identified in the ore zone are pitchblende, coffinite, U-Ti complex. Pitchblende, which is the major contributor of radioactivity, occurs as fine grained aggregates intimately associated with pyrite in carbonate and phosphatic matrix. Coffinite is fine grained and associated with pyrite. Other associated minerals are pyrite, chalcopyrite, molybdenite and collophane. The gangue minerals are dolomite, quartz and microcline.

All exploratory drilling and surface elevation data were synthesized using SURPAC Vision software to generate the 3-D ore body model and digital terrain model depicting the surface ground conditions and configuration of ore zone at different cut-off. Such studies helped in graphical visualisation of the orebody and arriving at an optimum reserve base with geo-statistical analysis of resources at varied cut-off. The model so developed helps in design and development of mining plan on short term and long term basis in a more realistic manner.

Mining Technology:

Several studies were made to develop the orebody at Tuammalapalle with an aim to produce the ore at an early date, minimise the cost of production and dilution through optimum level of mechanization and maximize the ore recovery. A visit to Union Mines of South Africa during Jan 2006 helped in fine tuning the mining scheme with several site specific improvements.

Mine entry: The entry into the mine is planned through a central decline at 9^0 gradient (divides the deposit broadly into two segments) along the apparent dip of orebody. Two more declines, 15m apart on both sides and parallel to the central decline are also planned. The central decline will be provided with a conveyor for ore transport and other two parallel declines will be used as service path for movement of men and materials. The size of the each decline will be 5 m x 3 m. All declines, developed following the orebody shall help in generating the ore at an early stage.

Mine development: The advance strike drives (ASDs) will be driven in the strike direction from both the service declines till the extreme limits of the orebody. As all the developmental work will be done in the orebody, the dilution is minimal in this method.

While planning for the haulage drive, the geometry of the ore body has been taken into consideration. The ramp has been planned to connect two ASDs and the same will be driven in apparent dip of 9^0 to smoothen the maneuvering of the underground equipment. The cross-section of the ramp would be 4.5 m x 3 m. Advance Strike Drive (ASD) developed along the orebody will have crown pillars of 5 m x 5m along the full strike length. The inclined distance between ASDs will be 39 m. Length of each panel will be 120 m along strike direction followed by 10 m wide rib pillar. Ramps will be driven between ASDs (level to level) at 9^0 gradient for movement of vehicles and transporting the ore to the conveyor. The panels will be developed following Breast stoping method using low profile jumbo drill, rock bolter, low profile loader, dozer and dump truck for bringing muck to the surface (till the completion of conveyor installation).

Top most ASDs in eastern and western side will act as ventilation drives. Other ASDs and ramps will serve as network for return path of air which will be exhausted to surface through four ventilation shafts.

Stoping operations: After development of the panel, extraction of panels will commence from 9^0 ramp, three faces operating in lead lag manner moving towards rib pillar. Open stoping will be practiced with pillars for support of stopes. No back filling is envisaged. The sequence of stoping will be top to bottom and away from declines, towards strike boundary. The trunk conveyors of ASDs will be fed with ore (- 4” size) through sizer and transfer to main decline conveyor. The mine is envisaged to produce 3000 T/day.

Processing Technology

In India, the operating plant at Jaduguda and plants planned at other places are designed with acid leaching technology. The carbonate host rock and other mineral characteristics at Tummalapalle do not favour the conventional processing of leaching the ore with sulphuric acid. A great deal of laboratory and pilot plant studies were conducted to develop the process flow sheet on alkali leaching and finalise the process parameters.

The mined out ore, after conventional crushing and grinding (80% passing 74-micron) will be thickened, repulped and subsequently subjected to alkali leaching by sodium carbonate and sodium bicarbonate solution**.** Leaching will be carried out in leaching tanks / autoclaves in series with a nominal residence time of 6.5 hrs at 130^0C and 6.0-8.0 Kg/Cm^2 pressure. The leached slurry will be filtered and the washed cake in the form of slurry will be disposed in tailings impoundment facility. The leached filtrate, after clarification and precoat filtration will be subjected to precipitation with the addition of sodium hydroxide. The final product, at a pH of 12 or above will precipitate as Sodium diuranate (SDU). A study to treat the barren liquor to regenerate sodium carbonate and sodium hydroxide before recycling has been taken up. The plant is being designed to process 3000 T/day.

Conclusion

The technology proposed for mining and processing of low grade ore at Tummalapalle is the result of extensive research work involving Bhaba Atomic Research Center (BARC), Atomic Minerals Directorate for Exploration & Research (AMD) and Uranium Corporation of India Ltd. (UCIL) of Department of Atomic Energy, Govt. of India. This has helped in expanding the uranium reserve base leading to substantial rise in uranium production soon. The work at site is expected to start by mid 2007. The successful implementation of the above technologies at Tummalapalle shall pave the way for opening up a few other deposits in adjoining areas occurring at the similar geological set-up.

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