Presented and published in the proceedings of National Seminar on " Underground metal mining: Status and Prospects", Dhanbad; Feb. 13-14, 2006.

Nature of Uranium Mineralisation and Development of Deposit at Turamdih, East Singhbhum District, Jharkhand

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ABSTRACT

Turamdih uranium deposit falls in the west-central part of the Singhbhum Shear Zone in the State of Jharkhand. Feldspathic-schist, chlorite sericite schist with magnetite, apatite and quartzite are the host rocks for uranium mineralisation, which belongs to the Dalbhum Formation of Proterozoic age. The uranium lodes are essentially parallel or sub-parallel to the schistosity planes. The controls of ore mineralisation include both lithological and structural. The principal uranium minerals are uraninite, pitchblende and davidite associated with magnetite and sulphide minerals. Lithological and structural controls, geometry of mineralised horizons, nature of mineralisation as depicted from evaluation and synthesis of surface and subsurface data indicate that the uranium mineralisation in different blocks could have been the manifestation of a single ore body.

About 4000 m of core drilling was done during the exploration stage to establish this medium tonnage and low-grade uranium deposit. On the basis of exploration data, mine entry construction was taken up with the development of decline (8^0 gradient) in the footwall side of the ore body. An integrated application software GEMCOM was used to process the exploration data. Though four major lodes were established, many minor lenses of varying width were also ascertained. The width of lodes show varying thickness ranging from 1.5 m to 40 m. Study of surface exploration data and subsequent sub-surface findings indicate highly erratic nature of mineralisation.

INTRODUCTION

Geological Survey of India first reported uranium mineralisation at Turamdih during 1965. Atomic Minerals Directorate for Exploration and Research (previously named as Atomic Minerals Directorate) took up the detailed exploration in this area during 1979. Turamdih uranium deposit is located in the East Singhbhum district of Jharkhand state at a distance of about 5 km south of Tatanagar railway station and Jaduguda underground uranium Mine of Uranium Corporation of India Ltd (UCIL a public sector enterprise under Department of Atomic Energy) is situated at about 25 km southeast to this deposit. Keeping in view, the requirement of uranium for the nuclear power programme of the country (20,000 MWe by 2020 AD), Turamdih uranium deposit was taken up for commercial exploitation by UCIL during 2001-02 (Gupta and Sarangi, 2005).

Vein type hydrothermal uranium mineralisation occurs in a 20 km long, arcuate stretch in the central part of Singhbhum Shear Zone (SSZ) which includes many of the uranium deposits of India namely: Kanyaluka, Bagjata, Jaduguda, Bhatin, Narwapahar, Garadih, Turamdih and Mahuldih (Fig.1) genetically similar to the Dominique-Peter deposit, Saskatchewan, Canada (Baudemont et al, 1995). From time to time many workers have studied on the nature of uranium mineralisation within SSZ (Bhola et al, 1965, Rao and Rao, 1983d, Mahadevan, 1988 and Virnave, 1999). The age of the uranium mineralisation in Singhbhum Shear Zone has been estimated to be between 1.48– 1.58 Ga (Misra and Johnson, 2005). Turamdih uranium deposit is hosted by schistose members of Dalbhum Formation (Sarkar and Saha, 1983) with a substantial contribution to the country's uranium reserves. The uranium mineralisation is also associated with copper mineralisation, prominent lodes of copper occurring towards south. The controls of the uranium mineralisation, mineralogical aspects, mining activity and modeling of ore body are presented in this paper.

Geological Setting

Turamdih uranium deposit falls in the west-central part of the Singhbhum Shear Zone. Feldspathic-schist, chlorite sericite schist with magnetite, apatite and quartzite are the host rocks for uranium mineralisation, which belong to the Dalbhum Formation of Proterozoic age (1.48-1.58 Ga; Misra and Johnson, 2005). This mineralised (Cu-U) stretch is a part of the 160 km arcuate belt known as Singhbhum Shear Zone, outstanding for its geological attributes and extensive mining activities. (Fig.1).

Chlorite-schist and feldspathic-quartzite-schist are the two major predominant lithounits hosting uranium mineralisation at Turamdih. The overlying quartzite horizon with NW-SE elongation is largely unmineralised. Quartzite and sericite schists are hanging wall and footwall marker horizons of uranium mineralisation respectively. Uranium mineralisation represented by uraninite is generally associated with the oxides like magnetite and Ilmenite.

CONTROLS OF URANIUM MINERALISATION

The Singhbhum uranium deposits in general and the Turamdih uranium mineralisation in particular exhibit both lithological and structural controls. Repetition of sericite and chlorite-quartzite-schist with magnetite and apatite horizons in the north and south and lithological sequence met within boreholes suggest the litho-controls on the mineralisation. Three major deformations (F_1, F_2 and F_3) and related metamorphic imprints have their effects on the rocks in the area (Sarkar and Saha, 1983, Virnave, 1999).

Evaluation drilling and structural analysis reveal that the subsurface behavior of the orebody is mostly affected by the (F_2) deformation event. Joint data collected from surface and subsurface was used in the preparation of rose diagram that depicts two major sets of joints in the study area (Fig. 2). The angle between the two major sets of joints is 62º and it represents shear joint. Thus, the area is seen to be controlled by shearing (Fig.2).

The correlation of the ore bands has, accordingly, been done taking fold patterns into consideration. The manifestation of these folds is best seen along the dip sections (Fig. 3a). F_2 folds at Turamdih, helps in linking other adjoining deposits and establishing the ore body as one and the same. The uranium mineralisation is predominantly lithologically controlled. However some structural controls were also noted in the area, especially some effects of the first stage deformations on the ore disposition. The (F_1) folds have caused the repetition of ore horizons, whereas the (F_2) deformation has contributed in bringing the lodes to shallow levels, even to the surface towards further west of the study area.

Uranium mineralisation of the Singhbhum Shear Zone may be described as veins or disseminated type and stratabound at places but the ultimate concentration is shear controlled as it is indicated by micro-folding and other structural features (Fig. 3a).

Ore mineralogical and textural characteristics

The uranium mineralisation at Turamdih is confined to the schistose rocks of Singhbhum Shear Zone (Fig.3b). Samples collected from surface and subsurface mine faces have been subjected to a detailed mineralogical characterization to understand the primary and secondary ore mineral assemblages, their textural relationships in order to decipher the controls and genesis of the mineralisation.

The principal uranium minerals are uraninite and pitchblende. Pyrite and chalcopyrite are the most abundant among the sulphide minerals, which occurs along with pyrrhotite, marcasite, many secondary copper minerals and molybdenite. The common accessory minerals are apatite, magnetite etc. (Fig. 3c). Uraninite is seen as euhedral, grey coloured with internal reflections and sometimes, zoned intergrowths. The secondary uranium minerals have been formed at the expense of uraninite along shear fractures. The uranium minerals occur predominantly as small irregular grains associated with mica minerals in chlorite schists and feldspathic schists (Fig. 3d). They occur as coarse grains with characteristic pattern of fractures associated with sulphides of Cu, Ni, and Mo and as typical pitted irregular disseminated grains, commonly associated with magnetite and ilmenite and are replaced by sulphides (Fig. 3d). The secondary uranium minerals were formed at the expense of uraninite along the shear fractures.

Exploration and Mine Development at Turamdih

The detailed exploration at Turamdih area was undertaken by AMD during 1979. About 4000 m of core drilling was completed by 1983 establishing a medium tonnage, low-grade uranium deposit (Gupta and Sarangi, 2005). A representative geological cross-section of the deposit displaying the nature of mineralisation intersected in drill holes is shown in Fig. 4. The deposit consists of several small lenses. The correlation of these lenses aided in formulating the exploration database and in computation of ore reserve. The problem of correlation and consequent estimation of ore reserve was intricate because of erratic nature of mineralisation and low concentration of uranium values.

Turamdih uranium deposit was taken up for commercial exploitation by UCIL during 2001-02. On the basis of exploration data already available, mine entry construction was taken up with the development of a decline (8^0 gradient) on the footwall side of the orebody. As the decline development progressed, the subsurface geological information became more pronounced. The acquired exploration data have been reinterpreted in the light of observations of different structural features that include the manifestation of fold patterns in the subsurface. On the basis of drill hole intersections and mine subsurface geological information, correlation of various mineralised intersections has been made for establishing the mineralised limits of various lodes. This led to the development of a 3D orebody model (Fig.5). Such a model provides configuration of the extent of mineralisation along strike and dip in 3D displaying the variation in width and grade that are interpolated from drill hole intersections of various cross-sections.

An integrated geo-mining software, GEMCOM has been used to process the exploration data. Use of the software was of aid in synthesizing the drill hole data, understanding the disposition of irregular orebody in 3D and planning the mine development openings (Fig. 5). A thorough understanding of drill hole intersections indicated highly erratic nature of uranium mineralisation. Although, four major lodes have been interpreted, many minor lenses of varying widths have also been ascertained. Width and dip of the lodes vary widely ranging from

1.5 m to 40 m and 7^0 to 40^0 respectively. Continuity along strike and dip of the lodes also show wide variation with lodes appearing and disappearing at different depths.

The economic grade of uranium mineralisation, in general starts at a depth of 50 m and extends upto 200 m. Of all the lodes deciphered in the 3D orebody model, lode 3 is the most prominent and persistent one extending for a strike length of 650m. Lodes of such irregular nature with low concentration of uranium posed a great challenge in planning for mine developments and in deciding the method of stoping.

Decline provides the main access to the mine, developed 60 m away from the mineralised zone in the footwall. At a depth of 70 m, a crosscut has been developed to access the lodes. Drives have been simultaneously developed to establish the configuration of major ore lenses. Lodes 1 to 4, as interpreted from the orebody model, was found to have expected geometry as shown in Fig. 5. With the rapid progress in mine development work, systematic sampling was also carried out to obtain data on thickness of ore lenses, dip and ore grade. Ventilation network was established by development of ventilation shafts.

The mine was commissioned in 2003. The development of decline was continued and ore lenses are now accessed in the lower level at a depth of 110m. Further, a level at a depth of 200m has also been planned. Development of decline has not only helped in early commissioning of the mine, but also facilitated the use of many high-productive, trackless equipments, viz. mine truck, loaders, drill jumbo, rock-bolting machine etc. Almost all the mining operations are now automated thereby avoiding direct contact of ore with the operators. A vertical shaft is now being sunken upto a depth of 250m, which will be utilized for ore hoisting from deeper levels.

Cut-and fill method of stoping has been planned with ramps as access into the stopes. Such ramps at 7^0 gradients will make movement of trackless equipment possible from one stope to another. For environmental safeguards and stability considerations, deslimed mill tailings will be used in the stope as backfill material (Sarangi, 2004). Presently ore produced from Turamdih mines is transported to Jaduguda plant for processing. However, a new mineral processing plant is under construction at Turamdih that will process the ore of Turamdih mine and other nearby mines at Banduhurang and Mohuldih proposed to be developed by UCIL in the very near future.

CONCLUSIONS

Widespread uranium mineralisation is seen associated with copper, nickel, molybdenum and other sulphide minerals in the Singhbhum Shear Zone. The principal uranium minerals are uraninite, pitchblende and davidite generally associated with magnetite, ilmenite and sulphide minerals. Further west to Turamdih uranium deposit, uranium mineralisation is found very close to surface, which is being taken up for commercial exploitation by opencast mining. Even further west to this area, another underground uranium mine has been planned. Towards south of Turamdih uranium deposit, economic grade copper values have also been reported / established, which may attract commercial mining ventures in coming years.

Singhbhum Shear Zone is the site for country's largest uranium inventory and uranium mining activity in this area is continuing for the last four decades. Presently four underground mines are in operation and three more have been planned. Further detailed study and understanding on the nature of uranium mineralisation in this area accompanied by deep drilling may possibly lead to the findings of better grade large deposits.

ACKNOWLEDGEMENTS

We are highly obliged to Mr R. Gupta CMD, UCIL for giving necessary permission to conduct studies on this deposit and for his valuable guidance and constant encouragement. We also take this opportunity to thank the Director, ISM and Head of the Department of Applied Geology, ISM for the facilities.

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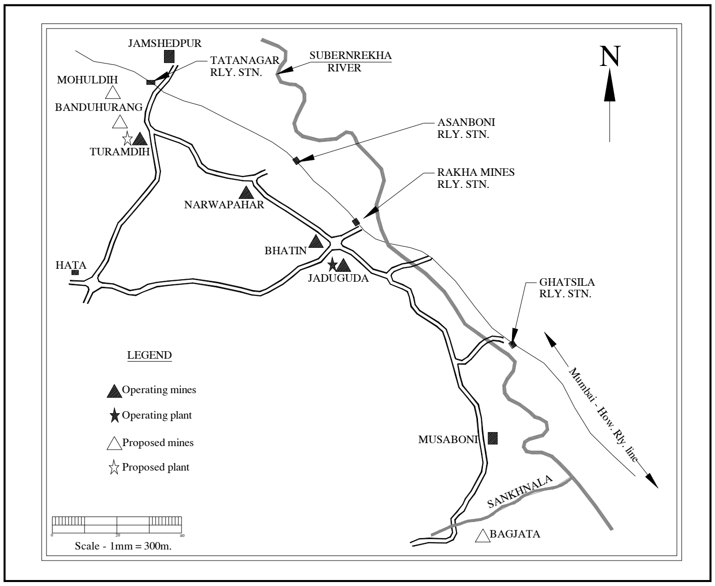

Fig. 1. Location map showing Turamdih uranium deposit

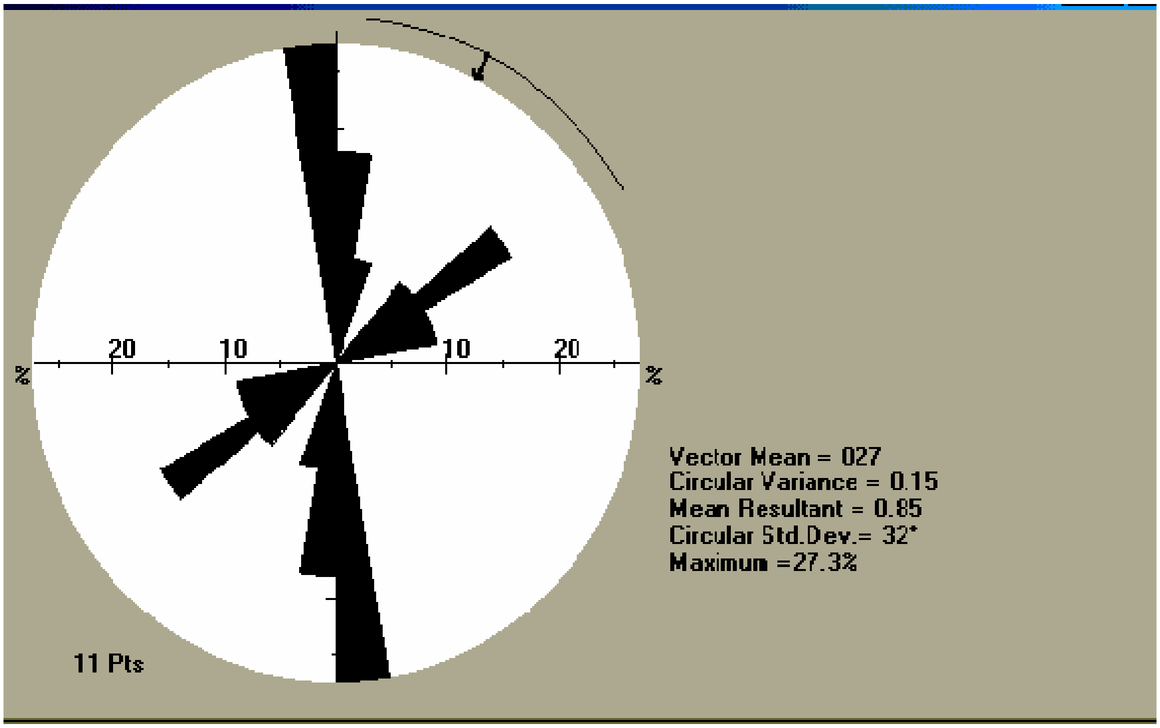

Fig. 2. Rose Diagram indicates predominantly two sets of joints.

Fig.3a

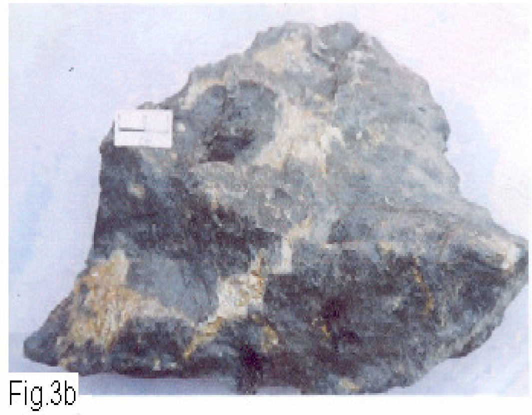

Fig.3b

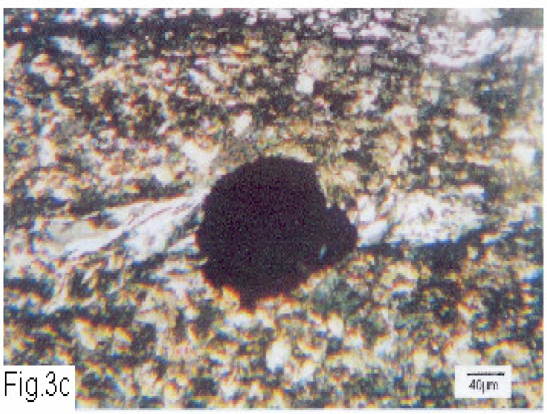

Fig.3c

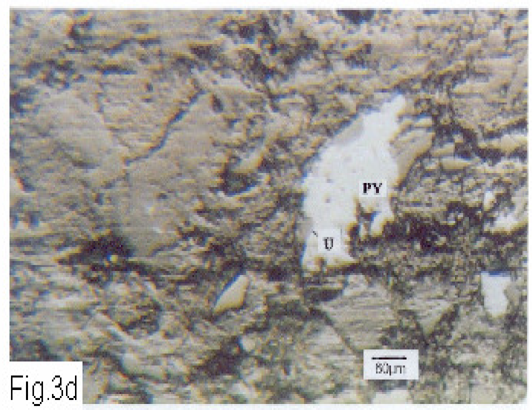

Fig.3d

Fig.3a. Field photo showing tight isoclinal folds in quartzite within main shear zone.

Fig.3b Hand specimen showing abundant sulfides as veins along with uranium mineralisation.

Fig.3c Photomicrograph exhibiting pressure shadow of magnetite grains in chlorite schist within the shear zone (Transmitted light, ppl).

Fig.3d Photomicrograph showing the uraninite in association with pyrite (Reflected light, ppl).

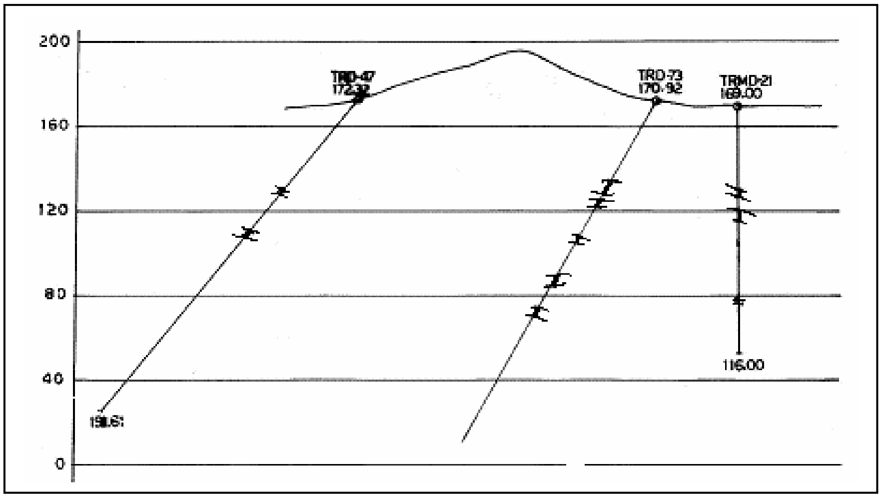

Fig.4. Representative cross section showing intersected mineralisation in boreholes.

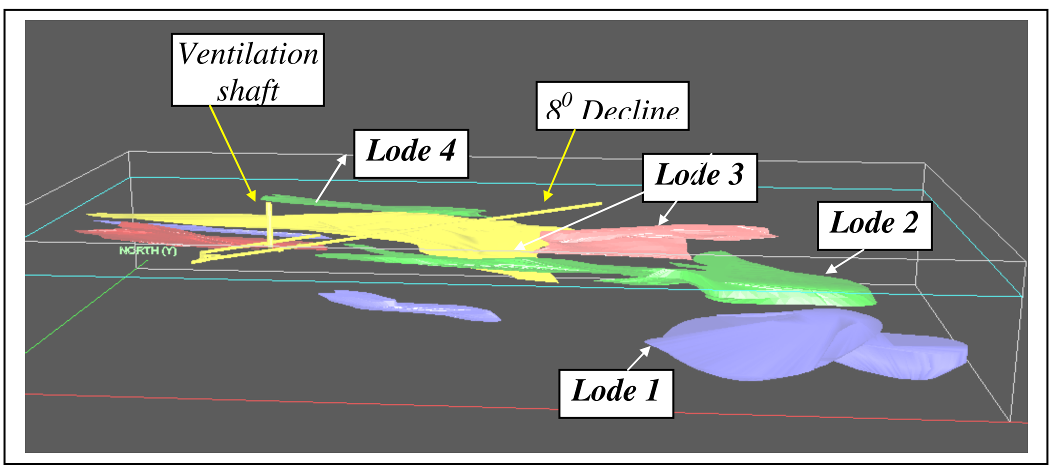

Fig.5. Orebody model and Decline at Turamdih.