SOME OBSERVATIONS ON URANIUM MINERALISATION AT TURAMDIH

By

A. K. Sarangi *, **D. R. Dash** ** and **P. P. Sharma** ***

Uranium Corporation of India Ltd.

Jaduguda, Singbhum East, Jharkhand

ABSTRACT

Occurrence of copper was known in Turamdih area since 1937. Widespread low-grade uranium mineralisation was first reported by AMD during the field investigation in 1967. The area was re-looked for detailed exploration during late 70s because of its proximity to established uranium mines.

Turamdih area falls in the central portion of Singhbhum Thrust belt. There are a number of low-grade, near-surface uranium deposits around Turamdih.

The most common host rocks for minerailsation at Turamdih are feldspathic schist and chlorite-quartz schist with abundant magnetite. The uranium lodes are normally parallel or sub-parallel with the schistosity planes. The principal uranium minerals are uraninite, pitchblende and davidite. Analysis on lithology, geometry of the ore horizons, nature of mineralisation indicates that the controls of ore minearalisation are both lithological and structural. Singhbhum granite is believed to be main geo-chemical source of uranium. Subsequent mobilization, concentration and redeposition of uranium are achieved through various overlapping geological process. Singhbhum orogenic cycle has played a dominant role.

The deposit is under development by UCIL unveiling many interesting geological features.

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* Chief Superintendent (Geology), Uranium Corporation of India Ltd., Jaduguda
E mail: **aksarangi@gmail.com**

** Dy. Superintendent (Geology), Uranium Corporation of India Ltd., Turamdih
E mail: **drdash97@rediffmail.com**

*** Chief Superintendent (Geology), Uranium Corporation of India Ltd., Narwapapahr
E mail: **ppsucil@yahoo.co.in**

SOME OBSERVATIONS ON URANIUM MINERALISATION AT TURAMDIH

Introduction:

Occurrence of copper was known in Turamdih area since 1937 in the course of some detailed geological studies carried out by various prospecting units including Geological Survey of India. However, the area came into prominence in Atomic Minerals map of India, when widespread uranium mineralisation was first reported by Atomic Minerals Directorate for Explorataion and Research (AMD) during the field investigation in 1967. Due to the poor grade of mineralisation, it was not very encouraging to pursue the detailed survey during that period. However, the area was re-looked for exploration because of its proximity to established uranium mines at Jaduguda, Bhatin and Narwapahar. The detailed exploration was completed by AMD during 1979.
Turamdih area falls in the central portion of Singhbhum Thrust belt, Jharkhand, known as store of many multi-metallic minerals. There are a number of low-grade, near-surface uranium deposits around Turamdih namely Banduhurang, Nandup, Keruadungri etc with the potential for underground / opencast mining. The field studies and underground mining taken up at Turamdih unveils some interesting observations on mineralisation in the area.

Location:

Turamdih uranium deposit (Latitude: 22^0 43" Longitude: 86^0 12") is located in Singhbhum East district of Jharkhand state. It is about 6 km south of Tatanagar railway station, the nearest railhead on Howrah-Mumbai line. Jaduguda, the well-known underground uranium mine of UCIL is situated at about 25 km southeast of this deposit. The deposit falls under Survey of India Toposheet No.73 J/2. The deposit is well connected by all weather metal road with Jamshedpur and Jaduguda.
The area around Turamdih uranium deposit exhibits a flat and moderately undulating topography lying within hill ranges in northern and southern side. The drainage pattern of the area is mainly controlled by streamlets feeding to nearby Kharkari River, a tributary of the Subernrekha river. The vegetation is nearly scanty comprising of bushes and a few small trees on the hill slopes.

Geological settings and uranium mineralisation:

Regional geology of the Singhbhum thrust belt has been the matter of passionate study and curiosity for many earth scientists for the past six decades. This 160 km long arc shaped belt stretching from Durapuram in the west to Bahargora in the east separates Singhbhum mobile belt in the north and the Singhbhum craton in the south. Although, Dunn & Dey (1942) did the pioneering geological work in this area, several theories and findings have been recorded by subsequent geologists, of which mention may be made on the findings of Banerji (1964), Bhola (1968), Dar (1972), Sarkar et al (1974), Rao & Rao (1983) etc. This arc shaped belt of 1-10 km width, is of very high economic significance since it hosts some big copper and uranium deposits located mostly in the central part.

Intense deep underground mining operations (upto a depth of about 1000 m) in this area have also revealed many interesting geological features, thereby adding substantial inputs to various geological concepts.
The most part of the thrust belt in east and central sector trend E-W, whereas in the western side the belt shows a NE-SW trend. It broadly follows the periphery of Singhbhum Garanitic craton in the south. The rocks of Singhbbum Thrust belt are, in general a thick pile of meta-sedimentary sequence consisting of pelitic arenaceous sediments (like quartz-sericite schist, quartz-chlorite schist, quartz-muscovite schist, quartzite etc) with some intervening basic lavas and mafic sills. The thrust zone is a site of intense multiphase deep tectonisation with acid and basic volcanism and hydrothermal metasomatic activity. All the rocks along this zone, except the basic rocks, have been metasomatically altered in varying degrees resulting in extensive chloritisation, biotitisation, sericitisation and feldspathisation. Copper and uranium mineralisation have taken place along the zone of thrusting, particularly in the central and south-eastern sector.
Intense exploration for uranium in Sighbuhum thrust belt since 1950 has resulted in identification of several major uranium deposits / occurrences, which account for lion's share of the Indian uranium inventory.
Uranium mineralisation in Singhbhum thrust belt, though cannot be conveniently grouped under any normal genetic types, some attempts have been made to arrange the intrinsic features. Following Dahlkamp's classification, the occurrences can broadly be grouped under two different categories - Paleo-proterozoic quartz-pebble conglomerate type and Meso-proterozoic sheared controlled hydrothermal type (Mahadevan, 1988). The Quartz-Pebble-Conglomerate type of mineralisation is poorly developed in the southern side of the basin bordering cratonic region of Singhbhum Granite. No major findings of this type have been reported so far. The Turamdih group of deposits (Turamdih-Nandup-Banduhurang) located towards the west central part of shear zone is shear-controlled-hydrothermal type, known for low-grade-high-tonnage deposits in the country. These group of deposits have now been taken up for commercial mining by Uranium Corporation of India Ltd.

Regional Stratigraphy:

The first notable geological work ever carried out on Singhbhum Thrust Belt by Dunn & Dey (1942) has provided a sound groundwork for study regional stratigraphy of the area. Subsequently, the stratigraphic succession has undergone several modifications based on some recent systematic studies (structural and petrograhic) supported by laboratory age determination data. A generalized chrono-stratigraphic succession of Singhbhum region as suggested by Saha et al (1988) is presented below.

Group	Formation	Member (Litho units)	Age
Kolhan		Newer Dolerite dykes & sills. Mayurbhanj Granite Gabbro-anorthosite-ultramafic rocks.	Ca.1600-950Ma Ca.2100 Ma Ca. 2100-2200 Ma
		Unconformity	
Dhanjori		Jagannathpur, Malangtoli, Dhanjori and Simplipal lavas, quartzite, conglomerate	Ca. 2300 Ma
Singhbhum	Dhalbhum Chaibasa	Pelitic and arenaceous meta-sediments with mafic sills.	Ca. 2300-2400Ma.
		Unconformity	
Iron Ore	Singhbhum Granite (Phase-III).	Epidiorite (intrusives) Upper shales with sandstones and volcanic rocks. Banded hematite jasper with iron ore. Sandstone and conglomerate	Ca. 3100 Ma.
		Unconformity	
Older Metamorphic (OMG)	Singhbhum Granite (Phase II and I) Metamorphic Tonalitic-Gneiss (OMGT)	Nilgiri Granite Bonai Granite Pelitic schist, quartzite, para-amphibolite, ortho-amphibolite	Ca. 3400-3500Ma Ca. 3775 Ma. Ca. 4000 Ma.

Geology around Turamdih

A detailed litho-stratigraphic sequence around Turamdih has been attempted covering a vast area – from outcrops of Singhbhum granite in extreme south to banded magnetite quartzite in extreme north. A thin conglomerate band separates the southern Singhbhum granite craton and thick pile of meta-sedimentary sequence towards north. This non-mineralised conglomerate horizon (polymictic?) is believed to represent the quartz-pebble conglomerate horizon reported in southern part of the basin elsewhere in the region. The conglomerate horizon is underlain by talcose mica schist towards north. This thick pile of mica schist grades into muscovite-sericite schist towards further north, which mark the footwall limit of uranium mineralisation at Turamdih. The mica schist is followed by bands of chlorite schist (with magnetite), feldspathic schists and quartz-chlorite schist towards north. Uranium mineralisation is mainly confined to these rocks (chlorite schist and associated quartzitic variations) which can be traced at least 5km east and west of Turamdih area. A thin band of banded magnetite-quartzite (sparsely developed) in the extreme north, mark the hangwall limit of mineralisation. Mapping of different lithological units in underground at 70m depth (1^{st} level) depicts some of the litho units described above. (Fig.1)

Stratigraphy

Group	Formation	Member (litho units)
Iron Ore		Feldspathic schist Banded magnetite quartzite Quartz chlorite schist Chlorite quartz schist Feldspathic schist Chlorite quartz schist Muscovite sericite schist Talcose mica schist Conglomerate **Unconformity (?)**
	Singhbhum Granite	

Structure

The area around Turamdih has undergone poly-phasal deformations involving tectonism and related metamorphic activities in recurring cycles, which have left the imprints on most of the rocks. The quartzite exposures in the northern part of the deposit exhibiting excellent fold patterns have been described as "monuments for structural geologists" by some earlier workers. (Fig. 2a and 2b)

The first phase of deformation (F_1) is of tight to isoclinal reclined folds with the development of axial plane schistosity (S_1), which at most places, is parallel to the bedding (S_0). The dominant schistosity (S_1) in the sector is axial planes of the earliest deformation (F_1). It has a regional arcuate trend following the northern fringe of Singhbhum Granite and dipping about 35º towards northeast in Turamdih area. F_1 folds are mostly preserved in the outcrops of quartzite (Fig 2b). Extensive mylonitisation in other litho units have greatly affected the F_1 fold patterns (Fig. 3a, 3b and 3c). The second phase of deformation (F_2) has resulted in ESE-WNW trending folds on S_1 planes. These are overturned towards south, asymmetrical type with shorter southern limb and longer northern limb and plunging about 10^0 to 15^0 towards ESE-WNW. Axial plane of these folds is generally seen as crenulation cleavage. The lineations pertaining to this phase occur in the form of puckers on the S_1 surface. Folds of this generation are abundantly preserved. Third generation of folding (F_3) is in the form of broad wraps plunging towards NNE and manifested by swing of strike at places (Fig 2a). This indicates minor intensity of deformation during the third phase of folding.

Superimposition of these three deformational phases has an important bearing on the overall structure and mineralisation pattern in the area. F2 folds are represented as doubly plunging synforms, which are isoclinal asymmetric type. The axis of these synforms trend WNW-ESE and plunge gently on either side. The feldspathic schist occurring at the core of the synforms is of disharmonic nature.

Uranium mineralisation:

The most significant uranium mineralisation at Turamdih is confined to chlorite schist and chlorite-quartz schist and to a lesser extend in feldspathic schists. Uraninite and pitchblende are the prominent uranium minerals with minor presence of brannerite, davidite and some secondary uranium minerals. Uraninite is the most predominant seen as euhedral, grey coloured mineral with internal reflections and sometimes, zoned intergrowths. The secondary uranium minerals have been formed at the expense of uraninite along shear fractures Uraninite grains occur within grain interstices of feldspathic schists and as pore fillings, cleavage plane impregnations and irregular tiny particles within chlorite and quartz-chlorite schists (Fig. 4a). Uranium ore shoots occur as sheet like conformable bodies parallel to downdip lineations and F2 fold axis. Width and dip of these ore lenses 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 problem of correlation and consequent estimation of ore reserve from exploration data was extremely intricate because of erratic nature of mineralisation and low concentration of uranium values. The economic grade of uranium mineralisation at Turamdih, in general starts at a depth of 50 m and extends upto 200 m.
Among the sulphide minerals, pyrite and chalcopyrite are most abundant. Magnetite and ilmenite are the common oxides. Veins of apatite and magnetite are generally found within mineralized horizons. Pyrite and magnetite grains are seen euhedral occurring as porphyroblasts in the matrix. Chalcopyrite has patchy occurrence.

Controls of mineralisation

While the mineralisation is confined to chlorite schist (with its quartzitic variation) and feldspathic schist, appearances of many ore lenses are possibly due to the isoclinal folding (F1). Closures of these folds vary in dimension resulting in thickening and thinning of ore lenses within small distances. Manifestation of F2 folds is best seen in integrating the ore lenses of Turamdih with mineralisation of nearby Nandup and Banduhurang deposits. F3 folds have least effect on ore lenses.

Genesis

Genesis of uranium deposits in Singhbhum shear zone has remained a matter of prolonged controversy, though a broad agreement emerges on role of possible hydrothermal fluid.
The Singhbhum granite, with an average uranium content of about 7 ppm and occurring in the south of the area as a stable cratonic block is believed to be the main geo-chemical source of uranium. The weathering of Singhbum granite before (during ?) lower Proterozoic period (non-availability of oxygen) and the sediments derived from this

granitic craton could have led to the syngenetic deposition of detrital uranium (tetravalent stage) forming a thick pile of sediments towards north. Gradual availability of oxygen in the atmosphere and on-set of Singhbhum Orogenic cycle (2000 Ma), which is represented by regional metamorphism, emplacement of basic rocks, widespread metasomatism, tectonic activities like shearing etc. could have helped in solubilisation of detrital uranium, transportation of the same in solution through favorable pathways and precipitation where in contact with reductants (like volcanogenic rocks and ferrous minerals) in favourable structural and / or stratigraphic locations. During metamorphism, connate water and structurally trapped water heated with frictional heat have aided in uranium remobilization. The shearing / deformation in two distinctly different episodes have provided conduits of high permeability and created structural confines like fractures, axial plane schistosity etc for redeposition and reconcentration of uranium. Shearing has also resulted in degradation of early Fe-Mg silicates and formation of chlorites. The sympathetic ferrous / ferric ratio helped in the fixation of uranium from hexavalent to tetravalent stage.

Mining

Turamdih uranium deposit was taken up for commercial exploitation by UCIL during 2001-02. Mine entry construction was taken up with the development of a decline (8^0 gradient), 60 m away from the mineralised zone in the footwall. This provides main access to the mine. At a depth of 70 m, a crosscut has been developed to access the lodes. Drives have been developed to establish the configuration of all ore lenses. Ventilation network has also been 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 105m. Further, levels at a depth of 140m and 180m have 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. A vertical shaft is now being sunk upto a depth of 260m, which will be utilized for ore hoisting from deeper levels. Cut-and fill method of stoping has been planned at Turamdih with ramps as access into the stopes.

Conclusion

The Singhbhum belt in general is perhaps the most intensively studied area of Peninsular India. Still several aspects on ore genesis, as have been postulated from time to time are open to methodical discussions.
Uranium mineralisation at Turamdih and adjoining areas like Nandup, Banduhurang and Keruadungri unveils some interesting observations, specially after opening of this deposit for mining. A good deal of petrological study on fresh rock samples along with the stratigraphy and structural study of surface and sub-surface structures may possibly elucidate further the widely believed general genetic philosophy of polycyclic mobilization of uranium by a combination of geologic processes, active over a considerable span of time**.**

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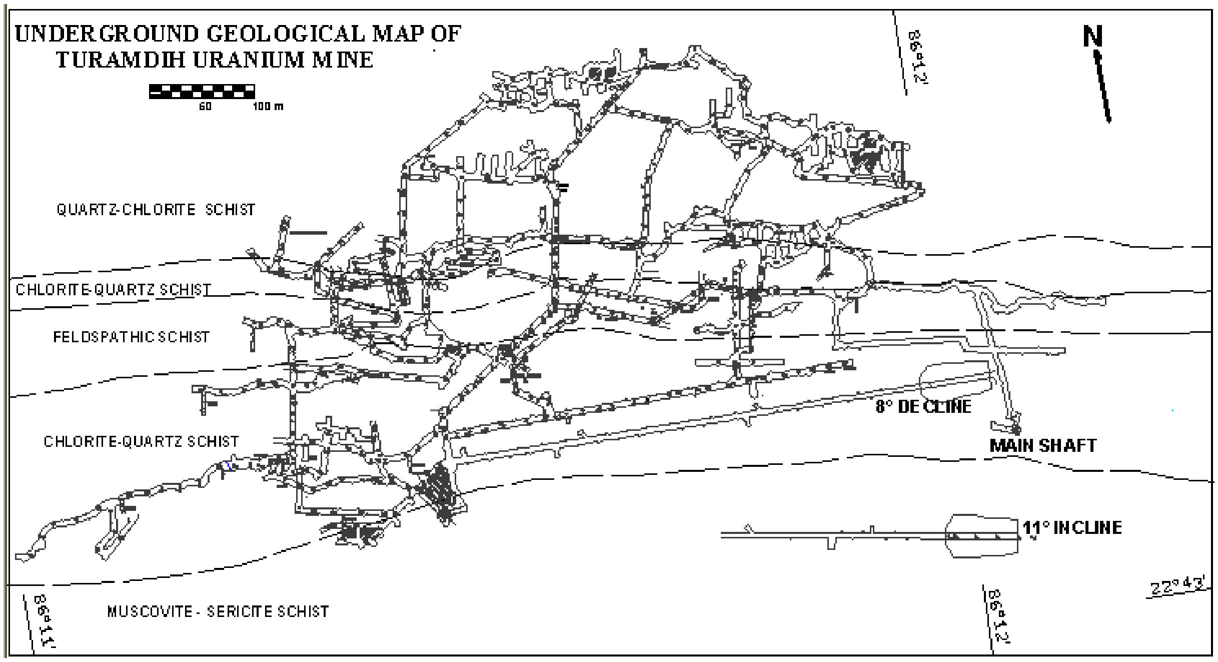


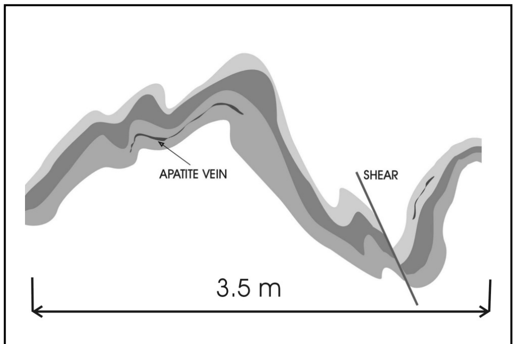
Fig. 1

Broad wraps in quartzites at Turamdih. Manifestation of F3 folds.

Fig. 2 (a)

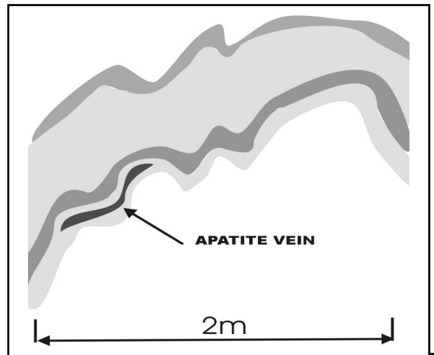
Tight isoclinal folds in quartzites at Turamdih. Manifestation of F1 folds.

Fig. 2 (b)



Folding and shearing along axial plane in feldspathic schist in Turamdih underground mine (HAND SKETCH)

Fig. 3 (a)

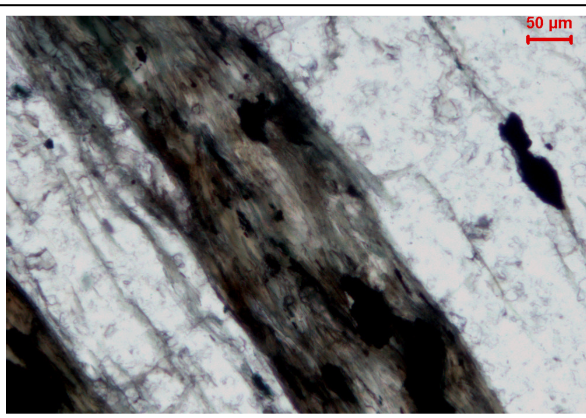


Folding in quartz-chlorite schist in Turamdih underground mine (HAND SKETCH)

Fig. 3 (b)

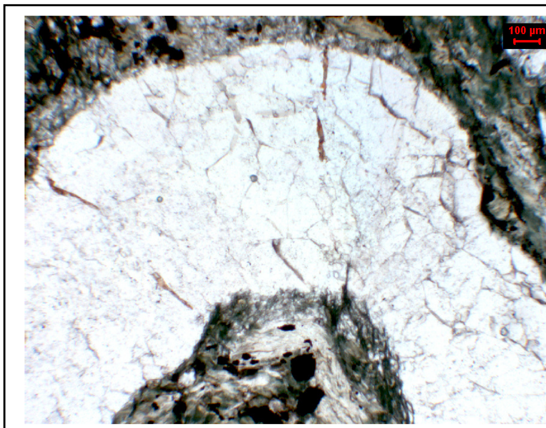
Folding in quartz-chlorite schist in Turamdih underground mine

Fig. 3 (c)



General appearance of quartz-chlorite schists showing alternate chlorite-rich and quartz-rich bands. Under transmitted plane polarized light

Fig. 4 (a)



Micro-fold defined by folded quartz vein / lense. Under transmitted plane polarized light

Fig. 4 (b)

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