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POTENTIAL FOR UNCONFORMITY-RELATED URANIUM DEPOSITS IN THE NORTHERN PART OF THE CUDDAPAH BASIN, TELANGANA AND ANDHRA PRADESH, INDIA

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INTRODUCTION

The intra-cratonic, Mesoproterozoic Cuddapah Basin in the Dharwar Craton of India hosts several types of uranium deposits in its various stratigraphic levels. Signatures of uranium mineralisation are recorded in the Gulcheru and Vempalle Formations in the lower part and along the unconformity between the basement granite and the overlying sediments of Srisailam / Banganapalle Formation in the upper part of the Cuddapah sequence. The Srisailam and Palnad sub-basins lying in the northern part of the Cuddapah basin hosts Proterozoic unconformity related uranium mineralisation. Uranium mineralisation in these sub-basins occurs close to the unconformity between the basement complex containing basement granitoid, basic dykes of Paleoproterozoic age and greenstone belt of Achaean age and arenaceous, argillaceous and calcareous sediments of Meso-Neoproterozoic age. Concerted sub-surface exploration over two decades has established three small to medium tonnage uranium deposits at Lambapur (˜1,200tU), Peddagattu (˜6,400tU) and Chitrial (˜8,000tU) along the unconformity between the basement Mahabubnagar granite and overlying Srisailam Formation in Srisailam sub-basin; and one small tonnage deposit at Koppunuru (˜2,300tU) close to the unconformity contact between basement granite and Banganapalle Formation of the Kurnool Group in the Palnad sub-basin. In all these deposits, uranium mineralisation is concealed and lies below the cover rocks at a depth of <5-150m. Uranium mineralization located in these sub-basins show dissimilarity with that of unconformity-type uranium deposits in Canada and Australia, especially in respect of basement and marked absence of palaeosol.

GEOLOGICAL SETTING AND URANIUM MINERALISATION

The Cuddapah basin, having a spread over 44,000 sq km, is the second largest Proterozoic basin in India, with a thick pile of sediments and subordinate volcanics and hosts Proterozoic unconformity related uranium deposits in its Northern part in the states of Telangana and Andhra Pradesh [1]. The Cuddapah basin comprises Papaghni, Srisailam, Palnad and Nallamalai sub-basins. The Srisailam and Palnad sub-basins lie in the northern parts of Cuddapah basin and exposes sediments of Srisailam Formation and Kurnool Group respectively [2]. The Srisailam, Palnad and part of Nallamalai sub-basins, developed over the basement granitoid of Paleoproterozoic, covers an area of ˜ 10,000 sq km.

The basement complex for the Srisailam and Palnad sub-basins comprises Archaean schist (Peddavoora Schist belt), Paleoproterozoic granite, basic dykes, pegmatites and quartz veins of Paleoproterozoic (2268±32 Ma to 2482±70 Ma) age [3]. Well-developed fracture systems (N-S, NE-SW, NW-SE) along with basic dykes traversing both cover rocks and basement cross cut the nonconformity surface. The N-S to NE-SW trending dykes in the basement have played vital role to increase thermal gradient to release uranyl ions into the solutions and remobilsation along fractures and to the unconformity plane. Grit to pebbly horizon immediately above the unconformity surface act as conducting system for uranium mineralisation.

The Srisailam sub-basin, covering an area of around 3000 sq km forms a prominent plateau, exposing Neoproterozoic sediments of Srisailam Formation, the youngest unit of Cuddapah Supergroup. The sediments show sub-horizontal dips due southeast, and attains a maximum thickness of 300m. The Srisailam Formation comprises a sequence of feldspathic to sub-feldspathic quartzite with intercalated shale, siltstone and

grit. The sediments directly overlie the basement rocks in its northern margins, whereas in the southeastern margin the sediments are underlain by Nallamalai Group metasediments with an angular unconformity. The northern fringes the Srisailam sub-basin has a highly dissected topography with several flat topped outliers occurring within the basement and rising 100 to 150m above the ground level. The Lambapur, Peddagattu and Chitrial uranium deposits are located in three such separate outliers [4]. The outliers of Srisailam Formation is characterised by a sequence of pebbly gritty arenite horizon successively overlain by shale, shale/quartzite intercalations and massive quartzite having thickness of 5-70m with a gentle dip of 3 to 5o towards southeast.

The basement granitoids are sodic in nature, with moderate to high Na2O/K2O ratio (0.09 - 1.62). Compositionally, they vary from granite to granodiorite and are strongly peraluminous with A/CNK ratio > 1.1 [4]. The granitoids, mineralogically characterised as biotite-granite, consists of an assemblage of albite-oligocalse, quartz, K-feldspar with accessory hornblende, biotite, apatite, sphene, zircon, allanite and epidote. These are equivalents of Closepet granite of Eastern Dharwad Craton (EDC). Alterations such as chloritisation, sericitisation, calcitisation and epdotisation are pronounced in the basement especially close to the unconformity. Pyrite, chalcopyrite, galena, ilmenite, anatase and hydrated iron oxides are the opaque minerals. Study of granitiod core samples shows two to three sets of foliations, traversed by dolerite dykes and quartz veins. Radiometric analysis of granite reveals fertile nature (˜20ppm of U) with U/Th ratio of 6.68 [5].

In all the three deposits in the Srisailam sub-basin viz. Lambapur, Peddagattu and Chitrial, uranium mineralization occurs close to the unconformity, both in the granites, basic dykes and vein quartz within the basement along with and the overlying pebbly arenite, with most part (>85%) in the basement [6]. Though, the ore body appears to be a blanket along the unconformity, scout drilling in various spacings in the entire outliers has indicated that the rich grade pods and ore shoots are confined to definite trends viz., NNE–SSW and NW–SE (Lambapur), WNW-ESE and N–S (Chitrial) and N-S in Peddagattu. The intensity of fractures within the granite and their intersections with the unconformity, thus apparently controls the grade of mineralization [7]. The ore bodies show gentle dips towards southeast and follow the basement slopes. Mineralisation is manifested in the form of radioactive phases viz. pitchblende, uraninite and coffinite as primary minerals and uranophane and autunite as secondary minerals. These are well exposed on the outcrops of granitoids at Lambapur and road cuttings of Peddagattu and Chitrial plateaus. Botryoidal and massive pitchblende occurs as thin veins sub-parallel to non-conformity surface, massive pods, in fracture planes of feldspar, as irregular segregations and also as adsorbed in globular organic matter. The massive pitchblende is replaced by coffinite at places. Extensive hydrothermal activity, both in the basement and overlying sediments is evidenced by high amounts of sulphides such as pyrite, chalcopyrite and galena. Petrographically, the pitchblende veins are found to cut across the basement granitoid and enter into the covers rocks.

EPMA studies of radioactive core samples of granitiod of Chitrial area have indicated that UO2 content in pitchblende and coffinite range from 71.37 to 88.14% and 59.97 to 73.91% and also has confirmed the presence complexes such as U-Si, U-Si-Ti and U-Si-Al. X-ray diffraction studies of uraninite indicate unit cell dimension of Lambapur area in the range of 5.3973Ao –5.4285 Ao and for uraninite of Chitrial area is 5.3959Ao. The oxygen content in the formula unit (UO2) is in the range of UO2.30 to UO2.69 in uraninite of deposits in Srisailam sub-basin. Evidences of remobilsation have been observed in the samples. Radiogenic lead of Lambapur reveals 480–500 Ma while the Sm–Nd data of uraninite yield an isochron age of 1,327±170 Ma as two phases of mineralizing events.

The Palnad sub-basin, having an extent of around 4,500 sq km, hosts the Koppunuru uranium deposit in its western part [8]. The sub-basin exposes Neoproterozoic Kurnool Group comprising a thick sequence of clastic and calcareous sediments. In the northern part of the basin, basement granite and gneisses are unconformably overlain by the sub-horizontal sediments. Banganapalle Formation, the lowermost sequence of Kurnool Group, comprises gritty arenite successively overlain by shale/siltstone intercalations and quartzites of high mineralogical maturity [9]. The fertile nature of the basement granite is indicated by higher intrinsic uranium (Av. 32 ppm; n=16) and high U/Th ratio (Av. 4.41; n=16) as compared to the average uranium and U/Th ratio of normal granite (U/Th =0.25). An inlier of the granite is exposed to the east of Koppunuru, along the upthrown block of the Kandlagunta fault trending WNW- ESE. Both the basement and the sediments are fractured and traversed by quartz veins trending N-S, NNE- SSW and WNW- ESE.

Uranium mineralisation in Koppunuru deposit occurs both in the sediments and in the basement manifested by three sub-horizontal ore lodes, two in the arenite of Banganapalle Formation and one in the basal polymictic grit/conglomerate of Banganapalle Formation, transgressing into basement granite, at places [10]. Pitchblende and coffinite are identified as primary uranium ore minerals in Koppunuru deposit. Traces of carbonaceous matter are associated with uranium mineralization along with sulphide minerals. EPMA analysis has indicated that pitchblende and coffinite contain 73.47 to 78.58% UO2 and 63.45–71.53% UO2 respectively, while mixed phases contain lesser uranium oxide (42.14 –47.90% UO2). In addition, uranophane, phosphuranylite, metazeunerite and U-Ti complex occur as secondary uranium minerals. The radioactive minerals are epigenetic in nature and occur as fine veins, fracture/cavity and grain boundary fillings. Other ore minerals are galena, pyrite, chalcopyrite, pyrrohotite, marcasite and traces of pentalandite. X-ray diffraction studies uraninite indicated unit cell dimension for Koppunuru deposit in the range of 5.4382Ao –5.4534Ao. The oxygen content in the formula unit (UO2) is in the range of UO2.15 to UO2.29 in uraninite in Palnad sub-basin.

Radiometric age of mineralized granite samples is 1,545 ± 140 Ma. In addition, dating of uraniferous quartzite samples by Pb-Pb step leaching method has indicated 576±180 Ma, 891±160 Ma and 936±60 Ma as mineralisation ages. This suggests multi-episodic nature of mineralization where uranium concentration/enrichment took place in different phases.

DISCUSSION AND CONCLUSION

The northern margins of Cuddapah basin is established as potential for hosting Proterozoic unconformity related uranium mineralisation. Litho-structural and metllogenic characters are well established for Lambapur, Peddagattu, Chitrial and Koppunuru uranium deposits. In Srisailam and Palnad sub-basins two major mineralization events are envisaged. Primary mineralization event took place during 1300-1500 Ma with a major mobilization / rejuvenation event around 450-950 Ma in Srisailam and Palnad Sub-basins in northeastern part of Cuddapah Basin.

Concerted exploration efforts in the northern margin of Srisailam sub-basin has established ˜ 20,000 tonnes of uranium oxide resources at a shallow depth of 75-120m. Large area of Srisailam sub-basin with considerable thickness of cover rocks is still unexplored and likely to multiply the resources with increase in tenor at a vertical depth of 200-250m. Extensive surficial exploration in other outliers and also in the main Srisailam sub-basin, viz. Amrabad, Akkavaram, Udimilla, etc. has resulted in establishing several surface uranium shows, thereby indicating the prevalence of metallogenetic factors observed in Lambapur, Peddagattu and Chitrial deposits which lie in the marginal portions, in the entire Srisailam sub-basin.

Similarly in Palnad sub-basin, the Koppunuru uranium deposit is unique in respect of the mineralisation pattern in the sediments, proximal to the unconformity contact with the basement granitoids. Structures have played a major role in controlling the mineralisation. Nearly, 150km stretch of the northern margin of Palnad sub-basin with similar litho-structural setup as that of Koppunuru is available for exploration. Ground radiometric and heliborne geophysical surveys in the entire stretch of the northern margin of Palnad sub-basin has delineated several surface uranium shows viz. R.V.Tanda, Mathamapalle, etc. and geophysical anomalies viz. Durgi, Daida, Gurajala, etc. Intensive sub-surface exploration is envisaged in several sectors of Srisailam and Palnad sub-basins.

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