

## **Uranium Metallogeny in India**

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Uranium deposits world over exhibit an uneven distribution through geological time, particularly their preponderance during Proterozoic and Phanerozoic Eons. 55% of world uranium resources belong to the Proterozoic time, bulk of which accounts for unconformity related type of deposits (Athabasca, Canada and South Alligator, Australia), to a lesser extend by breccia complex type of deposit (Olympic Dam, Australia) and some vein type of deposits. Phanerozoic sandstone type of deposits formed in continental fluvial or marginal marine sedimentary environment (Western Cordillera region in USA, Central Asia, Niger) also account for 21% of the world uranium resources.

Predominance of uranium metallogeny in the Proterozoic period takes is a consequence of emplacement of K-rich Archean granitoids and later erosion (and deposition) of detrital uranium rich sediments in intra-cratonic basins during Lower Proterozoic period. Subsequent development of O<sub>2</sub>- rich atmosphere led to the release of uranium from the cratonic region and their mobility through solution. Intra-cratonic rift basins received uranium through clast and solution. Formation of super continents leading to protracted period of weathering, growth of land based flora and fauna and deposition of red beds provided reducing conditions for successive precipitation, enrichment and blanketing of deposits. In Phanerozoic sediments, uranium deposition is linked with proximity to fertile granite basement as provenance, release of the metal rich continental clasts / detritus, episodes of acid or alkaline magmatism accounting for a magmatic source of ore forming fluids and reducing conditions prevailed by carbonaceous material, sulfides and hydrocarbons.

Study of ~ 3.28 million km<sup>2</sup> of Indian sub-continent, with rocks ranging from early Archean to recent time, is assumed to be favorable for hosting diverse types of uranium deposit. However, of the uranium reserves identified so far, the Proterozoic Eon accounts for nearly 76%, bulk of which comes from vein type deposits in Singhbhum Thrust Belt (Jharkhand) and a smaller amount from unconformity related and strata-bound type deposits in the Cuddapah basin (Andhra Pradesh). Sandstone type uranium deposits of Phanerozoic period (Mahadek basin) also account for about 16% of the Indian reserves.

The Singhbhum Thrust Belt, hosting a number of vein type deposits has remained as the primary target area for exploration. Genesis of these deposits is linked with Singhbhum granite as the main geochemical derivation of uranium. Mineralization was a result of weathering of the Singhbhum granite, possibly before the lower Proterozoic period, syngenetic deposition of detrital uranium, solubilization of uranium through oxyanion transport, transportation through solution and precipitation in contact with reductants. The Singhbhum orogenic cycle, represented by regional metamorphism, emplacement of basic rocks, and shearing helped in polycyclic mobilization of uranium in favorable structural and / or stratigraphic locales.

Exploration for the unconformity type large-tonnage high grade-uranium deposits has led to the discovery of two deposit types – unconformity-proximal and strata-bound (within carbonate) in the Cuddapah Basin. On the northern side, close to the unconformity (basement granite and its overlying Srisaïlam quartzites) cluster of uranium deposits have been found in the Srisaïlam outlier. Exploration in the contiguous area has shown presence of similar mineralization in the Palnadu and Kurnool sub-basins.

On the southern side of the Cuddapah basin, strata-bound type deposits occur in phosphatic siliceous dolostone, sandwiched between lower massive dolostone and upper shale and cherty dolostone with intermittent intra-formational conglomerate belonging to the Vempalle Formation. Mineralized dolostone is believed to have been deposited in inter-tidal environment with the source of uranium being the nearby fertile basement granites. Other ore forming factors are influx of O<sub>2</sub> during Mesoproterozoic leading to chemical liberation and concentration by biochemical reduction under euxenic conditions.

A number of sandstone type uranium deposits of the Phanerozoic period have been located in the Mahadek basin of Meghalaya. The sediments in the Mahadeks range from fluvial to marginal marine and are highly immature thereby retaining the uranium content in the rocks derived from the fertile granite provenance. In this regard, the Gondwana and Siwalik basins hold the promise of hosting deposits of similar nature. Other basins of India indicating uranium mineralization include the Bhima basin (unconformity, fracture controlled type), the Aravalli-Delhi fold belt (vein type), the Gwallior-Vindhyan basin (Breccia complex type), and other areas in Chhattisgarh and Orissa (quartz-pebble conglomerate type).