BOOK REVIEW

'METALLOGENESIS OF URANIUM DEPOSITS' Proceedings of a Technical Committee Meeting, Vienna, 9-12 March, 1987. International Atomic Energy Agency (IAEA) Vienna, 1989. 492 pp.

The International Atomic Energy Agency organised a technical committee meeting from 9th to 12th March 1987 at Vienna to review the current status of knowledge in the genesis of different types of uranium deposits. Sixty participants from twenty countries including India, participated in the meeting and the above publication of the IAEA records the proceedings which include 24 scientific papers, gist of discussions, specialist panel reports and recommendations for future work. The three salient aspects on which special attention was focussed at the meetings were : (a) formation of uranium deposits (b) use of metallogenic concepts in uranium exploration and c) deposit classification schemes and models.

The papers presented may be conveniently grouped into two categories, the first dealing with general and basic aspects of uranium metallogeny such as geochemical migration patterns of uranium, uranium mineralisation associated with biogenic sulphate-sulphide reduction processes, mobility of U-Th-REE in hydrothermal systems and the spatio-chronological position of Precambrian uranium deposits. The second category deals with geological and geochemical aspects of individual uranium occurrences/deposits in W. Europe, Canada, USA, Latin America, Africa, China and India.

In terms of deposit size and grade, Dahlkamp classifies Uranium Deposits as follows:

Deposit Size:		*Deposit Grade:*	
	Small reserves – 5000 t U_3O_8		Low – <0.15% U_3O_8
	Medium reserves – 5000 to 20,000 t U_3O_8		Medium – 0.15 to 0.5% U_3O_8
	Large reserves – >20,000 t U_3O_8		High – >0.5% U_3O_8

The minimum size for a commercially viable competitive target with reasonable infrastructure is placed at or above 8000 t U_3O_8, with an average grade of > 0.3% U_3O_8.

The geochemical behaviour of uranium, characterised by its solubility, ease of transport and precipitation/fixation results in a variety of sometimes overlapping and transitional genetic types that carry the imprints of multiphase mobilisation, metasomatism and reworking. The following 14 genetic types of uranium deposits recognised by Dahlkamp have to be viewed from the above context : 1. Unconformity contact (associated with lateritically weathered crystalline basement), 2. Subunconformity-epimetamorphic (strata-structure bound in late lower Proterozoic metasediments), 3. Vein Type, a) granite-related b) non-granite, 4. Sandstone, 5. Collapse Breccia, 6. Surficial, 7. Quartz-pebble conglomerate (L. Proterozoic) 8, Intrusive (magmatic) 9. Phosphorite, 10. Volcanic, 11. Metasomatic, 12. Synmetamorphic, 13. Lignite, 14. Black Shale.

Uranium mineralisation in the Himalaya and in the Dongargarh Supergroup (Bodal and Bhandaritola deposits), Central India, are the two major contributions by the officers of the Atomic Minerals Division (AMD), and are therefore of particular interest to the Indian Earth Science community. Saraswat and Mahadevan recognise following genetic types of uranium mineralisation with distinct temporal and spatial relationships in the Himalaya: 1. Stratiform remobilised (Proterozoic) – Larji-Rampur window in Simla and Kulu Dts. of H. P. ; Baleshwar, Ingedinala, Tunji – Pokri, Berinag of U. P. and Kishtawar, J and K. 2. Structurally controlled Hydrothermal (Proterozoic) – Dalings, E. Himalayas ; Jagdumb-Rongli-Rhenock in Sikkim ; Jamiri-Tai-Kaying in Arunachal Pradesh ; Mineralisation in Central Himalayan Crystallines close to the Main Central Thrust (MCT) in Kumalthi-Dharkot-Sileth-Brijranigad-Mamni belt of Tehri Dt., U.P. 3. Black shale - Phosphorite Type—Krol-Tal sequence, Sirmur Dt., M.P. to Tehri Dt., through Mussoorie (U.P.) ; Phosphorite rocks of Buxa Sequence, Rangit Window, Sikkim. 4. Sandstone Type—Siwalik sediments of Middle Miocene to Pleistocene age. 5. Disseminated and vein types—Greater and Trans-Himalaya ; Tertiary Granitoids and associated pegmatites with beryllium association.

The authors opine that the Uranium mineralisation in the Himalayas displays both syngenetic and epigenetic characteristics, indicative of prolonged periods of mobilisation.

The uranium mineralisation in the Rhyolite-Basalt Province of the Proterozoic Dongargarh Supergroup (Bodal and Bhandaritola deposits) is preferentially localised along the contacts of sheared metabasics and meta-acid volcanic sequences. Prolonged acid magmatism has leached out uranium from the preexisting volcanic sequences and deposited in favourable lithostructural locales resulting in economically significant uranium ore bodies (Singh *et al.*).

The panel on Uranium exploration suggests that unconformity-related deposits, sandstone deposits and breccia pipe deposits constitute the most important category as future exploration targets. Vein type deposits come next in importance and at the bottom of such a classification are the deposits in conglomerates, magmatic deposits and surficial deposits.

The panel on the formation of uranium deposits recognises the following basic steps of: (a) source mobilisation, (b) transport, (c) deposition, (d) reconcentration and (e) preservation, in the genesis of uranium deposits.

When uranium is present below Clarke value (about 1 to 2 ppm) it gets fixed in accessory minerals like monazite, apatite and zircon and is difficult to be leached by most hydrothermal solutions save by strongly alkaline ones involving Na-metasomatism. However, when uranium content exceeds the Clarke value, there is a tendency to fractionate into the melt during partial melting and may crystallise as uraninite, which is easily leachable by hydrothermal solutions. Thus regional uranium enrichment and metallogenic provinces appear to be plausible. Further, it has been noted that in the peraluminous leucogranites of the European Hercynian assaying 20 ppm U, 70–90% of it is located in uraninite. In subalkaline granites (calcium-rich meta-aluminous monzonites) with 12–20 ppm U, the uranium is located in uranothorite, which is extremely resistant to hydrothermal leaching.

The transport and deposition of uranium depends on several physico-chemical variables, prominent amongst them being: oxygen fugacity (fO_2), temperature, concentration of complexing anions, pH and the amount of fluids. Graphite (original reducing brines by decomposition of organic matter) may act as a reductant at low temperatures in unconformity related deposits. Reconcentration is related to successive hydrothermal circulation events at different times, as evidenced by large number of ages obtained for many deposits. Among the major unanswered questions about U-genesis is the U-content of the fluids in individual fluid inclusions.

It is interesting to note that both public and private funding of research on U-deposits is on the decline globally, indicating perhaps sufficient stockpiles of the strategic metal. Only high-grade, high reserve deposits are attracting attention for investments. The 'data sensitivity' and exaggerated security consciousness in the past has resulted in supression of information regarding uranium occurrences/deposits particularly in terms of grade and tonnage as well as vital geological and geochemical parameters. It is therefore very gratifying to note that several contributions in this IAEA publication deal with individual deposits indicating a new trend of openness that should be welcomed by all Earth-Scientists. The publication is commended for perusal not only as a state-of-art account of uranium metallogenesis but also as a contribution to the geology and geochemistry of this naturally radioactive element. The two articles on the Uranium mineralisation in the Himalayas and in the Dongargarh Supergroup are essential reading for all students of Economic Geology in India. The publication is available for consultation in the Geological Society of India Library at Bangalore.

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