Exploration for Rare Metals and the Indian Scenario – P. V. Thirupathi, *Atomic Minerals Directorate for Exploration and Research, Southern Region, Bengaluru. (E:pvthirupathi.amd@gov.in)*

Some of the elements in the periodic table are called as rare elements due their late discovery, rarity in occurrence, difficult extraction process and lack of industrial applications, till recent time. They include niobium (Nb), tantalum (Ta), beryllium (Be), lithium (Li) and cesium (Cs), which are also called as rare metals (RM). The end use, high demand, uncertain supply and no substitution by other elements made these elements critical and strategic. They have become essential constituents in the key areas of space, atomic energy and heavy industry to hand held electronic gadgets. In order to meet the growing worldwide demand for these elements, different geological environs are being explored. The Atomic Minerals Directorate for Exploration and Research (AMD), an exploration wing of the Department of Atomic Energy, is engaged in geological exploration for RM-bearing minerals along with U, Th and rare earth elements (REE) for fulfilling the objectives of country's nuclear programme.

The exploration for rare metals is carried out in four stages: i) regional and sub-regional reconnaissance surveys in favourable geological domains, ii) identification of host rock, iii) evaluation of host rock and their derived gravel/soil and iv) recovery of the mineral. The target areas are selected based on the literature accrued, interpretation of satellite imageries for delineating major lineaments, intrusive granite and ring complex nature of carbonatite bodies and interpretation of data obtained from airborne gamma ray spectrometry. Magnetic and gravity geophysical surveys also help in locating the host rocks, most importantly carbonatites. Pedogeochemical/soil sampling is another important and cost effective exploration tool for locating the host rock.

Carbonatites, alkali granites and granite pegmatites are the major sources for RM mineralisation. The carbonatites are the major source Nb, LREE, F, V and P and the major deposits are located in Brazil (Araxa, Tapira, Catalao & Seis Lagos), Australia (Mount Weld), Canada (St. Honore), Zaire (Lueshe) and Russia (Tomar deposit in Siberia). Pyrochlore is the major mineral in carbonatites and accounts larger part of world's Nb resources. It carries radioactive elements, viz., U and Th, in major abundance and REE, up to 6% by weight. The major RM-bearing alkali granites are located in China (Baerzhe & Hegenshan), Mongolia (Baikal region), Nigeria (Jos-Bukuru Complex) and United states (Bukuru Mountain Complex). Columbite, fergusonite, samarskite, betafite, fersmite, bristolite and monazite are the common major RM- and REE-bearing minerals in the alkali granites. Granite pegmatites, the principle sources for Ta, host most of the Be and Li and entire Cs. Columbite-tantalite is the most predominant Nb-Ta mineral with additional microlite, wodginite and tapiolite and subsidiary fergusonite and samarskite. Beryl is the common Be mineral, lepidolite, amblygonite and spodumene are the Li-bearing minerals and pollucite for Cs. The major granite pegmatites hosted Ta, Be, Li and Cs deposits are in Canada (Tanco), Australia (Greenbushes), Brazil (states of Minas Gerais & Espirito Santo) and Ethiopia (Kenticha pegmatite belt).

In India, the REE- and Nb-bearing carbonatites are associated with major lineaments and they include early-late Cretaceous carbonatites of Amba Dongar (Gujarat), Mer-Mundwara, Sarnu-Dandali-Kamthai (Rajasthan), Sung Valley (Meghalaya) and Samchampi (Assam), Neoproterozoic Newania (Rajasthan), Sevathur, Samalatti and Pakkanadu (Tamil Nadu) and Paleoproterozoic Hogenakal (Tamil Nadu) and Kollegal (Karnataka). Detailed evaluation of these carbonatites by AMD and other geological agencies resulted in establishing potential REE and RM resources.

The important Nb, Y and REE-bearing Neoproterozoic, alkali (A-type) granites of India are located in Kanigiri, Prakasam district, Andhra Pradesh, in Siwana ring complex in association with volcanic rocks, Rajasthan and Kullampatti granite in Salem district, Tamil Nadu. Columbite, fergusonite, samarskite, betafite, fersmite, bristolite and monazite occur as RM- and REE-bearing minerals. Other interesting alkali granites are exposed at Chengannoor in Alleppy district and Ambalavayal in Wynad district, Kerala.

At present, granite pegmatites are most favourable sources in India for recovering the RM-bearing minerals due to their coarse- to very coarse-grained nature and accumulation in eluvial and colluvial gravels. Estimation of the mineral potential and their recovery by physical beneficiation (gravity concentration) technique are simple, easier and cost effective. The major pegmatite belts of Rajasthan, Bihar (Jharkhand) and Nellore in India are known for their beryl, ruby mica and muscovite mica potential, respectively, with subsidiary Nb, Ta, REE and U minerals. The pegmatite terrains of Chhattisgarh, Orissa and Karnataka are the most significant hosts for Nb, Ta, Be and Li and their mineral production. The pegmatites of Beku area in Purulia district, West Bengal carry pollucite, the Cs mineral. The RM mineralised pegmatites are generally zoned and belong to LCT and NYF family. The Chhattisgarh and Orissa pegmatite belt is called Bastar-Malkangiri Pegmatite Belt (BMPB) where the mineralised pegmatites are intrusive into the metasediments, metabasics and granites. They contain columbite-tantalite, ixiolite, wodginite, beryl and lepidolite as RM-bearing minerals. The pegmatites are both Nb- and Ta-rich and majority belong to LCT family. The pegmatites of northern Orissa (Jharsuguda district) are emplaced within granite gneiss and along the contact between gneiss and amphibolite, carry columbite-tantalite, beryl and lepidolite as RM-bearing mineral and predominantly Nb-rich. The RM-bearing pegmatites of Karnataka are in southern part of Western Dharwar Craton and emplaced within the hornblende schist of ancient supracrustals of Sargur Group. They carry columbite-tantalite, tapiolite, microlite, beryl and spodumene as RM-bearing minerals. The striking similarities among all the three are that they are zoned and intimately associated with metavolcanics/meta sediments of Archaean age.

The pegmatites of BMPB, northern Orissa and Karnataka are the most viable and productive among all sources for RM mineralisation in India.

Extended Abstract of the Lecture delivered at the Monthly Scientific Meeting of the Geological Society of India on 11 March 2020

DOI: 10.1007/s12594-020-1493-1