High Incidence of Scandium and REY in the Garnets from Coastal Sands of India

The heavy mineral suite (economic) in beach, dune and offshore sands of Odisha, Andhra Pradesh, Tamil Nadu and Kerala coasts mainly comprises of ilmenite, garnet, sillimanite, rutile, monazite and zircon. Panda et al., 2017 reported high incidence (point analysis by EPMA) of REE (1500-5300ppm) especially HREE in the garnet collected from the Kalingapatnam coast of Andhra Pradesh. EPM analysis of a few garnet grains collected off Anjengo (Kerala) has also shown encouraging REE (1200-5000ppm) values (Beena et al., 2017). To understand the REE concentrations in garnets from Indian coast, nine samples were collected off Taingapatnam (Tamil Nadu), Nanjam (Tamil Nadu), Santepalle (Andhra Pradesh) and Bhavanapadu (Andhra Pradesh) and from the beaches of Yarada (Andhra Pradesh), Manavalakurichi (Tamil Nadu), Kanyakumari (Tamil Nadu) and Uvary (Tamil Nadu) (Fig.1). Out of nine samples, 7 samples viz; GRT-1 (ST-216), GRT-2 (ST-171), GRT-3 (ST-171), GRT-5 (SS-106), GRT-6 (SS-106), GRT-7 (SS-140), GRT-8 (SS-140) are pertaining to 4 cruises of MCSD, GSI as mentioned and the remaining 2 samples viz; GRT-10 and GRT-11 were collected from IREL Research Centre, Kollam and AMD, Thiruvananthapuram respectively . The samples contain economic heavy minerals mentioned above in different proportions were subjected to multiple processes for enriching garnet at IREL Research Centre, Kollam, Kerala using REDMS (Rare Earth Drum Magnetic Separator), CSS (Corona Static Separator), EPS (Electrostatic Plate Separator), IRMS (Induced Roll Magnetic Separator) and diiodo methane liquid (3.3 sp. gr.) to make the samples > 95% enriched in garnet. The enriched garnet samples were subjected to HR-ICPMS and XRD analyses for trace elements and mineral phases respectively at NIO, Goa.

Out of the nine garnet samples, five (GRT-1, GRT-2, GRT-3, GRT-6 & GRT-11) have high concentrations of Scandium (Sc) (244-386 ppm), seven have good contents of Yttrium (Y) (530-900ppm) (GRT-1, GRT-2, GRT-3, GRT-6, GRT-8, GRT-10 & GRT-11) and in six samples, encouraging results of REE (816-7472ppm) (GRT-1, GRT-2, GRT-3, GRT-6, GRT-8 & GRT-10) are also noticed (Table-1). The XRD analysis has revealed that the major mineral phase in all the samples is garnet with minor presence of quartz. The garnet in all the samples is of almandine-pyrope series type. Under binocular microscope, garnet grains are mostly red or light pink in colour.

At present, garnet is being widely consumed for its low end uses like abrasives in sand blasting, water jet cutting and polishing industries. Its utility has widened to water filtration industries in recent years. India is endowed with a vast garnet resources of beach and dune sand origin all along its coastal zones. Bulk of the garnet production in India comes from beach and dune sand deposits of Tamil Nadu with subordinate amount from Andhra Pradesh and Odisha (Panda et al., 2017).

The concentrations of REY in some of the samples are encouraging especially in view of the heavy demand that prevails for REY for strategic applications, hybrid vehicles, magnets, rechargeable batteries etc.

Scandium occurs in many ores in trace amounts, but has not been found in sufficient concentration to be mined as a primary product. The crustal abundance of scandium is 21.9 ppm (Rudnick and Gao 2003). As a result of its low concentration, scandium has been produced exclusively as a byproduct during processing of various ores or recovered from previously processed tailings or residues. Coal can contain significant Sc. Average Sc concentrations in a wide variety of coals from Asia range from 0.85 to 16.0 ppm, with an overall average of 4.3 ppm and a maximum value of 230 ppm (Arbusov et al. 2013). Consequently, coal fly ash can also contain significant Sc, generally several tens of ppm (Franus et al., 2015). The scandium values analysed in monazite pertaining to Chavara and Varkala beaches of Kerala are 4.5 and 11 ppm respectively (Krishnan et al., 2001). Scandium rarely concentrates in nature. It does not selectively combine with the common ore-forming anions, so time and geologic forces only rarely form scandium concentrations over 100 ppm. (http://www.scandiummining.com/s/scandium.asp). Scandium is not rare; however, finding commercially viable grades (>200-300g/t) of scandium is very rare. https://seekingalpha.com/article/4099363-scandium-boom-next-look-scandium-miners. In comparison

with the above data, the Sc concentrations in some of the garnets mentioned above are promising (244-386 ppm).

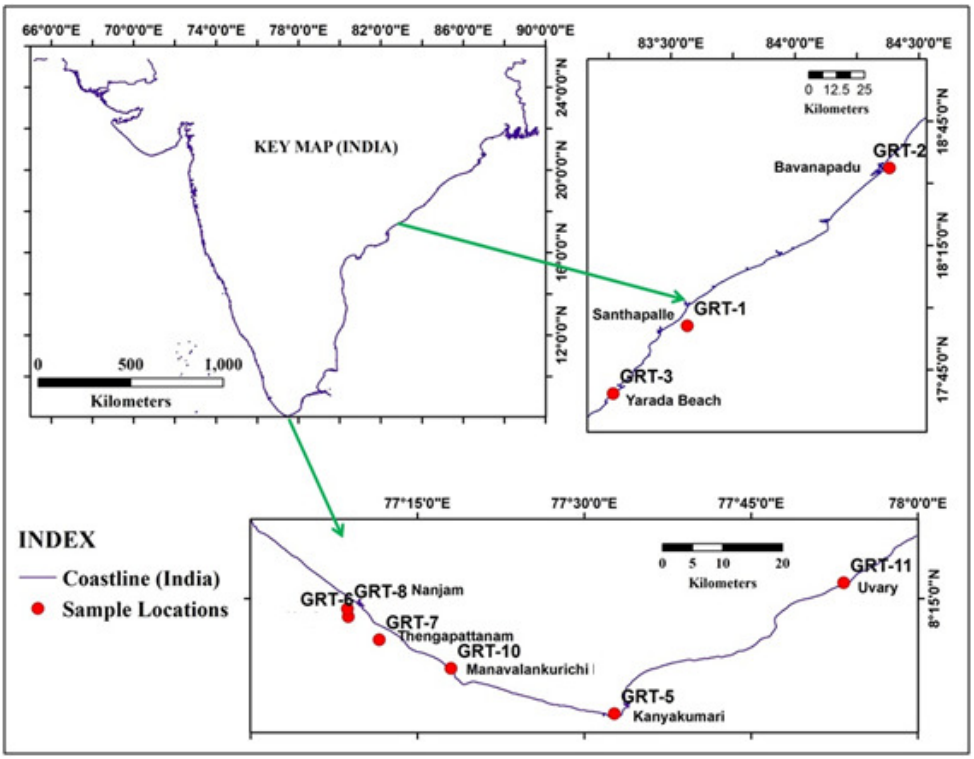

Fig.1: Map Showing Sample Locations

Table:1 Scandium and REY concentrations (ppm) in garnet from different locations

Sample No	REE	Sc	Y	Domain	Place
GRT-1	816.705	261.949	751.875	Offshore	Santhapalle
GRT-2	7472.295	352.788	900.248	Offshore	Bavanapadu
GRT-3	1590.518	258.58	640.12	Beach	Yarada
GRT-5	317.062	117.513	418.268	Beach	Kanyakumari
GRT-6	3366.543	244.074	583.374	Offshore	Nanjam
GRT-7	191.676	56.527	178.857	Offshore	Taingapatnam
GRT-8	3856.351	93.979	530.504	Offshore	Nanjam
GRT-10	993.753	93.324	553.126	Beach	Manavalakurachi
GRT-11	385.48	386.668	669.111	Beach	Uvary

Scandium is a costly metal and its global production is very small (~10 tonnes per year) as a by-product from mining of ores of titanium, rare earths, apatite, and uranium (Deady et al. 2014). Despite scandium's scarcity, over the past two decades multiple potential high-value commercial uses for the metal have been developed. The principal uses of Sc are in Sc-Al alloys and in solid oxide fuel cells. Minor amounts of Sc are also used in variety of other applications including electronics, lasers, mercury vapor lamps and lighting.

All garnet samples collected from different domains are not carrying high concentrations of Sc and REY. Hence, characterization of garnets having high values of Sc, Y and REE and their delineation in the coastal sands are of paramount importance for which detailed studies are under progress.

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