Geophysical Research Abstracts
Vol. 14, EGU2012-9271-3, 2012
EGU General Assembly 2012

The modes of occurrence of rare-earths ores and the issues on their beneficiation processes

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Rare-earths (RE) ores can largely be divided into the following four types in terms of the modes of occurrence. In each type of RE ores, there are some issues on beneficiation processes, which should be resolved for their successful exploitation.

1. Fine-grained phosphates with iron oxides: This type ores are commonly found from weathered carbonatite and IOCG deposits. The former is Araxa (Brazil), Zandkopsdrift (South Africa), Mt. Weld (Australia) and Yen Phu (Vietnam), and the latter Bayan Obo (China), Vergenoeg (South Africa) and Olympic Dam (Australia). Main RE minerals are monazite, xenotime and florencite contained in the aggregates of iron oxides such as goethite, hematite and magnetite. Fluorite often occurs in the latter type ores. The phosphates and iron oxides occur commonly as very fine grains (< 10 micron meters), and thus they are not readily separated by conventional physical processing.

2. Fluorapatite veins: This type ores are found from the deposits related to alkaline igneous rocks. Nolans Bore (Australia), Palabora (South Africa) and Mushugai Khudag (Mongolia) are the examples. RE is contained mostly in fluorapatite and associated monazite. It is expected that RE can be produced as byproducts of phosphorus fertilizer. However, dissolution of fluorapatite by sulfuric acid causes the coprecipitation of RE with gypsum, which is a refractory material.

3. Silicates and niobium oxides: This type ores are found from hydrothermally altered alkaline plutonic rocks or pegmatitic veins related to alkaline magmatism. Nechalacho and Strange Lake (Canada), Kvanefjeld (Greenland), Bokan Mountain (US), Norra Karr (Sweden) and Dubbo (Australia) are the representative deposits. Main RE minerals are zircon, eudialyte, mosandrite, fergusonite and allanite. They are relatively enriched in heavy RE, and it is expected that part of RE can be produced as byproducts of zirconium. However, their acid dissolution often causes the coprecipitation of RE with silica gel, which is also a refractory material.

4. Medium- to coarse-grained carbonates: This type ores occur in less weathered carbonatite bodies. Mountain Pass (US), Maoniuping (China) and Dong Pao (Vietnam) are the representative deposits. Bastnasite is a main RE mineral. Though, the ores can readily be beneficiated by conventional flotation and dissolved by acid solution, they are always depleted in heavy RE.