Characteristics and genesis of ion adsorption type REE deposits and related granites in South China

*Yan Hei Li[1], Mei-fu Zhou[1]

1. University of Hong Kong

Rare Earth Elements (REEs) are strategically important in high-technology industrials. Currently, China dominates the global production of REEs while the widespread "ion-adsorption type" deposits in South China are some of the major REE sources especially the more demanding heavy rare earth elements (HREEs). Therefore, it is critical to have an in-depth understanding on the characteristics and genesis of this type of deposit. This review will summarize the geochemical and mineralogical features of these deposits as well as their parent granite, and suggest the factors controlling the formation of these deposits.

Although prospects of ion adsorption type REE deposit have been discovered and explored in Vietnam, Myanmar, Thailand, Brazil, Malawi, and Madagascar recently, the majority of this type of deposit is located in South China, distributing over the Jiangxi, Guangdong, Fujian, Hunan and Yunnan provinces. In general, deposits can be categorized into the HREE-enriched, for example the famous Zudong deposit in southern Jiangxi province and the LREE-enriched type, such as the Heling and Dingnan deposit in southern Jiangxi province. Numerous geochemical analyses have indicated that the maximum REE enrichment, normally two- to three-fold enrichment compared to the parent granite, mostly occurs within the completely weathered zone (B horizon) with less concentration in the semi-weathered zone (C horizon). Accumulation of LREE at comparatively upper part while that for HREE at the lower part is also frequently observed in these deposits. Mostly, the REE pattern of the regolith is similar to the parent rock, except for Ce. Strong positive Ce anomaly is commonly observed in the upper part of the weathering profile while it shifts to a negative one at the lower part. It is likely due to the oxidation of Ce^{3+} to Ce^{4+} and the precipitation of cerite that removes Ce from fluids at shallow level. As for the mineralogy, clay minerals, particularly kaolinite and halloysite, are the key components on which the REEs are adsorbed. Nevertheless, organic substances and Fe-Mn oxyhydroxides likely play an important role. Furthermore, SEM observations show that a variety of secondary REE minerals exist in the regolith. Residual zircon, monazite, and xenotime may also contribute a certain amount of the resources. Traditionally, REEs are thought to be adsorbed onto clay minerals in ionic state, however, recent studies start to reveal that nano-REE particles and colloids are also adsorbed on clay minerals. These deposits are dominantly developed from the weathering of biotite and/ or muscovite-bearing alkali granite from Caledonian to Yanshanian period in the region. The nature of the parent granites is various, including S-type, A-type and highly-fractionated I-type. However, it is common that late stage metasomatism took place transferring part of the REEs into hydrothermal minerals, which are more susceptible to weathering, such as bastnä site-(Ce), synchysite-(Y), fergusonite, and allanite.

Under a tropical to sub-tropical climate, REEs are released from the parent REE-enriched granites during weathering. Along with infiltration of meteoric water, REEs are leached from broken down of REE-bearing minerals, and transported to the lower part, at where they are adsorbed by clay minerals and precipitate as secondary minerals. After a long period of weathering, REE accumulates at the lower part of the profile to form the deposit. Therefore, climate and duration of weathering, that control the intensity and extent of weathering, are significant to the ore formation. Exhumation is also important in keeping weathering active. Low-lying relief and slow denudation rate in South China help reduce the erosion of the regolith and preserve of the ore bodies. pH and redox environment of the regolith are other major factors and they control REE adsorption and secondary mineral precipitation in the regolith.