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Origin of the ~1.74 Ga, Anorthosite-hosted Damiao Fe-Ti-P Ore Deposit, North China

CHEN Terry Wei[1, *] and ZHAO Taiping[2]

1 *Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 510081, China*
2 *Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China*

The Damiao Fe-Ti-P ore deposit, hosted in the ~1.74 Ga Damiao anorthosite complex, is the only known anorthosite-hosted deposit in China. The deposit contains hundreds of ore bodies occurring as irregular lenses, veins or pods hosted in anorthosite and norite. These discordant oxide ores contain abundant but variable apatite, and are classfied into Fe-Ti ore, nelsonitic ore and oxide-apatite gabbronorite on the basis of apatite contents and ore structures.

Intrusive feature of nelsonitic ores and contrast densities between Fe-Ti oxides and apatite suggest that the nelsonitic ores have crystallized from an immiscible nelsonitic melt. Fe-Ti ores displaying similar compositional range of Fe-Ti oxides and silicate minerals are interpreted to have also crystallized from the immiscible nelsonitic melt, which is further supported by the spatially close association of Fe-Ti and nelsonitic ore bodies and their comparable mineral assemblages of plagioclase, pyroxene, Fe-Ti oxides and apatite. This interpretation that fractional crystallization of the immiscible nelsonitic melt forming both Fe-Ti and nelsonitic ores is well consistent with linear variations of Sr, Y, Th, U and REE contents of apatite and the parallel chondrite-normalized REE patterns.

On the other hand, oxide-apatite gabbronorite display relatively larger variable but more evolved compositions of silicate minerals than nelsonitic ores (and Fe-Ti ores), pointing to a separate origin in each case. Apatite of oxide-apatite gabbronorite contains lower Sr and MgO but higher REE contents and Y than those of nelsonitic ores, further indicating that nelsonitic ores are relatively more primitive. Based on their dissminated texture and continuous chemical variation, we considered that oxide-apatite gabbronorite may have formed by normal fraction crystallization process through a trend of iron enrichment in residual liquids, different from the immiscible origin for nelsonitic ores. Oxygen fagacity (fO_2) might be one of the important factors resulting in different forming processes for nelsonitic ores and oxide-apatite gabbronorite, because liquid immiscibility field expands generally with increasing fO_2. Higher fO_2 for nelsonitic ores is well indicated by their smaller negative Eu anomalies of apatite, because apatite readily accepts the Eu^{3+} into its structure but excludes the larger Eu^{2+}.

* Corresponding author. E-mail: chenwei@mail.gyig.ac.cn