Sr-Nd-Fe isotopic constraints on the origin of Kiruna-type deposit in Zanjan, NW Iran

*淺原 良浩[1]、眞野 航大[1]、壷井 基裕[2]、アジジ ホセイン[3,1]、SHIN Ki-Cheol[4]、李 承求[5]
*Yoshihiro Asahara[1], Kodai Mano[1], Motohiro Tsuboi[2], Hossein Azizi[3,1], Ki-Cheol Shin[4], Seung-Gu Lee[5]

1. 名古屋大学大学院環境学研究科地球環境科学専攻、2. 関西学院大学理工学部、3. クルジスタン大学工学部（イラン）、4. 総合地球環境学研究所、5. 韓国地質資源研究院
1. Graduate School of Environmental Studies, Nagoya University, 2. School of Science and Technology, Kwansei Gakuin University, 3. Faculty of Engineering, University of Kurdistan (Iran), 4. Research Institute for Humanity and Nature, 5. Korea Institute of Geoscience and Mineral Resources (Korea)

Iron oxide apatite (IOA; Kiruna type) deposit is recognized as an endmember of the iron oxide-copper-gold (IOCG; Olympic-Dam type) deposit (e.g., Hitzman et al., 1992; Knipping et al., 2015). IOA deposit is an important source to provide iron, phosphorous and rare elements including rare earth elements (REEs) and U. Origin and formation process of the IOA deposit remain controversial. Previous studies have proposed several ideas: hydrothermal fluid, that is non-magmatic surface fluid (e.g., Hitzman et al., 1992; Dare et al., 2015); a magmatic-hydrothermal fluid coming directly from magma (e.g., Pollard, 2006; Knippng et al., 2015); liquid immiscibility between a Fe-, P-rich melts forming IOA deposits (e.g., Henríquez and Martin, 1978; Hou et al., 2017). Evidence from oxygen and iron isotopes of magnetites in an IOA deposit indicates that the origin is magmatic (e.g., Jonsson et al., 2013; Bilenker et al., 2016).
We focus on a Kiruna type deposit in Zanjan, Northwestern Iran. Magnetite-apatite deposit occurs in the Zanjan area, which is part of the volcano–plutonic belt of the Tertiary Alborz-Azarbaijan arc. In this study, Sr, Nd and Fe isotopes and trace element compositions including REEs in the ore mineral and host-rock samples were analyzed to constrain the origin of Kiruna type deposit in Zanjan.
Chemical compositions of major elements indicate that the Zanjan host rocks are monzonite to granite, metaluminous to peraluminous and I-type. The host rocks have LREE-enriched and HREE-flat patterns with slightly positive or slightly negative Eu anomalies. Trace element compositions show that the magnetites in the Zanjan IOA deposit has a Kiruna-type characteristic on V-Cr diagram.
The magnetite and apatite show LREE-enriched patterns with strong negative Eu anomalies, suggesting that both of the minerals were formed in the last stage of crystallization differentiation. Iron isotopic compositions of the magnetites show positive values indicating that high-temperature hydrothermal fluid contributed to the magnetite formation. The Sr and Nd isotopic compositions of the apatite are consistent with initial Sr and Nd isotope ratios of the Zaker quartz monzonite of the main host rock, indicating that the apatite has the same source of the host rock. The magnetites in the ore have slightly high Sr isotopic ratios and similar εNd values compared with the quartz monzonite, indicating that the magnetite has the same origin as the host rock but was slightly influenced by hydrothermal fluid.

キーワード：磁鉄鉱-燐灰石鉱床、キルナ型、同位体、希土類元素、熱水起源、イラン
Keywords: iron oxide apatite deposit, Kiruna type, isotope, REE, hydrothermal, Iran