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Hf and Nd isotope decoupling in paleoarchaean TTG: Evidence from Singhbhum craton, Eastern India

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Abstract

Tonalite-Trondjhemite-Granodiorite (TTG) clan of rocks are the most dominant constituent of the continental crust in paleoarchean terranes. Origin and petrogenesis of this rocks are keys to understand important aspects of crustal evolution and geodynamic regimes of the early earth. Major and trace element geochemistry along with geochronology and different isotopic study unravel the most intriguing and difficult questions related to crustal evolution mechanisms that had been operative in paleoarchean. Geochemical data are most useful in characterizing different rock types, and help in conjecturing possible mechanisms of petrogenesis. Geochronological data yielded from either whole rock isotopic study or single mineral, constrain precise timing of emplacement. However, extensive study on different isotopic pairs have led to perception about behavior and partitioning of elements within different reservoirs.

Singhbhum craton in eastern India exposes gneissic to foliated sodic granitoids of TTG affinity. Based on field evidences and neutron activation data, earlier workers considered these TTG type of rocks as a single episode of emplacement. However, our recent geochemical study on TTG rocks show notable difference in Heavy Rare Earth (HREE) pattern in chondrite normalized REE plot. Accordingly, depending on absolute REE concentration and chondrite normalized REE pattern, TTGs have been grouped into two different types, namely, (1) High HREE TTG [low SiO2; high HREE avg. (Gd/Er)n=2.23; less fractionated REE avg. (La/Yb)n=27.9 and low Sr/Y avg. Sr/Y=53.59] and Low HREE TTG [high SiO2; depleted HREE avg. (Gd/Er)n=3.23; steeply fractionated REE avg. (La/Yb)n=46.11 and high Sr/Y avg. Sr/Y= 95.49]. There is little difference in the major element composition and mantle compatible elements of High HREE and Low HREE TTGs. Upadhyay et al. 2014 also reported tonalite-trondjhemite component and granite component within the TTGs. Tonalite and trondjhemite components of TTG were emplaced within 3.45-3.44 Ga; whereas, granite component were emplaced within 3.35-3.32 Ga. The two types of TTGs mainly differ in pressure sensitive signatures like Sr/Y and (La/Yb)n ratio. This indicates melting occurred at different crustal levels. Similar Sr content but variation in HREE infers, both the types are generated by melting in garnet stability field. However, HREE variation is controlled by amount of Garnet retained in the restite. Thus, in spite of melting of the source rock in garnet stability field, only the minor change in depth of melting and in turn different amount of retention of garnet in the source caused the difference in HREE pattern.

Pandey et al. 2017 studied Pb isotopes from leached K-feldspar separated from TTGs and indicated a homogeneous and relatively undepleted mantle source and near pristine character of the rocks. They also found Sr and Nd isotopic values to be near chondritic. From isotopic studies they concluded that only minor mantle depletion occurred prior to emplacement of TTGs in Singhbhum Craton in paleoarchean.

Hf isotopic studies from zircon grains, separated from TTG, yielded positive ƐHf values for all the dated samples. This observation differs from that of Pandey et al. 2017. Garnet is a phase which can fractionate Lu/Hf and Sm/Nd ratios in continental crust as $Kd_{Lu/Hf}^{garnet} \gg 1$ and $Kd_{Sm/Nd}^{garnet} \geq 1$. Hence, presence of garnet in the source retains Lu over Hf without significantly partitioning Sm over Nd. Melting of the source rock at garnet stability field to produce TTG causes Nd-Hf decoupling and higher ƐHf value than ƐNd.

References

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