Radiogenic ^{40}Ca in garnet: a new proxy for K loss during granulite-facies metamorphism

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The loss of heat-producing elements during high-temperature metamorphism of the lower crust plays an important role in stabilizing continents over geologic time. A large portion of the lower crust consists of granulite-facies metamorphic rocks, which are thought to represent residues from high-temperature partial melting of igneous and sedimentary protoliths [e.g. 1-2]. As a result, many incompatible trace elements show depletions in lower-crustal rocks [3]. However, the behavior of major heat-producing elements (such as potassium) is more difficult to constrain.

The transformation of ^{40}K to ^{40}Ca via beta decay may be exploited to understand redistribution of K during metamorphism. Garnets from several granulite terranes show large radiogenic ^{40}Ca enrichments (ε_{Ca} up to +42), which have inverse correlations with the grossular content of garnet and rough positive correlations with whole-rock peraluminosity (defined as molar $Al_2O_3/CaO+Na_2O+K_2O$).

Garnet excludes K, therefore excess ^{40}Ca must be inherited from radioactive decay in the protolith rocks, prior to garnet formation. We use measured whole rock K and Ca, garnet ε_{Ca}, and available protolith and metamorphic age estimates to estimate K loss during metamorphism and melting. Garnets with < 5% grossular from metapelites indicate derivation from high K/Ca protoliths (minimum K/Ca = 1 to 13), while garnets with higher grossular content from metabasites suggest protolith K/Ca < 1. Comparing to K/Ca measured today, we find that ~90% of granulites experienced K-loss during metamorphism, and the fractional loss typically varied from 60% to > 95%. These data can be used to constrain melt fractions and compositions. Such ε_{Ca} variations may be used to understand episodic gains and losses of K in a wide variety of geologic settings.

[1] White & Powell (2002) J. Met. Geo. 20, 621-632 [2] Bartoli et al. (2016) Am. Min. 101, 1543-1559 [3] Rudnick et al. (1985) GCA 49, 1645-1655.