Parageneses of allanite, monazite and xenotime in the Barrovian-type metapelites of the Imjingang belt, central Korea: Implications for radioactive element partitioning

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We investigated spatial distributions, microtextures and mineral chemistries of allanite, monazite and xenotime occurring in the garnet- to kyanite-zone metapelites, Imjingang belt, in order to delineate: (1) mineral parageneses and metamorphic reactions; and (2) chemical zonings associated with partitioning of radioactive elements. Allanite grains are ubiquitous in the matrix and within various porphyroblasts, but their abundance sharply decreases in kyanite-zone schists where monazite and xenotime crystals are present. Rims of allanite contain minute inclusions of thorium silicates. Monazite and xenotime are associated with garnet mantled by the biotite corona where xenotime crystals are particularly common. X-ray mapping of single monazite crystal shows relatively uniform Y and Ce contents compared to the anomalously high-Th spike. On the other hand, xenotime shows systematic, oscillatory zonings where Th, U and Si vary antithetically to Y and Yb. Chondrite-normalized REE patterns of monazite are nearly identical to those of allanite, in spite of higher absolute REE contents in the former, but are opposite to those of xenotime.

The presence of thorium silicates in the allanite margins suggests the participation of Th-rich phases in the allanite formation. Regional concordance of monazite-in and allanite-out isograds together with analogous REE patterns of both phases indicates that allanite is the significant source for Y and REE in the monazite formation. Moreover, the Th activity in the presence of thorium silicates might be high enough to nucleate high-Th cores of monazite, which resulted in the core-rim zoning patterns of Th, REE's and Ca in accordance with stoichiometric and charge-balance constraints. These zoning patterns favour simple monazite growth via a single reaction rather than multiple monazite growth by dissolution and reprecipitation. The close microtextural relationship and similar REE pattern between garnet and xenotime indicate that garnet is the major source for Y and REE in the xenotime formation. In contrast to monazite, Y and REE systematics control the overall chemical variation in xenotime. Temperatures estimated from the monazite-xenotime thermometry are in the range of 550-700°C, consistent with previous result based on metapelitic assemblages. It is thus likely that monazite and xenotime formed at the expense of allanite and garnet, and contemporaneously with the breakdown of garnet.