Deciphering the unique Th/La enigma in Alpine-Himalayan orogenic belt K-rich rocks

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The Th/La ratio has recently been used to constrain whether certain chemical features shared by arc magmas and continental crust are induced by subduction or are recycled from subducting sediment. Since neither fluids nor melts that transport slab material to the arc magma source are expected to fractionate Th from La, in normal circumstances the Th/La ratio of mantle-derived magmas should be no larger than 0.5. However, extremely high Th/La ratios (>>0.5) are prevalent in many Alpine-Himalayan orogenic belt (AHOB) K-rich volcanic rocks. Several hypotheses have been put forward to explain this enigmatic Th/La feature, but none have provided a convincing solution so far.

Here we propose a viable model which accounts for new geochemical data obtained from Turkish lawsonite blueschists and experimental results from previous works on melting processes of continental crust. The source regions of the AHOB potassic volcanic rocks consist of blueschist facies mélanges (including oceanic crust, oceanic and continental sediments) imbricated together with extremely depleted fore-arc peridotites, making up a mantle lithosphere that was newly formed during the convergence of microcontinents or other small continental blocks and oceans. The imbrication process takes place entirely at shallow depths (<80 km) and does not require any deep subduction of continental materials. The high Th/La feature is not from a single-stage process, but may result from multiple processes that steadily increase the Th/La ratio: (1) lawsonite with high Th/La (most likely from terrigenous blueschist), (2) loss of a hydrous fluid during lawsonite dehydration that leads to increased Th/La ratio in the residue, and (3) melting of amphibolite where the main minerals (such as amphibole and plagioclase) tend to hold back more La than Th, which further elevates the Th/La ratio.

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