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Geochemical consequences of subduction-zone metamorphism: Evidence from ultrahigh pressure metamorphic rocks, Western Tianshan, China

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Knowledge of elemental behavior during subduction-zone metamorphism (SZM) is important for an improved understanding of the subduction-zone magmatism and the origin of mantle compositional heterogeneity. Here we report the results of our study on blueschists and eclogites, of both sedimentary and basaltic protoliths, from western Tianshan ultrahigh pressure (UHP) metamorphic belt, Northwest China. The bulk-rock geochemistry shows that the basaltic protoliths vary in compositions from incompatible element depleted to enriched varieties, resembling normal ocean crust with seamounts. These, together with sedimentary rocks in the package, may be best described as a subducted/exhumed tectonic mélange.

We confirmed the general understanding that high field strength elements (HFSE, e.g., Nb, Ta, Zr, Hf, Th) and rare earth elements (REE) in rocks of both protoliths are immobile during SZM. The significant correlation of U with HFSE (e.g., Nb, Th) suggests that U is immobile, which is inconsistent with the common perception, but consistent with the interpretation that U behave as U4+ and that subduction zone metamorphic conditions may be more reduced than previous thought. Pb and Sr are mobile in rocks of both sedimentary and basaltic protoliths.

K, Ba, Rb and Cs are mobile in rocks of basaltic protoliths, but immobile in rocks of sedimentary protoliths. The latter is most likely controlled by the presence and the persistent stability of white mica throughout their petrologic history. Although (clino)zoisite is an important host of REE, U, Th, Sr and Pb, the mobility/immobility of these same elements is also controlled by other phases, such as titanite for REE, Th and U, paragonite for Pb and Sr, and carbonate for Sr.

Samples of basaltic protoliths without obvious retrograde overprints show a significant positive correlation of Sm/Nd with Lu/Hf, which is consistent with the first-order linear Nd-Hf isotope correlation in oceanic basalts if their sources were indeed recycled ocean crust. However, the lack of Rb/Sr vs. Sm/Nd correlation cannot explain the observed first-order Sr-Nd isotope correlation in oceanic basalts, suggesting that the residual ocean crust that has undergone SZM cannot be the major source material for oceanic basalts although they can contribute to the mantle compositional heterogeneity.

Retrograde metamorphism is common in our samples, and we reason that fluids released from within-slab serpentines (e.g., “abyssal peridotites”) may be an important agent for the retrograde metamorphism.