U-Pb garnet, zircon, and rutile petrochronology of eclogite xenoliths from the Navajo Volcanic Field (USA)

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Complementary insights from multiple mineral geochronometers are often indispensable to disentangle the complex multi-stage history of subduction-related rocks. Previous geochronological work on eclogite xenoliths of the Navajo Volcanic Field (NVF) sparked controversies about their origin, especially whether they are derived from oceanic crust of the Farallon plate, or from older continental lithosphere, based on occasional Proterozoic zircon U-Pb ages. We present new LA-ICP-MS U-Pb data from garnet, zircon, and rutile alongside geochemical and geothermobarometric data to test models for the origin and evolution of the NVF xenoliths.

The NVF comprises intrusions of serpentinized ultramafic microbreccia (SUM) which intruded the Colorado Plateau at ~30 Ma. Eclogite xenoliths from this SUM are mineralogically unusual, strongly resembling orogenic rather than typically bimineralic kimberlite-borne equivalents. Besides ubiquitous rutile, many contain zoisite pseudomorphs after lawsonite (with rare lawsonite relics), matrix monazite, and/or abundant pyrite along with rare coesite. Previous studies obtained peak P-T conditions around 4 GPa and 600°C. Chemically, some of the eclogites resemble mid-ocean ridge basalts, whereas most experienced varying degrees of multi-stage metasomatism. Zoned omphacite with Na-rich rims accompanied by an increase of whole-rock Na_2O contents (up to 11 wt%) and omphacite modes (sometimes >90%) reflects interaction with a siliceous fluid. Mg-rich garnet rims with mantle-like $\delta^{18}O$ are interpreted to reflect a massive hydration event just prior to entrainment in the SUM. The latter is also thought to have caused the crystallization of monazite with published ~30 Ma ages.

The various xenoliths yield variable garnet U-Pb dates, indicating garnet growth at different stages, but exclusively from the Cretaceous to shortly before SUM formation. The non-uniform garnet data may suggest that the NVF eclogite xenolith suite was assembled from rocks that entered the eclogite facies diachronously over tens of Myr. Metamorphic zircon ages cover a range similar to the garnet ages. Various stages of potential interaction with internally-derived (from lawsonite dehydration) and externally-derived (metasomatic) fluids may have induced (re)crystallization and/or partial re-setting of geochronometer minerals over a considerable time span.

There is currently no evidence for pre-Mesozoic metamorphism in the eclogites. By contrast, the hypothesis of a Proterozoic protolith origin is still under consideration, and can only be tested by dating rare igneous zircon cores. A zircon and rutile U-Pb dating campaign planned for the near future will reveal how the resultant ages relate to those obtained from garnet.