American Mineralogist, Volume 88, pages 1633–1643, 2003

Partial equilibrium of radiogenic and stable isotope systems in garnet peridotite during ultrahigh-pressure metamorphism

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ABSTRACT

A critical question in radiometric dating of metamorphic rocks is whether minerals used to define internal isochrons have achieved isotopic equilibrium during a given metamorphic event, followed by preservation of the equilibrium afterward. A garnet peridotite at Zhimafang in the Sulu terrane of eastern China shows incongruent U-Pb, Rb-Sr, and Sm-Nd ages. Zircon SHRIMP U-Pb dating yielded an isochron age of 224 ± 8 Ma, pointing to zircon growth during Triassic UHP metamorphism. Two mineral assemblages gave consistent Rb-Sr internal isochron ages of 201 ± 4 and 205 ± 4 Ma, but much older Sm-Nd internal isochron ages of 376 ± 16 and 378 ± 24 Ma. Apparently, the Sm-Nd radiometric system fails to reequilibrate among the dated minerals during the Triassic UHP metamorphic event for the garnet peridotite. This result is confirmed by the state of oxygen isotope equilibrium (or disequilibrium) among the constituent minerals in the garnet peridotite. In particular, garnet is not in oxygen isotope equilibrium with any other of the analyzed minerals. The degree of oxygen isotope disequilibria among the other minerals varies from pair to pair. Oxygen isotope equilibrium is observed only between orthopyroxene and olivine for both samples and between phlogopite and clinopyroxene for one sample. It appears that the U-Pb, Rb-Sr, Sm-Nd, and O isotope systems in minerals of the garnet peridotite are in partial equilibrium during UHP metamorphism, i.e., equilibrium with respect to some isotopes and minerals, but not all. Based on available experimental diffusion data, our study of the combined U-Pb, Rb-Sr, Sm-Nd, and O isotope systems in the garnet peridotite demonstrates that the time scale for the UHP metamorphism and subsequent HP eclogite-facies recrystallization is possibly in the range of about 12 to 26 Ma, which was not long enough for the reequilibration of the Sm-Nd and O isotope systems, but just long enough for the reequilibration of the Rb-Sr isotope systems. Therefore, the rate of Sr diffusion in phlogopite (thus Sr isotope reequilibration between the mafic minerals) is constrained to be faster than rates of Nd and O diffusion in garnet (thus Sm-Nd and O isotope reequilibration between the same minerals) under conditions of subduction zone metamorphism.