Extreme $^{18}$O depletion in eclogite from the Su-Lu terrane in East China

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Abstract: The unusually low $\delta^{18}$O values of $-10.3$ to $-6.8\%$ are found in mineral separates from an eclogite pod (containing quartz-schist bands) in the Su-Lu terrane, East China. These are the lightest oxygen isotope compositions so far reported for metamorphic rocks in the world. Oxygen isotope equilibrium has been approached among the minerals within both eclogite and quartz-schist. This not only yields the concordant isotope temperatures of $655$ to $765\degree C$, but also indicates that the rocks have exchanged oxygen isotopes with a very $^{18}$O-depleted fluid. A plausible interpretation for the anomalously low $\delta^{18}$O values of the eclogite pod is that it equilibrated isotopically with ancient meteoric water prior to eclogite-facies metamorphism and thus preserved the premetamorphic isotopic signature. The hydrothermally altered basaltic rocks kept this isotopic signature through all stages of progressive UHP metamorphism as well as subsequent exhumation and cooling. This provides insight into limited crust-mantle interactions under ultrahigh pressure metamorphic conditions in the suture zone of a continent-continent collision.

Key-words: oxygen isotopes, water-rock interaction, isotope geothermometry, eclogite, UHP metamorphism, continental collision, Dabie Mountains.

Introduction

Metamorphic rocks have oxygen isotope compositions that are usually similar to those of igneous and sedimentary rocks, with $\delta^{18}$O values ranging from $+6$ to $+18\%$, depending on the geochemical nature of protolith (e.g., Hoefs, 1987; Sharp et al., 1993). Unusually low $\delta^{18}$O values have been reported in cordierite-bearing granulites from the Stranways Range, Australia ($+0.1$ to $+6.8\%$, Wilson & Baski, 1978, 1983; Allen, 1981), in sapphirine-bearing granulate from Quairading, Australia ($+4.3$ to $+4.5\%$, Wilson & Baski, 1983), in Adirondack anorthosites ($+3$ to $+5.8\%$, Morrison & Valley, 1986) and wollastonite skarns ($-1.3$ to $+7.0\%$, Taylor, 1969; Valley & O’Neil, 1982, 1984), and in amphibolite-facies gneiss from Scottish Highlands ($-3$ to $+8\%$, Benner & Horne, 1994).

Both continental and oceanic eclogites have been commonly found to have low $\delta^{18}$O values: $+1.5$ to $+8.9\%$ in the Alps (Vogel & Garlick, 1970; Desmons & O’Neil, 1978; Nadeau et al., 1993), $+2.9$ to $+8.0\%$ in Norway (Vogel & Garlick, 1970; Agrinier et al., 1985), $+2.2$ to $+8.1\%$ in the Roberts Victor Mine (Garlick et al., 1971; MacGregor & Manton, 1986; Ongley et al., 1987), and $+2.9$ to $+5.6$ in South Africa (Shervais et al., 1988; Caporuscio, 1990; Neal et al., 1990). The presence of the low $\delta^{18}$O values in granulites and eclogites indicates the direct or indirect involvement of seawater or meteoric water in the formation of the high grade metamorphic rocks.

In this paper, we report exceptionally low negative $\delta^{18}$O values of $-10.3$ to $-6.8\%$ for minerals of an eclogite pod from the ultrahigh pressure (UHP) metamorphic Su-Lu terrane in East China. We will show that the most probable reason for these low $\delta^{18}$O values is isotopic exchange with meteoric water prior to continental collision and UHP metamorphism. This provides compelling