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# Unusual replacement of Fe-Ti oxides by rutile during retrogression in amphibolite-hosted veins (Dabie UHP terrane): A mineralogical record of fluid-induced oxidation processes in exhumed UHP slabs

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## Abstract

The replacement of rutile by Fe-Ti oxides is a common phenomenon during the retrogression of eclogites. Here, we report an unusual case regarding the replacement of Fe-Ti oxides by rutile during greenschist-facies metamorphic overprinting of veins in amphibolites (retrograded eclogites) from the Dabie ultrahigh-pressure (UHP) terrane, eastern China. The veins mainly consist of plagioclase, Fe-Ti oxides, and quartz, which crystallized from a Ti-rich amphibolite-facies fluid that formed during exhumation of the eclogites. Two types of textures involving the replacement of Fe-Ti oxides by rutile are recognized in the veins: (1) the first type is characterized by the development of rutile coronas (Rt-C) and other silicates (high-Fe epidote, muscovite, and chlorite) around the external boundaries of the Fe-Ti oxide grains, and (2) the second type is characterized by the formation of symplectitic intergrowths of rutile (Rt-S) and magnetite after exsolved hemo-ilmenite (H-Ilm) lamellae in the Fe-Ti oxides. The micro-textures, mineral assemblages, and Zr-in-rutile thermometry indicate that both replacement reactions involved mineral re-equilibration processes in the presence of an infiltrating fluid phase at ~476–515 °C, taking place by an interface-coupled dissolution-precipitation mechanism. Thermodynamic modeling reveals that both replacement reactions occurred during oxidation processes under relatively high-oxygen fugacity ($f_{O_2}$) conditions, approximately 2.5–4.5 log$f_{O_2}$ units higher than the fayalite-magnetite-quartz (FMQ) reference buffer. In situ Sr isotopic analyses of epidote (Ep-C) coexisting with the Rt-C suggest that the infiltrating fluid involved in the greenschist-facies replacement reactions was externally derived from the surrounding granitic gneisses (the wall rocks of the amphibolites). Compared with the rutile in the UHP eclogites (Rt-E) and amphibolites (Rt-A), the Rt-C is characterized by distinctly lower contents of Nb (<10 ppm) and Ta (<2 ppm) and Nb/Ta ratios (<10) and higher contents of Cr (>340 ppm) and V (>1580 ppm). These results provide a geochemical fingerprint for distinguishing the low-pressure (LP) rutile from relic high-grade phases in retrograded HP-UHP rocks.

Our results reveal that rutile can form during LP retrograde stage in UHP rocks by high-$f_{O_2}$ fluid-induced replacement reactions. The unusual replacements of Fe-Ti oxides by rutile-bearing assemblages during retrogression provide important constraints on fluid-mineral reactions and $f_{O_2}$ variations in exhumed UHP slabs.

**Keywords:** Rutile, Fe-Ti oxides, replacement reaction, fluid, oxygen fugacity, exhumation, Dabie UHP terrane