

High-pressure and high-temperature synthesis of Fe³⁺- and Fe²⁺-rich armalcolite

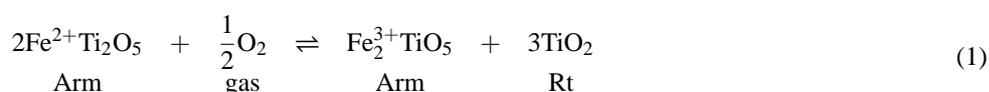
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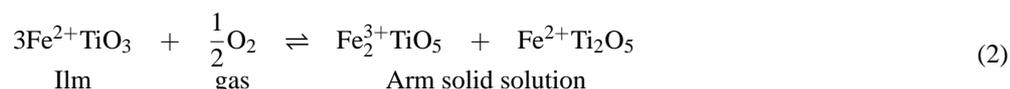
Armalcolite, an Fe–Mg–Ti oxide mineral with composition of (Fe_{0.5}Mg_{0.5})Ti₂O₅ found at Sea of Tranquillity on July 20, 1969, is stable at low-pressure and high-temperature under low oxygen fugacity (cf. Anderson et al 1970; Kesson Lindsley 1975; Friel et al 1977). Miyake and Hokada (2013) reported ferric-rich acicular armalcolite with an X_{Mg} of 0.136 and Fe³⁺/(Fe²⁺ + Fe³⁺) of 0.327 within porphyroblastic quartz in garnet–orthopyroxene-bearing quartzo-feldspathic gneiss from Mt. Riiser-Larsen, in a terrane with the highest ultrahigh-temperature metamorphic grade in the Napier Complex, East Antarctica. Armalcolite is an important accessory mineral indicating a high-temperature paragenesis (e.g. Lindsley 1991) and would be a possible key mineral of the ultrahigh-temperature metamorphism.

The pure (Fe_{0.5}²⁺Mg_{0.5})Ti₂O₅ is unstable below 1010 ± 20 °C at 1 atm (Lindsley et al 1974). The substitution of Al³⁺+Al³⁺, Cr³⁺+Cr³⁺ or Ti³⁺+Ti³⁺ for R²⁺+Ti⁴⁺ (where R²⁺ is a divalent cation) acts to stabilize armalcolite at lower temperatures (Kesson Lindsley 1975), and the incorporation of Fe³⁺ also reduces the temperature of armalcolite stability (Cawthorn Biggar 1993). The stability fields of armalcolite alone, a three-phase assemblage of armalcolite + ilmenite + rutile and a two-phase assemblage of ilmenite + rutile are divided by reaction boundaries with a positive *dP/dT* slope, indicating that the minimum temperature limit of armalcolite stability increases with increasing pressure (Friel et al 1977).

The author has started high-pressure experiments to determine the stability field of armalcolite. In this meeting the preliminary experimental results will be reported on the stability of Fe³⁺- and Fe²⁺-rich armalcolite. Figure 1 shows the coexistence of armalcolite, ilmenite and rutile recrystallised from the mineral mixture of ilmenite and rutile in the Pt capsule at 8 kbar and 1100 °C for 87 hours. Under high oxygen fugacity, ferropseudobrookite Fe²⁺Ti₂O₅ component oxidizes to form rutile + pseudobrookite Fe₂³⁺TiO₅ (Anovitz et al 1985):



and ilmenite 3Fe²⁺TiO₃ forms an armalcolite–pseudobrookite solid solution (Hayob Essene 1995):



These indicate that if the oxygen fugacity increases, reactions (1) and (2) progress toward the right-hand side; consequently, the temperature of the stability field of armalcolite decreases with increasing oxygen fugacity.

References

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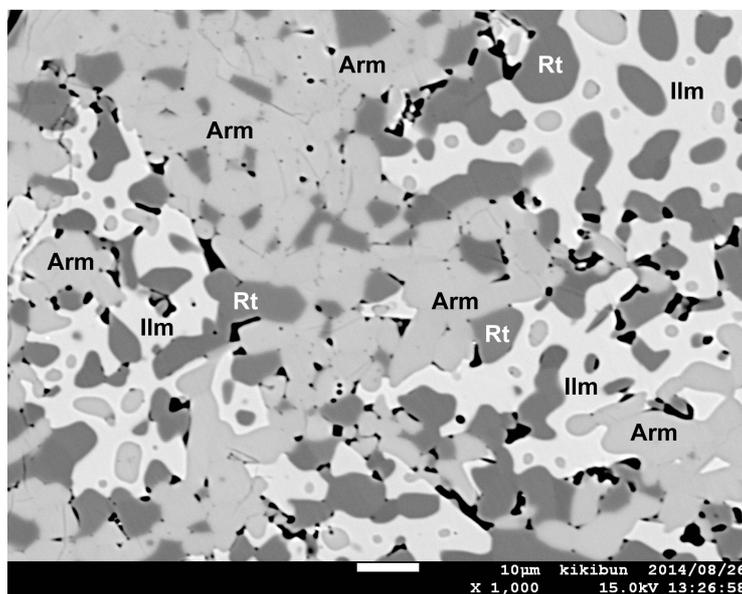


Fig. 1 Back scattered electron image (BSEI) of run products (run no. 140708) synthesised at 8 kbar 1100 °C for 87 hours in the Pt capsule from the mixture of ilmenite and rutile. Ilm, ilmenite. Rt, rutile.