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In situ X-ray diffraction study of phase transitions of $FeTiO_3$ at high pressures and temperatures using a large-volume press and synchrotron radiation

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ABSTRACT

The phase transformation from ilmenite to perovskite in $FeTiO_3$ was directly observed using synchrotron-based X-ray diffraction and a large-volume press. The perovskite phase is temperature quenchable at 20 GPa and converts into the $LiNbO_3$ phase at pressures below 15 GPa at room temperature. The $LiNbO_3$ phase transforms into the ilmenite phase at 10 GPa and 673 K. However, the back-transformation from the ilmenite to the $LiNbO_3$ phase was not observed, thus strongly suggesting that the $LiNbO_3$ phase is not thermodynamically stable but rather a retrogressive phase formed from perovskite during decompression at room temperature.

By cycling the pressure up and down at temperatures between 773 and 1023 K, the perovskite-ilmenite transformation could be observed in both directions, thus confirming that perovskite is the true high-pressure phase with respect to the ilmenite phase at lower pressures. The phase boundary of the perovskite-ilmenite transformation thus determined in this study is represented by P (GPa) = 16.0 (±1.4) – 0.0012 (±0.0014) T (K), which is inconsistent with $P = 25.2 – 0.01\ T$ (K) reported previously (Syono et al. 1980). The discrepancy could be attributed to the different experimental methods (i.e., in situ vs. quench) used in the two studies. The ilmenite-perovskite phase boundary with such a small slope would potentially serve as a useful geobarometer for ilmenite-bearing rocks derived from the deep mantle or for those shocked in meteor craters.

Keywords: Ilmenite, perovskite, $LiNbO_3$, phase transformation, X-ray diffraction, high pressure