Aluminum in rutile as a recorder of temperature and pressure

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Rutile has a convenient trait that it shares with other selected minerals: its major oxide composition is relatively constant in natural systems. Owing to this and its common occurrence as an accessory mineral in the crust, rutile has the potential to be a useful recorder of crystallization conditions. It is known, for example, that the solubilities of minor cations in rutile depend on temperature (T) and pressure (P), and Zr solubility in rutile has been calibrated as a function of these key variables [e.g., 1-3].

The focus of this study is on quantifying Al^{3+} substitution in rutile. Previous studies have demonstrated T and P dependencies of Al solubility in rutile under conditions of varying (sometimes questionable) relevance to petrology [4,5]. Such relationships offer possible thermobarometric applications; [Al] in natural rutile has in fact been shown to depend upon provenance [6]. Mantle rutile crystals have up to thousands of ppm Al_2O_3 whereas rutile from metapelites contains much less.

We report the results of experiments in which rutile was grown in equilibrium with corundum. To explore plausible rutile growth conditions, our experiments were performed over a wide range of T and P appropriate to the crust and upper mantle. Our results reveal a systematic and reproducible relationship between Al solubility in rutile and temperature and pressure, having the form

$$X_{Al2O3}(\text{rutile})=\exp(A+B\cdot P/T+C/T)$$

for crystals in equilibrium with pure Al_2O_3, where A, B, and C are constants. Our data reveal that Al solubility in rutile is positively correlated with T and P as well as with Al_2O_3 activity in the growth medium.

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