Experimental study of a low-alkali tholeiite at 1-5 kbar: effect of H₂O on Ca-Na partitioning between plagioclase and melt

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ABSTRACT: We have conducted high pressure melting experiments on a low-alkali tholeiite at both H₂O-saturated and -undersaturated conditions to investigate the effect of H₂O on the Ca-Na partitioning between plagioclase and melt. The characteristics of this study is to focus on near-liquidus plagioclase to exclude the effect of melt composition on plagioclase composition. Our results show that, at each pressure, An content of the near-liquidus plagioclase and the Kₓ°CAn almost linearly increases as H₂O content in melt increases. An content and the Kₓ°CAn of liquidus plagioclase increases with increasing melt H₂O and decreasing pressure, indicating that the condition of nearly H₂O-saturated at 2-3 kbar is preferable for the crystallization of most An-rich plagioclase (~An₅₀) at nearly constant melt composition. We suggest this pressure condition of 2-3 kbars plays an important role for the origin of An-rich plagioclase in H₂O-rich basalt. For many cases of arc basalts ejected at volcanic fronts, this condition might be achieved in some part of crustal magma chamber at the depth of 5-10 km, leading to crystallization of An-rich plagioclase.

1. Starting Materials
Starting material is a low-alkali tholeiite ejected from Iwate volcano, which is a representative Quaternary volcano located at volcanic front of NE Japan arc. The composition is shown in Table 1.

Right Figure shows that pl-melt equilibria have not been investigated thoroughly in hydrous low-alkali tholeiite system, and this study give the first data for pl-melt equilibria in hydrous low-alkali tholeiite system.

2. Back-Scattered Electron Images of Representative Run Products

3. Phase Relations for Low-Alkali Tholeiite (1WL16) under Oxygen Fugacity of NNO+1±1 log unit

Although it is difficult to discriminate between the individual effects of melt H₂O and temperature on An content and Kₓ°CAn, An content of the near-liquidus plagioclase and the Kₓ°CAn at each experimental pressure, most linearly increases as melt H₂O content increases.

4. Variations of An content of Near-Liquidus Plagioclase with Melt Compositions and Temperature
An content of near-liquidus plagioclase does not apparently depend on the melt CaO/Na₂O and Al₂O₃/SiO₂ ratios. Thus, variation of An content of near-liquidus plagioclase at given pressure is derived from effect of melt H₂O content and temperature.

5. Effect of H₂O on Plagioclase Composition and Partition Coefficient

6. Comparison with Previous Works for High-Alumina Basalts

Kₓ°CAn for low-alkali tholeiite are low, indicating there are some compositional effects.

7. What Conditions Does Most An-rich Plagioclase Crystallize?

Each of the An content and the Kₓ°CAn variations in a low-alkali tholeiite system can be described by following equation:

\[ \ln(An) = 927.91/T + 0.88298 - 0.02683/T + 0.01674 \times H₂O \]

(s.d. 1.4 mol%)

\[ \ln(Kₓ°CAn) = -1069.5/T - 6.7781 - 0.1094 \times P/0.00858 \times H₂O \]

(s.d. 0.19)

Figures show that nearly H₂O-saturated condition at 2-3 kbar is preferable for the crystallization of most An-rich plagioclase at nearly constant melt composition.

8. Isopleths of An content of plagioclase in terms of Kₓ°CAn and melt CaO/Na₂O ratio

Can An-rich plagioclase crystallize from “normal” low-alkali tholeiitic melt?