

Optimal condition for the crystallization of high-An plagioclase in hydrous arc tholeiite

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<http://www.kobe-u.ac.jp/volcano/hsato.html>

We conducted melting experiments on a low-alkali tholeiite ($\text{SiO}_2=52\text{wt.}\%$, $\text{MgO}=6.5\text{ wt.}\%$, $\text{CaO/Na}_2\text{O}=4.4$, $\text{Al}_2\text{O}_3/\text{SiO}_2=0.33$) under both H_2O -undersaturated and H_2O -saturated conditions to investigate the effect of H_2O on the Ca-Na partitioning between plagioclase and melt. Experiments were performed in the temperature and pressure ranges of 1000-1300C and 1-5 kbar, respectively, with varying H_2O contents of 0-12 wt.%. Redox condition was 0-2 log unit above NNO (nickel-nickel oxide) buffer. Temperature-bulk H_2O diagrams for the low-alkali tholeiite are constructed at 1, 2, and 5 kbar, and compositions of near-liquidus plagioclase and coexisting melt are determined. To exclude the effect of melt composition ($\text{CaO/Na}_2\text{O}$ and $\text{Al}_2\text{O}_3/\text{SiO}_2$ ratios) on plagioclase composition and to reveal the effect of H_2O on An ($=100*\text{Ca}/(\text{Ca}+\text{Na})$) content and $\text{KDCa-Na}=(\text{Ca/Na})_{\text{pl}}/(\text{Ca/Na})_{\text{melt}}$, we focused on the composition of near-liquidus plagioclases which crystallized from melts with nearly constant $\text{CaO/Na}_2\text{O}$ and $\text{Al}_2\text{O}_3/\text{SiO}_2$ ratios. Our experimental results show that, at each experimental pressure, An content of the near-liquidus plagioclase and the KDCa-Na almost linearly increases as H_2O content in melt increases. Each of the An content and the KDCa-Na variations in a low-alkali tholeiitic system ($\text{CaO/Na}_2\text{O}\sim 4.0-4.5$, $\text{Al}_2\text{O}_3/\text{SiO}_2\sim 0.27-0.33$) can be described by one equation using temperature, pressure, and melt H_2O content as parameters. An content and KDCa-Na of liquidus plagioclase increase with increasing melt H_2O and with decreasing pressure, elucidating that nearly H_2O -saturated conditions of 2-3 kbar is optimal for the crystallization of the most An-rich plagioclase (more than An88). We suggest this pressure condition of 2-3 kbar, corresponding to depth of 7-11 km, plays an important role for the origin of An-rich plagioclase in H_2O -rich low-alkali tholeiite. At pressures more than ca. 4 kbar, crystallization of liquidus Ca-rich clinopyroxene decreases the $\text{CaO/Na}_2\text{O}$ ratio of liquid, thus prohibiting the crystallization of high-An plagioclase from hydrous tholeiite