

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

Daisuke TAKAGI^{1*}, Hiroaki SATO¹, and Mitsuhiro NAKAGAWA²

1. Kobe University, JAPAN 2. Hokkaido University, JAPAN *e-mail: dtakagi@kobe-u.com

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 K_D^{Ca-Na} almost linearly increases as H₂O content in melt increases. An content and the K_D^{Ca-Na} 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 (>An₉₀) at nearly constant melt composition. We suggest this pressure condition of 2-3 kbar 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

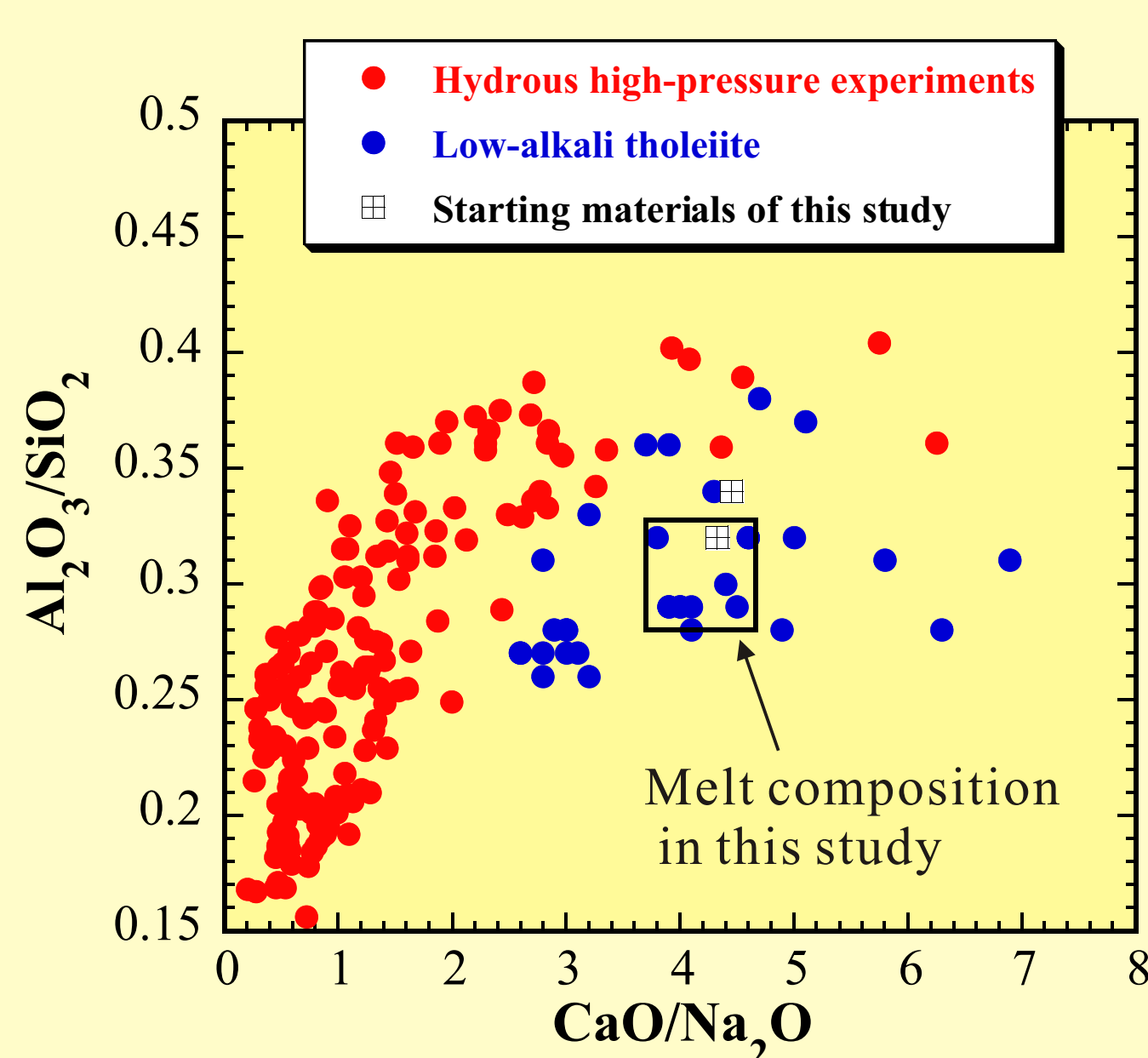
Starting material is a low-alkali tholeiite ejected from Iwate volcano, which is a representative Quaternary volcano located at volcanic front of NE Japan arc. The composition is shown in Table 1.

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

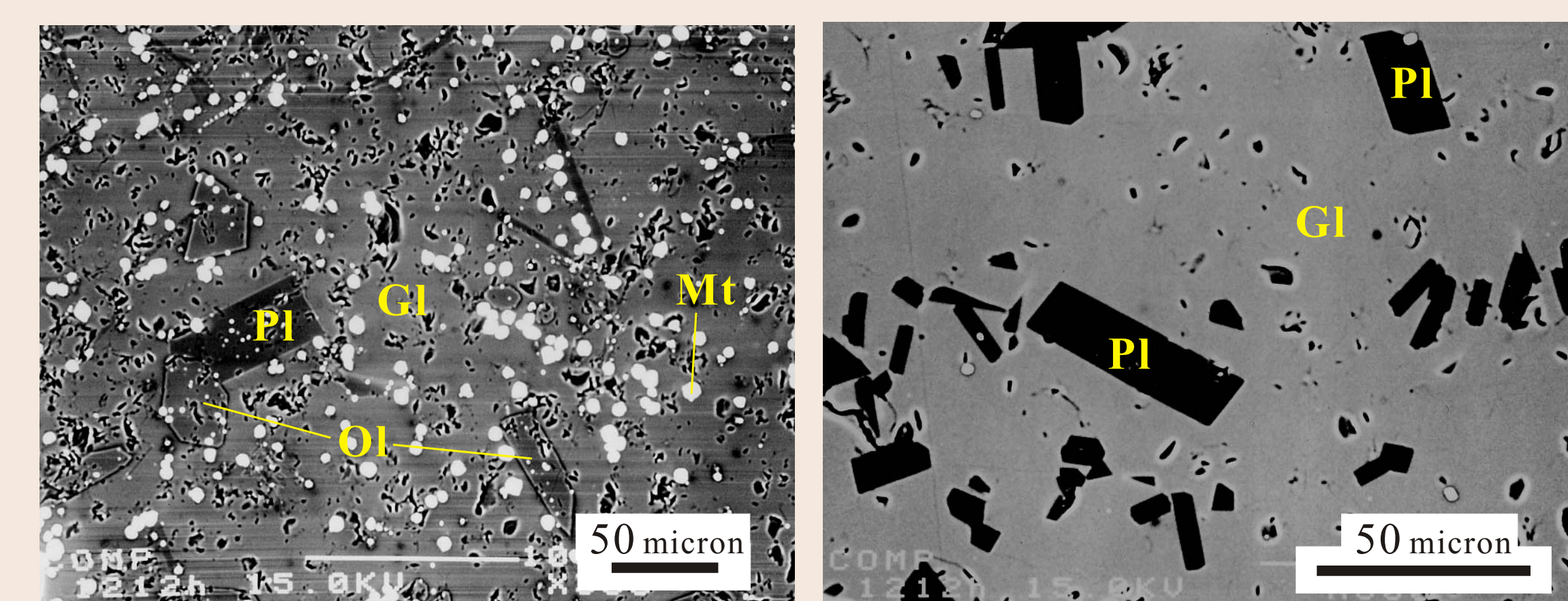
Table 1 Compositions of starting materials

[Wt. %]	Yakehashiri lava (IWL16)	
	Whole-rock	Glass
SiO ₂	53.09	52.00
TiO ₂	0.77	0.74
Al ₂ O ₃	16.88	17.45
Fe ₂ O ₃ ^b	10.43	10.94
MnO	0.18	0.17
MgO	6.53	6.50
CaO	9.61	9.72
Na ₂ O	2.22	2.18
K ₂ O	0.22	0.21
P ₂ O ₅	0.08	0.08
CaO/Na ₂ O	4.33	4.45
Al ₂ O ₃ /SiO ₂	0.32	0.34

^aXRF analyses, recalculate to 100%.
^bTotal Fe as Fe₂O₃.



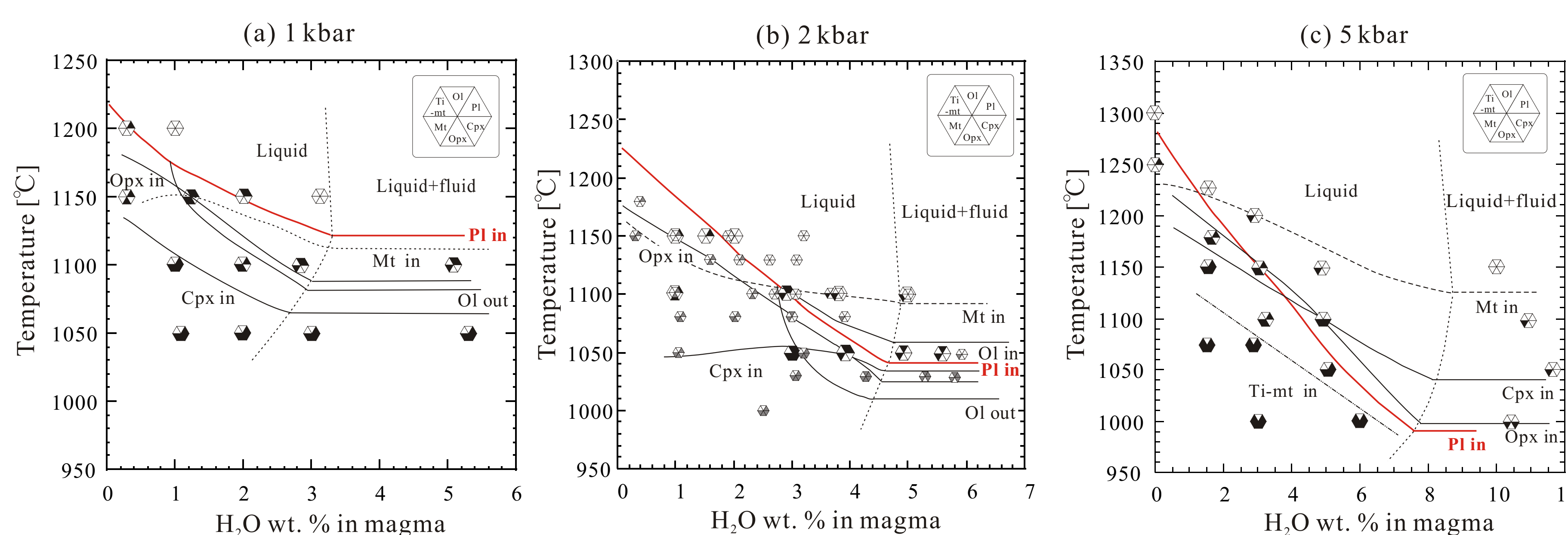
2. Back-Scattered Electron Images of Representative Run Products



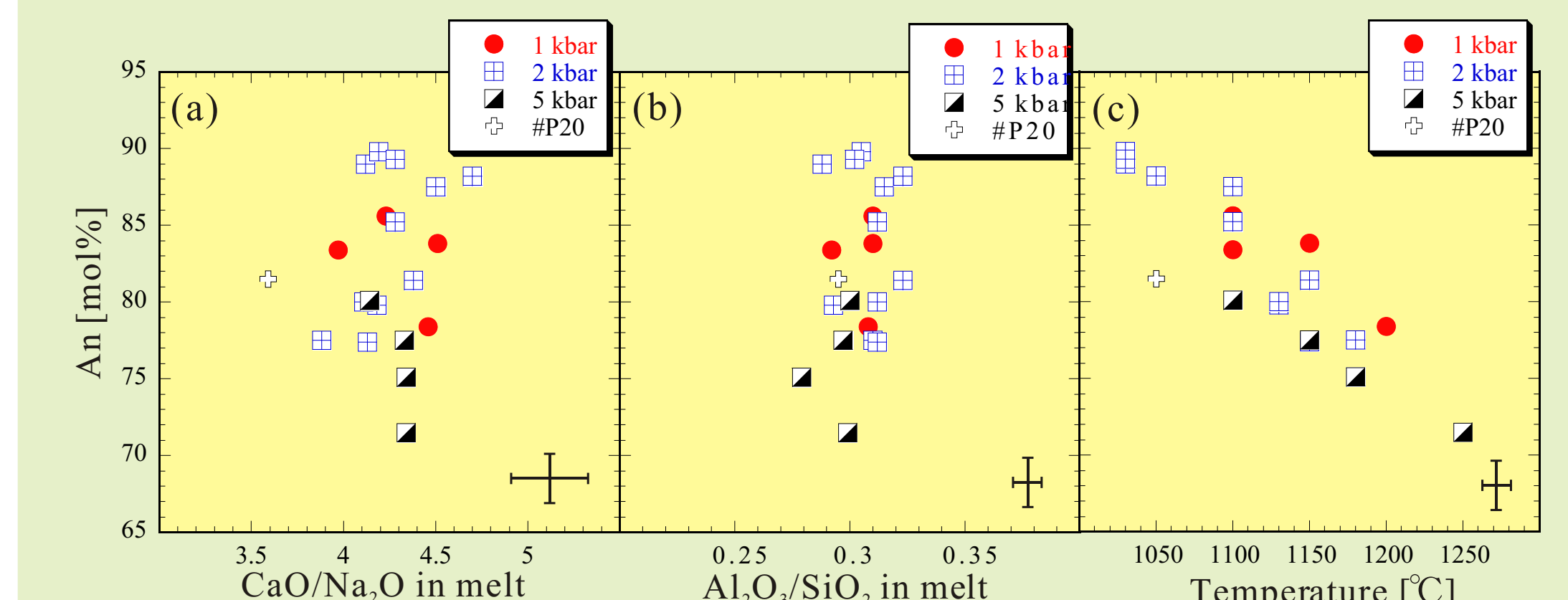
1 kbar, 1100°C, H₂O-saturated condition

5 kbar, 1250°C, dry condition

3. Phase Relations for Low-Alkali Tholeiite (IWL16) under Oxygen Fugacity of NNO+1±1 log unit



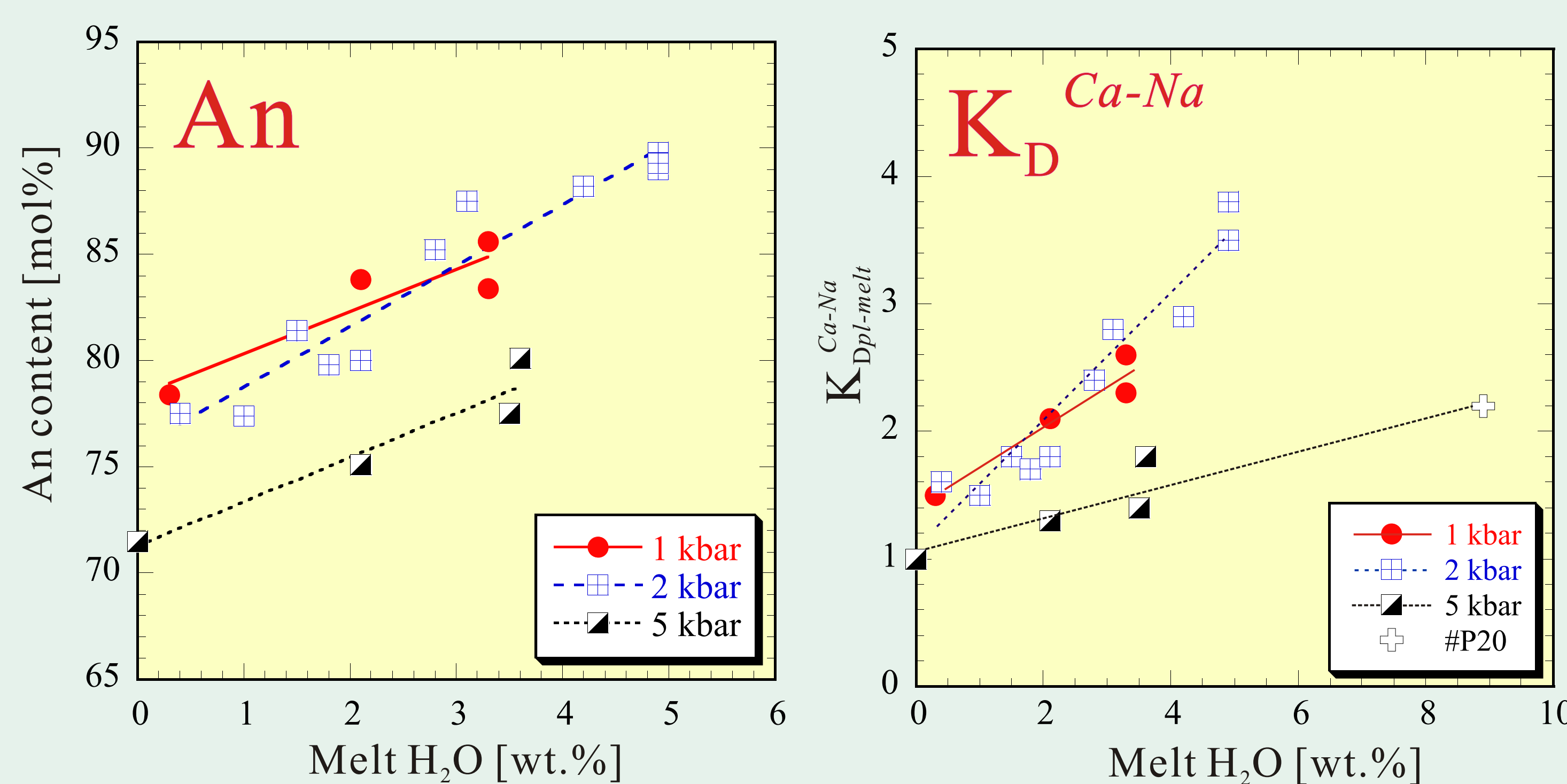
4. Variations of An content of Near-Liquidus Plagioclase with Melt Compositions and Temperature



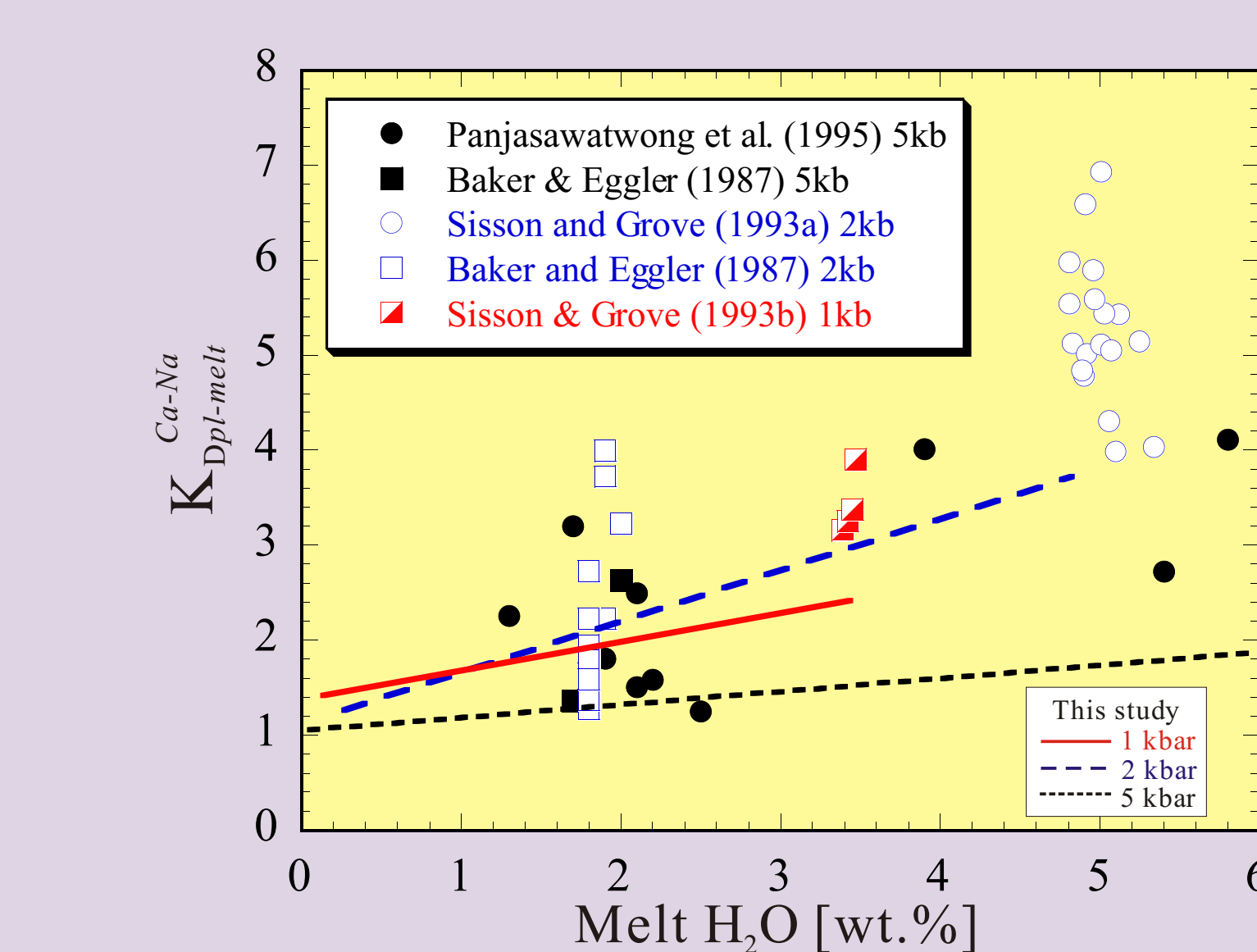
An content of near-liquidus plagioclase does not apparently depend on the melt CaO/Na₂O and Al₂O₃/SiO₂ ratios. Thus, variation of An content of near-liquidus plagioclase at given pressure is derived from effect of melt H₂O content and temperature.

5. Effect of H₂O on Plagioclase Composition and Partition Coefficient

Although it is difficult to discriminate between the individual effects of melt H₂O and temperature on An content and K_D^{Ca-Na} , An content of the near-liquidus plagioclase and the K_D^{Ca-Na} , at each experimental pressure, most linearly increases as melt H₂O content increases.



6. Comparison with Previous Works for High-Alumina Basalts



K_D^{Ca-Na} s for low-alkali tholeiite are low, indicating there are some compositional effects.

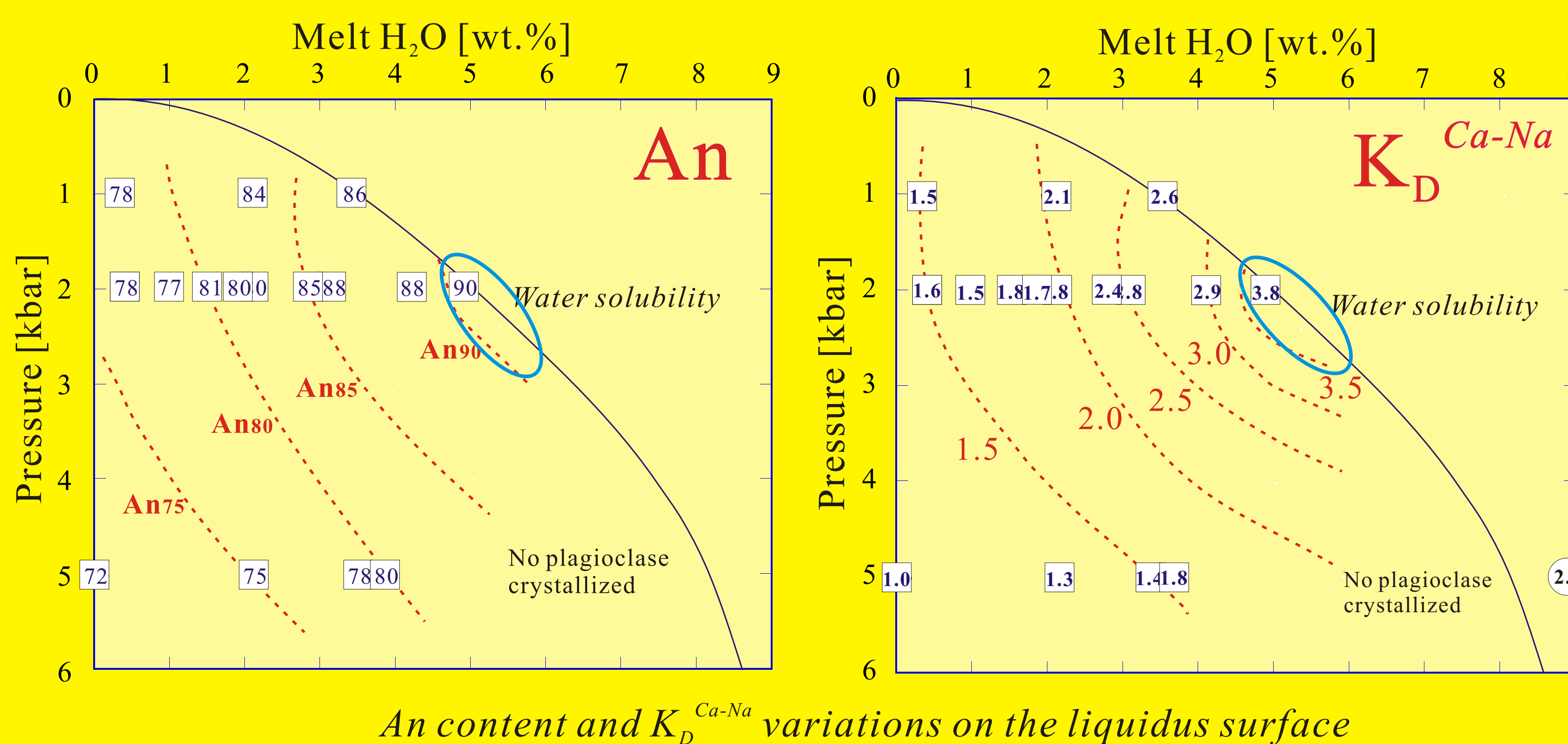
7. What Conditions Does Most An-rich Plagioclase Crystallize?

Each of the An content and the K_D^{Ca-Na} variations in a low-alkali tholeiitic system can be described by following equation:

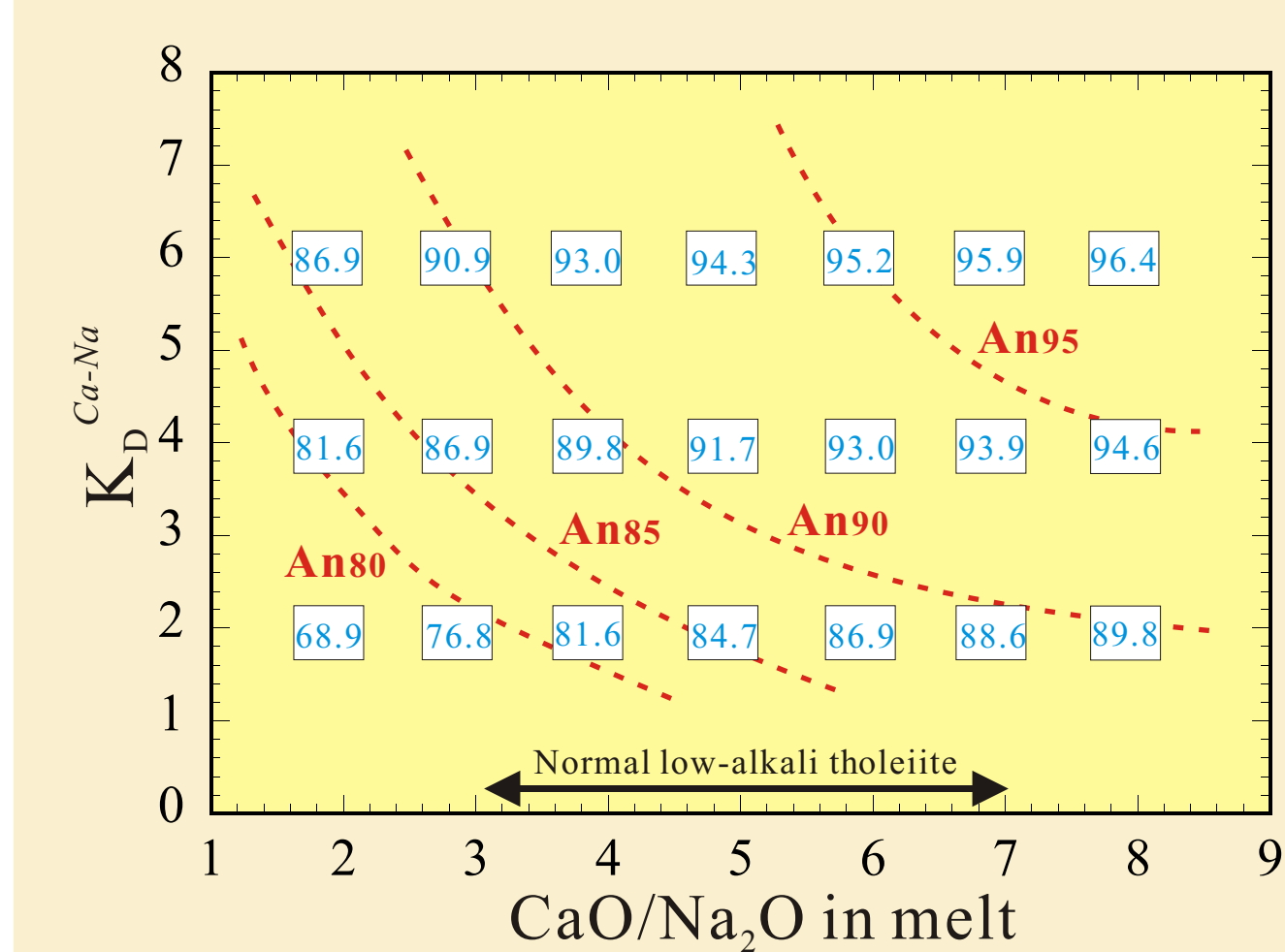
$$\ln An = 927.91/T - 0.86298 - 0.02693 * P/T + 0.01674 * H_2O \quad (s.d. 1.4 \text{ mol}\%)$$

$$\ln K_D^{Ca-Na} = 10695/T - 6.7781 - 0.1009 * P/T - 0.00860 * H_2O \quad (s.d. 0.19)$$

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 KD Ca-Na and melt CaO/Na₂O ratio



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