
Here we discuss some new and existing (1) experimental data that show the effects of pressure on crystal/liquid partition of major elements for orthopyroxene and plagioclase. Although the data are directly relevant to terrestrial massif anorthosites, they also have a bearing on lunar ferroan anorthosites.

We have run melting experiments on three starting materials in pre-saturated Pt-wire loops at QFM at 1 bar and in graphite capsules at 5 to 27 kbar. One material (500B) is rock powder from an anorthositic dike from the Nain Complex proposed to be a suspension of ~30% plagioclase in parental magma (2); the second material (HLCA) is partially crystallized synthetic glass with the composition of the average ferroan high-Al gabbro proposed to be the parental magma of the Harp Lake Complex of Labrador (3); the third (TI) is a rock powder from the fine-grained monzonitic border facies of the Bjerkreim Complex of Norway (4, #80123).

Some of the results on 500B and HLCA have been reported by (1) and show: a) that even a suspension of 30% plagioclase with the 500B composition would have an improbably high liquidus temperature; b) that experimental crystallization orders for 500B and related anorthositic dikes do not agree with those observed in the dikes themselves, indicating that the dikes are heterogeneous and crystallized as open systems; c) that liquidus plagioclase (plag) in both compositions becomes progressively more sodic with increasing pressure; d) that subliquidus orthopyroxene (opx) in HLCA becomes progressively more aluminous with increasing pressure; and e) at 10-12 kbar, where plag, opx, and augite are near liquidus phases in HLCA, opx has the composition of the most aluminous megacrysts from the complex (Fig. 1a) and plag has the same composition as the plag in the anorthositic rocks.

These features are consistent with a polybaric origin for massif anorthosites with most of the plagioclase and the few relic pyroxene megacrysts first crystallizing in the lower crust from a magma similar in composition to HLCA and then intruding upwards in plagioclase-rich mushes or suspensions (5).

Results of new experiments show that the pressure-dependence of Al2O3 concentration in orthopyroxene in HLCA is reversible (Fig. 1b and c). Solute rejection calculations based on the model of (6) show that, if high Al2O3 concentrations in opx are achieved by rapid crystal growth (e.g., 7), the expected correlation of compatible elements in opx, such as Cr, with Al is negative -- contrary to what is observed in nature (Fig. 2). Delayed nucleation of plagioclase (7) is another way to achieve unusually high concentrations of Al2O3 in opx that would produce a negative correlation of Cr and Al. Thus high-pressure crystallization and not kinetics is the likely explanation for the high Al2O3 concentrations in the opx megacrysts.

Previously, (8) demonstrated a temperature-corrected pressure effect on plagioclase composition for HLCA and 500B to 20kb. Fig 3a illustrates this effect for an additional composition (TI) and to higher pressure (27 kbar). The vertical axis is the difference between the albite (Ab) content of plagioclase calculated at 1 bar according to the model of (9) and the albite content observed in the experiments. To a first approximation there is a composition-independent increase of -1 to 2 Ab per kbar. However, examination of the individual partition coefficients for albite and anorthite (An) versus P/T (Fig. 3b and c) shows not only clear compositional dependences, but opposite sense for pressure-dependence of K_{Ab} and K_{An}. The variation of K_{Or} versus P/T is similar to that of K_{Ab}. Despite the low pressure/depth gradient on the Moon, these data may have a bearing on the petrogenesis of lunar ferroan anorthosites (LFA), which show at least three slightly different trends on the familiar Mg versus An diagram (10). Although differing parental magma composition is the most probable explanation, crystallization at different depths at the base of a growing crust would produce offsets in fractionation paths, as would polybaric processes such as have been proposed for massif anorthosites (5).

Fig. 4 illustrates a final aspect of the data, viz. that the simple molar partition coefficient for MgO between plagioclase and liquid has a negligible pressure dependence. Data for FeO are not shown because the analyses of mantles and rims of plagioclase crystals are prone to secondary fluorescence errors (11). These data have the most direct bearing on lunar ferroan anorthosites (LFA) where low concentrations of Fe and Mg have prompted speculations about pressure effects (11). Even though there are small compositionally dependent differences between lunar and terrestrial partition coefficients, the sense and magnitude of the pressure effect on the partition coefficient is very likely to be similar in both case. Given that most LFA appear to have crystallized from coticetic magmas (12), the low concentrations of Fe and Mg imply subsolidus exsolution of the Fe-Mg component (e.g., 13).

REFERENCES
PRESSURE EFFECTS IN ANORTHOSITIC MAGMAS, Longhi J. et al.


Fig. 1 Compositions of natural opx megacrysts (●) from Harp Lake (3) and experimental HLCA pyroxenes. a) Megacrysts and pyroxenes produced in isobaric experiments. Shaded boxes show 1σ variations. b) & c) Comparison of pyroxenes produced in isobaric experiments (shaded boxes) with individual analyses of pyroxenes produced in polybaric experiments (●).

Fig. 2 Compositions of opx megacrysts (●) from Harp Lake and compositional trend produced during rapid crystal growth (6). Weight partition coefficients are taken from the data of (1); v = crystal growth rate; numbers adjacent to curves are crystal sizes in cm; diffusion coefficient = 10⁻⁷ cm²/see.

Fig. 3 Pressure dependence of plagioclase/liquid partitioning. a) Difference between observed plag and plag calculated at 1 bar by the method of (9). b) Difference between the log of the observed Ab component partition coefficient (9) and that calculated at 1 bar (9) as a function of pressure (bars)/°K. c) Difference between the log of the observed An component partition coefficient (9) and that calculated at 1 bar (9) as a function of P (bars)/T °K.

Fig. 4 Variation of the molar plagioclase/liquid partition coefficient for MgO as a function of P (bars)/T °K. Experiments as in Fig. 3.