

LIQUIDUS-PHASE RELATIONS OF THE APOLLO 14 AND APOLLO 17 VLT VOLCANIC GLASSES; H.-K. Chen, J. W. Delano, and D. H. Lindsley, Dept. of Earth and Space Sciences, State Univ. of New York, Stony Brook, N. Y. 11794

Introduction

Very low-Ti (VLT) volcanic glasses have been reported from the Apollo 14 [1] and Apollo 17 [2] landing sites. Each variety displayed a fractionation trend that was interpreted [1,2] as being caused by olivine subtraction at low pressures. Delano and Livi [3] assigned both VLT groups to their Array II volcanic glasses and proposed that these lunar glasses could be better candidates for primary liquids than any mare basalts. If correct, these volcanic glasses could provide unambiguous information regarding the depth in the Moon of the mare source regions, in addition to the residual mineralogies during partial melting. With that expectation in mind, we have performed reconnaissance experiments on the most Mg-rich compositions [1-3] of the Apollo 14 and 17 VLT glasses.

Experimental techniques

The starting materials used in the experiments were synthesized from reagent-grade oxide mixes following the method of Lindsley *et al.* [4]. After homogenizing and drying, the oxide mixes were heated to 935°C for at least 7 days. The resulting mixture of crystalline phases, including olivine, clinopyroxene and plagioclase, served as the starting material for our reconnaissance experiments.

All the equilibrium experiments were performed in high-purity iron capsules (Johnson Matthey grade 1). The experiments at low pressure were carried out in a vertical furnace with iron capsules sealed in evacuated silica tubes. High-pressure experiments were carried out in a piston-cylinder, solid-media pressure apparatus; the furnace cell for the Apollo 14 glass included boron nitride, while that for Apollo 17 used pyrex glass between the outer talc sleeve and the graphite furnace. Pressure corrections of -7.5% (Apollo 14) and -18% (Apollo 17) were based on calibrations using those furnace assemblies in this laboratory. After each run, all the phases presented in the charge were analyzed using an ARL electron microprobe.

Apollo 14 results (Figure 1)

Olivine is the liquidus phase to at least 16 kbar. Pyroxene is the liquidus phase at pressures above 18.5 kbar. Although more work is needed in determining the phases presented in 18.5 kbar-pressure run, the liquidus is believed to be multiply saturated with olivine and pyroxene at a pressure of 18 ± 1 kbar and temperature of $1490 \pm 15^\circ\text{C}$.

Apollo 17 results (Figure 2)

A multiple-saturation point on the liquidus involving olivine and clinopyroxene was located at 18 ± 2 kbars and $1500 \pm 20^\circ\text{C}$ for the Apollo 17 VLT composition [2,3]. Unlike the results reported for a high-Ti composition [5] showing a change in the olivine/liquid K_D for Fe/Mg with pressure, this VLT composition shows a constant K_D of 0.34 ± 0.005 over the pressure-range investigated. The partition coefficients for Cr between olivine/liquid and orthopyroxene/liquid were 0.75 and 1.5, respectively, in agreement with other investigators [6].

Interpretation

If both of the VLT magmas were saturated with pyroxene + olivine in their respective source regions, then these experiments indicate that they were derived by partial melting at depths of 360 ± 20 km (Apollo 14 VLT) and 360 ± 40 km (Apollo 17 VLT). Since we cannot eliminate the possibility that olivine fractionation occurred during transit of these liquids from their source regions, these depths should be regarded as minimum values. The chemical systematics among all varieties of lunar volcanic glass seem, however, to

VLT VOLCANIC GLASSES

Chen, H.-K. *et al.*

require that $<<5\%$ olivine fractionation can have taken place [3]. The experimental effect on the liquidus phase relations of using sample-containers with $a_{Fe} < 1$ will be investigated.

References

[1] Delano (1981) Lunar Planet. Sci.-XII, p. 217-219. [2] Warner *et al.* (1979) Proc. Lunar Planet. Sci. Conf. 10th, p. 1437-1456. [3] Delano and Livi (1981) Geochim. Cosmochim. Acta, 45, p. 2137-2149. [4] Lindsley *et al.* (1974) Proc. Lunar Sci. Conf. 5th, p. 521-534. [5] Delano (1980) Proc. Lunar Planet. Sci. Conf. 11th, p. 251-288. [6] Huebner *et al.* (1976) Proc. Lunar Sci. Conf. 7th, p. 1195-1220. Schreiber and Haskin (1976) Proc. Lunar Sci. Conf. 7th, p. 1221-1259.

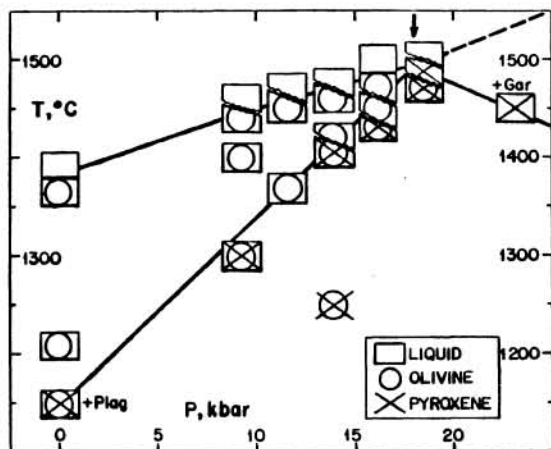


Figure 1. Liquidus-phase relations of the Apollo 14 VLT volcanic glass indicate that its source-region was at a depth of 360 ± 20 (18 ± 1 kbar) km in the Moon. The symbols at high pressures (> 5 kbar) have sizes commensurate with their estimated precision.

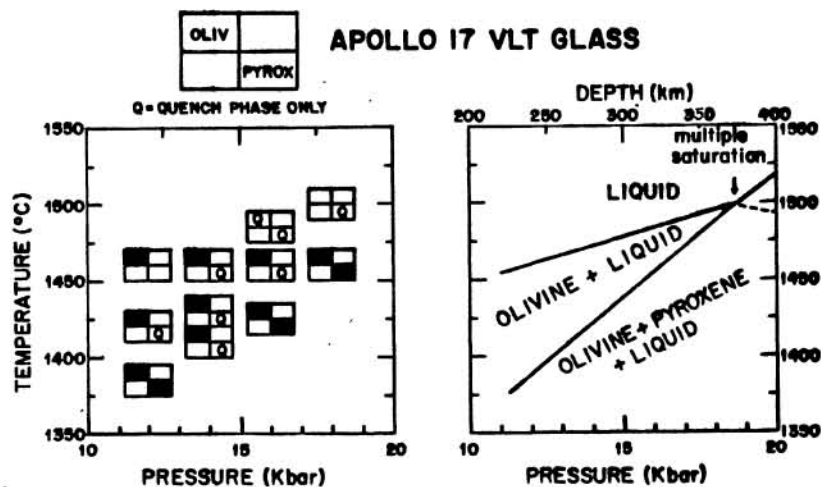


Figure 2. Liquidus-phase relations of the Apollo 17 VLT volcanic glass indicate that its source-region was at a depth of 360 ± 40 (18 ± 2 kbar) km in the Moon.