MOST OLIVINE IN THE LUNAR HIGHLANDS IS OF SHALLOW ORIGIN. G. Ryder, Institut für Mineralogie, Univ. Münster, W. Germany, and Lunar and Planetary Institute, 3303 NASA Rd. 1, Houston, TX 77058.

The origin of lunar highlands rocks and the lunar crust itself is poorly understood because of a paucity of igneous rocks. Information needs to be obtained from the chemical and mineralogical characteristics of breccias. In this study, major element and precise minor element (Ca,Mn,Cr,Ti,Al,Ni) microprobe analyses of olivine fragments in 76015, 76035, 72255, and ALHA 81005 were made in order to constrain their possible genesis. Some analyses of pristine lunar sample and Stillwater olivines were made for comparison, and Marjalahti was analyzed continually as a check on reproducibility. The precise minor element data of [1] is also used for comparison.

Careful attention was paid to gaining appropriate background positions (by scans). Analyses of 76015 olivines with and without silver paint screening showed that fluorescence was of significance for Ca-analyses only within about 30 microns of grain edges, but also showed that in such coarse grained melts olivines are zoned by reaction with the melt for distances up to at least 750 microns into the grain. In 76035, a very fine-grained melt from the same melt sheet [2], such reaction is limited to only a few microns. Thus 76015 is of limited use for the present objective, but data for 76035, 72255 (another fine melt), and ALHA 81005 (a soil breccia) should be useful. Discussion here is limited mainly to the calcium data.

Calcium in olivines is a significant petrogenetic indicator because it is partitioned more strongly into olivines at higher temperatures: the temperature affect on the partition coefficient is great. There is a pressure effect, but it is much smaller, as is a composition effect. The most significant unknown in the present study is not knowing the calcium content of the materials once in equilibrium with the olivines, but qualitatively even this is not too critical here. Olivines in mare basalts have 0.2 to 0.5% CaO. The breccia analyses are summarized in Figs. 1 and 2. Most olivines are quite magnesian, Fo > 80. In part this might be because of dissolution of Fe-olivines in the impact melts. Of more significance is that most of the Mg-olivines in the breccias have CaO contents which are higher

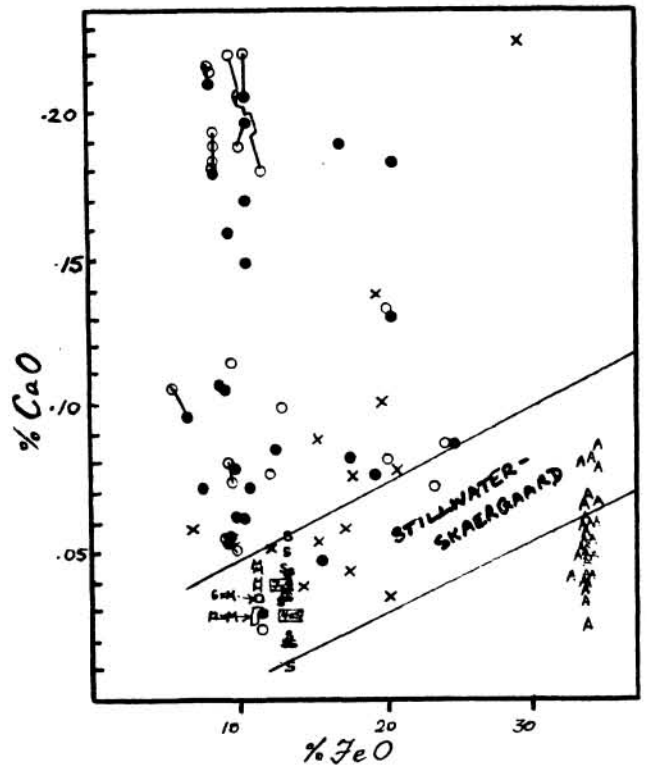

Figure 1.

CaO v. FeO for olivine fragments in 76035 (dots), 72255 (crosses), and comparitive data. Crosses and Black Dots are averages of 2 to 8 analyses, each with precision + 0.01% CaO, as are spot analyses of comparitive data. Circles are individual analyses with precision ± 0.003% CaO. Tie lines joins points on same grain. M = Marjalahti S = a Stillwater sample. A = 62237.

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than the terrestrial Stillwater-Skaergaard plutonic trend, higher than the lunar ferroan anorthosite trend, and higher than some Mg-rich pristine rocks. However; as shown in an accompanying abstract, dunite 72415 also has "high-Ca" olivines, and some other lunar trostolites do also. A straighforward interpretation of the data would be that most of the olivines in these breccias are of shallow-plutonic origin, not deep plutonic origin, unless they come from high-Ca melts of a type unknown. This would be in accordance with the conclusions of [3], that nearly all of the lunar highlands surface material is of shallow origin, and has implications for the petrogenesis of the highlands.

The olivine group in 76035 which has ∿ 0.20% CaO appears to be unique: it also has high Cr_2O_3 (∿ 0.20%) and Al_2O_3 (∿ 0.08%) and has not been recognized in any other lunar rocks. Its minor elements are like those in impact melts, but its Mg/Fe higher than in any impact melt. It could be derived from old impact melts. Another significant feature is that no olivines similar to those in ferroan anorthosites have been found in 76035. In a parallel study of plagioclase Mg and Fe (not reported) in 76035, few plagioclases possibly from ferroan anorthosites were discovered. The Serenitatis melt sheet appears to be of shallow origin, yet lack any trace of ferroan anorthosite.

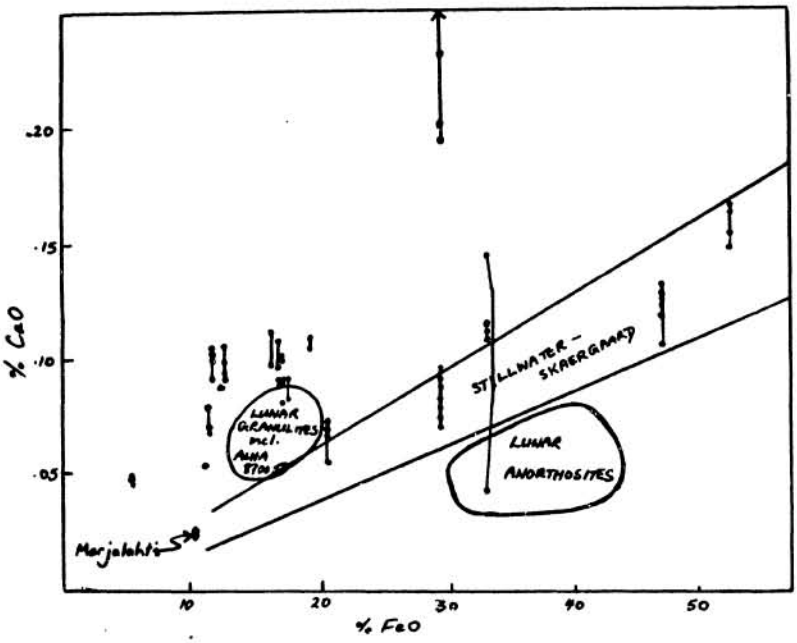

Figure 2.

CaO v. FeO for olivine fragments in ALHA 81005. Each point has precision ± 0.003% CaO. Tie lines join multiple spots on single grains.

References

[1] Smith J.V. et al. (1980) Proc. Lunar Planet. Sci. Conf. 11th, 55-569.
[2] Ryder G. (1982) Lunar Planet. Sci. XIII, 669-670.
[3] Horz, F. et al. (1976) Proc. Lunar Sci. Conf. 7th, 2931-2945.