SOLUBILITY OF CHROME IN COEXISTING OLIVINE, SPINEL AND LIQUID AT 1 ATM AND UNDER CONTROLLED fO2, Jagannadham Akella, NASA Johnson Space Center, Houston, TX 77058, and Oscar Mullins, Lockheed Electronics Corp., Houston, TX 77058.

A quantitative knowledge of the partitioning of elements between common rock forming minerals and silicate melts is essential to understand the petrogenesis of igneous rocks. The partitioning of chromium in silicate-oxide systems is of considerable petrological interest because it enters spinel, pyroxene, olivine and garnet: all are critical phases in petrogenesis.

A substantial body of data in the literature indicates that lunar crustal rocks have crystallized at lower oxygen fugacities than their terrestrial counterparts. Under the highly reducing conditions present on the Moon, chromium probably existed as Cr^{2+} and as such might distribute between phases differently than Cr^{3+} does on Earth. This argument was invoked by some authors (1,2) in explaining the high Cr contents of lunar olivines and mare basalts compared to their terrestrial analogs. There is not much experimental data on the Cr partitioning in synthetic silicate systems under controlled oxygen fugacities, to verify this hypothesis.

The purpose of the present investigation is to determine the solubility of chromium, titanium and aluminum between coexisting olivines, spinels and liquid under equilibrium conditions as a function of temperature and varying redox conditions. All the experiments were conducted in a gas-mixing furnace (3) and the coexisting phases were analyzed using an ARL electron microprobe. A pyroxene composition, En_68, Fs_18, Wo_15, was chosen, to which was added 10 mole % CaTiAl_2O_6 and 2 mole % of CaCrAlSiO_6. Preliminary results are presented here from the experiments at 1 atm pressure and between 1350-1750°C.

Compositions of the coexisting olivines, spinels and liquid are plotted as a function of their Mg/(Mg+Fe) ratio in Figs. 1, 2 and 3 for runs between 1350°-1175°C. The chrome content of olivine (Fig. 1) drops linearly with decreasing Mg/(Mg+Fe) ratio of the olivine, however TiO_2 in the same range shows a slight increase. The chrome content of the spinel phase (chrome pleonaste) decreases sharply with decreasing Mg/(Mg+Fe) ratio, however the solubility of Al_2O_3 and TiO_2 increases with a decrease in the Mg/(Mg+Fe) ratio. The Cr/Al ratio in the spinel phase changes from 2.0 to 1.4 with increasing Fe/Mg ratio. The TiO_2 and Al_2O_3 contents of the coexisting liquid increases as the Mg/(Mg+Fe) ratio and Cr_2O_3 contents decrease (Fig. 3).

Composition of the olivine crystallized under different redox conditions and at 1250°C (Table 1) shows, that Cr_2O_3 content of the olivine increases with increasing Mg/(Mg+Fe) ratio and also with decreasing fO2. There is a three fold increase in the solubility of chrome in olivine at 1250°C and log fO2 = -12.4 compared to the olivine crystallized at log fO2 = -8, and this sharp increase is partly due to the absence of coexisting spinel phase at lower fO2.

The Cr_2O_3 contents of the coexisting olivines, spinels and liquids are presented as a function of both temperature and fO2 in Table 2. The data indicates that the Cr_2O_3 content of the liquid and olivine increases with decreasing fO2 at all temperatures. At a constant fO2 (approximately), the solubility of chrome in all three phases decreases with decreasing temperature.
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It is interesting to note that the solubility of $\text{Cr}_2\text{O}_3$ in the spinel phase is slightly higher under redox conditions corresponding to the Fe-FeO buffer. The reason for this is not understood at the present time. Our experimental results also suggest that under reducing conditions the solubility of chrome increases in the olivine (1,2 and 4) and the coexisting liquid, and this can explain the high chrome contents observed in lunar mare basalts.

References

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FIG 1

OLIVINE
\( f_{O_2} = I_W \)

FIG 2

SPINEL
\( f_{O_2} = I_W \)

FIG 3

LIQUID
\( f_{O_2} = I_W \)

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