A COMPARISON OF TEXTURAL AND CHEMICAL FEATURES OF SPINEL WITHIN LUNAR MARE BASALTS.

C. K. Mulcahy[1], L. A. Taylor[1], and C. A. Goodrich[2],
1 ***Planetary Geosciences Institute, Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996-1410; 2 Dept. of Physical Sciences Kingsborough Community College, Brooklyn, NY 11235.***

Abstract

Lunar mare basalts contain abundant Ti- and Cr-rich oxide minerals. The spinels display a variety of textures including composite grains of chromite and ulvöspinel that have both optically sharp and gradational contacts. EMP profiles for Cr and Ti across these contacts show that they are both chemically sharp and exhibit a gap in both Cr and Ti. Compositional ranges reported in this study agree well with data presented by El Goresy [1], who reported a compositional gap in lunar basalt 12063 and none in 12018. However, we maintain that a compositional gap does exist in the 12018 spinel.

Introduction

Lunar mare basalts differ from most terrestrial basalts in that they have abundant Ti- and Cr-rich oxide minerals, such as ilmenite, spinel and armalcolite. These phases are intriguing in that they can be sensitive to their conditions of formation such as fO_2 of crystallization and cooling rate. Spinel, in particular, is an important indicator of petrogenetic conditions because it crystallizes throughout most of the cooling history of a rock, and is sensitive to physiochemical changes during its paragenesis. In this study we focus on the detailed chemistry and paragenesis of the spinel phases in mare basalts.

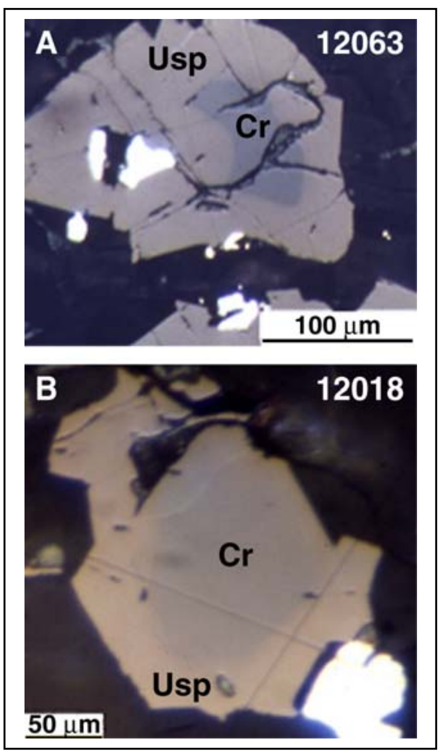

Figure 1. A. Sharp spinel contact; B. Gradational contact. Chromite is blue; ulvöspinel is tan.

A suite of thin sections of A-12 basalts were selected, from the curatorial facility at JSC, specifically with spinels containing a variety of textures.

Spinel compositions in mare basalts exhibit an effective solid solution between chromite, ulvöspinel, and hercynite, with no Fe^{3+}. Three major spinel occurrences have been observed in this suite of mare basalts: 1) Blue, early-formed chromite typically as inclusions in either olivine or pyroxene; 2) Tan, late-stage ulvöspinel generally found in groundmass; and 3) Composite spinel grains, occurring in all silicate associations and consisting of chromite with ulvöspinel overgrowths. These spinels display two types of compositional zonations, both optically sharp and optically gradational contacts (Figure 1).

Methods

Profiles across spinels with both types of contacts were conducted using the EMP facilities at the University of Tennessee. Profile analyses were performed approximately every 4 µm and were judged for quality by both oxide and cation totals. For simplicity, analyses from only two contrasting Apollo 12 basalts are presented here, 12018 and 12063. Rock 12063, 75 is a fine-grained, sub-ophitic olivine basalt, containing composite spinel grains with optically sharp contacts (Figure 1 A). Rock 12018, 75 is a medium-grained, porphyritic olivine basalt, where the composite spinel grains have optically gradational contacts (Figure 1 B). Compositions of spinels in each basalt are plotted on a Ti-oxide ternary and show a compositional gap in spinels from basalt 12063 and no compositional gap in spinels from 12018 (Figure 2).

Results

Spinel compositions from both basalt thin sections are shown in comparison to data presented by El Goresy *et al.* [1]. They reported compositional ranges of spinels in 12063, 18 and 12018,75 that are similar to ours, though their data are shifted slightly towards ulvöspinel.

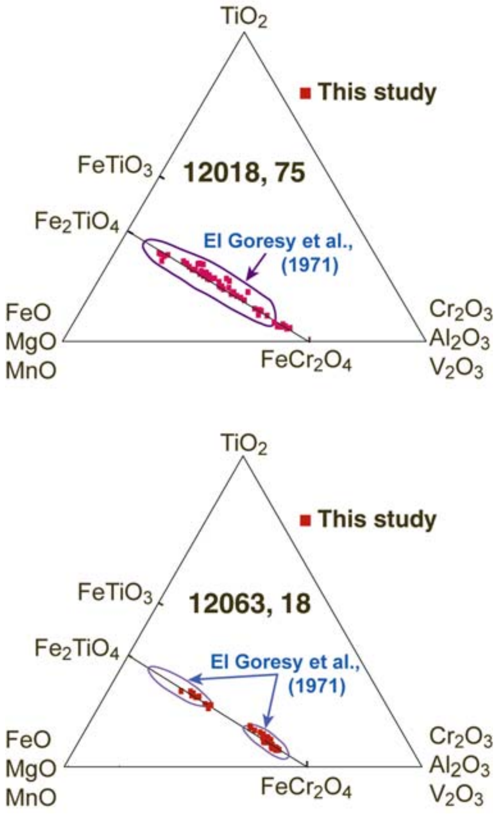

Figure 2. Spinel compositional data for 12018,75 and 12063,18.

They also reported an effective complete solid solution between chromite and ulvöspinel in spinels in 12018. When a single compositional profile across a spinel grain is plotted, however, a gap exists between chromite and ulvöspinel in basalt 12018, 75. This occurs in spinels with both sharp and gradational contacts. There are a few analyses that lie within the compositional gap in both 12018 and 12063, but these intermediate compositions can be attributed to edge effects.

Discussion

A compositional gap exists in spinels in both lunar basalts, 12063 and 12018, albeit much smaller in 12018, even when color change appears gradational (Figure 1B). This gap is obviously the result of some change in conditions during crystallization of the basalts. Several hypotheses have been suggested, including the possibility of a peritectic reaction between the earliest crystallizing spinel, chromite, with the melt, resulting in the crystallization of ulvöspinel [3]. Another possibility is the disappearance of chromite as a crystallizing phase as a result of the onset of crystallization of clinopyroxene and later appearance of ulvöspinel after change in melt composition [2]. In order to address these possibilities, spinel compositions were compared with the composition of co-crystallizing silicates.

Not unexpected, comparison of spinel chemistry with compositions of coexisting silicates also reveals the compositional gap (Figure 3). Cr content decreases with Mg # of host pyroxene in both, 12018, 75 and 12063, 18. This suggests a decrease in Cr content of spinel with fractionation.

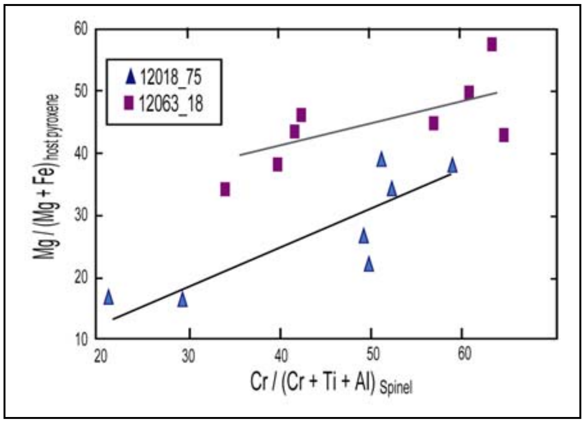

Figure 3. Variations in Cr content in spinel with host silicate composition.

Conclusions

Compositional profiles across composite grains show a chemically sharp gap in Cr and Ti in both the optically sharp and optically gradational contacts. Cr content decreases with Mg# of host silicate. A plot of this relationship also shows a gap in Cr content. This compositional break between the chromites and ulvöspinel is to be expected based on the crystal-chemistry of both phases, in that they have normal- and inverse-spinel structures, respectively.

References [1] El Goresy *et al.* (1971) *LPSC II*; [2] Irvine (1967) *Can. Jour. Earth Sci.*; [3] Kushiro *et al.,* (1970) *Trans. Amer. Geophys. Union*.