ELEMENT FRACTIONATION BETWEEN IMMISCIBLE MELTS; Paul
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Interelement ratios of such elements as K,Y,U,Rb,P,REE are
relatively unaffected by crystal-liquid equilibria in basaltic
magmas and as a result, these ratios are thought to be represen-
tative of the source area (1).   Interelement correlations can be
altered, however, by the onset of silicate liquid immiscibility
(2).   For example, K/P ratios are typically close to unity in
lunar basalts whereas they are increased to 20 to 100 in silica-
rich immiscible melts (3).   The petrogenetic significance of
this fractionation process depends on how much immiscible melt
was produced on the moon.   Lunar basalts typically contain only
small volumes (1-2%) of immiscible melt (3).   The granitic com-
ponent of lunar soils is also small (1-2%) and limits the volume
of silica-rich immiscible melt.   However, we have shown (4) that
the metal-rich immiscible liquid can be 4 times more voluminous
than the silica-rich liquid.   Therefore geochemical criteria
need be developed to recognize and evaluate the role of liquid
immiscibility in the evolution of the lunar crust.

Exsolution experiments in $CaO-SiO_2$ melts were performed to
determine how some trace elements are partitioned between im-
miscible melts.   These melts are used as simple analogues to
lunar immiscible melts and should yield semi-quantitative data.
The data for SrO are most complete and are as follows: SrO(wt%
CaO-Rich)/SrO(wt% SiO_2-Rich) = 14.3/1.6 = 9; 8.0/0.7 = 11;
1.7/0.04 = 42.   Note that fractionation increases as the SrO
content is reduced indicating that trace concentrations of SrO
may be strongly concentrated into SiO_2-poor immiscible melts.
Preliminary data for La, Dy and Y show that these elements are
increased two fold in CaO-rich melts.   These are minimum values
since phase separation was incomplete in these experiments.

K,Na,Al and Ba are enriched in the silica-rich immiscible
lunar melt whereas Fe,Ca,Mg,Mn,P and Ti are enriched in the FeO-
rich melt (3).   The degree of fractionation for a given melt
composition will depend on the proximity of the critical state.
The silica-rich melts are enriched in cations that can enter
tetrahedral coordination (Al) and cations which are needed for
charge balance (K,Na,Ba).   Metal-rich glasses are enriched in
cations of high field strength that cannot tetrahedrally coordi-
nate oxygen.   Binary SiO_2 systems of these oxides contain stable

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two liquid fields to very high temperatures (1700°C - 2000°C). Cations of high field strength demand the most efficient screening by oxygen anions. In SiO_2-rich polymerized melts, these cations cannot obtain coordination polyhedra of oxygen and are partitioned into a SiO_2-poor, less polymerized melt (5,6). On the basis of this model, trace elements such as P,U,REE,Zr,Sr, Y,Ti among others should partition into the metal-rich immiscible melt whereas monovalent cations of low field strength such as Rb,Cs,Na and Li would tend to follow K and Al into the SiO_2-rich melt. Note that these elements have metastable critical points at low temperatures (1000°C to less than 700°C).

Interelement ratios such as K/U, Rb/Sr, K/La and Ba/Zr are strongly affected by liquid-liquid phase separation whereas ratios such as K/Rb, Ni/Mg and Mn/Fe are not. For example, under favorable conditions K is increased 20 fold in the SiO_2-rich melt. Even a moderate enriched of 3-5 times of U, La or Zr in the metal-rich melt could alter the K/U, K/La, and K/Zr ratios by two orders of magnitude. These geochemical criteria cannot be applied indiscriminantly since interelement correlations can also be upset if late crystallizing minerals incorporate these elements in more than trace amounts eq. whitlockite, zircon.

Possible limits to the occurrence of liquid immiscibility on the moon include the following:

(1) High pressures may render the two liquid field unstable or metastable. We have obtained immiscibility in lunar melts at 300 bars at 1000°C so that immiscibility can occur to a depth of 6 km.

(2) The presence of H_2O may render the two liquid field unstable. Warner (7) found no evidence of a two liquid field in the $MgO-SiO_2-H_2O$ system at 10 kb. It is not known if the two liquid field exists in the anhydrous state at 10 kb.

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