CHEMICAL AND EXPERIMENTAL CONSTRAINTS ON THE GENESIS OF APOLLO 15
AND APOLLO 17 KREEP BASALTS. Anthony J. Irving, Lunar Science Institute,
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The melt-textured KREEP basalt fragments found at the Apollo 15 and 17
sites are distinct in many respects from other highland melt rocks. As dis-
cussed by Irving [1], these KREEP basalts have homogeneous melt textures, lack
xenolithic debris, contain metal with indigenous lunar Ni and Co contents, and,
in particular, are uncontaminated by meteoritic siderophile elements. Such
features have led most workers to conclude that these KREEP basalts are igneous
lavas and not impact melts.

Chemical variation in the KREEP magma series

One feature of Apollo 15 KREEP basalts which has not been emphasized is
their relatively wide range of chemical compositions. In Fig. 1 published and
unpublished data for K₂O and 100 Mg/Mg+Fe (Mg-value) are plotted for 38 samples
of Apollo 15 KREEP basalt (all with confirmed intersertal or subophitic igneous
textures). The Mg-values range from 74 down to 45 with a corresponding regular
increase in K₂O from 0.5 to ~ 1.6%. The estimated composition [2] of a
meteorite-free KREEP-rich quartz monzodiorite clast (QMD) associated with KREEP
basalts in 15405 also lies on this trend (within analytical uncertainty). A
regular decrease in Al₂O₃ content with increasing abundances of K₂O, trivalent
rare earths and other LIL elements is also observed for Apollo 15 KREEP basalts
[1]. The Apollo 17 KREEP basalts apparently show much less chemical variation
(Fig. 1) but there are very few analyses; furthermore, since all known samples
derive from a single boulder, it is possible they are all related to a single lava flow.

Melting experiments at 1-5 kilobars

Melting experiments have been carried out at pressures of 1-5 kb on 12-
component synthetic glasses with the compositions of Apollo 15 KREEP basalt
15386 and a magnesian Apollo 17 KREEP basalt (17KB - Table 1). The experiments
were done in Mo-wound internally-heated gas apparatus using unsealed Mo
capsules [c.f. 3]. Charges were held above the liquidus for one hour, cooled
to run temperatures, and held for 19-20 hours. Microprobe analyses of hyper-
liquidus charges indicated no bulk compositional changes during runs, except
for minor addition of Mo (as metal blebs). For both compositions, the liquidus
is at 1135 ± 10°C at 1 kb, 1160°C at 2 kb, and 1185 ± 10°C at 5 kb. Subcalcic,
low-Al pyroxene (CaO ~3%, Al₂O₃ ~3%) and calcic plagioclase (~An₇₅) co-exist
with liquid within 70°C of the liquidus of both compositions at 1-5 kb. At
3 kb, the actual liquidus phase is pyroxene for the 15386 composition, and
plagioclase for the 17KB composition.

Although these experiments are preliminary, it seems clear that neither
composition has a liquidus multiple saturation point within the range of
pressures corresponding to the lunar crust and uppermantle. Thus, both
15386 and 17KB are best interpreted as evolved liquids related to more
primitive liquids by fractionation of subcalcic pyroxene and calcic plagioclase.
This conclusion (for 15386) was also made by McKay and Weill [4]. If the
compositional range in Fig. 1 is a reflection of this fractionation trend,
then the liquid parental to the Apollo 15 KREEP magma series may have an
Mg-value as high as 74 or greater.

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Green et al. [5] studied the phase relations of a KREEP-like composition up to 7 kb and found olivine to be the liquidus phase at 1 atm. and 5 kb. However, this composition (G) is well outside the compositional range of the KREEP magma series, in particular because of its low SiO2 and high K2O and Al2O3 relative to its Mg-value (Fig. 1, Table 1).

Discussion

McKay and Weill [4] assumed that the evolution of 15386 could be well approximated by the phase relations at 1 atm. in the olivine-anorthite-silica pseudoternary system [6], and calculated a parental liquid lying at the olivine-plagioclase-pyroxene peritectic point which has an Mg-value of 72. This composition (P) is very similar to that of SAO 465-11, the most primitive Apollo 15 KREEP basalt analyzed so far [7] - see Table 1. Nevertheless, there are two important assumptions in McKay and Weill's calculation. Firstly, it is assumed that 15386 fractionated at the lunar surface. If the KREEP magma series fractionated deeper in the lunar crust, the 1 atm. phase relations do not apply. Just how much the cotectics, peritectics and phase compositions change with increased pressure (and hence temperature) remains to be experimentally confirmed. The second assumption is that TiO2 (1-2%), Na2O (-0.6%), K2O (~0.5%), P2O5 (~0.5%) and Cr2O3 (~0.3%) do not have a significant effect on the phase relations.

In the case of the Apollo 17 KREEP basalts, a putative parental liquid has not yet been recognized. Such a liquid would have lower K2O and higher Cr2O3 than the parental Apollo 15 KREEP magma, and would most likely be assigned to a different partial melting scheme (i.e. different source mineralogy, depth, or degree of melting).

Experiments are continuing on several reconstructed parental KREEP magma compositions in attempts to define in more detail possible partial melting models for their origin.
CONSTRAINTS ON THE GENESIS OF KREEP BASALTS

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References

TABLE 1. Experimental and natural KREEP basalt compositions (see text).

<table>
<thead>
<tr>
<th></th>
<th>15386</th>
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<th>G</th>
<th>P</th>
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