**VERY HIGH POTASSIUM (VHK) BASALT: A NEW TYPE OF ALUMINOUS MARE BASALT FROM APOLLO 14.** J. W. Shervais, L. A. Taylor. Department of Geological Sciences, Univ. of Tennessee, Knoxville, TN 37996; and J. C. Leul, Battelle Northwest, Richland, WA 99352.

One of the most important aspects of mare basalt petrology/geochemistry is the insight it can provide into the mineralogical and chemical constitution of the Moon's upper mantle. As probes of the lunar interior, mare basalts record the early history of melting and differentiation and help us to estimate the Moon's bulk composition (e.g., 1). Lunar mare basalts differ from their terrestrial counterparts in having low ratios of volatile/refractory elements and relatively high abundances of elements with high ionic potentials (e.g., Ti, Zr, Nb). Similar to terrestrial subalkaline basalts, mare basalts always have K2O/Na2O weight ratios much less than one (2).

We have recently discovered a few varieties of low-Ti, high-Al mare basalt at the Apollo 14 site that violates the generalized statement above. In so doing, this new rock type promises to significantly increase our understanding of the lunar interior. This new basalt is characterized by high abundances of K, +Na, and K/Na values between 500 and 1500 (Fig. 1). Accordingly, we have proposed that this new basalt type be referred to as Apollo 14 "VHK" (Very High Potassium) basalt (3).

In our preliminary report last year, we described briefly a large (~2 gm) clast from breccia 14305 (3) and compared it to a coarse-fine fragment described by Warner et al. (4). A continued scrutiny of breccia 14305 has yielded four more clasts of VHK basalts, as well as an unrelated clast of ilmenite ferrobasalt.

** Petrography:** Apollo 14 VHK basalt is medium to coarse-grained rocks consisting of olivine (2 generations), pigeonite, augite, plagioclase, K-feldspar, chromite-ulvospinel, ilmenite, and mesostasis glass. They have ophitic textures, with small, flat plagioclase laths enclosed in the much larger and more abundant pyroxene. Plagioclase (An83-94; An90-92) forms 25-30 modal %—not enough to account for the high Al2O3 of the whole rock. Much of this alumina is present in K-feldspar and glass.

Olivine (Fo63-73) is the primary liquidus phase in 3 of the 6 samples, suggesting a parent magma with an Mg# > 47. This olivine has been partially resorbed and subsequently overgrown by pigeonite. Pigeonite also occurs as phenocrysts, both in these rocks and in the 3 samples which lack liquidus olivine. Pigeonite phenocrysts are zoned outward into thick epitacttic overgrowths of augite (Fig. 2). The transition from pigeonite cores to augite rims is rather abrupt and is marked by [a] the presence of intergrown plagioclase laths and [b] abundant inclusions of glass, neither of which occur within the pigeonite core. This paragenetic sequence is also recorded in the pyroxene chemistry: pigeonite has high Mg# with a 1T/1M = 4; augite has lower Mg#, Al and Cr, with a 1T/1M = 2. Fayalite (Fo32-Fo49) and K-feldspar (Or86-94; 0.1-4.7% BaO) both occur as late crystallizing phases associated with mesostasis glass (K2O = 10%, SiO2 = 75%). A Ti, Cr-spinel phase occurs both as inclusions in olivine or pigeonite (low Ti chromite) or interstitially (ulvospinel). Ilmenite forms interstitially and is low in MgO (1.6-3 wt%).

Although the mineralogy of the VHK basalts does not differ remarkably from many other low-Ti mare basalts, the modal abundances of K-feldspar and K, Si-rich glass are unusually high and account for the unusual chemistry of these rocks.

**Geochemistry:** The major element geochemistry of Apollo 14 VHK basalt is remarkably similar to other Apollo 14 low-Ti, high-Al basalts: Al2O3 = 9.9-13.4%, TiO2 = 1.7-5.1%, Na2O = 0.34-0.58%, CaO/Al2O3 = 0.8-0.99, Mg# = 49-60. Among the major elements, only K2O (0.56-1.40 wt%) is unusual. The trace elements are also similar to other low-Ti basalts. The compatible elements contents are high, with Ni = 40-100 ppm and Co = 28-40 ppm. K, Rb, and Ba are all enriched relative to the REE (Fig. 3) and increase with increasing REE. The REE have moderate abundance levels and flat to slightly LREE-enriched patterns (Fig. 3). The increase in La/Lu ratio with increasing REE cannot be modeled quantitatively by fractionation.
of the liquidus phases observed. The positive correlation between K\(_2\)O and Ni (Fig. 4) argues against any interrelationships based on fractional crystallization or variations in partial melting. The K\(_2\)O-Ni correlation is explained by non-modal variations in the content of mesostasis phases (glass, Kspar, fayalite) in the smallest analyzed samples. Because the distribution coefficient for Ni increases as MgO (liquid) decreases, late crystallizing Fe-rich olivines can be richer in Ni than Mg-rich, liquidus olivine (5). Nickel distribution coefficients also increase with increasing alkali content. We note that 3 of the 4 REE-rich samples were analyzed in aliquots <10 mg in weight, enhancing the possibility of non-modal variation.

Age: Shih et al. (this volume) report an Rb-Sr internal isochron age of 3.86 ± 0.07 AE for the largest sample of VHK basalt, with an initial \(^{87}\)Sr/\(^{86}\)Sr ratio of 0.7094. This requires a maximum source ratio Rb/Sr = 0.04 (atomic) until the time of melting, when the ratio was increased to 0.61 (Shih et al. this vol.). This implies a significant increase in the Rb/Sr ratio of more than 15.

Discussion: In our preliminary report on VHK basalt (3), we suggested several possible origins for this enigmatic rock-type. These included: (1) mixing of low-Ti basalt with lunar "granite", (2) partial melting of a magma ocean cumulate enriched in Kspar by post-cumulus crystallization, (3) direct melting of a primitive lunar interior, and (4) K-metasomatism of a low-Ti basalt source region, causing partial melting.

The first of these possibilities can be excluded because the amount of granite necessary to reproduce the observed abundances and ratios varies by more than an order of magnitude. In particular, U, Th and Zr are too high in the granite to yield reasonable results. The second possibility, melting of a K-rich cumulate, is inconsistent with the low initial Sr ratio. Direct melting of a primitive lunar interior (origin 3) cannot explain either the relative enrichment of Ba or the negative Eu and Sc anomalies (Fig. 3).

Metasomatism of a low-Ti basalt source region by a K-rich melt phase, causing partial melting, is the only possibility which is consistent with most of the major and trace element data. It leaves unanswered, however, important questions regarding the nature and composition of the fluid phase, why it was selectively enriched in K, Rb and Ba, and where these elements reside in the lunar mantle. In answering these questions, we may penetrate beneath the magma ocean to the earliest periods of lunar history.