

APOLLO 15 KREEP BASALTS: AN INTEGRATED APPROACH TO DETERMINING ORIGIN AND EVOLUTION

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Introduction: The origin of KREEP-rich lunar basaltic rocks is enigmatic. Two hypotheses for the formation of these KREEPy rocks are: 1) that KREEP basalts are the result of partial melting of the lunar interior, and 2) result of incorporation of KREEPy and basaltic material in to an impact melt.

Warren [1] proposed the use of Highly Siderophile Elements (HSE) to determine between these two hypotheses. Impact melts are enriched in HSE's when compared to other lunar materials due to the HSE-enriched nature of the impactors; however, obtaining accurate HSE abundance's requires the destruction of a relatively large amount of sample limiting the method of [1] to samples with sufficient mass remaining.

Varying petrographic methods have also been used to determinate between these two hypotheses for KREEP basalt formation. Quantitative petrographic methods have been proposed [2], which used Crystal Size Distributions (CSDs) to differentiate between Impact melts and pristine basalts. Qualitative Petrographic methods have also been used [3], using porphyritic texture and crystal intergrowths to determine that 15434.181 is basalt with a two stage coming history, although porphyritic textures can develop in a single stage cooling history (e.g., [4]).

Although Ryder [2] noted that 15434.181 is a basalt derived from partial melting as it is consistent with the pristine melts in Figure 2 [5]. There is evidence however, that the large orthopyroxene crystals are not phenocrysts as Ryder thought, but are xenocrysts [6], which would remove the need for a 2 stage cooling history [7]. This raises the question, are other Apollo 15 KREEP basalts consistent with 15434,181 in that they are pristine KREEP basalts that have incorporated orthopyroxene (or remnants thereof) xenocrysts?

15243 represents a collection of 4 to 10 mm fines from station 6 and was initially thought to be made up mare basalt/impact melt fragments. Subsequently, petrographic and whole rock chemical analysis showed that some of the subsamples were KREEP basalts (,43 and ,60 among others) [8]. 15243,60 was described as a KREEP basalt with lath shaped plagioclase, and smaller euhedral pigeonite [8]. An element map of ,60 can be found in Figure 1a, pyroxenes can clearly be seen and possess Mg rich cores (in blue). KREEP basalt fragment 15243,43 contains euhedral orthopyroxene and plagioclase with

a fine-grained ground mass [8]. An element map of ,43 can be seen in Figure 1b.

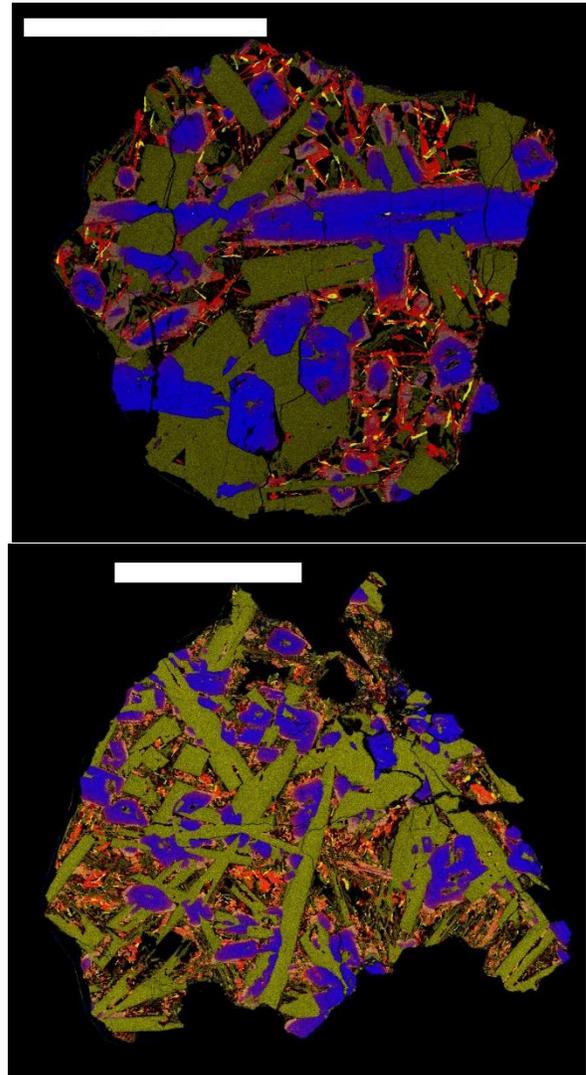


Figure 1: element map of 15243, (a) ,43 (top) and (b) ,60 (bottom) color key Red Yellow and Blue, correspond to Fe Ca and Mg, respectively. White scale bar is 1mm.

Method: CSD's were created following the method described by Neal et al.. [9] and Roberts and Neal [2] by first creating photomosaics of each sample by assembling individual photomicrographs in *Adobe Photoshop*®, and then tracing the phase of interest (with the outline of the sample, and importing the data from *Photoshop* into *imageJ* to give the area of the sample and the best fit ellipse of each crystal of the phase of interest. Dimensions of the best fit

ellipses and area of the sample were imported to *CSDslice* [13] and *CSDcorrections* [14] More details can be found in [9-12].

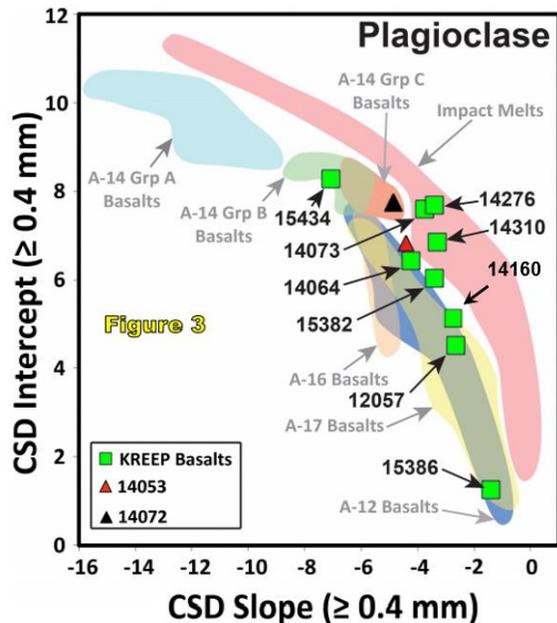


Figure 2: Comparative CSD diagram Robert's and Neal

Electron Probe Micro Analysis (EPMA) was carried out at Washington University in St. Louis using a JEOL JXA-8200 electron microprobe. These data allowed the determination of mineral compositions, for the calculation of partition coefficients, and for trace element analysis using Calcium concentrations as an internal standard. Accelerating voltage was set to 15 kv, beam current was 25 nA and spot size was 3-5 μm (spot size was made smaller for ease of use and site selection). Plagioclase, pyroxene ilmenite and potassium feldspar, were the mineral phases analyzed on samples 15243,6,43 and ,60; and 15386,3. Elemental x-ray maps were made, and were then used to guide the analysis (e.g., Fig. 1).

Conclusions: Although data are still being collected, preliminary conclusions can be made. The pyroxenes of 15386,3 and 15243,43 are consistent with

pyroxenes from KREEP basalt 15434, and pyroxenes from known impact melt 14310,25 are distinct (see Fig. 3). These differences are most evident in pyroxenes with a Wo% content of less than 10%; in addition 15386 is consistent with other pristine melts when comparing CSDs (Fig. 2). This leads to the preliminary conclusion that both 15386,3 and 15243,43 are pristine KREEP basalts with pyroxenes of a similar origin to the pyroxene xenocrysts of 15434,181. However 15243,60 pyroxenes are not consistent with pyroxenes from 15434,181 (see Fig. 3); pyroxenes from 15243,60 are however similar to 14310,25, leading to the possibility that 15243,60 represents an impact melt.

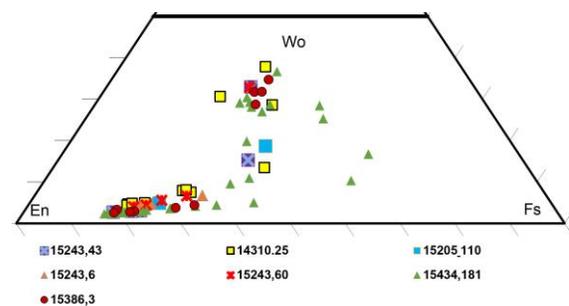


Figure 3: OPX quad plot, 15434 and 14310 are present for reference (using data from [5], respectively). 15243, 60 is similar to that of 14310,25, while ,43 is similar to 15434,181. 15243,6 falls between 14310 and 15243. 15386,3 is similar to that of 15434

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