FELDSPAR VARIABILITY IN NORTHWEST AFRICA 7034.
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Introduction: The martian meteorite Northwest Africa 7034 (and pairings) is a breccia that provides important information about the rocks and processes of the martian crust (e.g., 1-3). Additional information can be gleaned from the components of the breccia. These components, specifically those designated as clasts, record the history of their parent rock (i.e., the rock that has been physically broken down to produce the clasts). In order to study these parent rocks, we must first determine which clasts within the breccia are derived from the same parent. Previous studies have begun this process (e.g., 4), but the search for genetic linkages between clasts has not integrated clasts with different grain sizes. We begin to take this approach here, incorporating igneous-textured clasts with both fine and coarse mineral grains.

In NWA 7034, almost all materials (clasts and breccia matrix) are composed of the same mineral assemblages (feldspar, pyroxene, Fe-Ti oxides, apatite) with largely the same mineral compositions [1, 4-6]. Bulk breccia Sm-Nd systematics define a single isochron [7]. These observations are consistent with a majority of the components within NWA 7034 originating from the same geochemical source and crystallizing at roughly the same time.

However, the Rb-Sr system as measured in the bulk breccia does not define a single isochron [7]. Because feldspar is often a major host of Rb and Sr in igneous rocks, we chose to examine this phase more closely in a variety of clasts within NWA 7034 to look for both evidence of genetic relationships between clast types and evidence for a secondary process that may have altered the feldspar, and thus disturbed the Rb-Sr isotopic system.

Methods: Feldspar grains from multiple thin sections and probe mounts in the UNM collection were examined using electron microprobe analysis for major and minor elements using the methods of [4]. LA-ICP-MS was used to measure trace elements using methods described in [2]. Detailed textural and qualitative chemical examination was performed using BSE imaging and EDS analysis on a FEG SEM.

Results and Discussion: Feldspar occurs as (1) large mineral fragments, often existing in isolation, (2) as part of small rock fragments containing pyroxene, Fe-Ti oxides, apatite, and zircon, (3) as an important part of finer grained clasts within the breccia (e.g., basalt clasts, trachyandesite clasts, melt clasts), and (4) in the fine-grained breccia matrix [4-5]. The majority of feldspar is plagioclase, however alkali feldspar is also present, found mostly as large mineral fragments and occasionally in fine grained igneous-textured clasts (trachyandesite clasts, basalt clasts, and FTP clasts). Feldspar compositions are shown in Figure 1. The measured coarse-grained feldspar is both plagioclase and alkali-rich, with compositions similar to those of fine-grained feldspars. Albite in the fine-grained clasts is small, rare, and does not represent whole grains, while albite in the coarse-grained feldspars was most often measured as exsolution lamellae.

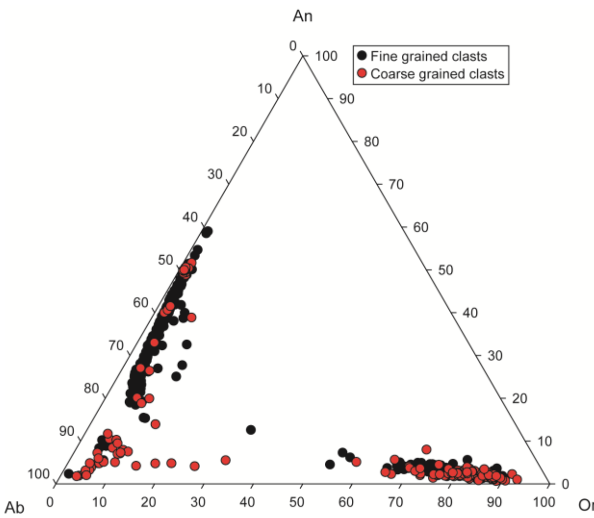

Figure 1: Feldspar ternary showing compositions from fine- and coarse-grained clasts. Fine grained clast data from [4].

Coarse-grained alkali feldspar exhibits a perthitic texture, which was not observed among alkali feldspar in the fine-grained clasts, and tends to have more cracks and small pores (Figure 2). The exsolution texture is consistent with the contrasting cooling histories inferred between the two feldspar populations based on differences in grain size. Alternatively, the occurrence of albite in the large alkali feldspar is also consistent with a mutual replacement reaction of the alkali feldspar in a hydrothermal system (e.g., 8), although further examination is needed to determine if this process has occurred. Alkali feldspar grains in contact with the matrix contain small regions of albite in the outer few µm of the grain. This albite represents a process that proceeded on a much smaller scale than the possible alteration of the large perthitic feldspar noted above.

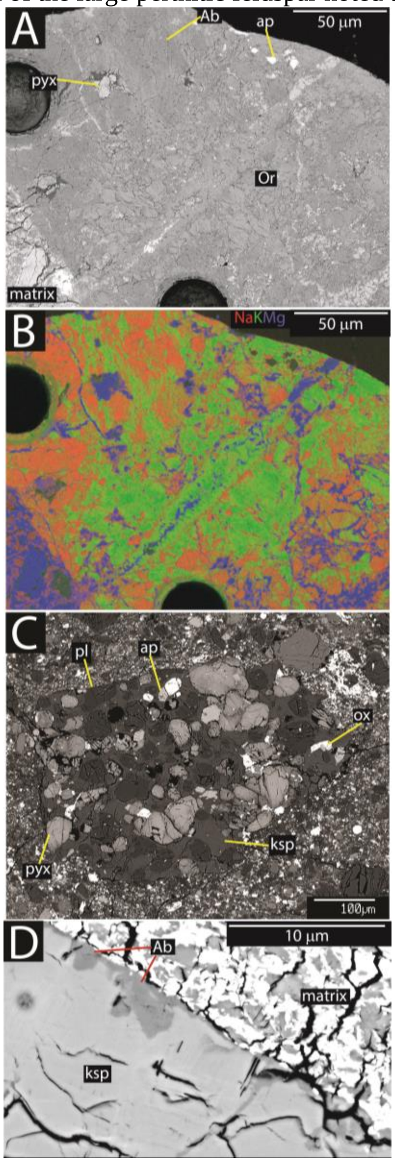

Figure 2: A and B: BSE image and NaKMg X-ray map of a coarse-grained feldspar containing perthitic texture and numerous small cracks and pores. C: Alkali feldspar bearing fine-grained clast for comparison. Note the lack of perthite. D: Coarse-grained alkali feldspar showing small regions of albite near the grain rim.

Rb and Sr were measured in multiple feldspar grains from both coarse- and fine-grained clasts. Plagioclase shows slight variation in Rb/Sr between clasts of different grain sizes (0.006-0.697, Figure 3). Only coarse grained alkali feldspar was measured for trace elements. These grains show relatively consistent Rb/Sr, with higher ratios than those seen in the plagioclase (0.892-3.762). Rb/Sr is expected to increase with increasing Or#, and the observed constant ratios (with the exception of one grain) with increasing Or# is consistent with a disturbance to the feldspar. The bulk breccia plagioclase and whole rock measurements from [7] have similar Rb/Sr ratios (0.112-0.200 bulk plagioclase, 0.107 whole rock) and also have Rb/Sr ratios within the range of the fine-grained plagioclase.

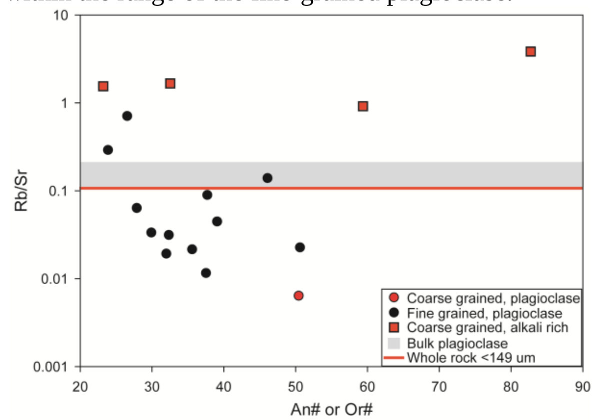

Figure 3: Rb/Sr vs. An# (An/An+Ab) for plagioclase and Or# (Or/Or+Ab) for alkali feldspar. Coarse-grained feldspar is shown in red while fine-grained feldspar is shown in black. Bulk rock plagioclase Rb/Sr ratio is shown by the gray bar, while the whole rock value is shown by the red line [7].

Summary: The fine-grained feldspar could be genetically related to the coarse-grained feldspar due to similarities between their major element compositions. However, further investigation into the trace element compositions, textures, and mineral associations are needed in order to fully assess this possibility.

Alkali feldspar appears to be altered in the coarse-grained clasts and pristine in the fine-grained clasts based on texture and Rb/Sr ratios. The origin of the perthitic texture observed in alkali feldspar within the coarse-grained clasts requires additional investigation to determine if they were affected by hydrothermal processes, a possibility also identified by [5] in alkali feldspars with similar textures. Evidence for secondary processes has also been observed in coarse-grained pyroxene by [9] and in certain large protobreccia clasts by [3]. McCubbin et al. [3] also noted in their altered protobreccia clast an elevated concentration of alkali-rich feldspars relative to the rest of the breccia and higher K_2O contents in metamict zircons found within that clast. Secondary alteration of alkali feldspars could lead to the observed disturbance of the Rb-Sr system.

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