UNUSUAL CRACKS AND PORES IN BRECCIA 15418 AND LUNAR DUNITE 72415; D. Richter, R. Siegfried, and G. Simmons, Dept. of Earth and Planetary Sci., MIT, Cambridge, MA 02139.

Lunar samples 15418 and 72415 have unusual microcrack features, indicating complex histories of fracturing and annealing.

15418. Introduction. New data on this breccia consist of extensive petrographic microscope (PM) observations and electron microprobe analyses of PTS 154 and DSA and SEM observations of a 1x1x2 cm block. The sample has very low crack porosity and contains many cracks sealed with glass. We suggest that the sample was extensively annealed after its last major shock event.

PM and Probe. The PTS contains abundant evidence of thermal annealing--healed cracks, glass sealed cracks, devitrified glasses, 'reaction rims', and recrystallized plagioclase grains. The healed cracks are marked by planes of opaque (probably metallic Fe) <1μ and by grains of non-opaques 1-2μ in size and richer than the host in Mg, Fe, Mn.

The most prominent crack feature in PTS 154 is a set of sealed cracks that contain a partially devitrified brown glass bounded symmetrically by clear and 'speckled' anorthite. The clear anorthite is mainly well-crystallized laths oriented normal to the crack. Flow structures are not seen. Grains of anorthite, olivine, and pyroxene within the glass-sealed cracks have not reacted with the glass despite extensive thermal annealing. The composition of the glass differs significantly from the other phases in the rock, based on several hundred probe analyses. Typical profiles of the variation of Fe, Ti, and Mg across the crack are shown in Fig. 1 and the distribution of phases in the vicinity of the profile is shown in Fig. 2.

SEM. Several episodes of cracking and crack healing which occurred after the initial complete recrystallization of the breccia can be distinguished with the SEM. Healed cracks marked by strings of inclusions or voids are common in single grains of plagioclase and pyroxene. A long sealed crack 10-90μ wide completely transects the 1 cm wide block. It is sealed with partially devitrified glass and may be similar to the glass filled crack in the PTS although the border of anorthite was not recognized. The crack truncates most, but not all, of the healed cracks in the grains adjacent to it. The few open cracks which crosscut all other textures are interconnected and irregular in direction. These cracks are similar to shock induced cracks described in other lunar samples [1], but their width is <0.1-0.5μ compared to 1-5μ in mare basalt 15075. The most recent cracking, then, may have been due to a very mild shock event.

DSA. The open cracks in 15418 were characterized by the DSA technique, which used high precision strain measurements to determine the distribution of crack closure pressure and the crack porosity of a sample [1]. Fig. 3 shows the differential

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strain curve and the closure pressure distribution for 15418,43. Data in three orthogonal directions are available for 15418, with two gauges in the 3 direction. The difference between the curves for gauges 3a and 3b is an indication of the heterogeneity of the sample. 15418 has the very broad spectrum that is characteristic of lunar samples [1]. The porosity due to cracks closing at $P \leq 2kb(\zeta_V(2kb))$ is .17% and the volumetric compressibility at $2k\bar{b}$ $(\beta_V(2kb))$ is $2.13Mb^{-1}$. The values of the parameters are much lower than that for any other lunar sample we have examined [1].

72415. Introduction. SEM observations on a 5 mm cube combined with PM observations on PTS 26 indicate a very complex history of several fracturing events and extensive annealing.

PM. The PTS 26 contains abundant crack features in both the large grains of olivine and in the cataclastic matrix. The petrography of this PTS is described in [2]. Within the large olivine grains, we recognize (1) healed cracks (marked by planes of solid inclusions or spherical voids) that are probably of tectonic origin, (2) cracks sealed with very fine grained crystalline plagioclase, and (3) tubes of squarish cross-section. Some of the large olivine grains contain extremely abundant, randomly located pores <1-2μ in diameter. The large grains are separated by a cataclastic matrix that is mainly olivine. Locally, the matrix is plagioclase which may have been intruded into the rock during one of the later fracturing events. The complexity of the fracturing-annealing history is illustrated by one very large olivine grain that was shocked, then broken into a dozen fragments that retained the original crystallographic orientation and shock-lamellae and the region between the grains filled with plagioclase and followed by at least one more fracturing then sealing event.

SEM. The textures of 72415 observed in the SEM are striking because: (1) the rock contains very few microcracks; (2) the matrix is a highly porous mass in which individual grain boundaries are indistinguishable; (3) the large clasts contain many pores and healed cracks, but very few open cracks; (4) the grain boundaries of the large clasts are partially welded to the matrix.

In thin section, the matrix appears to be crushed olivine without recrystallization [2]. In the SEM the matrix appears to be small angular clasts and continuous spongy masses. The crack-bridges in the spongy matrix have no compositional difference from larger clasts which could be detected with the SEM x-ray dispersive analyser. The pores between matrix grains are angular to subspherical in shape and vary from 0.1-2μ in size. The matrix contains almost no open cracks, but boundaries along the large clasts contain relatively long irregular slots.

The large clasts contain abundant healing fractures such as isolated and parallel sets of linear arrays of pores. Abundant randomly oriented voids are common. The large clasts contain

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a few open cracks which are fairly linear and <0.1μ wide. The cracks which make the sample 'friable' are long, transgranular fractures 50-100μ wide.

We examined the Chassigny (dunite) meteorite, the Twin Sisters (WA) dunite, and peridote bomb from Kilbourne Hole (TX) with the PM and SEM and found no similarity in their textures to the unusual textures of 72415.

Conclusions. The features in both 15418 and 72415 probably resulted from elevated temperatures after the last major shock event for each rock.

References. [1] Simmons, G., Siegfried, R., and Richter, D., 1975, Proc. Lunar Sci. Conf. 6th, p. 3227-3254. [2] Dymek, R.F., Albee, A.L., and Chodos, A.A., 1975, Proc. Lunar Sci. Conf. 6th, p. 301-341.

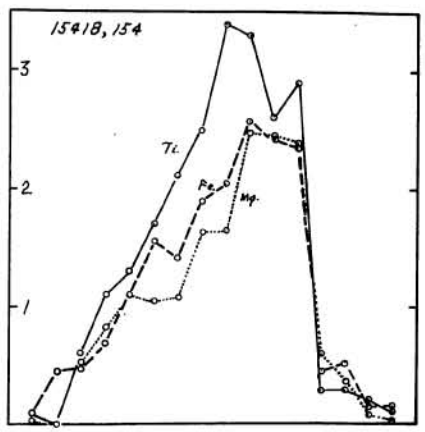

Fig. 1. Variation of Fe, Mg, and Ti across the glass sealed crack. Scale for Fe and Mg is % and for Ti is 0/00, calculated as oxides. See Fig. 2 for locations.

Fig. 2. Glass sealed crack. The typical distribution of phases is symmetrical about the glass, but pyroxene and olivine crystals sometimes replace the speckled plagioclase. The clear anorthite adjacent to the brown glass is typically oriented with [010] normal to the sealed crack.

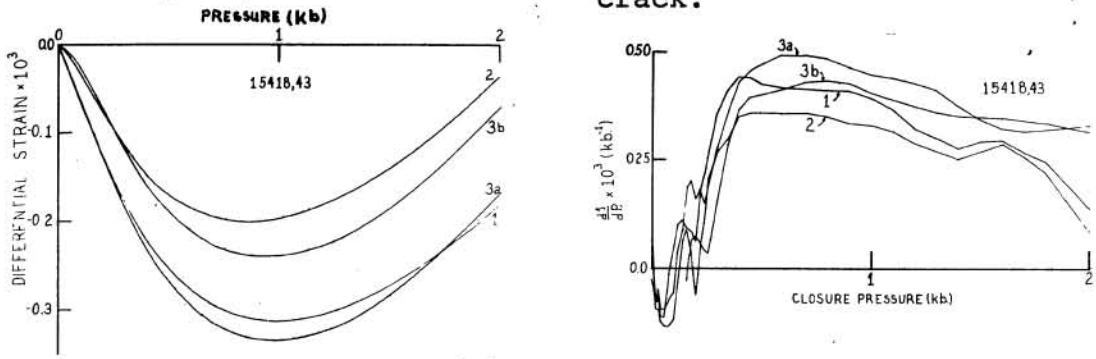

Fig. 3. DSA results.

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