LASER PROBE ^{39}Ar-^{40}Ar DATING OF IMPACT MELT GLASSES IN LUNAR BRECCIA 15466. M. A Laurenzi[1,2] and G. Turner[1]. [1]Department of Physics, University of Sheffield, UK. [2]IGGI, CNR, Pisa, ITALY.

Previous attempts to date lunar soil breccias and impact melt glasses have proved to be extremely unreliable because of their great complexity. They are a mixture of genetically unrelated rock fragments, minerals, glasses, previous breccias and regolith fragments, held together by impact glass, and complicated by the presence of solar wind implanted gases and cosmogenic nuclides. The use of a laser probe enables us to analyse noble gases in samples as small as 1 microgram and hence to make age determinations on the individual breccia constituents.

The laser used in the present study is a Nd-glass laser with a wavelength of 1060 nm, an ouput of about 350 mJ and a pulse length of 180 μs. It is focussed onto the sample through a microscope with a reflecting objective, and the gas released from individual laser shots admitted directly to a sensitive sector focussing mass spectrometer with an electron multiplier detector. The gas is simultaneously gettered and the (reproducible) instrumental background blanks during the period of analysis were equivalent to; 6.7 ± 1.3, 1.4 ± 0.2, 4.0 ± 1.0, 2.8 ± 0.7, 460 ± 65 (x 10^{-14} ccSTP of Ar), respectively, for masses 36, 37, 38, 39 and 40.

Breccia 15466 comes from the summit of Spur crater. It is made up of dark glass containing a variety of clasts. The glass constitutes about 90% of the sample, the remaining part being regolith breccias, glass spheres, mineral and lithic fragments. Previous analyses have been reported from our laboratory by McConville (1) during the period when the laser probe was under development. Due to the lower sensitivity of the spectrometer at that time, multishot laser extractions were combined with conventional stepped heating analysis. The stepped heating data on a (mainly) glassy fragment indicated a rough correlation between $^{40}Ar/^{36}Ar$ and $^{39}Ar/^{36}Ar$, the slope of which corresponded to an apparent age of 1.4 Ga. A $^{38}Ar/^{36}Ar$ vs $^{37}Ar/^{36}Ar$ correlation for both laser probe and stepped heating data on the same glass fragment corresponded to a cosmic ray exposure age of 75 ± 5 Ma. The laser probe $^{40}Ar/^{36}Ar$ vs $^{39}Ar/^{36}Ar$ data showed considerable dispersion which indicated that the stepped heating "age" was probably an artifact representing some kind of average for the glass and the small fragments occluded by it. The apparent ages of individual measurements varied from several Ga to values which were indistinguishable from the cosmic ray exposure age. McConville concluded that the data was consistent with an age of melting for the glass similar to the exposure age and that the high stepped heating age was in all probability an artifact.

The ability to make 'single shot' age determinations which relate to individual 80 μm (1 μg) regions of the sample has clarified the situation considerably and confirmed McConville's tentative conclusions. Measurements have been carried out on several areas of the glass, together with a series of measurements on three white (anorthositic) clasts. The data from each of these individual areas is much more coherent than that obtained previously. The glass is characterised by a very uniform Ca/K ratio of 48, which is illustrated by a $^{37}Ar/^{36}Ar$ vs $^{39}Ar/^{36}Ar$ correlation (fig. 1, solid circles). ^{37}Ar and ^{39}Ar are produced in the reactor by neutron activation of Ca and K respectively. The ^{36}Ar is predominantly solar wind and the correlation arises from the wide variation (factor 10) in its concentration. The $^{38}Ar/^{36}Ar$ vs $^{37}Ar/^{36}Ar$ correlation corresponds to a cosmic ray exposure age of 60 ± 12 Ma, not significantly different from the previous measurement. The initial ratio (0.208) is higher than the solar wind $^{38}Ar/^{36}Ar$ ratio

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(0.19) and this together with scatter in the correlation, far in excess of experimental error, is evidence of a pre-exposure history of the glass and incomplete degassing during the breccia forming event. The $^{40}Ar/^{36}Ar$ vs $^{39}Ar/^{36}Ar$ correlation also shows scatter, due to variation in the trapped $^{40}Ar/^{36}Ar$ ratio. Nevertheless it is plainly evident that the glass is very young and considerably younger than the (spurious) stepped heating age referred to above. The apparent age obtained from the slope is imprecise, 130 ± 90 Ma, but indistinguishable from the cosmic ray exposure age, and indicates that the glass (and the breccia) formed very recently from preirradiated near surface material.

Three anorthositic clasts were also analysed. Because calcium feldspar is partly transparent to the laser beam some heating of the underlying matrix occurred and the gas released is a mixture of radiogenic and cosmogenic argon from the anorthosite, together with variable amounts of solar wind from the matrix. One of the clasts was totally dominated by solar wind. The other two clasts gave well defined ^{40}Ar-^{39}Ar ages (1910 ± 70 and 3370 ± 380 Ma) and exposure ages (910 ± 30 Ma and 169 ± 8 Ma). The extent to which the correlations from which these ages were calculated were affected by radiogenic and cosmogenic argon from the glass can in principle be constrained by the Ca/K ratio, and is probably small. This constraint can be conveniently visualised and applied using a 3D correlation diagram, such as figs. 2 and 3 for clast 2 and glass. Whatever the precise value of the clast ages it is not possible to attach to them any detailed significance beyond the qualitative observation that they are very high and relatively unaffected by the heating of the melt glass.

In summary the data show clearly that the glass, and by implication the breccia, is young. Its age, 60 ± 12 Ma may be the age of Spur crater. The very high age obtained with stepped heating analyses on a selected glass fraction seems to invalidate similar data obtained on other breccias.

(1) P. McConville, Meteoritics, 18, 350-352, 1983.

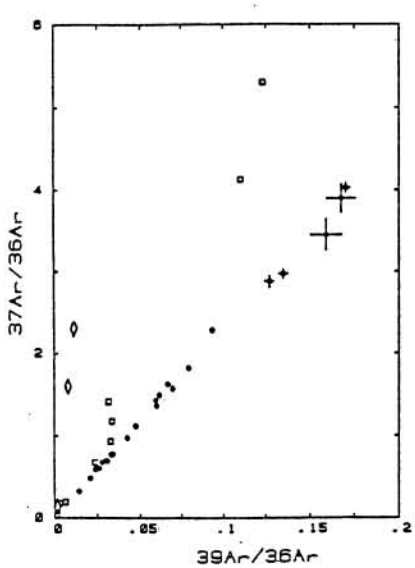

FIG.1

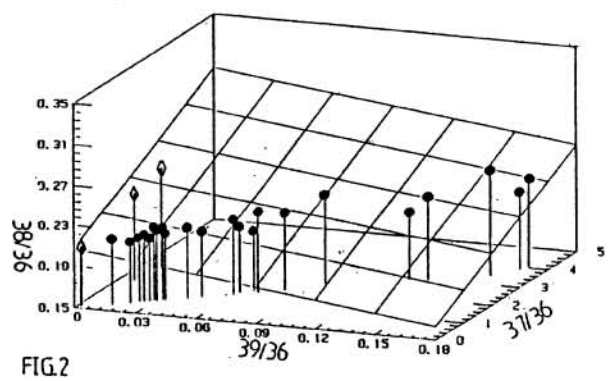

FIG.2

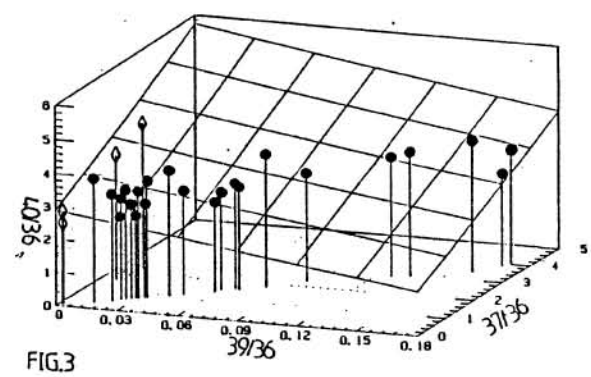

FIG.3