CHARACTERISTICS OF IMPACT MELTS IN THE LUNAR HIGHLANDS: R.A.F. Grieve*, A.G. Plant**, M.R. Dence*. *Earth Physics Branch and **Geological Survey of Canada, Dept. of Energy, Mines and Resources, Ottawa.

Samples from the Apollo 16 site can be compared more closely with the products of large terrestrial impacts, which formed craters 20-60km in diameter, than those from other missions. As craters in this size range are common in this part of the lunar highlands, detailed comparison is encouraged. Here we concentrate on samples interpreted as impact melts from the highlands.

The suite of impact melt products ranges from glasses to fine and medium grained igneous rocks with sub-ophitic and poikilitic textures. Xenocrysts, some partly digested, recrystallized or overgrown, are generally a conspicuous 10 to 20% of the mode. The range in grain size and textures can be closely matched in samples from craters such as Lake Mistastin, Labrador and Clearwater Lake, Quebec, where the sheets of impact melt on the crater floor reach thicknesses of more than 100m. Field and laboratory studies at these and other craters demonstrate that extreme thermal metamorphism and partial melting play only a minor role in the formation of impact melts and breccias, and in contrast with other authors (1,2) we consider that this was also the case at the Descartes site. The principal mechanism in the formation of impact melts is the dynamic mixing of totally melted and locally homogenized materials from close to the point of impact with less strongly shocked rocks. The latter are incorporated into the melt during its movement across the floor of the expanding cavity. During movement, but mainly after coming to rest, assimilation and thermal metamorphism, including local partial melting, of the inclusions by the surrounding hot melt matrix takes place. Lunar examples of partial melting processes have been noted in rocks 64455 and 65075 (3) and in fragments from soil 12070 but appear to be relatively as rare on the moon as they are on earth.

Representative compositions of lunar impact and partial melts are illustrated in Figs. 1 - 3. Samples analysed include glasses, lithic fragments of impact melt and small, chondrule-like bodies with a fine granular matrix. The compositional array is roughly fan shaped with anorthositic rock compositions at the apex, and a base ranging from granitic to iron-rich partial melt compositions. A tight cluster of compositions at 26-28% Al_2O_3 (Figs. 1,2) is formed by the majority of the glasses, including all glass coatings on other fragments and by a few lithic fragments. Most of the latter, the chondrule-like fragments and a number of small glass chips have more varied compositions with less than 24% Al_2O_3. The high alumina cluster corresponds to glass compositions named highland basalt by Ridley et al. (4), while most of the less aluminous group are in the range of the Low K Fra Mauro basalt composition. A small number of more extreme mafic or siliceous compositions includes a granitic glass notable for having 2.5% Na_2O.

Data from terrestrial analogs (5,6) indicate that small glassy masses from craters with heterogeneous target rocks show a spread of compositions along various mixing lines, with a tendency to cluster about the mean composition of the country rocks. Larger bodies of impact melt show a smaller spread due to more complete mixing of larger volumes of country rocks (7), but many still fall on mixing lines between country rocks of diverse compositions. Only in very large (≥100km) impact craters are there likely to be bodies of melt sufficiently large for gravitational differentiation to be important.

The spread of analyses in the Apollo 16 samples is remarkable considering the evidence for many large impacts in the history of the lunar highlands. In keeping with the terrestrial observations, the diversity of glass analyses is greater than that of the crystalline impact melts. The extreme glass compositions, by this analogy, probably approach the compositions of primary crustal rocks, while lithic fragment compositions are closer to local or regional averages. It is likely that the tight cluster around the highland basalt composition is a good average composition for the dominant components of the upper lunar highland crust (4). In this case repeated bombardment has apparently produced a significant homogenization of primary rock types which may be represented by coarser-grained components of some Apollo 16 rocks, anorthosites and less aluminous, more mafic rocks, such as troctolites (8). The wide compositional scatter, particularly in FeO, MgO (Fig. 3) and K_2O, of the less aluminous rocks and glasses indicates that in this range convergence towards a homogeneous composition is much less complete. The data are consistent with the view that there are no large bodies of specific Fra Mauro melt composition, and that each melt in this range represents a mix of local rocks of extreme composition, lying near the low-alumina base of the fan-like array (Figs. 1-3), with material from the dominant anorthosite-troctolite suite.

The highland model thus derived is in substantial agreement with some previous suggestions (9,10); an upper highland crust approximately 20km thick of highland basalt composition, differentiated into an anorthositic upper layer with more mafic rocks below, studded with small pockets of rocks of variable residual compositions, including granites and rocks high in Fe-Ti-K. In this model there is no requirement for magmas of Fra Mauro composition to be generated internally. However the model does require a period in early lunar history when igneous differentiation processes dominated over the homogenizing effect of impact. This may place some restraints on the duration of the postulated intense period of bombardment ~4 AE (11).

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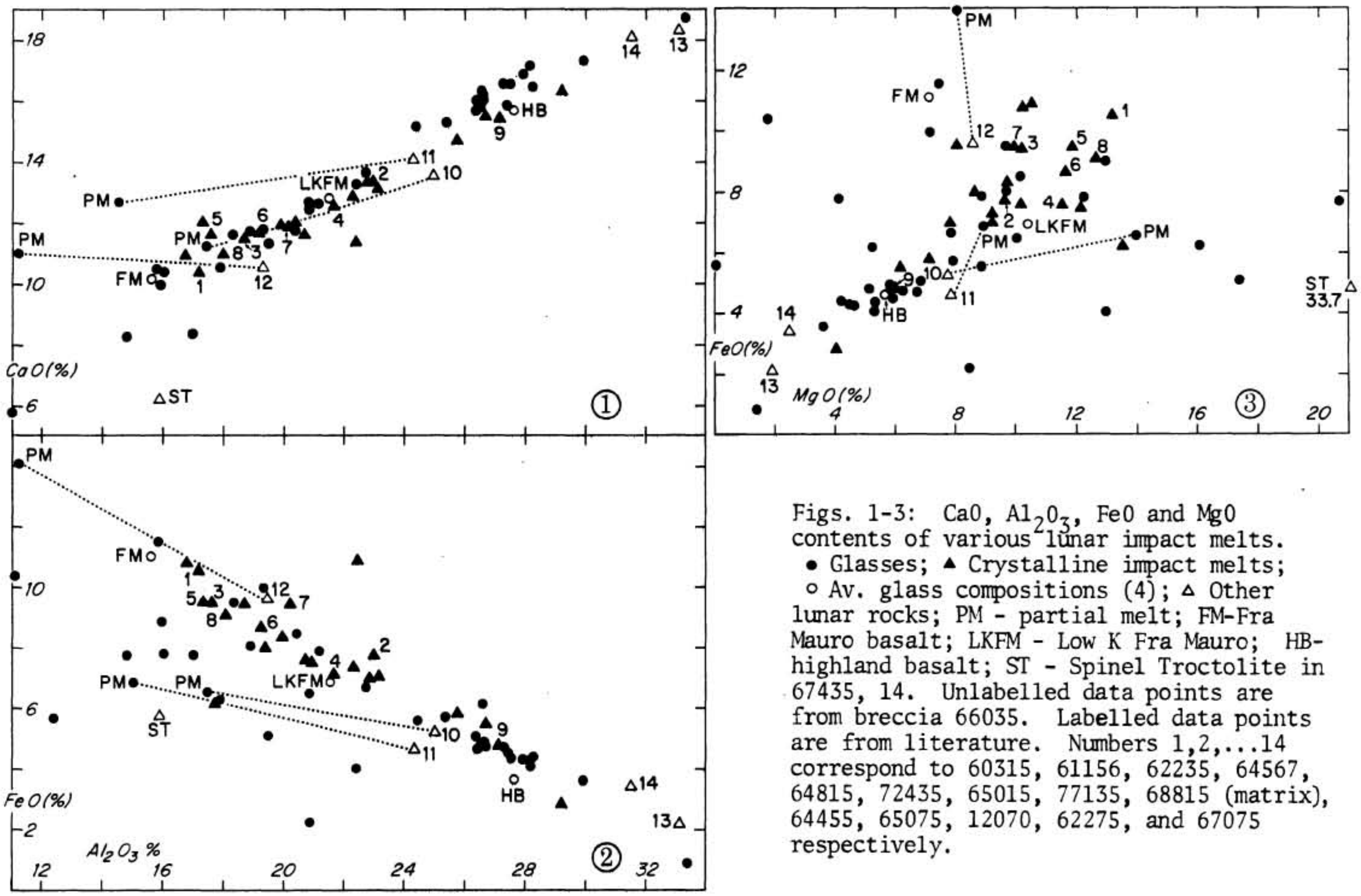

Figs. 1-3: CaO, Al_2O_3, FeO and MgO contents of various lunar impact melts. ● Glasses; ▲ Crystalline impact melts; ○ Av. glass compositions (4); △ Other lunar rocks; PM - partial melt; FM-Fra Mauro basalt; LKFM - Low K Fra Mauro; HB-highland basalt; ST - Spinel Troctolite in 67435, 14. Unlabelled data points are from breccia 66035. Labelled data points are from literature. Numbers 1,2,...14 correspond to 60315, 61156, 62235, 64567, 64815, 72435, 65015, 77135, 68815 (matrix), 64455, 65075, 12070, 62275, and 67075 respectively.