CORRELATION OF THE THERMAL HISTORY OF LUNAR AND SYNTHETIC GLASS BY DTA AND X-RAY TECHNIQUES, by D. R. Ulrich* and J. Weber**, ***

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Differential thermal analyses have been performed on portions of glass specimens returned by the Apollo 16 mission. Specimens were taken from a 0.5 gm sample of glass coated anorthosite rock 64455-21 and from selected particles of 1-2 mm fines from a 0.5 gm sample 68842-4. The glassy crust of 64455-21 was found to be completely amorphous and its chemical composition was determined by electron probe x-ray microanalysis. The "glass" specimens selected from 68842-4 were found to be predominantly crystalline.

Bulk synthetic glass specimens were prepared in accordance with the electron probe data and compositional refinements were made until a close match was obtained between the electron probe x-ray data from the lunar glass and the synthetic glass. The composition of the glass which most closely matched that of the lunar glass from 64455-21 and which behaved in a similar manner to this lunar glass in DTA studies, is as follows: 46 w/o SiO_2; 25 w/o Al_2O_3; 10 w/o CaO; 12 w/o MgO; 6 w/o FeO; 1 w/o Na_2O. The synthetic glass was prepared by melting the raw batch in a platinum crucible in an argon atmosphere. A fluid melt was obtained between 1350 and 1400°C: each melt was held at 1400°C for 1 hour to allow homogenization and was then cooled at various controlled rates.

Melts of the above composition readily devitrified if cooled slowly, i.e. taking more than 30 minutes to cool from 1400°C to room temperature. X-ray diffraction analysis of the devitrification phases gave similar results to those obtained from lunar glass samples after DTA experiments. Crystalline phase compositional analyses are continuing: the predominant phase is of the plagioclase type with the possible substitution of Al by Fe.

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THERMAL HISTORY OF LUNAR AND SYNTHETIC GLASS

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Thermograms obtained by DTA contained well-defined exothermic peaks which are characteristic of glasses that have been rapidly cooled from the molten state. Quenched glass has a high fictive temperature (i.e. the high temperature structure is "frozen-in" which creates a non-equilibrium strain-state in the glass at room temperature)[1]. The structure of rapidly cooled glass can be changed by the heating cycle inherent to thermal analysis if the time/temperature relationship of the cycle is sufficient to anneal the glass and allow structural rearrangement. In the lunar glass sample annealing was observed in the temperature range from 650 to 770°C, when the heating rate was 10°C/minute. A large crystallization exotherm was evident at about 930°C. The lunar glass did not melt below 1200°C.

The DTA data from synthetic glass was compared to the lunar glass sample from 64455-21. The closest match to the annealing exotherm and crystallization behavior was obtained on a specimen that had been cooled from 1400°C to room temperature at a rate of 140°C/minute. The x-ray data from this sample before and after heating were also virtually identical to those obtained on the lunar material.

Cooling of the lunar glass over a period of several minutes appears consistent with observations of interactions at the interface between the glass and the underlying rock.

Comparisons of the data obtained from the lunar and synthetic glass are also being made with data obtained previously from studies of the devitrification of Tektites and other synthetic glasses.

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(1) J. E. Stanworth, "Physical Properties of Glass", Oxford, 1953, pp. 158-169.