CALCULATIONS AND MEASUREMENTS OF SPECIFIC GRAVITIES OF LUNAR MATERIALS by D. A. Cadenhead and J. R. Stetter, Department of Chemistry, State University of New York at Buffalo, Buffalo, New York 14214.

Measurements of specific gravities or absolute (maximum) densities of lunar materials are of considerable importance in themselves, as well as in the evaluation of many other important properties including elasticity, thermal diffusivity, dust motion and soil densities, porosities and compressibilities. Such absolute densities may be calculated, via a normative mineral composition, from chemical analysis data and a knowledge of the densities of the various minerals, as has been done by Mizutani and coworkers [Mizutani et al (1972), Mizutani and Newbigging (1973) and Mizutani and Osako (1974)]. We have calculated an absolute density for sample 14321 using the analysis of Scoon (1972) and mineral densities quoted by Hurlbut (1963). We have also calculated the density for 15015 using an analysis of Eglinton et al (1975). The minerologic composition, given by the European Consortium [Eglinton et al (1975)], was taken from one of several available, and consisted of an analysis of the sawdust collected when the large breccia was divided for allocation to the various consortium members. It was felt that this should provide a representative evaluation of 15015.

Experimental measurements of absolute densities involve the problem of ensuring that the fluid selected must penetrate all voids, bugs and microcracks otherwise erroneously low values will be obtained. This is of little concern with large solid rock fragments, but for exposed soils and small surface rock fragments such errors can be very serious. It is for this reason, that helium makes an excellent density measuring fluid. Both its small size and near zero chemical reactivity permit its penetration into the smallest of microcracks. In addition, it has the considerable advantage of being non-contaminating and virtually non-adsorbing at room temperatures [Kini and Stacy (1963)]. This means that the helium maintains a near constant density up to the solid interface.

On the negative side helium has a low density and the changes brought about by displacement of this fluid are difficult to detect. Our approach has been to utilize an adapted gas-adsorption volumetric system to evaluate this displacement and hence the absolute density. The sample is placed in a specially designed sample chamber and outgassed overnight at a temperature not exceeding 150°C. The pressure of the helium in a well-defined volume of the system which includes the sample chamber is then measured and compared with a similar measurement taken in the absence of the sample. The well-defined volume is kept to an absolute minimum by design of both the adsorption system and the sample chamber. Pressures were measured with a sensitive UHV Baratron system. All density measurements were repeated a minimum of six times. The results for both calculations and experimental determinations are shown below in grams/cc. The maximum and minimum values reported reflect uncertainties in the density values of the various minerals [Hurlbut (1963)].

SPECIFIC GRAVITIES

Cadenhead, D. A.

Sample	Calculated Absolute Density Maximum	-	Minimum	Experimental Absolute Density
14321,156	3.21	-	3.01	3.2 ± 0.1
14321,74	3.21	-	3.01	3.2 ± 0.1
15015,29	3.15	-	3.06	3.0 ± 0.1

There would appear to be good agreement between calculated and experimental values obtained by us as well as with a calculated value for 14321 [Mizutani (1973)] of 3.09 grams/cc. The errors shown for the experimental values are maximum values, mean errors are one third to one half of these values and place the two 14321 samples at the upper end of the calculated range, with that for 15015,29 at the extreme lower end. It is of interest to note that 15015,29 was a surface fragment of 15015 created by partial melting of the matrix, an origin consistant with a lower density.

The results clearly indicate that the relatively simple and rapid procedure of helium pycnometry produces accurate absolute density measurements without the need for a chemical analysis. More important, is the point, that the experimental value is that for the particular fragment under study. It would seem possible to obtain indications of density variations within an individual rock or from one soil sample to another. We believe that helium pycrometry provides a superior method for obtaining absolute densities.

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