POROSITY, OR ITS ABSENCE, IN LUNAR AND TERRESTRIAL SAMPLES, D. A. Cadenhead and M. G. Brown, Department of Chemistry, State University of New York at Buffalo, Buffalo, N. Y. 14214.

In a recent article in SCIENCE (1) by J. A. O'Keefe, it is postulated that the absence of high porosity or pumice-like material in the lunar samples is a result of an absence of water vapor (2) and/or volatiles (3) and that this prevents foam formation in molten rocks. The concept clearly has merit but in the light of facts, which we cite below, does not provide a satisfactory explanation and, at the very least, requires some modification.

While lunar samples are essentially dehydrated, they should not be considered devoid of water vapor. Thus, outgassing of lunar materials inevitably results in the release of water vapor over a wide temperature range (4). First, physisorbed, then chemisorbed water is released. This is followed by water vapor created by surface dehydroxylation (5). Undoubtedly, much of the physisorbed and some of the chemisorbed water represents terrestrial contamination (6), however, much of this water is real, presumably being created by solar wind interaction with the lunar soil surface (7). Clearly, lunar samples are not totally devoid of water vapor.

With volatiles, it is once again widely accepted that lunar materials have low or negligible volatile content. Recent evidence, however, especially with samples exposed less than 100 m.y., indicates that significant amounts (>1%) exist on the surfaces of both volcanic (8,9) and non-volcanic (10) samples. Of particular interest, are the findings of significant surface concentrations of volatiles on microspherules of the Apollo 17 Taurus-Littrow orange soil (8,9) and the Apollo 15 green glass soil (9). In the original hypothesis (1), it was assumed that an absence of such surface-located volatiles was the cause of the formation of microspherules. Clearly, this part of the argument requires significant modification.

It must be agreed that high porosity in lunar samples is a relatively rare phenomenon, though such porosity may be created by exposure to polar vapors, particularly water vapor. It should not, however, be accepted that lunar samples are incapable of possessing such porosity. The best documented instance of this was that of 15015,29 which exhibited high porosity in the immediate surface region (11). Somewhat perversely, 15015 would appear to be an impact breccia rather than a volcanic cinder (5,12). Other examples of relatively high porosity presumably also exist, a likely candidate being 75081 (13). We are currently carrying out further studies of 75081. In addition, many other samples show macroporosity to a small extent (11).

If lunar samples do contain trace water vapor and volatiles, and are capable of forming high porosity structure, why then are lunar volcanic cinders so conspicuously absent? One possible contributing factor could be the relatively low viscosity of lunar basalts (14). However, similar terrestrial low viscosity materials can be made to form porous structures. A better
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Explanation suggests itself when the mechanism of formation of cinders is considered in more detail.

Cinder-like porosity is created by gas evolution during the solidification of molten rock (11). Under very high gas pressure, or extremely rapid outgassing conditions, the molten material is ejected as a fire-fountain. Typical terrestrial fly ashes are created in this way. Interestingly enough there are a number of physical and chemical similarities between lunar microspherules and terrestrial fly ash (15). Presumably the very hard vacuum (~10^-13 torr) existing at the lunar surface produces rapid outgassing. Where large amounts of gas are produced, a fire-fountain occurs. Where small amounts of gas evolve, degassing occurs too rapidly to permit the formation of porosity as the rock achieves a semi-plastic state. In other words, cinder-like porosity depends on a moderate gas evolution over a prolonged period of time. The hard lunar vacuum and a reduced rate of cooling are probably the most significant factors preventing the formation of highly porous material.

As already indicated, we are currently studying 75081. It is being compared with 15015, 29 and 74220 in terms of outgassing and porosity characteristics. A comparison is also being made with a Hawaiian volcanic soil (16). We hope to further establish the factors which most affect the physical characteristics of lunar and terrestrial volcanic samples.

REFERENCES

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