Volcanic Ash: Terrestrial versus Extraterrestrial

Abstract. *A principal difference between terrestrial and extraterrestrial lavas may consist in the greater ability of terrestrial lavas to form thin films (like those of soap bubbles) and hence foams. It would follow that, in place of the pumice and spiny shards found in terrestrial volcanic ash, an extraterrestrial ash should contain minute spherules. This hypothesis may help to explain lunar microspherules.*

Many terrestrial volcanic deposits contain either pumice (a solidified rock foam) or volcanic shards, which are fragments of pumiceous rock. On the other hand, pumices and the spiny shards derived from them are rare in returned lunar samples. A part of the cause is no doubt connected with the fact that felsic lavas foam more easily than mafic lavas; but this is not the whole story, because there are terrestrial basaltic cinders although the known examples of lunar felsic rocks are not pumiceous or shardy.

To understand why this may be so, let us consider how bubbles are formed. The bubbles that are important here are not merely gas inclusions in a liquid (single-walled bubbles) but are double-walled, like soap bubbles; they consist of a thin film of liquid between two gases.

Double-walled bubbles cannot be formed in pure substances, such as water, because the film at the top of the bubble is being pulled downward under gravity. Surface tension acts equally in all directions and hence does not have any net effect; thus the bubble thins at the top and eventually ruptures.

Bubbles can, however, be made in impure materials such as soapy water. In this case, the primary effect of the soap is to reduce surface tension, which we here think of as surface energy, expressed in joules per square meter. It is then clear that the soap will tend to move into the surface layer, because this process reduces the surface energy. The resulting layer of soap at the surface of the water film has the effect of stabilizing it mechanically, because, when the film is stretched thin, the surface layer is diluted and the surface tension therefore increases. This increase in surface tension pulls the film in the direction of the thin places and resists further thinning. This reasoning explains why bubbles can be blown in soapy water but not in pure water.

Clearly, something of the same kind must happen in terrestrial lavas to permit bubble formation. McBirney and Murase (*1*), quoting measurements by Parikh (*2*), postulated that in terrestrial lavas it is water that reduces the surface tension and so permits foaming. Bikerman (*3*) has noted that low surface tension and volatility are closely correlated both in theory and in fact.

The question then arises whether the very dry and volatile-poor lunar lavas are capable of forming double-walled bubbles. One way to find out is to search for cases where two single-walled bubbles have come into contact. If the single-walled bubbles coalesce, this result suggests that the material cannot support a thin film; but if a thin film—a septum—is observed to survive, separating the bubbles, then the material can evidently support double-walled bubbles. Bell, who has observed bubbles in lunar glasses (*4*), has informed me that he has not thus far observed septa of this kind.

It might be thought that viscosity would promote foaming, and in fact it may do so under special circumstances (*3*, p. 98). But, in general, bubble-wall textures are observed in terrestrial ash of all types, including basalts (of low viscosity) as well as rocks of intermediate and high silica content (and high viscosity) (*5*).

A violent uprush of gas through a liquid that cannot form a foam might very well produce a shower of small liquid droplets, which might cool to glass spherules instead of the pumices, shards, and cinders of terrestrial volcanic eruptions. Perhaps this hypothesis explains why typical volcanic materials are so rarely observed in the lunar samples or in meteorites. Their place may be taken by the microspherules that are observed on the moon. This argument may help us to understand why spherules are so rarely seen in terrestrial volcanic deposits.

I therefore predict that experimental measures will show a marked difference between lunar and terrestrial lavas in the ability to produce foams. When the experiment is done, attention should be paid to Parikh's finding (*2*) that the surface tension of a dry silicate melt is affected by even small quantities of water in the gas with which it is in contact.

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References and Notes

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Muscle Crossbridges: Absence of Direct Effect of Calcium on Movement Away from the Thick Filaments

Abstract. *Fluorescence depolarization experiments show that the rotary mobility of myosin heads is hindered by the assembly of the thick filament. Calcium, with or without magnesium adenosine triphosphate, does not alter this hindrance in synthetic filaments. This implies that calcium does not directly move the crossbridges toward thin filaments on activation of muscle.*

It is generally agreed that muscle contraction is caused by the action of ATP (*1*) fueled impellers (crossbridges) operating between two kinds of interdigitating filaments. On neural stimulation, calcium ions are released from the sarcoplasmic reticulum and interact with the contractile apparatus. Some time ago, Ebashi and Endo (*2*) established that a Ca-activated protein "switch" resides on "thin" (actin-containing) filaments of vertebrate muscles. Several workers have since suggested a parallel Ca^{2+}-driven mechanism on the "thick" (myosin-containing) filaments.

The reasons for this current speculation are diverse. Early ideas of crossbridge size and shape (*3*) would require the globular heads of myosin (subfragment 1 or S-1 moieties) to travel radially for some distance in order to contact actin. The mass shift away from the thick filament axis—inferred from changes in the vertebrate muscle x-ray diffraction pattern on activation—seems to occur even when filament overlap is ostensibly zero (*4*). This effect could arise from an actin-independent mechanism on thick filaments. Indeed, isolated molecules from certain invertebrates do seem to have a myosin-based regulatory system (*5*). But this system has not been found in vertebrate skeletal myosins, nor is it clear that such a system could be re-