YIELD STRENGTHS OF FLOWS ON THE EARTH, MOON, AND MARS. H. J. Moore, U.S. Geological Survey, Menlo Park, Ca. 94025, D.W.G. Arthur and G. G. Schaber, U.S. Geological Survey, Flagstaff, Az. 86001

Yield strengths of lava flows can be calculated from remote measurements of their thickness, width, levees, and gradient. The flows are considered to be Bingham Plastics (1,2). Yield strengths of flows on the Earth, Moon, and Mars vary and may reflect differences in volatile content, fraction of entrained solids due partly to cooling (1), silica content (2), or some combination of these factors. Despite these variables, it may be possible to distinguish flows with low silica contents from those with high silica contents by remote measurements of flows at some distance from their vents, where they should be depleted in volatiles. Geologic interpretations of the process producing the flows are also required.

Direct measurements of molten, volatile-rich basaltic lava in the Makaopuhi lava lake, Hawaii, indicate a yield strength near $10^2 N/m^2$ (3). Remote measurements of flows on Mauna Loa, 600 m from the rim of Mokuaweoweo lava lake, indicate a yield strength near $4x10^3 N/m^2$, whereas several kilometers from the rim the yield strengths are near $2x10^4 N/m^2$. The differences cannot be interpreted in terms of silica content alone because the silica contents of Mokuaweoweo lava are quite uniform (≈51%). Similar results are found for Mt. Etna (2,4). The differences in yield strength appear to be the result of changes in volatile content, which should decrease rapidly with distance from the source, and the fraction of entrained solids, which should increase with cooling and distance from the source (3,1).

Two types of lunar flows have been examined: lava (1,2,5) and impact melt (1,6). The Imbrium lava flows have yield strengths (near $2x10^2 N/m^2$) compatible with a low silica content. It seems probable that the volatile content was low at the time the flows stopped, some 190 km from their vent, and that flows have low silica contents, like other mare basalts (38%-45%). Flows of impact melts have markedly variable yield strengths (10^3-$5x10^4 N/m^2$), and they average near $2x10^4 N/m^2$. Comparison of the average yield strength of flows of impact melt with the Hawaiian flows several kilometers from their vent implies a silica content near 51%, but compositions of samples from both the uplands and maria of the Moon are typically much lower than 51% SiO_2. The varied and generally high yield strengths of melts could result from a varied content of solids such as shocked rock and breccia. Low yield strengths may indicate largely melt, and high yield strengths may indicate relatively large amounts of entrained solids. Thus, volcanic flows must be distinguished from flows of impact melt as well as other types of flows.

Yield strengths of the Martian volcanic flows of Arsia Mons (≈$10^3 N/m^2$,7) and Olympus Mons (≈$3x10^4 N/m^2$,8) are comparable to those of the flows on the flanks of Mokuaweoweo. Volatile contents of the Martian flows were probably low because the flows were measured at considerable distances from their vents. Thus, the Martian flows probably have low silica contents (<51%). Silica contents for the flows of Arsia Mons are probably ≈45%, as inferred by comparison with yield strengths of terrestrial flows at large distances from their vents (see 2,5). Such a low silica content is compatible with Viking results (9). The flows of Olympus Mons are more silicic than those of Arsia Mons. If the volatile contents and entrained solids were the same, the differences between the yield strengths of the Arsia Mons and Olympus Mons flows may be the result of differentiation.

Although much needs to be learned about lava and calculated yield strengths, the technique holds promise as a means of obtaining rough estimates of silica contents of volcanic flows by remote measurements.

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