VOLCANISM ON MERCURY: (SOME) OPEN QUESTIONS AFTER MESSENGER. Paul K. Byrne[1], Christian Klimczak[2], Jennifer L. Whitten[3], Lauren M. Jozwiak[4], Brett W. Denevi[4], Kathleen E. Vander Kaaden[5], Francis M. McCubbin[6], Lillian R. Ostrach[7], David A. Rothery[8], and Jack Wright[8], [1]Planetary Research Group, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27695, USA (paul.byrne@ncsu.edu), [2]Department of Geology, University of Georgia, Athens, GA 30602, USA, [3]National Air and Space Museum, Smithsonian Institution, Washington, DC 20560, USA, [4]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA, [5]Jacobs, NASA Johnson Space Center, Houston, TX 77058, USA, [6]ARES NASA Johnson Space Center, Houston, TX 77058, USA, [7]U.S. Geological Survey, Flagstaff, AZ 86001, USA, [8]School of Physical Sciences, The Open University, Milton Keynes, MK7 6AA, UK.

Introduction: The MESSENGER mission enabled a remarkable advancement in our understanding of Mercury's volcanic character and history, but the legacy of that mission has also been to challenge us with yet more questions of the innermost planet.

The View After MESSENGER: Recognition that Mercury's two primary surface units, the smooth plains and the intercrater plains, share a similar mode of emplacement [1,2] is strong evidence for voluminous flood-mode volcanism early in the planet's history. Hints of serial effusive eruptions preserved in some smooth plains deposits [3] suggest similar processes for the formerly smooth intercrater plains [2], although geological boundaries along which these older plains can be divided are only starting to be recognized [4]. The identification of such discrete portions would better constrain estimates of effusive volcanic fluxes early in Mercury's history. Similarly, establishing how to distinguish between fluidized ejecta deposits and flood basalts would assist in determining the relative contribution of each of these materials to the early, widespread resurfacing of the planet [2,5,6]. The surprising discovery of explosive volcanism on Mercury [7] also required a reassessment of the planet's volatile inventory [8]. The volatile species that drove these eruptions remain uncertain, as does the timing and duration of pyroclastic activity.

A major outstanding issue relates to the composition of Mercury's rocks, most of which are volcanic. Geochemical measurements from the MESSENGER XRS and GRS indicate that the dominant rock types on the planet are alkali-rich komatiites and boninites [9]. Yet the spatial resolution of these measurements varies considerably across Mercury, and so there may be local differences in surface composition that cannot be resolved with available data, especially in the southern hemisphere. And, at present, there is no independent means by which we can verify these compositions at the outcrop scale or their petrological or mineralogical interpretations: there are no robust candidates for samples from Mercury in any of the world's meteorite collections. As a result, the precise compositions (and compositional variability) of the rocks on the surface of the planet remain to be fully characterized.

Equally unclear is the character of Mercury's very earliest volcanic activity: What were conditions like at the onset of major plains volcanism? Was there a substantial if transient atmosphere from early volcanic outgassing? And is there a record in the planet's crustal stratigraphy of a change in composition from deep to shallow levels that reflects progressively lower degrees of partial melting as interior cooling took hold? Tackling these questions would further enhance our understanding of the thermal evolution of Mercury, and of terrestrial planets in general.

The interplay between the planet's volcanic and tectonic evolution requires more study. For example, the initial state of global contraction is characterized by extension at the surface [10] and so, as Mercury's early lithosphere cooled initially at a rate faster than the interior, it must have experienced tensile stresses in a manner similar to the thermal contraction of ponded lavas [e.g., 11]. Incipient extension has not been substantially investigated for Mercury, and any such deformation probably preceded the emplacement of even the oldest surface now preserved on the planet [6]. Yet an early phase of rifting, in which those rifts facilitated the rapid and widespread eruption of material onto the surface, is consistent with the growing body of evidence that Mercury's early history featured widespread effusive volcanism.

Outlook: Our understanding of Mercury's volcanic character has never been more comprehensive, but there is much left to learn. The MESSENGER mission has given us compelling reasons to continue to investigate Mercury, and it is worth going back [12].

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