PRODUCTION FUNCTION OF OUTGASSED VOLATILES ON MERCURY: IMPLICATIONS FOR POLAR VOLATILES ON MERCURY AND THE MOON.

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Introduction: Critical to the understanding of current polar volatiles on the Moon and Mercury are: (1) volatile sources [internal, delivered (impacts of comets, asteroids, and micrometeorite debris), and environmental (e.g., solar wind)], (2) variations in the delivered volatiles for each source as a function of time (the production functions), (3) the delivery pathway from sources to sinks (primarily polar cold traps), (4) sequestration, storage, and retention processes, and (5) variations in cold-trap stability through time.

Water ice has been observed at the poles of both Mercury and the Moon; however, ice deposits on Mercury appear to be more extensive and pure than those on the Moon. We are interested in the overall flux of volatiles delivered to the polar regions of these two airless bodies (the *production functions*). It is possible that a difference in relative sources of the volatiles may contribute to the differences between the polar deposits observed today. In this contribution, we focus on the possible sources for volatile delivery to Mercury and the Moon including (1) comets/asteroids, (2) micrometeorites, (3) solar wind implantation, and (4) volcanic outgassing, which we focus on initially.

On the Moon, the contribution of volatiles from pyroclastic [1] and mare eruptions are currently being assessed. The contribution of volatiles from volcanism on Mercury has not been carefully estimated; thus, questions remain about how the production function of volatiles has evolved through the planet's history.

Methodology: Following the approaches of [2–4], first the production of volcanic basalt released through the major volcanic smooth plains from Mercury is determined as a function of time. Next, the release of volatiles derived from the volcanic plains as a function of time is estimated. The total mass of erupted lava is calculated by multiplying the estimated volume of volcanic deposits [e.g., 5] by the bulk density of typical smooth plains on Mercury (~3014 kg/m3) [6]. This mass is multiplied by estimates of volatile species [e.g., 7–8], to estimate mass ranges of potential volatiles for mercurian plains.

We then compare the estimated production functions of volatiles released over the histories of Mercury (from this analysis) and the Moon (from [2]). Finally, geologic maps are constructed of the polar regions of Mercury and the Moon through time to estimate the mean and peak fluxes of volatiles to cold traps. Specifically, maps of polar topography are used to reconstruct each era of mercurian and lunar history on the basis of crater ages [e.g., 9–10]. For each era, estimates of volatiles are added to existing cold traps, as delivered from (1) impactors [e.g., 11], (2) solar wind implantation [e.g., 12], and (3) volcanic eruptions (as estimated for Mercury in this analysis and for the Moon in [2]). These estimates do not account for losses; therefore, these maps provide maximum estimates.

Results: While volcanic activity may have occurred as recently as ~1 Ga on Mercury [13–14], the majority of effusive volcanic activity occurred early in the planet's history [3]. Overall, the volume of flood basalts produced peaked ~3.5 Ga and diminished through time. The duration of effusive volcanic activity on Mercury and the Moon is similar [3, 15].

Implications: The delivery of volatiles to both Mercury and the Moon peaked >3 Ga. While ice on the Moon appears to be relatively ancient on the basis of its degraded nature, the ice on Mercury appears to be relatively fresh, given (1) distinct albedo surfaces, [16], (2) sharp albedo boundaries [16], and spatial coherence within PSRs. Given that Mercury is subjected to the same space weathering and impact processes as the Moon, and possibly even higher regolith overturn rates [17], we expect any relatively old ice on Mercury to exhibit similar heterogenic traits as observed for the lunar ice. Thus, given the chronology of volatile fluxes derived here, we ask what the ultimate fate of these early-delivered volatiles is. It is possible that older volatiles are trapped in Mercury's subsurface, below the sensing depths of radar observations and neutron detections. In summary, the Moon provides a framework from which to investigate Mercury for traces of ancient volatiles.

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