DELIVERY AND REDISTRIBUTION OF VOLATILES ON MARS DURING THE BASIN-FORMING EPOCH: AN OVERVIEW. D. A. Kring[1], [1]USRA Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058 (kring@lpi.usra.edu).

Introduction: Samples collected during the Apollo era suggest impact bombardment of the lunar surface was particularly intense early in solar system history [1,2]. There are hints that the lunar cataclysm was actually an event that resurfaced planets throughout the inner solar system [3,4]: meteoritic fragments from the asteroid belt indicate objects between 2 and 5 AU were shock-metamorphosed between ~3.5 and 4.0 Ga; furthermore, our first sample from the ancient cratered highlands of Mars (meteorite ALH84001) was shock-metamorphosed 3.92 Ga [5]. Thus, the process first detected on the Moon may have greatly affected all inner solar system planets, including Mars.

Basin-forming Epoch on Early Mars: If the same bombardment that affected the Moon also affected Mars, then at least 6,000 impact craters with diameters in excess of 20 km were likely produced [4]. Many of these were basin-forming impact events and, although there is still discussion about the ages of the largest basins (Utopia, Chryse, Hellas, Argyre, Isidis), there is a possibility that all of them were produced in a short (<200 Ma) interval of time. The resurfacing of Mars may have been so severe that Noachian features may have been produced in a rather short period of time associated with the bombardment, rather than an extended period of time that stretched back to ~4.5 Ga.

Source of Impacting Objects: Rare geochemical fingerprints of impactors in the Apollo impact melts suggest the impacting objects were dominantly asteroids, rather than comets or Kuiper Belt objects [4]. In addition, the size distribution of impact craters on the Moon and Mars seems to require impactors with a size distribution similar to that seen in the asteroid belt [6]. The latter suggests that less than 15% of the impactors were comets, consistent with the current flux. The noble gas composition of Mars atmosphere also hints that the contribution from comets was small [7].

Implications for Mars: Calculations of the delivery of biogenic elements to Earth during a period of late heavy bombardment [4,8] serve as an initial proxy for conditions on Mars. These results indicate that substantial biogenic material, including water, was delivered to planetary surfaces. However, they also indicate that the bulk of these materials must have already been present because the flux, although substantial, cannot provide the inventory currently observed. Thus, most biogenic elements, including water, were likely part of the original complement of accreted material. A late heavy bombardment may have augmented abundances of biogenic elements in planetary surfaces and redistributed them, but it was not the primary source of those materials.

Redistribution of Water: Large impact events in water-bearing planetary crusts, like that on Mars, will generate vast subsurface hydrothermal systems [e.g., 9-12]. These systems may span the entire diameter of a crater and extend to depths of several kilometers. They can also be very long-lived on Mars [13,14] and, thus, may have chemically and mineralogically altered Mars' crust [15-17]. This may be a major source of the phyllosilicates and other alteration phases identified in Noachian terrains. Even if the water is frozen in Mars' crust prior to an impact, it can be liquefied and vented to the surface. Vented material might be added directly to the atmosphere and/or form a crater lake as part of a more complex hydrological cycle.

These same impact events will vaporize hydrous material during the compressional phase of the impact and eject it into the atmosphere during the excavation phase. Vapor-rich plumes may have altered short-term weather and potentially long-term climate on Mars. Substantial precipitation may have followed [18]. Both this process and that associated with impact-generated hydrothermal activity may be the source of, or a contributor to, aqueous surface flow that carved the Noachian surface of Mars.

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