IMPACT SPHERULES AS A GLOBAL SOURCE OF SAND ON MARS

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Introduction: Erosion by sand has shaped the martian surface, and dune fields are abundant on Mars today. However, the origin of martian sand is still not well understood. Here we constrain the origin and alteration history of sands on Mars by investigating the global composition of martian dunes. In particular, we seek to better understand the distribution of glass from impacts and explosive volcanism, which we hypothesize may be important components of global dunes based on local spectral studies [1-3] and in situ investigation by MSL [4].

Approach: We use a combination of orbital visible/near-infrared (VNIR) and thermal infrared (TIR) spectra, and apply techniques optimized to detect amorphous materials: (1) analysis of the position and shape of VNIR iron bands to detect glass, and (2) a new TIR spectral library with additional glass and secondary amorphous endmembers [5]. CRISM spectra were extracted from 41 dune fields between 70N-70S and compared to OMEGA spectra from the north polar sand sea. TES spectra from 90 dune fields between 75N-75S produced high-quality fits when deconvolved using our spectral library.

Results: We find that the vast north polar sand sea and 22% of smaller dune fields exhibit VNIR spectra consistent with high abundances of glass, and an additional 25% of dune fields may contain a significant glass component. In TES spectral models, 15% of small dune fields contain significant glass (10-50% of primary minerals) and another 15% of small dune fields have alteration components that are dominated by secondary amorphous silicates. Amorphous materials are found at all latitudes in both data sets, but high abundances of glass, secondary amorphous materials, and crystalline alteration products are more common at high latitudes. The larger number of glassy dune fields detected via VNIR spectra compared to TIR models is likely due to masking of glass in TIR models by secondary silicates, either due to their spectral similarity or the presence of a physical coating [1,6].

Discussion: Processes that produce deposits with high glass abundances (>50%) are relatively rare, where the most common glass-rich deposits on Earth are phreatomagmatic tephra from ice- or water-magma interactions [7,8]. Impacts may also provide a source of glass-rich sand. While proximal impact ejecta is expected to be a mix of melt and country rock, distal impact spherules (e.g., microtektites) are mostly composed of glass [9].

High glass abundances at high latitudes could be enhanced by ice-magma interactions [10,11], and moderate glass abundances at equatorial latitudes could be produced from a variety of sources (tephra, glassy lava flows, proximal impact ejecta, etc.). However, in the northern plains, where glassy sediments are the most widespread, volcanic edifices have not been identified. While a contribution from ice-magma interactions from external or buried sources is possible, impact spherules represent another possible source [12]. Indeed, simple impact accumulation models suggest that impact spherules could produce a global equivalent layer on the order of 50 cm thick over the Amazonian, with hundreds of spherules per sq. cm over the past 5 million years alone.

Thus, in the northern plains and north polar sand sea, we hypothesize that the primary source of glass sand is distal impact spherules. In situ observations by the Phoenix lander in the northern plains show a significant population of rounded, lustrous, smooth, and dark sand grains [13] that are more consistent with impact spherules than more commonly vesicular hydrovolcanic tephra [14]. These grains are much more abundant than similar grains at equatorial landing sites [15]. In addition, the VNIR spectral properties of the northern plains show weak 2 μm iron bands relative to stronger 1 μm iron bands, which is consistent with reduced Fe-bearing glass expected for spherules produced from condensation melts. These results suggest that impact spherules have likely been a source of sand across Mars, and may be concentrated in areas without other significant sand sources, like the northern plains.

Future sample return may help test this hypothesis. Mars 2020 will soon acquire a sample of surface sand from the equatorial site in Jezero crater for eventual return to Earth via Mars Sample Return. Based on the identification of candidate impact spherules in sandy regolith at other landing sites, it is likely that the Mars 2020 regolith sample will include impact spherules and other impact materials for detailed laboratory study.

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