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Discrimination of Aqueous and Aeolian Paleoenvironments by Atomic Force Microscopy— A Database for the Characterization of Martian Sediments

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In the search for aqueous habitats on Mars direct proof of (ancient) flowing water is still lacking, although remote sensing has provided indications of young fluvial systems. To demonstrate that such proof can be given, we examined surface marks on recent terrestrial sand grains by atomic force microscopy (AFM) and applied a quantitative three-dimensional analysis that can numerically distinguish between aeolian and aquatic transport mechanisms in sedimentary deposits on Earth. The surfaces of natural quartz grains as well as olivine, feldspar pyroxene, and monazite sands of known origin were imaged, each image yielding a three-dimensional map of the mineral surface. A fully automated analysis of distribution patterns of the structural elements that constitute the grain surfaces shows that wind-transported quartz grains have short linear elements irregularly distributed on the surface. Linear elements on water-transported grains, however, are longer with orientations that reflect the mineral symmetry. Because the surface patterns found on aqueous grains are due to preferential etching, they can be used as diagnostic fingerprints for the existence of past or present aqueous transport systems. We used a cluster analysis of the crosscorrelation distance of distribution patterns in the structures of aeolian and aquatic sand grains to build a phenogram that provides a map for the relationship of the various sediments found on earth. The analysis shows that the method is highly significant and that water and wind transport can clearly be differentiated. In particular, feldspar and olivine sands contributed even more to the discrimination than quartz grains, which indicated that the method is promising for its application on future missions to Mars. Assuming that martian aqueous sand grains exhibit similar erosional patterns to mineral grains on Earth, simple AFM experiments on a Mars lander would be capable of proving the activity of flowing water in modern runoff systems and of analyzing the paleoenvironments of Mars.