EOLIAN EROSION EXPERIMENTS ON SOFT SEDIMENTARY ROCKS – MEASUREMENTS OF EROSION RATES, TEXTURAL OBSERVATIONS, AND IMPLICATIONS FOR MARS ROVER GEOLOGY

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Introduction: Sedimentary rocks of varying lithologies are exposed at the surface of Mars, and subject to wind abrasion and erosion during high-energy storms [1]. Since water has been largely absent from the Martian surface for quite some time, it is likely that many erosional features seen today are the result of eolian abrasion occurring over hundreds of millions of years. On Earth erosion of evaporites and mudstones is typically accomplished by aqueous erosion, even in areas that receive very little rainfall. As a consequence it is very difficult to observe eolian erosion features associated with evaporites and mudstones in modern terrestrial deserts. To better understand eolian abrasion features of soft sedimentary rocks (shales, evaporites), a wind-chamber was constructed to simulate this process. Previous experiments utilized a series of abrasives (hematite, basalt, and quartz sand mixtures) applied to various lithologies to constrain erosional patterns within a closed environment. In these experiments clay-rich mudstones had the highest rates of erosion (up to 1 gram/day). However, adhesion crusts, typical on the windward rock face, acted as a shield against further abrasion for other lithologies [2]. In new experiments, continuous removal of loose dust was implemented to prevent formation of adhesion crusts. This resulted in more consistent abrasion rates, and erosional patterns that correlate with lithology and orientation.

Methodology: A circular wind-abrasion chamber with a rotating propeller was used to simulate a constant wind speed of ~30 km/h. A vacuum cleaner was attached to the chamber and set on a timer circuit to remove suspended fine particles. Fine to medium quartz sand was used as an abrasive. Eleven samples, clay-rich mudstones, silt-rich mudstones, muddy siltstone, dolomite, and anhydrite were cut, smoothed, and anchored to base of the chamber. Samples were photographed, measured, and weighed before and after each run. The experiment lasted for 114 days. After the first 30 days, the chamber was opened to photograph, measure, and weigh the samples, which were then placed back into the chamber and run for another 84 days.

Observations: All samples showed significant removal of original material, with erosional rates correlating to composition and orientation. In mudstone samples, abrasion strongly accentuated fine-lamina details (etching), caused pedestal formation, and polishing. In places, accumulation of quartz sand was observed to form dune-like structures that partially covered samples and reduced erosion.

Evaporite samples displayed the highest rates of erosion (up to 1.6 grams/day; 0.75%/day), reflecting lower hardness of the anhydrite. Clay-rich mudstones also showed high levels of abrasion (1.0 gram/day; 0.52%/day), whereas black shales were more resilient (0.2-0.8 grams/day; 0.18%/day). This is most likely due to strong cementation and high organic content of the black mudstones. Clay-rich mudstones have higher erosion rates than mudstone samples with high silt content. The muddy siltstone fell into the middle of the mudstone range (0.4 grams/day, 0.12%/day), reflecting weak bonding of quartz silt grains by phyllosilicates. The dolomite sample was more resistant than the shales (0.6 grams/day; 0.19%/day), probably due to tightly interlocking dolomite crystals.

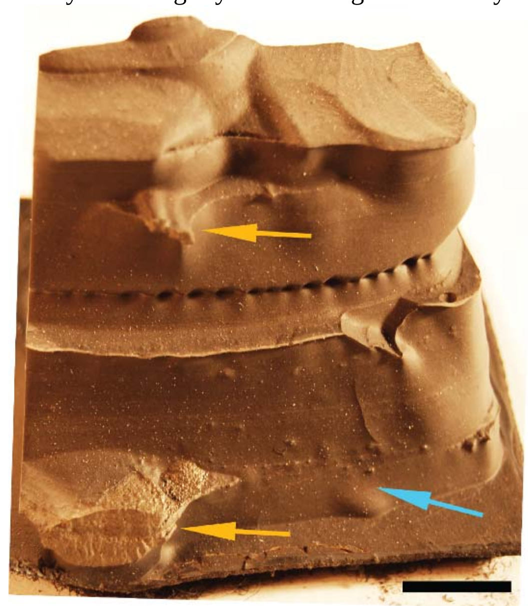

Figure 1: Erosional features observed after experiment with clay-rich black mudstones Abrasion of shale sample. Features include accentuated fine-lamina details/etching, pedestal formation (orange arrows), and polishing (blue arrows). Scale bar 1 cm long.

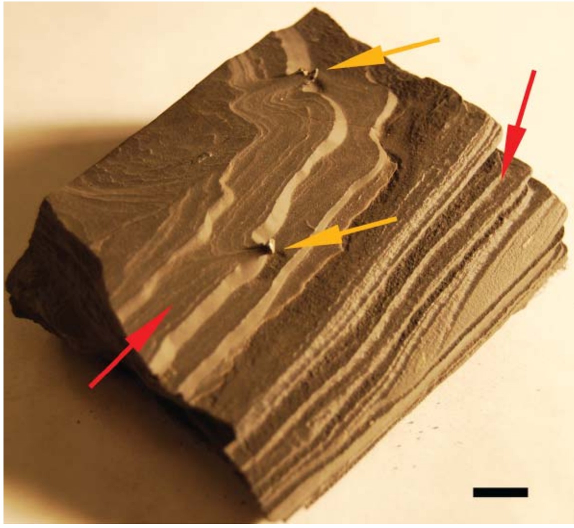

Figure 2: Erosional features observed after experiment with silt-rich black mudstones. Features include accentuated fine-lamina details/etching (red arrows), and pedestal formation (orange arrows). Scale bar 1 cm long.

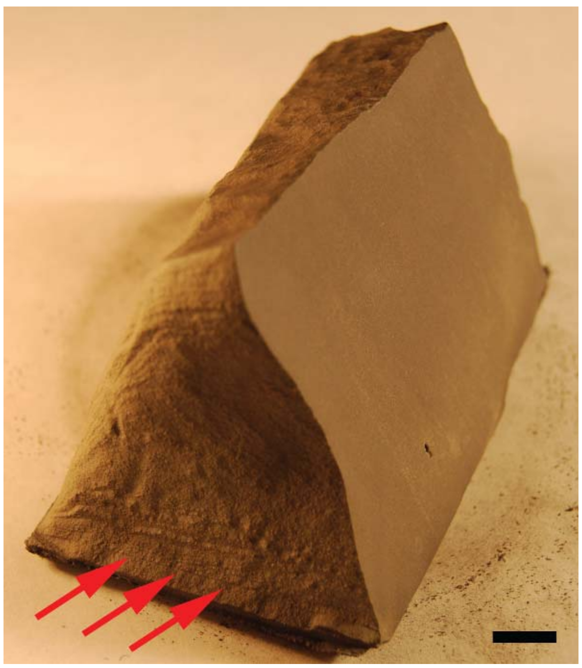

Figure 3: Erosional features observed after experiment with muddy siltstone. Red arrows point to accentuated fine-lamina that are etched out in fine detail. Scale bar 1 cm long.

Conclusions: The highest rates of erosion were observed in the initial 30 day period, owing in part to higher topographic relief. During this period, the slope of sample faces gave higher relief, allowing accelerated erosion (as high as 4.1 grams/day for evaporites). At this time, all of the samples had undergone denudation by way of superficial peneplaination. The results of the subsequent 84 days show significantly slower rates of erosion, as would be expected from the (more) streamlined up-wind surfaces with lower relief (only up to 0.7 grams/day). Erosional trends appear to follow composition of sample and orientation, with softer evaporates eroding at the highest rates, and well cemented silt-rich mudstones exhibiting the slowest rates of erosion. Given geological time spans and the measured rates of erosion, eolian erosion is likely to sculpt out landforms of significant on the Martian surface.

References: [1] Results from the Microscopic Imagers on the Mars Exploration Rovers, Herkenhoff K. E. and The Athena Science Team (2005) AGU fall meeting, P11E-02. [2] Howald, T. V. and Schieber, J. (2009) *LPSC 40*, Abstract #2052. [O'Donnel, K., Howald, T. V. and Schieber, J. (2010*) LPSC 41*, Abstract #1113.