TERRESTRIAL ANALOGS TO THE MPF LANDING SITE: INVESTIGATION OF MORPHOLOGIES OF SANDER IN NORTHERN ICELAND

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Introduction: High-energetic fluids were the most likely candidate to form the morphology at the mouth of Ares Vallis, the landing site of Mars Pathfinder (MPF). This interpretation is based on large-scale photogeology of Viking high-resolution orbital images [1, 2], and confirmed in many respects by examination of MPF data on a local scale [3]. However, it is not an easy task to define the geomorphologic processes that lead to the present appearance of this small area of the Martian surface. There are few places on Earth which show similar features. In order to support interpretation of MPF images we investigated a type of landscape in northern Iceland to find analogs of the Martian morphology MPF imaged. Various processes formed the actual morphology there, i.e.: high-energetic water and mud flows, ice (glaciers), wind, volcanism, mass wasting, and their respective combination. Though catastrophic floods named Jökulhaups are the regionally dominant process, the combination of Jökulhaups with various other processes can result in landscapes that are quite similar in appearance, changing within a few kilometers. So the interpretation from a single set of images (as MPF provided) should be treated with caution.

Approach: The Jökulsa a Fjöllum ("JaF") river in NE Iceland is a ~120 km long high-energetic drainage system through relatively young volcanic deposits [4]. JaF originates under Vatnajökull, the biggest glacier outside Earth's polar latitudes, covering several volcanoes, some of them still being active. Subglacial eruptions can lead to a catastrophic increase in the amount of water, rocks, icebergs and mud that JaF and the other glacier-draining rivers have to carry within a short time. These Jökulhaups have a large effect on the morphology of the landscape in the glacier's foreland. The resulting type of landscape is called sandur. These sander plains show all signs of this chaotic and extremely turbulent events such as unsorted distribution of sediments. Seasonal processes finally sculpt the landscape we see today: frost, the increase of water after snow-melt, and strong winds during the relatively dry summer season. The location near the polar circle, in combination with frequent resurfacing events due to flows that often change their direction, prohibits the growth of a substantial vegetation cover, giving the JaF area together with its imprints from the last ice age, its blocks of weathered lava flows, its river sediments of a great scale of sizes, and its traces of wind deposition, an appearance similar to the MPF landing site. We catalogued and described these varying types of morphologies in a ~5 km wide and ~50 km long sander strip along both sides of the river. Distributions of rock sizes, rock diameters in xyz-directions, rock profiles, dug-in depths, and the percentage of ground cover have been measured at several locations. We performed ~15 digital and analogue (film) "simulations" of stereo imaging under similar geometric conditions as the Imager on Mars Pathfinder (IMP), providing an excellent spatial impression of the test areas' morphologies; the equipment did not allow photogrammetric measurements to a greater quantitative extent. High-resolution aerial photography has been used to support the understanding of the processes that led to the respective morphology.

Observations and results: When comparing the observed morphologies on Iceland with images from the Martian landscape provided by IMP it is mandatory to point out that in case of the JaF river deposits we look at young quaternary resurfaced area, whereas the landscape around the Sagan Memorial Station probably is about 3.3 billions of years old [3] - be the processes that formed both locations alike or not. There is one remarkable observation beside the geologic interpretations. In the JaF sandur, it proved to be very difficult to classify rocks from the photographs alone, both stereo and non-stereo, although conventional photography shows the imaged area in much higher resolution than IMP did in Ares Vallis. To draw conclusions from the shape of rocks alone, seen from IMP-comparable distances, can be misleading; rectangular "Flat Top"-like candidate "sediments" proved to be massive basalt; possible conglomerates with "outwashed pebbles" proved to be vesicular basalt. This was even more evident when reducing the resolution of our conventional images artificially to IMP-comparable values. Measurements of rock-size distributions in the size range >5 cm at locations where the Jökulhaup sedimented its load proved to be almost analogous to those obtained around the MPF lander [5], showing the typical curvilinear distribution of sediments deposited by a high energetic fluid in log-log diagrams. However, in some cases these distributions are more linear, showing the possible combination of sedimentation processes with primary fragmentation or simple gravity motions. The interpretation that we are dealing with a combination of more than one process is supported by the observation that deposited rocks are rounded to different degrees. The situation becomes even more complicated where rocks from weathering in-situ basalt flows added to the local morphology.

Conclusions: The investigated JaF sandur proved in many respects to be similar to what we know from the MPF site and therefore can serve as a terrestrial analog of the Carl Sagan memorial site. From our investigation we conclude that not one but numerous processes and their combinations are responsible for the shape of the landscape. In our interpretation the morphology of the JaF sandur is primarily formed by Jökulhaups and subsequently modified by water, ice, and wind. Our in-situ investigation of the sandur and the interpretation of image of this area have shown that in several cases the geologic interpretation of images alone can yield misleading results. To avoid misinterpretation of imaging data it is absolutely necessary to have very high spatial and spectral resolutions, combined with additional information from complementary data sets. This information can partly be provided e.g. by returned samples of the martian surface. This would provide ground truth and therefore greatly improve our understanding of endogenic and exogenic processes which led to the formation of the rocks exposed on the surface. Rovers, allowing to look at rocks of interest under different viewing angles and analyzing these rocks geochemically are also very helpful (see Sojourner) but cannot replace detailed in-situ investigation by human beings.

References:

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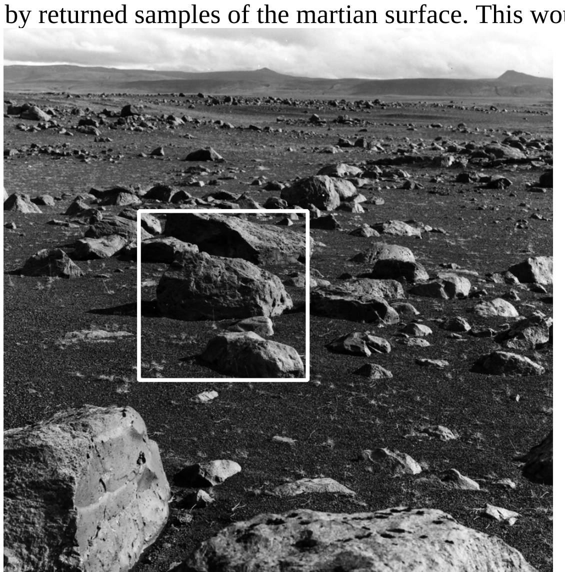

Fig.1: Sandur surface with unsorted rocks of varying roundness

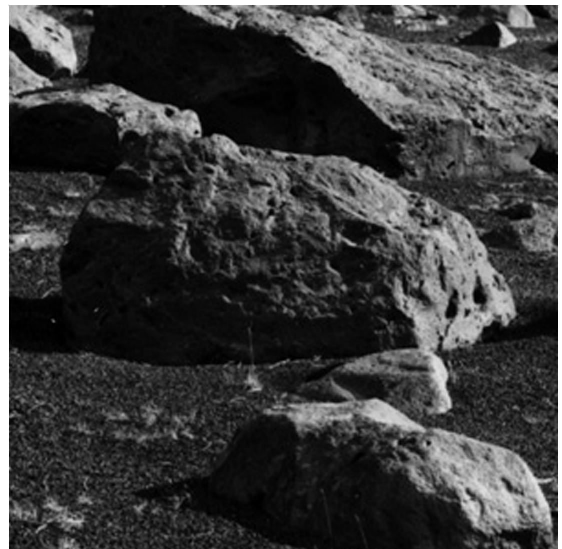

Fig.2: Vesicular basalt (enlargement of lefthand-side image)

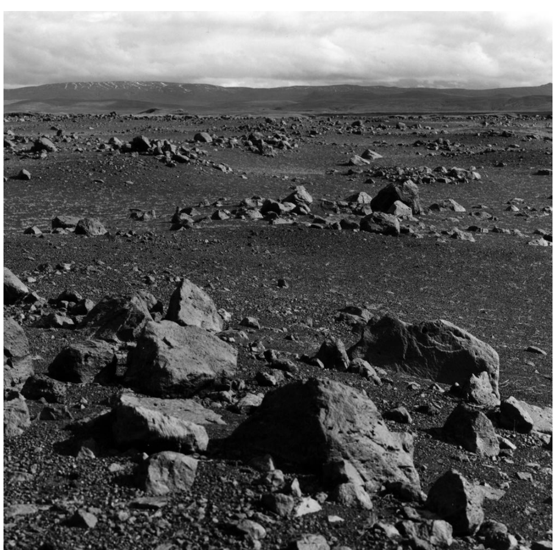

Fig.3: Typical sandur morphology with gullies and “rock gardens”

Fig.4: Massive basalt boulder similar in shape to “sedimentary Flat Top” (scale is 25 cm)