Ripple Orientations on Martian Dunes Document Diverse Wind Flow Patterns

James R. Zimbelman, Molly B. Johnson, Jennifer O’Brien
Center for Earth and Planetary Studies, National Air and Space Museum
Smithsonian Institution, Washington, DC 20013-7012
40 study sites were examined; 7 with JMARS, 33 with ArcGIS

Here we present results from the first 7 locations, measured using JMARS software

MDAP grant NNX12AJ38G
Ripples Mapping Procedure

- Only Small Dunes (small or no slip face)
- Avoid places near slip face, if present
- Avoid places with superposed ripples
- Draw line perpendicular to crest, (crests of three adjacent ripples)
Statistical ‘Moments’ of a Distribution

“Moments are the sums of the integer powers of the values”

**Mean** – First moment; value around which clustering occurs

**Variance** – Second moment; ‘width’ or ‘variability’ around mean
(Standard Deviation is square root of the variance)

**Skewness** – Third moment; degree of asymmetry around mean

**Kurtosis** – Fourth moment; ‘peakedness’ or ‘flatness’ relative to a normal (Gaussian) distribution (K=3)

**Median** – value for which larger and smaller values are equally probable

**Mode** – value where distribution is a maximum

Figure 14.1.1. Distributions whose third and fourth moments are significantly different from a normal (Gaussian) distribution. (a) Skewness or third moment. (b) Kurtosis or fourth moment.

1 – Hellespontes

Weak bimodal, with pronounced wing
Longitudinal, (transverse)

n = 1493

SITE 1 - HELLESPONTES

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN</td>
<td>144.36</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>161.06</td>
</tr>
<tr>
<td>STD DEV</td>
<td>38.26</td>
</tr>
<tr>
<td>SKEWNESS</td>
<td>-1.30</td>
</tr>
<tr>
<td>KURTOSIS</td>
<td>1.09</td>
</tr>
</tbody>
</table>

MODE 1: 171
MODE 2: 162

Regional map by Y. Ku (CTX images)

HiRISE frame PSP_007633_1350, 44.86 S, 38.80 E
2 - Gale Crater

SITE 2 - GALE CRATER

MODE 1: 112

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN</td>
<td>113.70</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>114.69</td>
</tr>
<tr>
<td>STD DEV</td>
<td>13.72</td>
</tr>
<tr>
<td>SKEWNESS</td>
<td>0.40</td>
</tr>
<tr>
<td>KURTOSIS</td>
<td>3.07</td>
</tr>
</tbody>
</table>

n = 144

Unimodal

Longitudinal, barchanoid

Regional map by Y. Ku (CTX images)

HiRISE frame PSP_009571_1755, 4.46 S, 137.50 E
3 - Nili Patera

Non-modal, (nearly random)

Barchan, barchanoid ridge

Regional map by Y. Ku (CTX images)

HiRISE frame PSP_017762_1890, 8.78 N, 67.32 E
4 - North Polar Erg

SITE 4 - NORTH POLAR

- Mean: 51.49
- Median: 25.24
- Standard Dev: 56.47
- Skewness: 1.35
- Kurtosis: 0.38

n = 370

Unimodal, with wing

Barchanoid

Regional map by Y. Ku (CTX images)

HiRISE frame PSP_010019_2635, 83.51 N, 118.54 E
5 - Aonia Terra

Bimodal, with wing

Transverse

HiRISE frame ESP_013785_1300, 49.80 S, 293.10 E

Regional map by Y. Ku (CTX images)
6 - Ius Chasma

Unimodal, with pronounced wing

Transverse ridge
7 - Arabia Terra

SITE 7 - ARABIA TERRA

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>124.47</td>
</tr>
<tr>
<td>Median</td>
<td>125.35</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>15.43</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.44</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>5.03</td>
</tr>
</tbody>
</table>

n = 279

Unimodal, with wings

Barchan

Regional map by Y. Ku (CTX images)
Conclusions

Three ‘classes’ of ripple orientation: unimodal, bimodal, and ‘random’

No association with regional setting, elevation, dune type

Dune surface slope direction may be a factor in orienting surface wind