PRELIMINARY ESTIMATES OF SEDIMENT VOLUME IN THE NORTH POLAR SAND SEAS OF MARS.

N. Lancaster and R. Greeley, Department of Geology, Arizona State University, Tempe, Arizona 85287-1404

The North Polar region of Mars contains major accumulations of aeolian sediment in the form of extensive sand seas and dunefields (1, 2). An estimate of the volume of sediment contained in the sand seas is necessary in order to assess their role in the martian sedimentary cycle. Spatial variations in sediment volume may provide information on the ways in which the sand seas have accumulated and suggest possible origins and sediment sources. In this abstract we provide a preliminary estimate of dune sediment volume based on studies of dune morphometry.

The approach used combines data from terrestrial analogs of martian dunes with detailed mapping of dune morphometry (dune spacing, cover) from Viking Orbiter images. Studies of dunes in terrestrial sand seas have shown that dune cross-sectional area increases exponentially with dune height, whereas dune height increases linearly with dune spacing (3). Therefore areas of large dunes, although widely spaced, represent a net accumulation of sediment. The sediment thickness represented by the dunes is given by their equivalent, or spread-out, sediment thickness (EST). A relation between EST and dune spacing for terrestrial dunes (EST = $0.7101 + 0.0059 Sp$) provides the means to derive estimates of sediment thickness from a parameter (dune spacing) that is relatively easily measured on orbital images. In many areas, dunes do not completely cover the surface, so estimates of sediment thickness need to be reduced in proportion to the area covered by dunes. These estimates of sediment thickness should be considered as minimum values; they are estimates of the sediment contained in the dunes, and do not take into account sediment that has accumulated below the dunes.

Average dune spacing, and the percentage cover of dunes were measured on Viking Orbiter images of the North Polar region of Mars ($> 70^\circ$N). Calculations of EST were derived from these measurements and the relation above, and mapped at a scale of 1:5 M (Fig. 1). Four major sand seas can be identified (Table 1), similar to those mapped by Tsoar et al. (1) and Dial (4). Within each sand sea, the area covered by dunes ranges from less than 5% to complete cover, with a mean cover of 50.7%. Dune spacing in the sand sea ranges between 150 and 2955 m, with a mean of 512 m. Most North Polar dunes have a crest-to-crest spacing of 300-650 m. Very widely spaced dunes ($>900$ m) are mostly scattered barchans in marginal areas of the sand seas. Assuming that martian dunes are a similar shape to terrestrial dunes, most are therefore 12 to 26 m high, based on relations between dune spacing and height for transverse dunes in a variety of sand seas (3).

Equivalent sediment thickness for the sand seas ranges from 0.10-0.50 m to a maximum of 5.0-6.0 m, with a mean of 1.81 m (Table 1). EST is between 2 and 4 m over wide areas of the sand sea between 100 and 260$^\circ$W. Average EST is greatest in this area and significantly lower in the other dune areas. Within each sand sea, EST follows a consistent pattern, with the greatest sediment thickness in the center, decreasing toward the margins.

<table>
<thead>
<tr>
<th>Latitude (°)</th>
<th>Longitude (°)</th>
<th>Area (km²)</th>
<th>Dune cover (%)</th>
<th>Mean EST (m)</th>
<th>Sediment volume (km³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>74-80</td>
<td>40-70</td>
<td>1.06 x 10⁵</td>
<td>37.5</td>
<td>1.28</td>
<td>155.6</td>
</tr>
<tr>
<td>76-81</td>
<td>85-105</td>
<td>5.00 x 10⁴</td>
<td>42.8</td>
<td>1.33</td>
<td>62.3</td>
</tr>
<tr>
<td>76-83</td>
<td>110-260</td>
<td>4.70 x 10⁵</td>
<td>57.0</td>
<td>2.13</td>
<td>935.7</td>
</tr>
</tbody>
</table>
Sediment volumes (Table 1) were computed from the isopachs of sediment thickness (Fig. 1). The total volume of sediment contained in the dunes of sand seas of the North Polar region is 1195 km$^3$, of which 78% lies in the large sand sea between 110 and 260° W. This estimate is an order of magnitude less than that of Thomas (5), but is based upon more realistic views of the size of the majority of martian dunes, and the amount of sand they contain.

This new estimate of dune sediment thickness tends to support hypotheses that the dune sands were derived from the polar layered deposits (e.g.1,5,6). There are clear relationships between eroding scarps and areas of dunes. Major areas of dunes, such as those between 40 and 70° W, lie downwind of major dissected areas of the perennial polar cap. It is perhaps significant that the major area of dunes between 110 and 260° W lies between the present limits and large outliers of the perennial ice. Dissected areas of the polar cap and layered deposits extend for some 3.3 x 10$^5$ km$^2$ (5). If the layered deposits contained only 1% sand-sized material, some 275 m would have had to have been eroded to provide enough sediment to form the dunes. This is consistent with the local relief of 200-800 m noted by Blasius and Cutts (7).

Fig. 1. Equivalent sediment thickness in the North Polar sand seas of Mars. Isopachs in meters.

References