SOUTH POLAR REGION OF MARS: TOPOGRAPHY AND GEOLOGY. P. M. Schenk[1] and J. M. Moore[2], [1]Lunar and Planetary Institute, Houston TX 77058 (schenk@lpi3.jsc.nasa.gov), [2]NASA Ames Research Center, Moffett Field CA 94035 (jmoore@mail.arc.nasa.gov).

Introduction: The polar layered deposits of Mars represent potentially important volatile reservoirs and tracers for the planet's geologically recent climate history. Unlike the north polar cap, the uppermost surface of the bright residual south polar deposit (Fig. 1) is probably composed of carbon dioxide ice [e.g., 1]. It is unknown whether this ice extends through the entire thickness of the deposit. The Mars Polar Lander (MPL), launched in January 1999, is due to arrive in December 1999 to search for water and carbon dioxide on layered deposits near the south pole (SP) of Mars.

Polar Mapping: To characterize both the general and detailed topography of the MPL landing zone and the SP layered deposits, we analyzed Viking Orbiter stereo imaging and generated the first detailed Digital Topography Models (DTMs) of the region (Fig. 2). The anaglyphs allow direct geologic interpretation of albedo patterns, various landforms, and the relationships among various types of features. LPI stereogrammetry software [2] was used to map topography quantitatively. DTMs (Fig. 2) permit precise determinations of local elevations and slopes, and estimates of deposit volumes (Table 1). Vertical contour intervals ranged from 60 to 160 m. Although MOLA will map this region in mid-1999, we used Viking stereo images to map the topography to provide reliable topographic data for MPL landing site selection at the earliest date.

Polar Topography: Our images and topographic maps reveal that the south polar layered deposits of Mars are topographically complex and morphologically distinct from the north polar layered deposits. The dominant feature is a 500-km-wide topographic South Polar Dome (SPD) that rises 3 km above the surrounding plains (Fig. 2). This dome underlies the residual ice cap but is at least 50% larger in area. The highest parts of the SPD are located directly over the extrapolated location of the buried rim of the 850-km-wide, 1.5-km-deep Prometheus basin. Erosional scarps and terraces indicate that this dome was once more extensive and has undergone erosional retreat.

Elsewhere, the layered deposits form a vast plateau 1 to 1.5 km high extending ~1000 km beyond and mostly to one side of the SPD (Figs. 1, 2) . This plateau, referred to as the South Polar Mega-plateau (SPMp), is relatively flat at kilometer scales, although it is cut in places by troughs and depressions, which have locally steep scarps. Contiguously flat kilometer-scale regions the size of the landing ellipse are present. These are in the form of plateaus 100-300 km wide and 1 to 2 km high. The largest of these plateaus has been proposed as an MPL landing site. A number of arcuate troughs within the layered deposits are floored by rugged material that resembles crater rim material [3].

Polar Volumes: The volume associated with the south polar layered deposits may be approximately comparable to those of the layered deposits at the north pole [4]. Surrounding cratered plains are relatively flat in our DTMs. We assume that the volume of the buried Prometheus rim is negligible and that there has not been isostatic compensation. From these assumptions and an estimated average relative height of ~1.4 km, we estimate the volume of the SPD (by itself) to be on the order of 295,000 km^3 (Table 2). This is ~25% that of the minimum volume estimated for the NPC (1.2×10^6 km^3 [4].

Extrapolating from an average elevation of 1 to 1.5 km and a surface area of ~1,300,000 km^2 (excluding the SPD), we infer that the volume of deposits within the mega-plateau region of the SP layered deposits is 1.3 to 2×10^6 km^3. The minimum total volume of all layered deposits at the south pole of Mars is on the order of 1.6×10^6 km^3. This is similar to the maximum volume associated with the north polar layered deposits (1.7×10^6 km^3 [4]. Although this doubles the current probable inventory of surface ice on Mars, it still falls far short of accounting for the inferred volume of water on Mars in the past.

Volatile Inventory: Our topographic data obviously cannot directly address the composition of the south polar deposits on Mars. However, based on our topographic profiles and recently derived flow laws for solid CO_2, Nye et al. [5] have modeled the creep of the south polar dome. They conclude that the topography of the dome probably cannot be supported if it were composed dominantly of CO_2 ice. This modeling neglects the effects of basal melting, which would only further reduce the capacity for topographic support. We therefore conclude that the dominant volatile in the SP layered deposits is probably water ice.

The estimated polar inventory is equivalent to a global water layer 15 to 20 m deep. (Erosional retreat suggests that these volumes were considerably higher in the past.) This estimate falls almost an order of magnitude short of the total volume of ~1.5×10^7 km^3 or more attributed to the proposed ancient northern plains ocean [6]. Other estimates range from 40 to nearly 1400 m equivalent ocean depth [7]. If such large amounts of water existed on Mars in the past, then the vast bulk of this water was probably subsequently lost to other reservoirs [e.g., 8]. Apparently, only a minor fraction of this ancient global water layer was incorporated into the polar ice deposits. If layered deposits include a large dust fraction, then the disparity between the volume of water currently observable and that predicted for early Mars is even greater.

MPL Landing Site Selection: The MPL landing zone (73˚ -78˚ S, 170˚ -230˚ W) measures ~500 by 1000 km and coincides roughly with the outer portion of the SP layered deposit (Fig. 1), a region characterized as a dissected plateau and relatively smooth at kilometer scale distances. Locally steep slopes can locally exceed 10° at km-scales and may pose a landing hazard. However, these areas are widely separated by areas of low relief that are considerably larger than the size of the final landing ellipse.

One proposed MPL landing site is a 300-km wide, 2-km high plateau near the edge of the layered deposits (Fig. 4). This flat plateau is large relative to the final landing ellipse (~6 by 50 km), and high-relief features are not evident. Long-wavelength undulations have local slopes of only a few degrees and do not pose a landing hazard, unless they expose locally steep outcrops corresponding to individual layers. Our results do not address the question of the meter- or centimeter-scale roughness of the landing zone, which may be answered by MOC and MOLA data. The hard choices facing the site selection team are the scientific significance of landing on exposed layers traded off against the potential hazard these and other textures may pose to a successful landing.

References:

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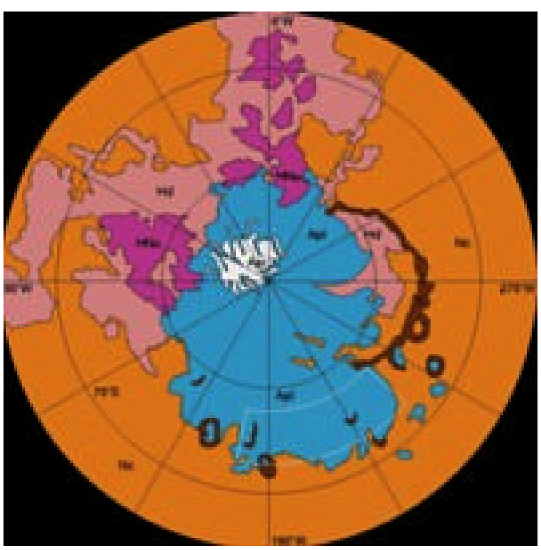

Figure 1. Geologic map of South Pole region of Mars [from 3]. Scene width is 3000 km. Layered deposits are blue. White box is MPL landing zone.

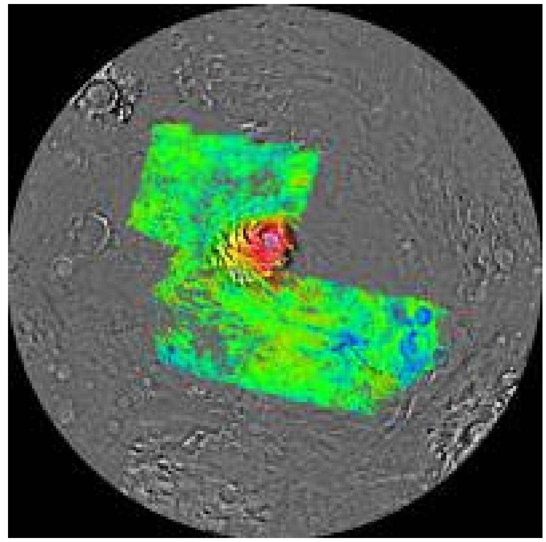

Figure 2. Topographic map of South Polar region of Mars. Data from Viking stereogrammetry [9]. Blue is low, red high. Approx. 3 km of relief is portrayed.

Figure 3. Topographic profile across South Polar Dome. At left are smooth plains, at right are layered deposits within the South Polar Mega-plateau. Profile line is oriented roughly vertically in Figure 2.

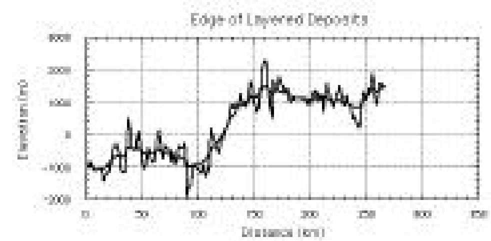

Figure 4. Topographic profile across edge of South Polar Layered Deposits. Jagged line is data, smoothed curve shows data after smoothing to reduce noise. Elevated plateau lies within an area proposed as the MPL landing site. Location –74° lat., 225° long.

Table 1: Estimated Areas and Volumes of South Polar Layered Deposits on Mars

	Area (km^2)	Volume (10^6 km^3)
Layered deposits	1,530,000	~1.6-2.3
Mega-plateau	1,325,000	~1.3 - 2.0
SP Dome	205,000	0.3
Residual Ice Deposit	87,000	-
North Polar Cap [4]	1,040,000	1.2 - 1.7