Determining the Heights and Distributions of Swiss Cheese Features on Mars South Polar Residual Cap using Photoclinometry.

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Introduction: In 1999, the Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) acquired images with spatial resolution of a few meters which showed a multitude of unusual features on Mars south polar residual cap (SPRC) [1]. These features, which do not occur on the northern cap, are informally referred to as "Swiss cheese." They include quasi-circular depressions with steep walls and flat bottoms, as well as a multitude of oddly shaped pits, remnant mesas, and highly elongated "Fingerprint" terrain [1]. MOC images from 1999 and 2001 showed that the walls of some of these features were retreating at a rate of 1-3 m/y, implying ongoing climate change [2].

Thomas *et al*. identified two main types of Swiss cheese features (SCFs) within the residual cap using MOC (fig. 1). An older unit, unit A, is distinguished by its shape and the presence of polygonal cracking on its upper surface. A younger unit, unit B, is identified by its fewer layers and smoother terrain [1].

The current observed retreat rate of SCFs predicts the entirety of this thin veneer will disappear within a few millennia if the lost CO_2 is not being redeposited elsewhere on the cap [2].

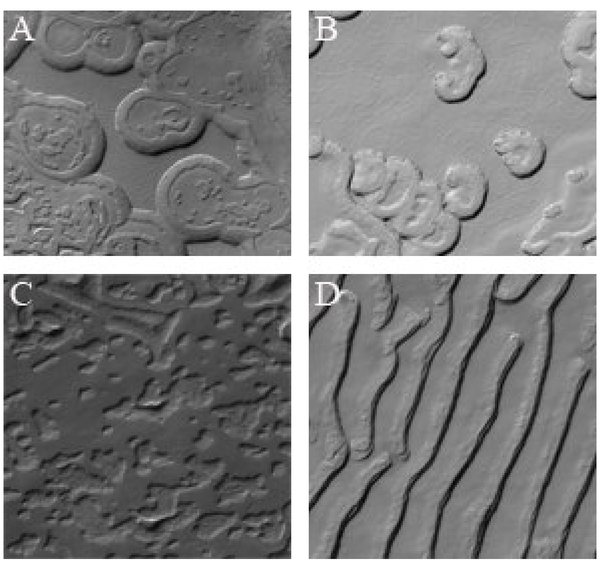

Figure 1. A) Unit A mesa with quasi-circular depressions and separated by a moat from surrounding unit B terrain. B) Unit A Curl depressions elongated with circular or mushroom-shaped appearance. C) Unit B with smoother surface, fewer layers and irregular depressions. D) Unit B Fingerprint terrain is remarkably consistent in size and spacing while extending for large distances across the SPRC [3].

Determining the thickness of the thin CO_2 veneer of the SPRC is an important part of understanding its stability [4]. Mapping the heights and distributions of unit A and unit B is necessary to obtain an accurate average height for the SPRC using remote sensing [4].

We can determine the porosity of the CO_2 ice by combining an accurate average height estimate with column density measurements [5]. The porosity of the SPRC CO_2 ice has implications for how the SPRC formed and may answer questions about the nature and composition of the cap.

Our findings further these goals and indicate that the SPRC is thicker at the edges of the cap then it is at the center, possibly due to redeposition of the mass lost from SCF retreat.

Photoclinometry: Photoclinometry is a technique used to compute topographic profiles from an image brightness distribution given constant (uniform) albedo [6]. Here we use the USGS ISIS program PC2D which creates a Digital Elevation Map (DEM) from the least squares fit for the shaded topography that would best produce the input MOC image [7]. Because photoclinometry assumes constant albedo across the scene, our DEMs are limited to only MOC images with highly uniform albedo.

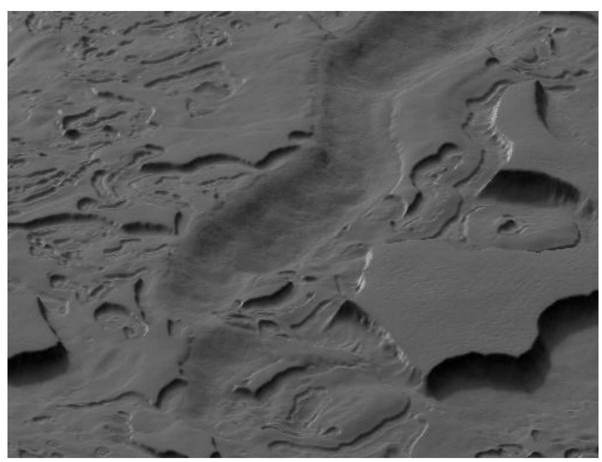

Figure 2. Digital Elevation Map with unit A mesa on right, surrounding unit B terrain and bisecting ridge.

Data: Using MOC images from ~1.5-3 m/pixel resolution, we selected SCFs based on uniformity of albedo and low pixel saturation to use for photoclinometry. These images were then run through PC2D to create 181 DEMs. Average mesa heights were calculated from 8,484 individual measurements.

Results: Analysis of DEMs generated from MOC images gives results consistently thinner than previous SCF measurements made using the shadow method [3, 8]. Mapping of these results provides a distribution indicative of a SPRC that is thicker in its outer regions then it is at its center.

Our results show that the largest SCFs, unit A (with surrounding unit B) and "Curl" dominate the outer regions of the SPRC. They also show the much smaller "Fingerprint" terrain almost exclusively occupies the inner portions of the SPRC. These results may support previous studies that have shown the residual cap expanding at its perimeter [9].

	Betz et al.	Thomas et al.
Unit A	8 ± 2.52m	9.3 ± 1.7m
Curl	5.3 ± 1.4m	8.3 ± 2m
Unit B*	1.9 ± .33m	1.1 ± .4m
		2.4 ± .5m
Fingerprint	2.8 ± .46m	3.5 ± 1.3m

*Thomas et al. measure single and double layer thickness for unit B

Figure 3. Average unit height results with comparison to previous shadow measurement heights.

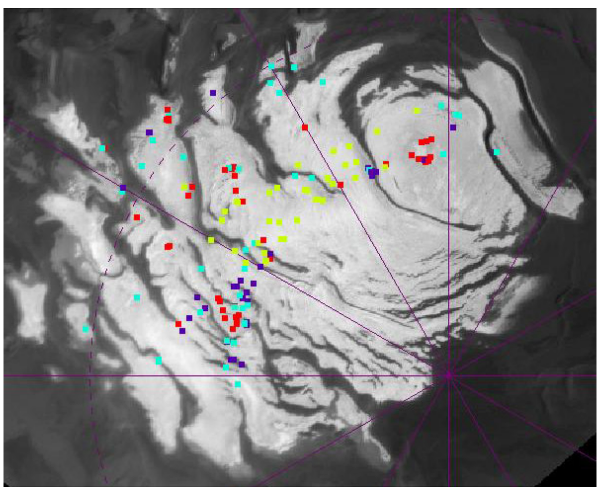

Figure 4. Distribution of DEM locations on MGS Wide Angle map. Purple squares indicate unit A locations, red indicates Curl, yellow indicates Fingerprint, and blue indicates unit B.

References: [1] Thomas P.C. et al. (2000) *Nature*, 404, 161-164. [2] Malin M.C. et al. (2001) *Science*, 294, 2146-2148. [3] Thomas P.C. et al. (2005) *Icarus*, 535-559. [4] Titus T.N. et al. (2008) in *The Martian Surface*, Edited by Jim Bell, III. Cambridge 578-598. [5] Tokar R.L. et al. (2003) *GRL*, 30, 10-1-10-4. [6] Watson K. (1968) USGS Professional Paper 599-B. [7] Kirk R.L. et al. (2003) Advances in Planetary Mapping 2003.[8] Byrne S. and Ingersoll A.P. (2003) *GRL*, 30, 29-1-29-4. [9] Winfree K.N. and Titus T.N. (2006) *LPS XXXVII*, Abstract # 2283.

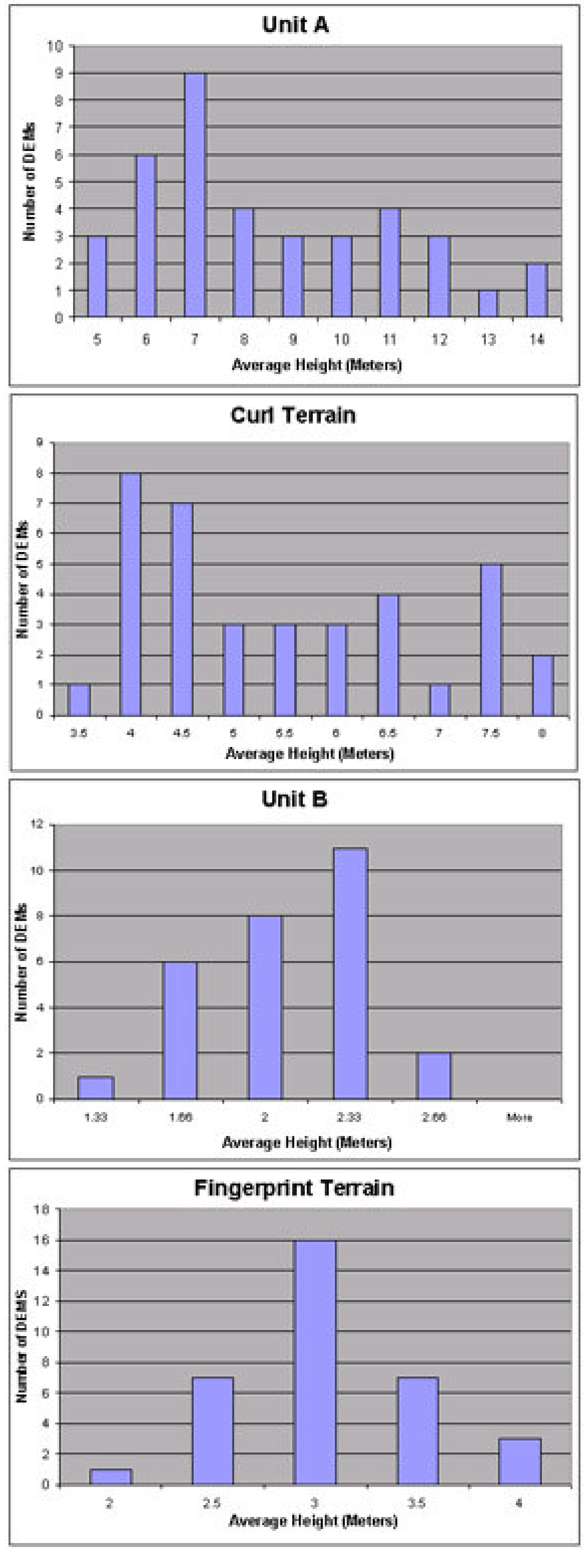

Figure 5. Histograms of average unit heights.

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