South polar residual cap of Mars: features, stratigraphy, and changes. P. C. Thomas[1], M. C. Malin[2], K. S. Edgett[2], P. B. James[3], B. A. Cantor[2], R. Williams[2]

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Mars Orbiter Camera (MOC) images show that the south residual cap consists of at least two major layered units deposited at different times separated by a period of degradation. The older depositional unit is a series of 4-6 layers, each ~2 m thick, expressed in mesas and large areas with polygonal troughs in its upper surface (Fig. 1b,c). This deposit, here termed unit A, has been embayed, and in many areas largely removed, by expansion of quasi-circular depressions (Fig 1b,c).

Surrounding the remnants of unit A are thinner, smooth-surfaced deposits, here termed unit B, occurring in one to three layers, each 1-2 m thick (Fig. 1a,b). Many depressions within unit B (Fig. 1a,b) display topographic moats, which have a bimodal size distribution, and there is a virtual absence of moats within depressions less than 40 m diameter. This bimodality, the occurrence of narrow moats within larger ones, and the observation that moated material inside depressions is always thinner than the surrounding materials is most easily explained by deposition of a layer after erosion of moats to an average width of about 50 m, followed by more backwasting of all layers.

The morphology shows that development of the south residual cap involved at least these steps: 1) deposition of unit A over much of the area of the residual cap; 2) erosion, largely by scarp retreat (backwasting) of much of this material; 3) a hiatus in this erosion, during which the first layer of unit B was formed; 4) formation and expansion of depressions in unit B; 5) deposition of another unit B layer; 6) erosion by scarp retreat of about 50 m of moat widths as well as start of development of moats between mesas of unit A and layers of unit B; 7) another unit B depositional event; 8) current backwasting of both units A and B.

We have expanded the one Mars year observations of changes made by [1]. The results, summarized in the Table, show that landforms in unit A are backwasting ~1½ times the rate of those in unit B. All types of moats are expanding, thus they are not equilibrium forms retreating with the scarps. Additionally, both the change measurements and the survey of the cap morphology show that all the upper surface topography of the residual cap is erosional; any summer redeposition of CO_2 within the cap is minimal.

The erosion of unit A before the formation of unit B, at current rates, would have taken many Mars decades to over 100 Mars years. The timescale for the curls (Fig. 1a) is somewhat shorter, and is much lower than previously modeled [2] because the measured rates are much higher than the model assumed rates. Most depressions in unit B could have formed in 10-20 Mars years, although the largest depressions could have taken several times longer. The widths of the moats around mesas of unit A are consistent with the backwasting of unit A resuming at about the time that erosion of unit B started (Table).

Mesas of unit A and included large depressions are visible in Mariner 9 images taken in 1972 (Fig. 1c). Albedo differences and the calculated timescale for moat formation strongly suggest at least one layer of unit B was deposited between Mariner 9 and Viking observations as suggested previously [3].

Climate changes on these time scales cannot be related to orbital forcing: the shortest period is likely ~5×10^4 y [4]. The key difference in the layers of units A and B from a typical seasonal CO_2 cover appears to be deposition with textures that preserve a high albedo, in contrast to some of the complex changes in optical properties seen in the usual annual CO_2 cap [5]. We speculate that this depositional difference may arise from climate effects of preceding global dust events, which can occur on decadal time scales [6].

Table Rates of scarp retreat in south residual cap

type	change, m 1y	change, m 2y	size m	timescale Mars y
Unit A	6.8±2.6	14.2±3.2		
Unit B	4.6±2.4	8.6±2.7		
Large circular		15.0±3.4	575±260	77
Curls		14.3±3.2	200.4±59.5	28
Generic, unit B		[8.6]	45.0±31.3	11
Moats, unit B		8 .1±3.8	75.8±19.9	17
Moat between A and B		12.0±3.9	86.2±24.9	14

Sizes and changes were determined by interactive digital measurement of raw MOC images. 1 year changes measured in 18 image pairs; 2-year changes measured in 27 image pairs. Uncertainties in rates and sizes are one standard deviation of measurements. The change is the difference in diameter of a depression or of septa between depressions for one or two Mars years.

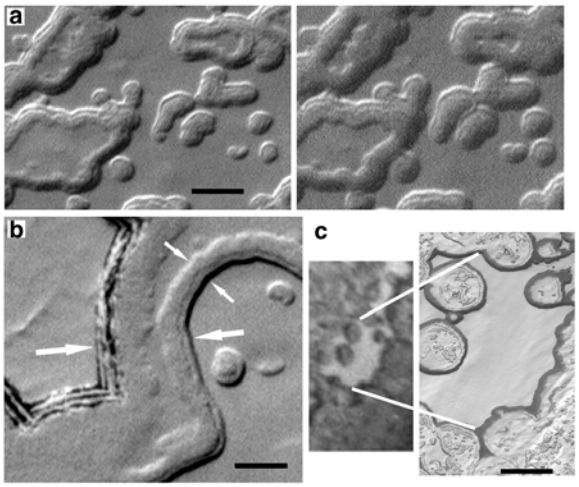

Figure 1 All images are illuminated from lower right. **a,** Two Mars year changes in curled depressions in unit B. M08-02089 (left), R06- 01503, 86.0°S, 87.2°W, scale bar 50m. **b,** Two generations of moats around mesa of unit A. Larger arrows show moat, about 75 m across between mesa and unit B layer. Smaller arrows show moat formed in fill of the larger moat. Image R11-02744, 86.8°S, 83.8°W, scale bar 50m. **c,** Comparison of Mariner 9 frame DAS 06029803 with MOC image M15-00205, 87°S, 342°W, shown at different scales; lines connect common points. Scale bar 1 km.

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