HOW THE MARTIAN SOUTH POLAR RESIDUAL CAP LOSES MASS. P. B. Buhler[1], A. P. Ingersoll[1], B. L. Ehlmann[1], C. I. Fassett[2], J. W. Head[3], [1]California Institute of Technology, Department of Geological and Planetary Science, MC 170-25, Pasadena, CA, 91126, bpeter@caltech.edu, [2]Mount Holyoke College, Astronomy Department, South Hadley, MA, 01075, [3]Brown University, Department of Earth, Environmental and Planetary Sciences, Providence, RI, 02912

Introduction: The martian South Polar Residual Cap (SPRC) comprises 1-10 m thick deposits of CO_2 ice on top of the martian south polar cap that persist throughout the entire martian year. The thicker deposits are known to exhibit quasi-circular pits and a polygonal fracture pattern on their upper surface, thus becoming rougher with age [1,2]. In this work we document new morphological features on the SPRC, which we use to describe a process of CO_2 sublimation capable of explaining the erosive morphology of the SPRC.

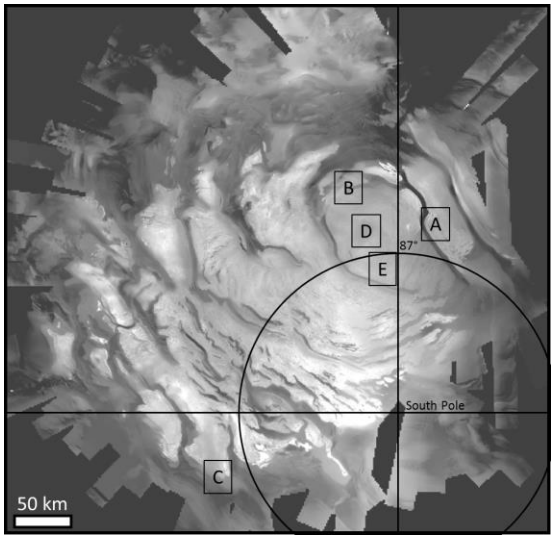

Fig 1. A mosaic of CTX images taken in MY 29 indicating study locations on the SPRC. Circle is 87° S.

Methods: We use HiRISE imagery to track changes in SPRC morphology over Mars Years (MY) 28-32 in five locations on the martian south polar cap that were chosen to sample a wide range of morphologies [cf. 3] and a broad areal extent (Fig. 1).

Results: (I) We document dark fans that appear on the sides and bases of the CO_2 deposits in southern spring (Fig. 2). We interpret these fans as evidence of the internal sublimation of CO_2, which becomes pressurized and then ruptures the solid CO_2 deposit, venting the CO_2 gas along with dust trapped inside the CO_2 mesas, creating a dark fan similar to the fans seen in the 'Spider Terrain' in the seasonal CO_2 deposit [4].

(II) We document the formation of cracks (Fig. 3) and subsidence (Fig. 4) on the upper surface of the CO_2 deposits in the southern spring and summer. We interpret these features as the external manifestation of internal structural failures of the CO_2 deposit due to internal sublimation and mass loss indicated by the fans.

(III) We observe that pits (Fig. 5) exploit the surface cracks as nucleation sites.

We thus infer that internal sublimation (indicated by dark fans) leads to collapse and subsidence of the CO_2 mesas, which in turn provides nucleation sites for the ubiquitous pits of the SPRC. This process also explains the previously noted increase in roughness of the upper surface of the mesas as they become older [1,2].

References and Acknowledgments: [1] Thomas, P.C. *et al.* (2005) *Icarus*, *174*, 535-559. [2] Byrne, S. and Ingersoll, A.P. (2003) *Science*, *299*, 1051-1053. [3] Thomas, P.C. *et al.* (2009) *Icarus*, *203*, 352-375. [4] Piqueux, S. (2003) *JGR*, *108*, 1-9. We gratefully acknowledge NASA MFRP and Caltech SURF funding.

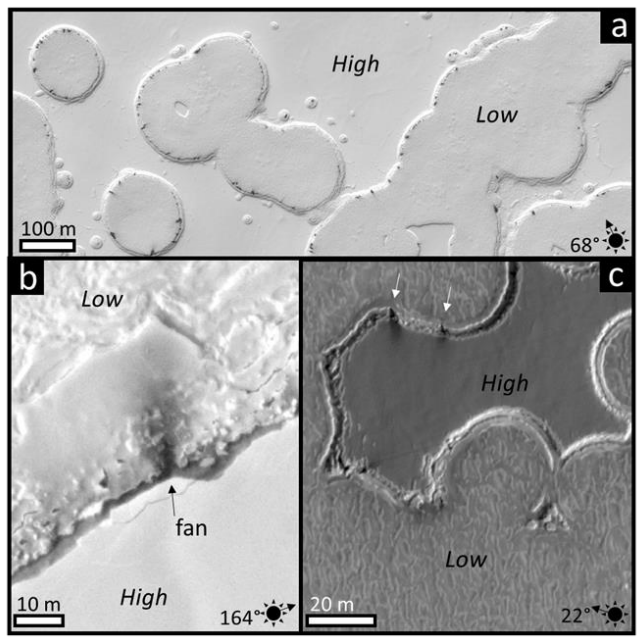

Fig 2. a. Dark fans with areas ~10 m^2 appear exclusively near the edges of CO_2 deposits, beginning in mid-spring. MY 31 L_S 275, Area C. **b.** The long axis of the fan is typically oriented perpendicularly with respect to the edge of the CO_2 deposit, the narrowest width of the fan is closest to the CO_2 deposit, and the fan is typically darkest in the narrow region close to the CO_2 deposit. MY 28 L_S 285, Area E. **c.** Dark fans are apparent on the upper surface of a mesa, indicating the draping of dark material entrained in a pressurized gas flow rather than from dark material deposited by a downhill flow under the action of gravity. MY 28 L_S 237, Area C. L_S = *Solar Longitude.* HiRISE images.

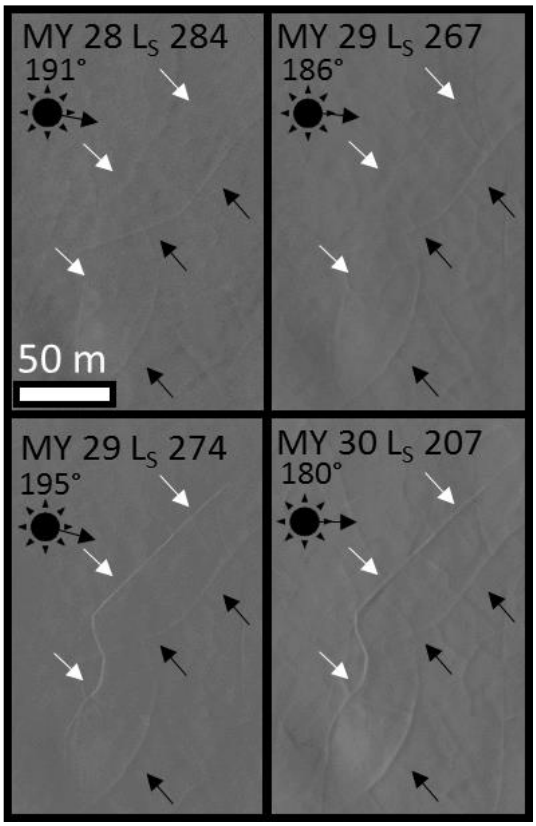

Fig 3. A crack on the upper surface of a CO_2 mesa is visible over the course of 3 Mars years (black arrows). A new crack forms suddenly between MY 29 L_S 267 and 274 (12 days) and is visible the next year (white arrows). Area A. HiRISE images.

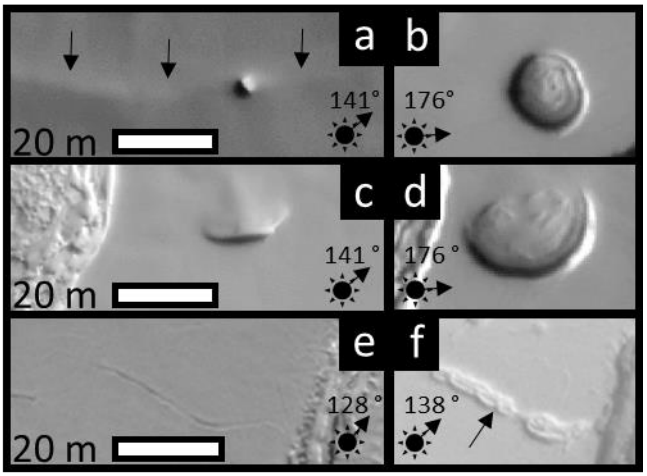

Fig 5. Different types of pits. **a.** Quasi-circular pit forms along crack (arrows). **b.** Same pit 5 Mars Years later. Note approximately uniform depth of pit. **c.** Linear collapse that **d.** grows to become a crescent-shaped pit 5 Mars Years later. Note upper half of pit is shallower than lower half. Area B. **e.** A crack that becomes **f.** a trough with cusps (arrow). Area C. HiRISE images.

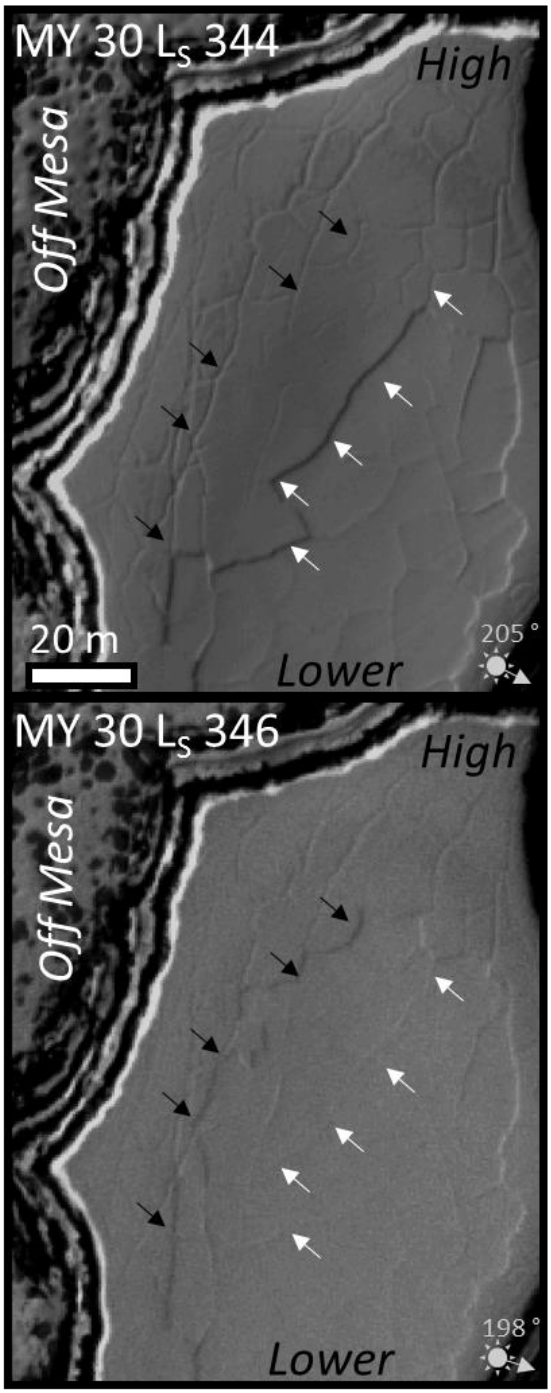

Fig 4. Over the course of four days (from top panel to bottom) a small ridge (white arrows) disappears and a new ridge appears in the later image (black arrows) along the locations of cracks in the earlier image. Due to the fast rate of change, we interpret this as a large polygonal area vertically subsiding by 10s of centimeters (as based on shadow measurements) instead of horizontal sublimation. Area A. HiRISE images. Top panel is 25 cm/px, bottom panel is 50 cm/px.