RESIDUAL SOUTH POLAR CAP OF MARS: MRO RESULTS, INTERPRETATIONS, AND PUZZLES.

P. C. Thomas[1], P. B. James[2], W. Calvin[3], R. M. Haberle[4], M. C. Malin[5] [1]Center for Radiophysics and Space Research, Cornell University, Ithaca NY 14853 pct2@cornell.edu , [2]Space Sciences Institute, 4750 Walnut St. Boulder CO 80301, [3]Dept. Geological Sciences, University of Nevada, Reno NV 89577, [4]Space Science Division, NASA Ames Research Center, Moffet Field CA 94035, [5]Malin Space Science Systems, San Diego CA 92191

Introduction: The residual south polar cap (RSPC) of Mars is a group of depositional units, largely composed of CO_2 ice, that is undergoing active change [1,2] and which displays unique morphology [3]. This work first briefly summarizes recent findings from MRO data (Context Imager, CTX, [4] Compact Reconnaissance Imaging Spectrometer for Mars, CRISM [5], and High Resolution Imaging Science Experiment on Mars Reconnaissance Orbiter, HiRISE [6]) recently submitted for publication [7].

Summary findings: From CTX images we have found that the older, ~10-m thick units of the RSPC cover only a few percent of the residual cap. Younger, thinner units cover the rest, and an approximate inventory gives less than 380 km^3 of CO_2 ice in the RSPC, which represents ~2% of the total mass of the Mars atmosphere (~0.1 mb pressure if sublimated).

All units continue to erode at similar backwasting rates for the last four Mars years; in some features these rates appear to apply as well to the period since Mariner 9 and Viking Observations in Mars years 9 and 12 (1972 and 1978).

Erosion of scarps is not a simple backwasting of exposed surfaces. The upper surfaces of all units appear nearly stable over many Mars years. The backwasting of scarps is initiated by scarp-parallel fractures, with the separated blocks forming ridges that decay over several Mars years. In some instances there is top-down erosion, largely in the older, thicker units, that leaves complex, darker debris behind that requires more than 10 Mars years to be completely lost.

CTX data show changing albedos throughout the summer in all units, apparently including some redposition of ice in late summer. Different subunits start summer with the same high albedo, but the subsequent evolutions vary considerably, suggesting different thicknesses or composition changes with depth. This recycled material is apparently very thin, but may be important in thermal balances.

CRISM data show that the debris in ramps from the thicker units and in downwasted areas is largely CO_2 ice, though some water ice patinas and inclusions are present.

Individual layers are difficult to identify with the exception of instances ~0.1 m in thickness on upper surfaces of some areas. Exposure of layers in walls of eroding materials is rendered obscure (at best) by debris accumulations and the nature of the scarp-parallel fracturing.

Interpretations and puzzles The only well-observed layering is ~0.1 m, much thinner than current total annual accumulations. Variations in atmospheric dust and/or condensate clouds may alter the thermal budget sufficiently to yield net annual deposition or erosion of 0.1 - 0.2 m equivalent depths [7,8]. Upper surfaces of the thicker units, however, appear to have been nearly stable for long periods, and some post-Mariner 9 deposits have changed by small fractions of a m in 19 Mars years [7]. Thus, it is not clear how much, if any, of the depositional conditions of the residual cap apply to the last 19 Mars years.

The complicated style of backwasting, and the presence of specific instances of downwasting suggest that initiation and propagation of erosion of depressions in the RSPC may partly involve heat flow from below. Heat flow would be effective only if in water-ice rich materials that could sustain higher temperatures than the CO_2. Part of the backwasting process clearly involves mechanical effects to initiate fractures and generate the series of ridges ubiquitous for the thicker units and common (but not universal) in the younger, thinner ones [7]. It is conceivable that this might include gas-driven stresses in the residual ice, much as proposed for some parts of the annual cap [9].

What is the future of the RSPC? Parts of it have so far lasted in excess of 100 Mars years [3,7], and if built up at ~0.1 m per Mars year, might have taken an additional 100 Mars years to form some sections. There have been modest changes on the overall scale of the cap in 20 Mars years [10]. Yet it is not a "permanent" geologic feature. The CO_2 layers are distinct from the underlying water-ice-rich layered deposits, and are draped over what is relatively young (for Mars) topography. The backwasting mechanism could take many Mars decades to remove the last of the older, thicker unit at current scarp retreat rates. Even the downwasting occurrences do not remove all materials for many Mars years. The thinner units have been augmented in some places since Mariner 9, so in terms of the present climate (activity over the last 20 Mars years) the RSPC could last far longer than our current 20-year observing period, even though most years show erosion of depressions. With no extra accumulation events and only the current average erosion, even the thinner, younger unit could last Mars decades.

There could be something of a distinct "end-game" with effects of a decreasing average albedo if the area of the ice cap is progressively reduced.

We are still puzzled by the actual physical makeup of the RSPC materials, such as CO_2 grain size, porosities, method of deposition, trace constituents, and macroscopic structures within layers.

It is hoped data received in Mars year 29 (2009) will illuminate more of the downwasting and backwasting processes, and summertime recycling of materials within the RSPC. Critical evaluation of the evolution of the downwasted materials, the primary "window" into the nature of these deposits, is possible with further CTX, CRISM, and HiRISE data.

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