CRYOVOLCANISM AS A POSSIBLE ORIGIN FOR PANCAKE-DOMES IN THE MARS 98 LANDING SITE AREA: RELEVANCE FOR CLIMATE RECONSTRUCTION AND EXOBIOLOGY EXPLORATION.

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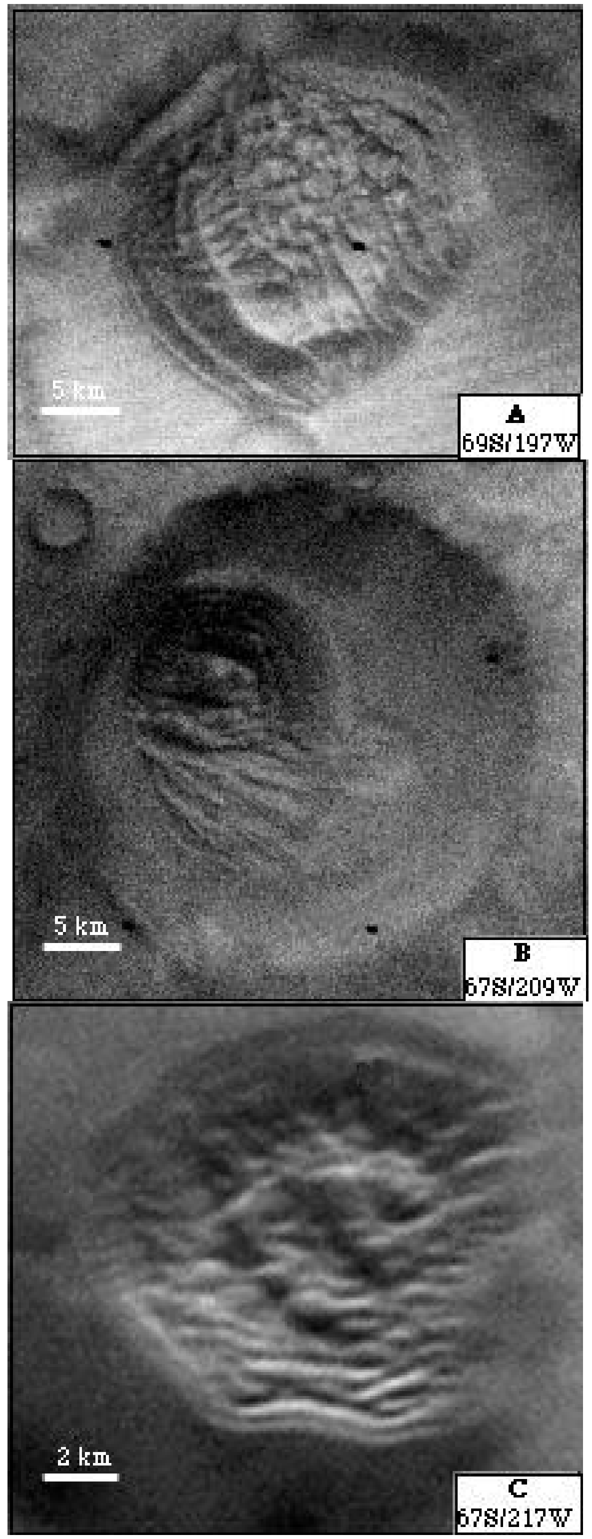
Introduction: Pancake-dome structures are observed in the high latitudes of the martian southern hemisphere. These structures occurr in an area between [65°S/72°S and 90°/220°W]. They are present always in impact craters within the transitional zone between the polar deposits and the cratered uplands. Although aeolian structures can be associated with the pancake-domes as isolated dunes or dune fields, and dune streaks, the combination of morphologic and geometric characteristics, and location of the domes favors the hypothesis of structures formed by ice-volcanism along fractures generated after the impact versus aeolian accumulations or pingo-like structures.

Cryovolcanic processes: Cryovolcanism is, by definition, a gas-driven eruption process of partially melted water ice that may be contaminated, (i.e., CH_4, CO, CO_2, H_2S, and N_2). The void spaces formed by the gases between water molecules generate a crystalline lattice named clathrate. The rising of the temperature drives the contaminant gases out of the clathrate lattice, thus the effective viscosity of the melt is reduced. Such melt becomes less dense than the remaining solid ice, and percolates upward through, for example, fractures, and solidifies when it reaches regions where the temperature is below 176K. The crystallization of the melt increases with its ascent, thus the viscosity increases. As the pressure decreases near the surface of the melt-column, the release of the gases by evaporation increases, and the clathrate is decomposed in a partially decrystallized melt of water ice and gases. As the voids are reduced, vents are formed by underpressure gas release.

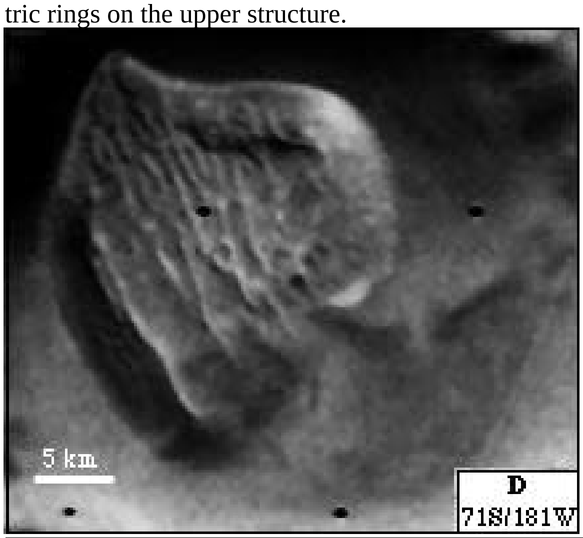
Evidence for cryovolcanic constructs at the South Pole. We propose cryovolcanism as a possible explanation for the south polar domes on Mars. This hypothesis is supported by the physical environment, and the morphology of the observed structures.

1. Physical Environment: The surveyed region is generally described as 1.5-km thick layered deposits covered seasonally by CO_2 frost (Thomas et al., 1992) underlain by H_2O ice. In addition, CO_2-H_2O clathrates of the $CO_2 6H_2O$ type may have been formed at depths ≥10m (Miller and Smythe, 1970). Clathrates are stable at pressure superior to 100 mb. When the pressure and the temperature are raised above the stability limit, the clathrate is decomposed into water ice and gases, resulting in explosive eruptions. The fact that these



pancake-shaped domes are only observed in impact structures suggest morphogenic processes associated with high pressure and high temperature conditions that are likely to generate eruptive conditions for clathrates. Eruptions are also favored by the formation of fracture networks in the deepest part of the crater bottom.

2. All the domes show common characteristics. They are observed at the bottom of impact craters, mostly ranging between 40 to 50-km diameter, with few larger or smaller exceptions. They are round at their base and show concentric rings (see Figs.B, and C). This observation rules out the possibility of an aeolian construct. The figures A to D show circular dome-like structures, which is the dominant morphology. Their comparison illustrates a process of dome formation most likely by the emergence of underground material, which can be assimilated to the formation of terrestrial volcanic lava domes. The hemispheric structure visible in figures B and C suggests a symmetric supply from the base of the dome that is confirmed by the existence of concentric rings on the upper structure.



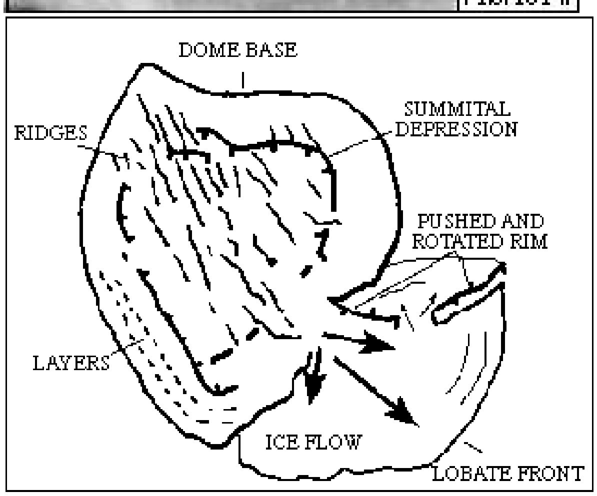


Figure E: Breached dome D, with associated flow.

All domes show a summital depression, especially well identified in Figs. A and D. The diameter of the depressions displays a recurrent ratio of 0.6 relative to the diameter of the dome base. The morphology of these depressions presents comparable characteristics to ice-cored mounds such as: collapses, summital fracture patterns (especially well shown in Fig. A), and release of inner material (Figs.D and E). However, the concentric rings are typical of eruptive conditions.

Relevance for Mars exploration: The potential presence of cryovolcanism in the South Polar region of Mars could have exciting implications for climatology and exobiology. In the event that subsurface ices were brought to the surface through cryomagmatic activity, a record of past climate and atmospheric history would become accessible. It could also be the first evidence of the presence of clathrates on Mars. In addition, potential organic matter or microorganisms trapped in ancient ices could be accessible at the present surface.

Studies of Antarctic core samples of one million year old permafrost reveal the presence of viable microorganisms (Cameron and Morelli, 1974). Similar findings have been reported in ice cores, the first of which were discussed by Frankel (1886) and Egorova (1931, 1940). Recent studies by Abyzov et al., (1979, 1982) reported the existence of viable microorganisms from Antarctica, at depths of 1,500-2,400m, in glacier layers determined to be 100,000-200,000 years old. According to Abyzov, the isolated microorganisms are representatives of both prokaryotes and eukaryotes, and include yeasts, fungi, spore - and non-spore forming bacteria, and actinomycetes.

The Antarctic analog is obviously one of great interest with respect to polar studies on Mars, and strongly supports the need for coring in exobiological, as well as climatological studies. In the near-term, the 1998 lander and penetrators could potentially provide information that would further support the presence of cryovolcanism in the martian South Polar region. A scientific goal would then be to direct future missions with coring capabilities to these areas of interest.

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