ANNUAL PUNCTUATED CO_2 SLAB-ICE AND JETS ON MARS. H. H. Kieffer, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001

Thermal Emission Spectrometer (TES) observations indicate that some areas of Mars' seasonal south cap, informally called the "Cryptic" region, are composed of CO2 ice of indeterminately large grain size [1,2]. The low albedo of this material indicates that a large fraction of the solar flux is being absorbed in or beneath this slab. The surface reflection and transmission of a plane-parallel slab of pure CO2 were calculated using the complex index of refraction [3]. A CO2 ice slab is virtually transparent to solar radiation (72% of solar energy incident at 60 degrees off-vertical will reach the bottom of a 1 m thick layer) whereas thermal emission effectively comes from about 8 mm depth. The upper cm or so is in net radiative loss and will anneal any initial porosity or cavities that form in this region.

The winter condensation of CO2 probably includes atmospheric dust in roughly its average mass fraction in the atmosphere, about 3.E-4. This dust has little effect on thermal spectral fluence in the slab. Dust will modify the depth of penetration of sunlight, but does not influence the basic aspects of the model as long the solar penetration is greater than thermal flux attenuation length. Embedded dust grains will absorb solar flux and form individual small gas pockets. If the CO2 deposit is impermeable, the grain will rest on a microscopic gas layer of subliming gas, and "burrow" downward. Because of the net flux loss environment, the hole will probably seal in at the top, yielding a sealed finite vertical columnar hole that travels downward with the grain. When the grain reaches the bottom of the impermeable layer, it will be ejected downward. This self-cleaning, self-annealing process will tend to reduce the amount of dust in the ice through the spring. Because the net solar flux is greater toward the top of the slab, the uppermost particles will move most rapidly, resulting in concentration of dust as a descending "curtain" in the slab, leaving clean ice above.

Porosity will generally be sealed in a region that grows downward from the surface. Thus, the gas formed by springtime sublimation generally cannot diffuse upward through the CO2 deposit. Localize gas escape pathways thru the slab must develop; those large enough to carry adequate warm gas from the sub-slab layer to remain open will grow into vertical columnar vents. It is difficult to predict the spacing of such vents, but they collectively must carry the total sublimation gas flux of about 10 kg/m^2/day.

The sub-slab lateral gas velocity will depend upon the geometry of the flow; the average velocity must initially decreases away from the vent. Because the thermal inertia of the Cryptic region is low [4], it is likely that the surface material is loose, and that channelized flow will develop by scouring, beginning near the vents and radiating outward. Although velocities on the order of ten m/s are required to initiate transport of fine material by saltation [5,6], injection of dust released from the CO2 into the lateral flow may initiate motion and scouring at lower velocities; 2 mm/s vertical velocity is adequate to maintain atmospheric dust in suspension. Also, the initial gas flow is likely to be diffuse flow through the soil (versus stream flow above the soil in classic saltation), and small soil grains may begin to move well before saltation threshold velocities. Dark radially converging dendritic patterns are visible in MOC images of some portions of the spring polar cap [7]; these have been termed "black spiders" by the MOC team [8]. In this model, these patterns represent channels formed by sub-slab channelized flow of the sublimation gas toward the vents. Increasingly large particles could become entrained closer to the vent.

The velocity in the vents will be approximately .005 X^2 m/s, where X is the ratio of vent separation to vent diameter. For example, for vents 1 m in diameter spaced by 100 m, the gas velocity would be ~50 m/s. When the jets exhaust into the atmosphere and velocities decrease, the coarser entrained material will fall out in the prevailing downwind direction; in this model, the oriented dark fans seen in the MOC images are caused by this process.

This is an exotic model that agrees with observations thus far. It predicts that the dark fans will be oriented into the prevailing wind, that they are seasonal and will disappear with, or shortly after, the CO2 is gone, and that the "black spiders" will be found only in the Cryptic region.

References:

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