THE COLLAPSE ORIGIN OF DENSITY FLOWS ON MARS. N. Hoffman, WNS GeoScience, 22 Marlow Place, Eltham VIC 3095, Australia (nhoffman@vic.bigpond.net.au).

Introduction: The origin of outburst "floods" on Mars is widely known to be associated with the collapsed chaos zones. Previous authors have concentrated on mechanisms for outbursts of water to provide the erosive and transport medium of the "floods". Within the White Mars paradigm it is now recognised that liquid water is an unlikely contributor to the flow and that gas-supported density flows are the most likely regime. In this section I discuss the failure mechanisms of layered regolith and the initial generation process for a gas-supported flow.

Water: The main constraints on water as the fluid responsible for the Amazonian outburst "flood" channels are volumetric. There does not appear to be enough water on Mars to supply the floods, in the absence of a recycling system. The volume of water needed for each flood is too great for the supply area. The floods require too great a flow depth. The porosity available in any competent regolith or sediment is inadequate to supply the needed liquid:solids ratio. (A thick lahar-like slurry needs ~1:1. A more fluid catastrophic flood needs >2:1. Porosity can supply 0.4:1).

Ice: If, instead, we look at intercalated ices, there is no limit on the proportion of solid ices which can be stored in a stable icy regolith. If we can transform these ices to fluids on a relatively short timescale, then each collapsed and disintegrated block can supply the fluid for the transport of its own debris. The overall planetary volume constraint is easily met because one-time non-recycled transport takes place.

Water ice has a negative pressure-melting curve and tends to freeze on decompression. In addition it has a relatively high melting temperature, compared to present and palaeo surface temperatures. Water has a high latent heat of vaporisation and low vapour pressure so the generation of a gas phase is slow and weak (<50 mbar).

CO_2 ice, on the other hand, has a positive pressure-melting curve and will liquefy on decompression. Both solid CO_2 and CO_2 clathrate will readily transform to vapour at pressures of 2-5 bar with much lower latent heat requirement (The phase transition of CO_2 clathrate to water ice plus CO_2 vapour is kinetically controlled and decrepitation may occur over a period of hours, not instantaneously).

Layers: A layered icy regolith will be prone to slip and detachment on volatile rich layers, especially if there is local warming from geothermal sources. As Mars warmed up during the late Hesperian, extensive terrains became vulnerable to collapse. In the vicinity of steep topography such as large crater rims, the inflated flanks of volcanic edifices and the global topographic dichotomy, collapse became inevitable

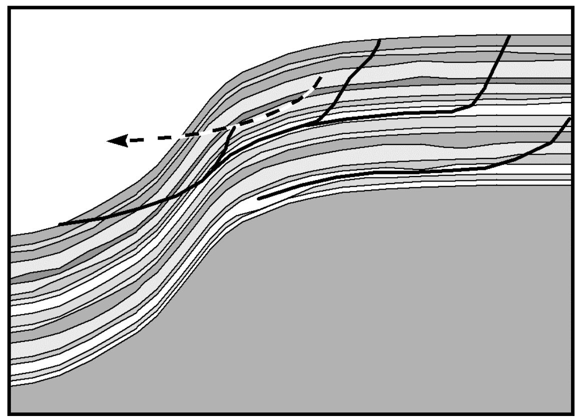

Figure 1: The initiation of collapse in layered icy regolith by detachment faulting near steep topography.

Early Stages: Once collapse initiated, each block would become rapidly depressured and the CO_2 ice within it would generate significant volumes of liquid CO_2, lubricating shear on icy layers and promoting liquefaction of the entire block. The result would be thick slurry rafting large residual blocks of layered regolith. This would head downslope and spread out over surrounding plains. In some instances, flow stopped at this point with a ponded slurry and grounded blocks forming Mesas and pyramids.

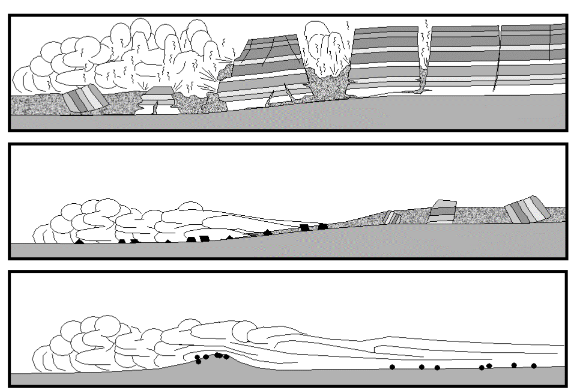

Figure 2: Generation of icy regolith slurries from collapse of layered terrain leads to flow transition

into cold gas-supported density flows that form the Amazonian outburst "flood" channels and their associated topographic and textural enigmas. Surrounding areas receive additional airfall of fine debris, blanketing small craters and adding to the uppermost layers/

Flow transition: If slopes were sufficient, the flow would continue to accelerate and become turbulent. The collapsed material would thin out and lose more pressure and begin to generate vapour internally. The mass would transform into a dense gas-supported avalanche and sweep downslope as a density flow, scouring a distinctive flat-bottomed channel and depositing large boulders. These density flows created the outwash "flood" channels on Mars.

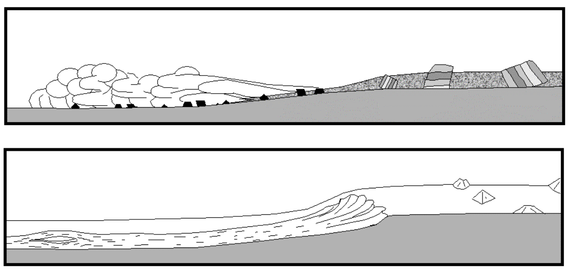

Figure 3: Comparison of density flow in motion and the resulting morphology and texture after flow ceases. Note stranded blocks with pyramidal or mesa forms, and minor local slumping. Transition zones between flow regimes are preserved as surface chutes leading from flat plains to incised channels.

Conclusions: Lambert and Chamberlain [1,2] have already introduced this collapse scenario, but concentrated on shallow liquefaction and disintegration, attempting to explain the surface erosion process by liquid CO_2. The White Mars paradigm of atmospheric evolution shows that liquid CO_2 at surface was limited to the Noachian and early Hesperian epochs. By introducing gas-supported density flows as the main erosive, transport, and depositional agent in the Amazonian, we avoid the earlier problems and now find that deep instability of the regolith is the explanation for the scale of the chaos zones, the depth of Mars' canyons and the voluminous outflows.

References: [1] Lambert R. St J. and Chamberlain V. E. (1978) *Icarus*, **34**, 568-580. [2] Lambert R. St. J. and Chamberlain V. E. (1992) Abstract - NASA *MSATTMA Workshop*