FRESH POLAR CHANNELS ON MARS AS EVIDENCE OF CONTINUING CO_2 VAPOUR-SUPPORTED DENSITY FLOWS. N. Hoffman, Victorian Institute of Earth and Planetary Science, La Trobe University, Melbourne 3086, Australia. Email: n.hoffman@latrobe.edu.au

Introduction: Recent work has shown, surprisingly, that active channel systems exist in widespread but specific locations on Mars [1]. Although conventionally interpreted as evidence for water flow, their context more firmly argues for the involvement of CO_2 at cryogenic temperatures, and argues against liquid water.

Channels within the South polar cap at 71^o South are fresh and presumably carry annual flows as the polecap ablates each spring. These are the freshest evidence for channels anywhere on Mars, with activity within the last Martian year. The temperature at this location has an annual mean around 200K making liquid water a very difficult proposition, in sufficient quantity to carry sediment 1.5 km downslope.

By providing a missing link between the Amazonian outburst "flood" channels and modern Mars, this discovery is a major argument for "White Mars"[2] - a uniformitarian view of Mars as a planet which has always been cold, dry, and dominated by the phase changes of CO_2, not water.

Morphology: The distinctive morphology of recent channel features on Mars (Figure 1) and their association with chaos zones has been used as prima-facie evidence of subsurface outbursts and water flow.

The combination of a collapse alcove, a funneling system of erosion "chutes" feeding into a central leveed channel and a terminal distributory fan are equivalent to features expected in Momentum-dominated dilute fluid flow systems on Earth.

They mimic, albeit at reduced scale, the association of chaos zones, channels, and depositional plains observed in the older Amazonian outburst "floods" [3, 4]. It is likely that similar processes are responsible for both types of channel so understanding the modern channels will help us to understand the older, larger ones.

Arguments against water: The locations of the flows are in colder-than-normal polar-facing slopes which are unlikely to reach the thawing point of liquid water unless extremely deliquescent brines are involved. Something of the order of concentrated HCl or H2SO4 solution might suffice, and these would certainly have interesting chemical consequences, yet we see no visible signs of the buildup of sulphate, chloride, or other salts in the area from which the medium should have evaporated.

The location of the origin point of the flows is very interesting. On Earth, springs of subsurface water are almost always found at the foot of cliffs and in the topographic low points down the centre of valleys. These flows on Mars originate in locations well up the sides of cliffs and although perched aquifers might be responsible for some such features, the fact that <u>all</u> the features are perched, and none occur on the sunny side of the valleys is suspicious. Simple subsurface aquifers are unlikely explanations for these channels, and therefore alternative models involving storage of subsurface and near surface ice are preferred [1].

Even if the thawing of stored water ice is responsible, the high specific and latent heat capacity of water makes thawing unlikely unless energetic volcanic or hydrothermal systems exist. In this case we should see signs of nearby volcanic activity or of the primary hydrothermal system discharging into the valley bottom as expected from elementary hydrostatic principles. Neither of these associations is observed.

Gas-supported flows: Alternative analogues are ideally found in volcanic pyroclastic flows where short-duration gas-supported flows descend from collapse alcoves in a source region of volatile-rich hot magma. Similar chutes, leveed flows, and distributory fans are found along the channels [2]. However, the features on Mars are clearly not volcanic, since no vents or cones are present in the vicinity.

CO_2 Support: Instead, It is likely that the gas support for the flows on Mars comes from Carbon Dioxide [2]. CO_2 has interesting properties that make it ideal for supporting flows on modern-day Mars.

CO_2 is a common constituent of the atmosphere and participates in annual snow and frost build up at the polecaps and in cold sheltered places like these poleward-facing alcoves.

CO_2 has lower specific and latent heat requirements, is far more common on Mars, and melts at much lower temperatures then any reasonable brine.

CO_2 has a high vapour pressure even at moderate cryogenic temperatures and transits to liquid at 216K, very close to Martian mean temperature. At this temperature it already has a vapour pressure of >5 bars, and therefore is not stable at surface, however in the subsurface the lithostatic head of a few hundred metres of rock is sufficient to maintain it in liquid state in a subsurface CO_2 "Liquifer"[5].

CO_2 Density flows: Collapse of an alcove that overlies or abuts such a CO_2 liquifer will allow an explosive outburst of the liquid which will flash to vapour within the avalanche debris itself. This will rapidly develop into a gas-supported density flow [2] in exactly the way that pyroclastic flows form by collapse of lava domes on Earth.

Even without the presence of liquid CO_2, a flow may also form from avalanches of CO_2 dry ice and debris. The release of potential energy and grinding of the dry ice will lead to rapid sublimation and development of a similar, albeit less energetic debris cloud and the formation of a small flow.

New Polar Gullies:. A new occurrence of gullies and leveed channels has been found at 71 degrees south (Figure 3) - ***within the annual frost accumulation of the polecap***. Here, annual mean temperatures are buffered to below 200K which strongly suggests that CO_2 permafrost is the responsible agent, not water ice. Furthermore, the freshness of this gully system despite annual burial suggests that ***this gully system is active at the present day and literally renews itself with fresh flows each Martian spring***.

Although water flows are technically possible in this location under the hot summer sun when dry regolith can warm to +10^o C or more, it is far more likely that the water will sublime directly to vapour or form the barest trickle of liquid water, not a debris-carrying stream.

Discussion: Although water is the fluid of choice for flows on Earth, it is an exotic species on modern Mars, especially in the polar regions where new channels have been discovered.

Gas-supported CO_2 density flows are thus by far the most likely mechanism for the recent flow channels. This establishes a continuity of CO_2 density flows on Mars with those in the Amazonian and earlier that carved the outburst "flood" channels [2], and with the earlier "Mud Ocean" mass flows [6, 7].

Although the role of CO_2 is still conjectural in all these flow scenarios, they are all entirely credible within a single uniformitarian model of a cold dry Mars with a thin atmosphere, slowly evolving under the influence of the increasing solar constant. This cryogenic model of "White" Mars [2] is far more logical and consistent than "Blue" models that insist on paradoxical episodes of liquid water activity on a geochemically dry planet.

References: [1] Malin, M.C. & Edgett, K.S. (2000) *Science 188,* 2330[2] Hoffman, N (2000) *Icarus 146*, 326-342. [3] Milton, D.J. (1974) *JGR 78*, 4037-4047 [4] Baker, V.R. (1982) *The Channels of Mars* [5] Vlassopoulos, D (1997) *LPI Workshop on Early Mars*. abstract 3008 [6] Tanaka, K.L. & Banerdt W.B. *LPSCXXXI*. abstract 2041 [7] Hoffman, N. Tanaka, K.L. & Kargel J.S. (2001) *This Conference.*

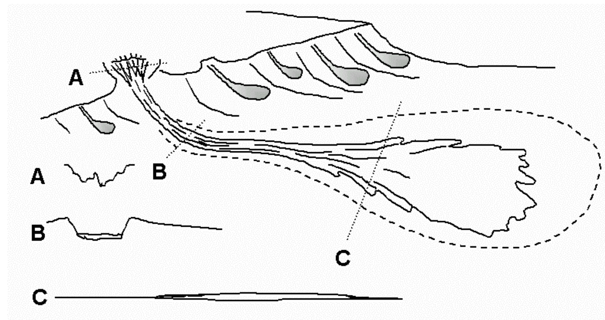

Figure 1. Cartoon of flow features expected for a CO2 gas-supported density flow on Mars – details of channel and depositional lobe enlarged.

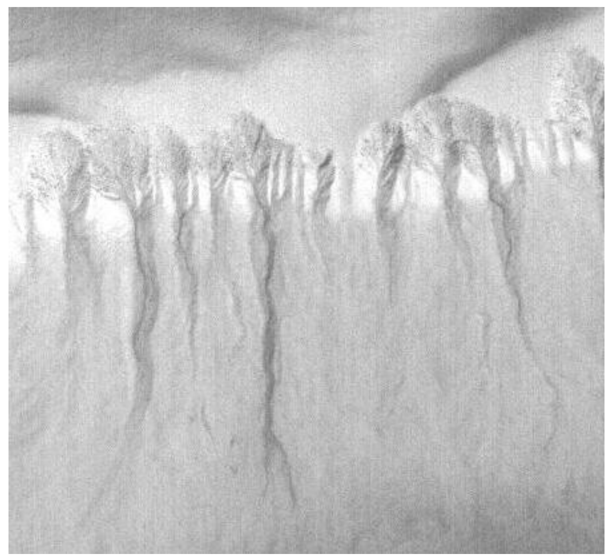

Figure 2: An example of recent flow channels on Mars at 71^o South - part of image M1003736 courtesy **MSSS/NASA/JPL**