FLUID-SUPPORTED DENSITY FLOWS ON EARTH AND MARS 2: PYROCLASTIC ANALOGS. N. Hoffman, WNS GeoScience, 22 Marlow Place, Eltham VIC 3095, Australia (nhoffman@vic.bigpond.net.au).

Introduction: A number of authors have referred to the striking similarity between the surface deposits and morphology of Mars and those in terrestrial volcanic deposits such as pyroclastic flows and ignimbrite plains. That analogue has generally been discounted due to the lack of appropriate source vents for the material.

Now that the White Mars paradigm explains the Amazonian outburst "floods" as the generation of voluminous cold gas-supported density flows by catastrophic local collapse of layered icy regolith, the observational constraint is removed. Now, we understand that any locally steep terrain segment on Mars may potentially have given rise to these cryoclastic flows and can concentrate on the morphology and depositional textures of such flows.

Analogs: On Earth, density flows are commonly seen in submarine turbidites (see accompanying paper) and volcanic pyroclastic flows. These latter are limited in their duration and volume by the size and eruption rate (or collapse volume) of the initial source of hot material and its inevitable rapid cooling. Pyroclastic flows on Earth travel only a few tens of km to ~100km before being quenched by cold surfaces. Water on Earth is particularly effective at quenching pyroclastic flows since the densest part of the flow which contains the bulk of the thermal energy typically plunges underwater and is rapidly engulfed, leaving only the lower density ash-prone component of the flow to continue over water. This may not be an insignificant flow in its own right. For example, the 22,000 yr B.P. Campanian Ignimbrite around Naples, Italy [1] covers 30,000km2 with extensive deposits. On the Sorrento Peninsula, deposits are over 40m thick despite crossing 35 km of open water in the Bay of Naples and overtopping a 700m-1000m ridge.

On Mars, the flows would be initially less energetic, but would have the ability to persist for many hours to a few days, due to continuing decrepitation and sublimation of CO_2-bearing ices (CO_2 clathrate and solid CO_2). Flows on Mars could have been enormous in volumetric terms compared to earth, being limited purely by the extent of the terrain involved in each collapse event. Flows involving 1,000,000 km^3 are not unreasonable on Mars, whilst on Earth the largest Caldera-forming events (e.g. Tambora, Yellowstone) are only a few thousand km^3. Quenching on Mars would not be likely due to the lack of standing liquid bodies in the Amazonian epoch.

Diagnostic evidence for gas-supported flows rather than long runout avalanches include a characteristic parallel striation on the surface from a combination of linear scouring and deposition. Flow channels tend to be broad, flat-bottomed, and weakly sinuous with teardrop islands around terrain obstacles. At the terminus of pyroclastic flows are huge flat plains where the flow has spread out and collapsed. Large boulders litter the surface of the flow in a random pattern strikingly evocative of the vicinity of the Pathfinder Lander, situated in one of the Chryse "outwash" channels.

Figure 1: Pyroclastic flow channel from Unzen volcano, Japan.

Figure 2: Surface deposits including random boulders from Unzen pyroclastic flows

Figure 3: Boulders deposited by a pyroclastic flow on Martinique. Compare to the large rocks strewn around the Pathfinder landing site.

Some of the peculiarities of pyroclastic flows include their ability to densify or expand depending on the terrain they cross. They may slow down or stop, then reform or generate secondary flows from the unstable margins of thick deposits. Momentum is a significant aspect of their flow, therefore they are able to flow uphill a considerable distance and cut erosional gullies through passes in ridges. The flows have significant thickness, compared to the amount of material transported, yet are often confined by relatively low banks that define the extent of the basal high-density part of the flow.

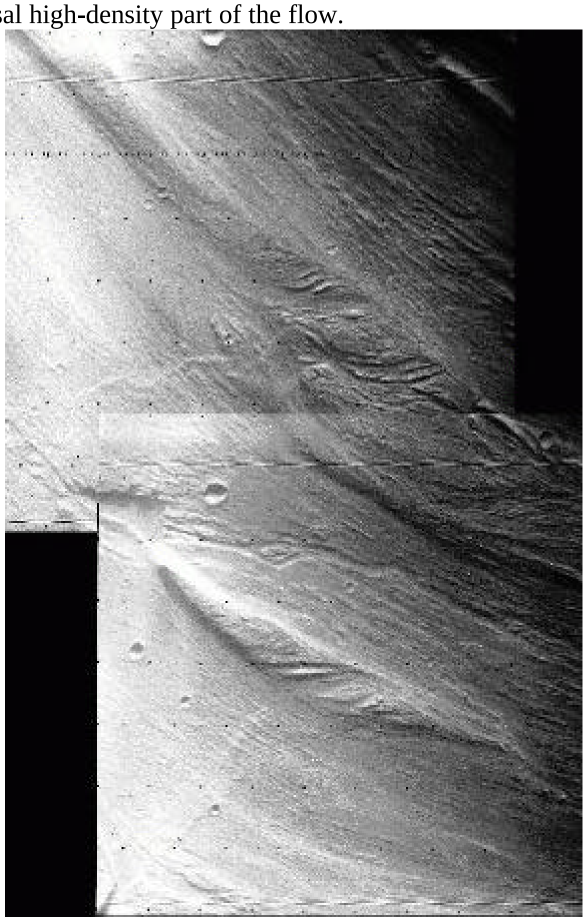

Figure 4: Within Kassei Vallis, flow-bounding ridges are cut across by shortcut flows that travel uphill to cross the ridges. Viking orbiter frames 655A42&44, north to right.

All of these features are seen on Mars. In fact, some flows show multiple transitions between depositional and erosional states, and between wide flat plains and incised channel morphologies. It is likely that on Mars, a third flow transition may exist between a gas-supported density flow and a liquid CO_2 lubricated slurry, as pressure builds with depth in the flow. The study of cold density flows (cryoclastic flows?) on Mars will teach us much about our sister planet, and about our own.

References: [1] Fisher et al. (1996) *Jour. Volcan. Geotherm. Res.* **56**, 205-220