FLUID-SUPPORTED DENSITY FLOWS ON EARTH AND MARS 1: TURBIDITE ANALOGS. N. Hoffman, WNS GeoScience, 22 Marlow Place, Eltham VIC 3095, Australia (nhoffman@vic.bigpond.net.au).

Introduction: The similarity between terrestrial submarine turbidite flows and Martian outburst “flood” channels has already been suggested [1], from the assumption that Mars’ lower gravity would be simulated by the buoyancy offered to sediment in a submarine flow. In this paper, the similarity is further explored from the different controlling principle that both are density flows involving an active fluid support. On Earth, that support comes from the water. On Mars, the fluid is gaseous CO_2, liberated from icy regolith that is involved in the initial collapse event and subsequent transport. Examples of real Earth bathymetry are compared to Viking photomosaics in terms of scale, morphology, and process.

Problems with Floods: The study of Martian surface processes has long suffered from the perception that liquid water has been active in the geological past. Now that the new White Mars paradigm of CO_2- based volatile cycling, transport, and erosion has been developed, it is possible to understand more clearly and explain more completely many of the enigmatic features of Mars. In particular, the Amazonian outburst “floods” have been difficult to explain because a considerable flow depth is apparent in each of many multiple outbursts. The volume of liquid water required to originate and sustain such flows is extreme. Since little sign of Amazonian fluid recycling is seen, the process appears to be a one-way transport of fluid from the equatorial regions to the Northern plains where, regrettably, there appears to be insufficient evidence for large bodies of standing water. At times, this evidence is used to suggest that there must have been an Oceanus Borealis which is now obscured by later reworking, but this argument is distinctly circular.

Carbon Dioxide: The one-time flow of fluid from equatorial regions is here shown to involve the structural collapse of equatorial regolith, saturated with solid CO_2, frozen out of the primordial Martian atmosphere. The dearth of evidence for standing bodies of water or other fluids of this age is explained by prevailing low atmospheric pressures which allow the CO_2 to largely transform to vapour and escape to temporarily replenish the atmosphere. In the process, the CO_2 gas is able to act as an active fluid lubricant and supports the density flow of disintegrating regolith.

Turbidite Analogs: In the last decade, detailed seabed bathymetry has extended far enough down the continental slopes to image the zones where turbidites are initiated and grow in their initial stages. Figure 1 shows a section of the Eastern Margin of the USA, extracted from NGDC online image data. This section of the continental shelf is an area where shelfal sediment is shed off the edge of the continental shelf over a broad sector, and many individual turbidite streams are sourced. The material initially plunges down sharp ravine-like canyons but then focuses into a series of broad, flat-bottomed channels with internal flow-parallel striations. These channels weave about in a manner extremely similar to the Amazonian “flood” channels on Mars, leaving ellipsoidal or teardrop islands between major strands of the channel. Note that due to the extreme water depths, this area has never been subaerially exposed. All the features we see are the result of erosion and deposition by channelised density flows embedded in an aqueous fluid medium.

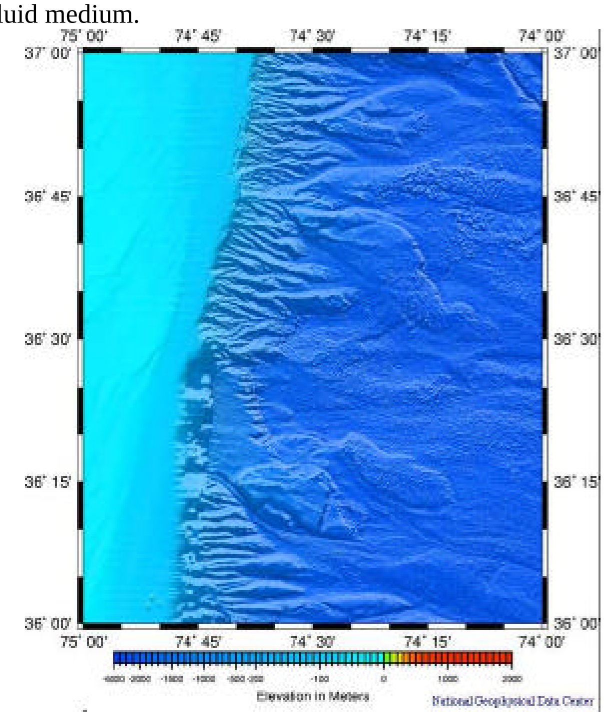

Figure 1: Turbidite runout channels in the West Atlantic. Frame height 110 km. Water depths range from 300m to about 4 km.

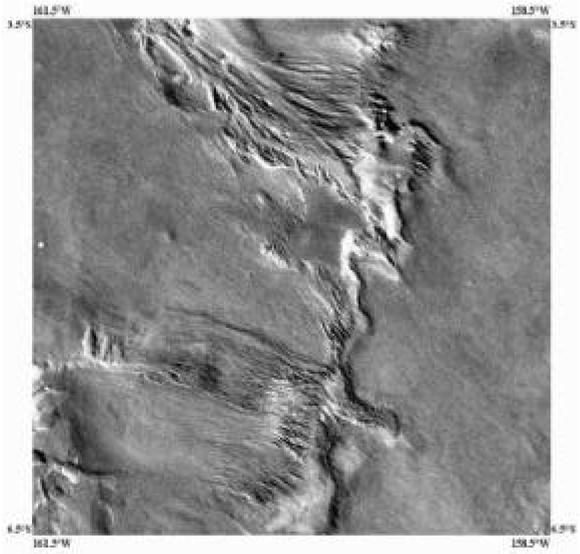

Figure 2: An appropriate Martian analogue would be the margins of the Mangala Vallis outwash plains where a flat debris apron transforms into and feeds a very similar pattern of coalescing ravines that transforms into identical channels.

Off the Northwest Coast of Australia, a compilation of low-resolution 2D seismic data shows headwall-sapping canyons that focus into turbidite runout channels that swing round and head for deep water. The situation is geometrically similar to the Chryse erosion channel network. Of particular interest is the mode of turbidite generation here. Segmental collapse of the surface layers of sediments leads to a direct correlation between large-scale amphitheatre geometries containing collapsed blocks - an analogue to Martian Chaos zones, connecting onto “flood” channels that are wholly submarine.

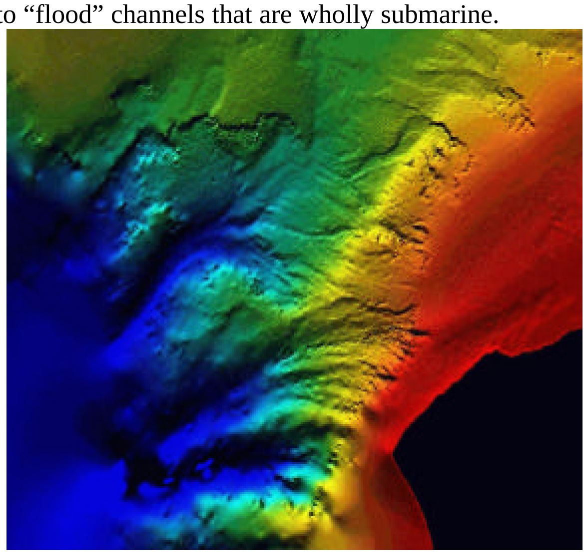

Figure 3: Submarine turbidite channels on the North-West shelf of Australia, eerily reminiscent of the Chryse outflow channels, complete with zones of “chaos”. Frame width 140 km.

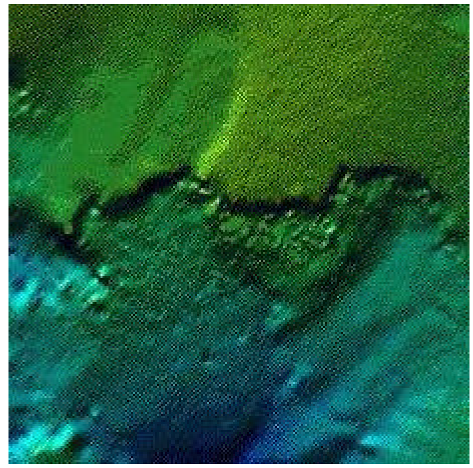

Figure 4: detail of “Chaos” zone of slumped km-scale fault blocks from layered sediments. Frame width 60 km.

Conclusions: It is clear that there is a striking physical similarity between the Amazonian “flood” channels on Mars and submarine turbidites on Earth. Key diagnostic features are: Broad flat channels with relatively low banks, and parallel grooves along the base. Origin at slumped margins or at multiple feeder ravines or chutes, ultimate destination in broad, low relief distributory fans or plains (not shown here). Long transport distances down low gradients, and the ability to carry coarse debris.

That similarity arises not because of a matching of effective gravitational force but because both types of flow are fluid-supported density flows. On Earth, the fluid is water. On Mars it is CO_2, largely in the vapour-phase.

References: [1] Kornar P. D. (1979) *Icarus* **37**, 156-181.