# IGNEOUS ACTIVITY AND THE ORIGIN OF THE FRETTED CHANNELS, SOUTHERN ISMENIUS LACUS, MARS

M.W. Carruthers: Department of Geology and Geography, University of Massachusetts Amherst, MA 01003

Evidence for igneous activity near and within the fretted channels in southern Ismenius Lacus (30-45N, 315-350W) suggests that interactions between igneous intrusions and ground ice may have been instrumental in the development of the fretted channels in this region. Evidence for igneous activity includes: 1) a maar-like closed depression at the head of the main channel in MC5-SC; 2) a mound of dark material within the main channel in MC5-SC; 3) uplift of, or levee formation on channel flanks; 4) rough, dark material in the lowlands of the fretted terrain; and 5) dark material on the floors of craters exhumed by the fretted channels.

Two major fretted channel systems, Mamers Valles in MC5-SW and an unnamed system in MC5-SC, incise the lower Hesperian ridged plains unit [1] of the highlands just south of the dichotomy boundary. The channels, first defined by Sharp [2], are generally hundreds of km long, 5-10 km wide, and greater than 1 km deep, with steep walls (>20°) and flat floors. Also present are closed canyons with similar steep walls and flat floors, and collapse depressions which are very near, connected to, or grade into the main fretted channels.

The presence of the closed canyons and collapse depressions is important in several respects: 1) closed canyons, having no outlet to the lowlands, could not have formed by running water or backwasting from the lowlands; 2) collapse depressions could not have formed by surficial erosion or backwasting, but instead suggest removal of material from below the surface layer; 3) the spatial relationship between collapse depressions and fretted channels suggests that collapse precedes channel excavation in the fretting process.

The presence of a significant amount of ground-ice in the fretted terrain and adjacent highlands has been fairly well established [3]. Carr [4] suggested that removal of material from collapse depressions and closed canyons could result from some combination of melting, seepage, and evaporation of ground-ice and water. Schultz and Glicken [5] proposed that some impact crater exhumation and channel development within and from craters could have evolved as a result of ice thaw and liquidification of sediments by the heat of igneous intrusions localized within the brecciated zone beneath crater floors. Their study included a number of floor-fractured craters and fretted channels in Ismenius Lacus, but the mechanism was not applied to the fretted terrain or the fretted channels as a whole. Squyres et al. [6] attributed the initiation of Dao Vallis on the southern flanks of Hadriaca Patera to interactions between ground ice and igneous intrusions or lava flows. Dao Vallis, though not associated with the fretted terrain, is very similar in morphology to the fretted channels.

Photoclinometric methods as outlined by Davis and Soderblom [7] were employed in this study to quantify the topography across channels, depressions, and possible igneous features. Unfortunately there are many uncertainties and assumptions involved in this method. Use of the asymmetric method requires an accurate estimate of the flat field value (dn of a pixel of a flat-lying surface) which is indicative of the albedo. It is difficult to define the flat field across channels because 1) channel material is commonly lighter than flank material so that a single flat field value is not valid for a profile across a channels 2) if channel flanks are sloping then there is no place nearby to estimate the flat field.

Error has been minimized by measuring the same profiles on images with different lighting angles, by matching opposing wall heights where it is reasonable to assume they are the same, and by constraining wall heights with shadow measurements where images with low incidence angles are available. Assuming that the haze factor (a measure of atmospheric and surface scattering of the light) has been estimated accurately, the general profile should be acceptable, but it should still be kept in mind that wall height and slope and flank slope measurements are rough.

Strong evidence for intrusive and possibly volcanic activity in southern Ismenius Lacus is found at the southwestern portion of the main channel in MC5-SC (35.5 N, 334 W). Here the channel terminates against a fracture bound block separating it from an irregular, closed depression (fig. 1, a). The depression is centered on a broad rise with smooth upper flanks and lower flanks incised by 400 to 800 m wide, 2 to greater than 20 km long valleys radial to the depression. A 4 km long, 50 to 100 m high dome sits on the depression floor.

This feature is interpreted to be a modified maar crater. A shallow intrusion into an ice or water-rich layer beneath a brittle cover could lead to an eruption of steam, regolith and country rock, and volcanic ejecta. Lobes on the lower flanks, radial to the crater, may be pyroclastic surges or debris flows. The inner dome may be a later volcanic construct or an exposed part of the intrusion. This feature is indicative of near-surface igneous activity which may have occurred throughout the region, initiating and aiding the development of fretted channels.

Approximately 120 km NE of the maar-like structure, the channel incises a roughly circular region whose flanks rise towards the channel. Within the channel is a gullied mound of dark material 8 km across and several hundred meters high (fig 1, b). This appears to be an eroded cinder cone formed after channel excavation. Cinder cones commonly form after the explosive phase of maar crater formation when there is not enough water left for phreatomagmatic activity. The channel itself may have been initiated by shallow intrusion, a maar-type explosion and excavation, or, as the cuspate nature of the walls suggests, a number of smaller intrusions or phreatomagmatic explosions. It is difficult to determine whether the 1° to 7° slopes of channel flanks surrounding the cinder cone are a result of volcanic construction or of uplift due to intrusion. Similar outward sloping topography is found along the flanks of Mamers Valles. In places small lobes and scarp fronts, in addition to the smooth texture of the material, are suggestive of levees of volcanics or mobilized sediment.

Additional evidence for igneous activity associated with the formation of the fretted channels includes a region of particularly dark material exposed in the lowlands just north of the boundary scarp around 40N. 330W. At high resolution the material has a mottled appearance, and is very rough compared to the nearby highlands and smooth channel material which embays it. The unit is of relatively high relief, standing above the lowland channel floor, but slightly lower than the highlands. These dark units are interpreted to be exposures of resistant, unweathered, mafic volcanics or shallow intrusives, either of which could provide heat and mechanical force to initiate or promote the growth of the fretted channels and the southern fretted terrain.

Smoother, low relief dark material flooded by light, smooth channel material is found on the floors of exhumed craters in Mamers Valles. This in conjunction with their leveed outer flanks suggests that rimless, ejectaless craters which are incorporated into channels and are commonly interpreted to be exhumed impact craters, may instead have an endogenic origin, or may be of mixed origin as proposed by Schultz and Glicken [5].

A general model for fretted channel growth can be drawn based on observations in southern Ismenius Lacus: ice and water, melted and vaporized by the heat of shallow igneous intrusions escapes through fractures and small vents, leading to ground subsidence. Excavation of closed canyons and fretted channels proceeds by: 1) phreatic or phreatomagmatic explosions; 2) extensive fracturing of the surface layer and mobilization of saturated material; or 3) secondary wall collapse, headward erosion, and flow of debris from walls and down channels [8, 9]. Fretted channels grow preferentially through impact structures which may serve as loci for igneous and hydrothermal activity and channel initiation, and as low resistance growth routes [10].

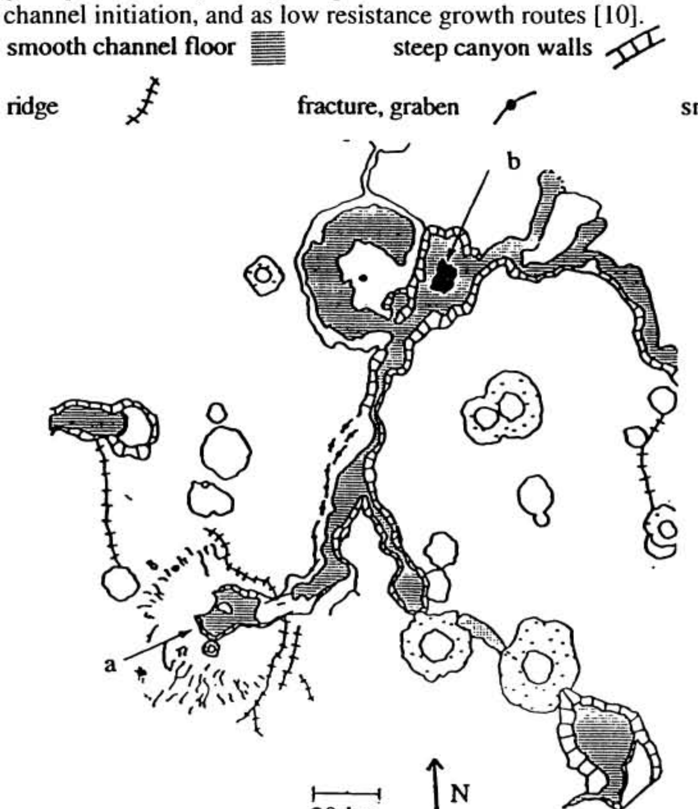


Figure 1. Geomorphologic sketch map of the southwestern portion of the main fretted channel in MC5-SC. (a) Closed canyon interpreted to be a maar crater. (b) Dark mound interpreted to be a volcanic construct. Sketched from Viking orbiter images 231s33 - s38, 567a08.

References: [1] Greeley, R. and J.E. Guest. (1987) USGS Map I-1802-B. [2] Sharp, R.P. (1973) *JGR*: 78, 4073-4083. [3] Squyres, et al. (1992) in *Mars*, Kieffer et al. eds. Tucson: University of Arizona Press, 1498 p. [4] Carr, M.H. (1986) *Icarus*: 68, 187-216. [5] Schultz, P.H. and H. Glicken. (1979) *JGR*: 84, 8033-8047. [6] Squyres, S.W. et al. (1987) *Icarus:* 70, 385-408. [7] Davis, P.A. and L.A. Soderblom. (1984) *JGR*: 89, 9449-9457. [8] Squyres, S.W. (1978) *Icarus*: 34, 600-613. [9] Lucchitta, B.K. (1984) *JGR*: 89, 409-418. [10] Carruthers, M.W. (1994) *Eos*: 75, 217.