THE CHENIER CRATER FLOWS: EVIDENCE FOR AN ORIGIN AS TSIOLKOVSKY IMPACT MELT

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Introduction: The origin of the flows in Chenier crater have long been the subject of intense debate. A variety of volcanic [e.g. El-Baz and Worden (1), West (2), Villella (3)] and impact [Whitford-Stark and Hawke (4)] origins have been suggested. As a result of recent studies of lunar impact melt and clastic debris deposits, sufficient evidence now exists to demonstrate an impact melt origin for these enigmatic flows.

Morphology of flow units: The two flows under consideration occur in the floor of Chenier crater which is a 37 km pre-Tsiolkovsky impact structure located 21.5 km northeast of Tsiolkovsky. The longest flow (flow 2) extends for 14.7 km and varies in width from ∿3 to ∿5 km. The flow thickness is quite variable, being thin where the unit crosses a topographic inflection. There is evidence that the flow material originally covered a larger area but moved downslope to merge with the main unit. The surface texture of flow 2 varies from pitted to generally smooth and exhibits neither longitudinal nor transverse ridges. The shorter of the two flows (flow 1) is 8.7 km in length and varies from about 1.5 to 2.3 km in width. Topographic data suggests a maximum of thickness of about ∿150 m. Lateral ridges exist along portions of the flow and one or more grooves can be seen along much of the length.

Although the flows are concentrated in topographic lows, portions are draped over subjacent terrain from which they failed to completely drain. Such relationships suggest emplacement as fluidized flows and are common in impact melt deposits around other lunar craters [e.g. King crater; Howard and Wilshire (5), Hawke and Head (6)]. The lobate form of the deposits also suggests fluid emplacement.

Origin and mode of emplacement: The Chenier flows clearly overlie Tsiolkovsky ejecta deposits and thus were emplaced after the termination of radial flow of crater ejecta. The flows appear to have originated high on that portion of the Chenier crater wall adjacent to Tsiolkovsky. The apparent source can be identified in the vicinity of a major landslide scar visible on Apollo photographs as well as the topographic map of the area. Abundant lineations clearly demonstrate that the flow material moved down the Chenier wall to the crater floor. The presence of a scar in the source area is a further indication that flow formation was initiated after the deposition of Tsiolkovsky ejecta and hence the fluidization of the flow material cannot be attributed merely to forceful ejection. It is instructive to note that the apparent source area for the flows was adjacent to a hummocky but generally flat Tsiolkovsky ejecta unit which is strikingly similar to deposits interpreted to be composed of clast-bearing impact melts by Hawke and Head (6). Similar material was probably present in the source region of the flows prior to their development.

An extremely efficient emplacement mechanism is required to account for the transport of flow material far beyond the base of the originating slope. The flow unit traveled a maximum horizontal distance of ∿26 km, experienced a maximum vertical drop of ∿1.9 km, and has a low effective coefficient of friction (0.073). Flow 2 would have traveled an even greater distance had it not encountered the elevated terrain on the northeast side of the Chenier crater floor. This low coefficient of friction implies an extremely efficient mode of transport. Such mobility would not be expected of a dry flow of clastic debris emplaced after the termination of the cratering event when a radial velocity component due to forceful ejection would no longer be important. Dry lunar avalanches clearly due to local slope failure are not very efficient. Howard (7) noted that only a rare few of the avalanche deposits recognized on crater walls extend beyond the steep crater wall out onto the floor. Typical of these few is the landslide on the wall of Jansen B crater (Diameter = 17 km). The coefficient of friction of this landslide is 0.435, much higher than the 0.073 calculated for the Chenier flows. Additional studies of certain lunar clastic debris deposits that were previously thought to have been very efficient (e.g., the Apollo 17 light mantle) have demonstrated that they were partly propelled by impact processes [Howard (7), Lucchitta (8)]. In light of the above considerations, it appears that the Chenier flows are not dry clastic debris deposits but were fluidized by some agent. In view of the absence of a significant lunar atmosphere and the anhydrous nature of the Apollo samples, air and water can be ruled out as fluidizing agents. The one liquid component known to be capable of producing such fluidized deposits is impact melt, which, as discussed above, was probably present in the source region of the Chenier flows.

Relationship of Chenier flows to other Tsiolkovsky melt deposits: As discussed above, the hummocky, flat unit in the vicinity of the source of the Chenier flows is probably composed of clast-bearing impact melt. This unit is well within the zone of melt deposits seen on other portions of the Tsiolkovsky rim (4,5,6,9). In addition, the unit

is not in the approach direction for the oblique impact and occurs adjacent to a Tsiolkovsky rim crest low, both factors which have been shown to be important in controlling melt distribution. Clearly defined melt ponds have been identified in the vicinity of the hummocky unit and flow source. Impact melt ponds and flow features have been identified between the hummocky region and the Tsiolkovsky rim crest, on that part of the crater wall adjacent to the hummocky unit, on the south rim of Chenier crater, and are quite abundant further to the south.

Conclusions and Implications: An analysis of the Chenier flow units has shown that they are not likely to be clastic debris flows or volcanic deposits. Based on flow unit morphology and morphometry, stratigraphy, and relationship to Tsiolkovsky melt deposits, as well as comparison with other lunar impact melt deposits and landslide deposits, it is concluded that the Chenier flow units are composed of clast-bearing impact melt and were emplaced as melt-fluidized flows after the termination of the Tsiolkovsky impact event.

The criteria developed in this study can be used elsewhere on the Moon to distinguish flows of impact melt from clastic debris deposits. If it can be demonstrated that a given flow was initiated and emplaced after termination of crater ejecta radial flow and if the deposit exhibits a low effective coefficient of friction, an impact melt origin is suggested.

References:

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