WET DEBRIS FLOW DEPOSITS NEAR ELYSIUM MONS: EVIDENCE FROM CRATER MORPHOLOGY

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Numerous indications of sub-surface ice have been cited in the Elysium region (e.g. 1,2). Of particular interest are the complex channel systems that issue from fissures to the north and west of Elysium Mons, and the associated deposits (fig. 1). The channeled deposits, identified as unit Ael_3 (3), have been interpreted as lahars (4,5), with the morphological evidence for this being summarised in (5). An analysis of crater characteristics in the region gives further credence to the laharic nature of these materials.

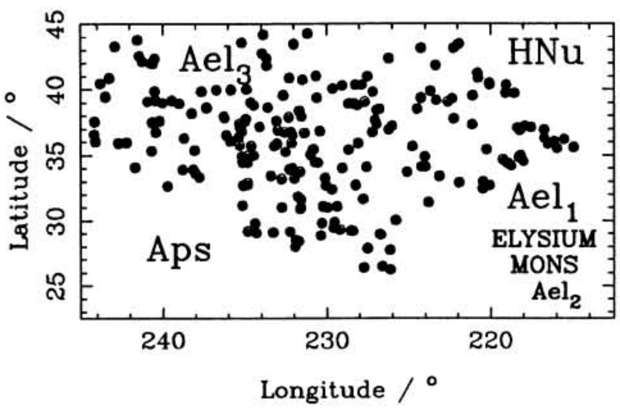

Figure 1: *Location of Ael_3 craters.*

As part of a comprehensive analysis of crater morphology, a database (6,7) containing details of 7489 craters was subdivided according to geologic unit (3,8). Graphs of ejecta diameter against crater rim-to-rim diameter (hereafter EvsΦ) for each selected set were investigated, on the premise that the gradient of these plots would indicate the mobility of the ejecta which is presumed to reflect the degree of fluidization (9,10,11,12). In this way the fluidity of the ejecta could be examined as a function of crater diameter which is indicative of the depth of materials excavated during the impact.

The majority of the 30 geologic units studied showed a well-defined relationship between these variables, with many exhibiting significantly higher values of EvsΦ at larger crater diameters (fig. 2a). Where sufficient data existed, the trends could be best represented by two linear fits. It is assumed that the gradients and the position of the break points indicate the volatile concentration and the depth to volatile-rich strata respectively. The locations of the break points and the gradients for craters smaller and larger than this value were obtained using the method detailed in (7). Several units only had one gradient, but in all cases these occur where a limited range of craters has been detected, thus these values are representative of EvsΦ gradients of smaller craters only.

The gradients obtained in this way averaged 2.4 ± 0.4 for craters below the break point and 3.9 ± 0.8 for those above. In all instances bar one, the gradients for craters larger than the breakpoint were found to be significantly higher than those for the smaller craters. This would be consistent with the notion that the shallow layers of the units are volatile poor, and that larger craters become more fluidised as they tap into a volatile rich level at depth. The one exception to the rule occurred for the unit Ael_3. The EvsΦ plot (fig. 2b) for the 140 craters with ejecta on this unit yielded a high gradient of 3.22 ± 0.22 for *small* craters, which *decreased* for craters of 7.4 km and over to a gradient of only 2.34 ± 0.30. The gradient for large craters in this instance is subject to high error due to the scatter of data points. It is clear however

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that the gradient for *small* craters is anomalously high; it is greater than that calculated for small craters on any other units, and is comparable with the minimum gradients of larger craters. This value is much higher than the gradients obtained for small craters in surrounding units (Ael_1 2.34±0.07, Ael_2 1.93±0.08, Aps 2.33±0.18). It is also higher than the relevant gradient for all small craters at this latitude (7).

Discussion

It therefore appears that there is a localised enrichment of near-surface volatiles in an area which is restricted to the Ael_3 unit. This interpretation is further supported by initial investigations of the morphology of the ejecta. The Ael_3 unit contains the highest concentration of double ejecta craters within the limits of the larger study area (245—155° Longitude, 20° S—45° N)(13). All of these have a very fluid appearance, and over two thirds of them have crater diameters smaller than 7.4 km. Other morphological characteristics that might indicate the action of volatiles are currently being examined.

This work has provided further evidence that the Ael_3 unit built up from volatile-rich materials. Moreover, the deposits *retained* volatiles at shallow depths for a considerable time since the impact craters post-date the unit. The wet debris flows postulated by (4,5) would provide a plausible mechanism for the inferred volatile enrichment of these deposits, particularly since water is likely to be trapped in the deposits initially. In the case of predominantly fluid transport, the solid load would tend to be emplaced nearer to the source, while the water flowed away or was lost to the atmosphere. Christiansen (5) concludes that the deposits were the result of lahars issuing from fissures in the flanks of Elysium Mons, with the associated channels being carved by later, more water-rich phases of activity. He further suggested that the source of the water was below the volcanic province, an idea which is compatible with the results being obtained in this analysis.

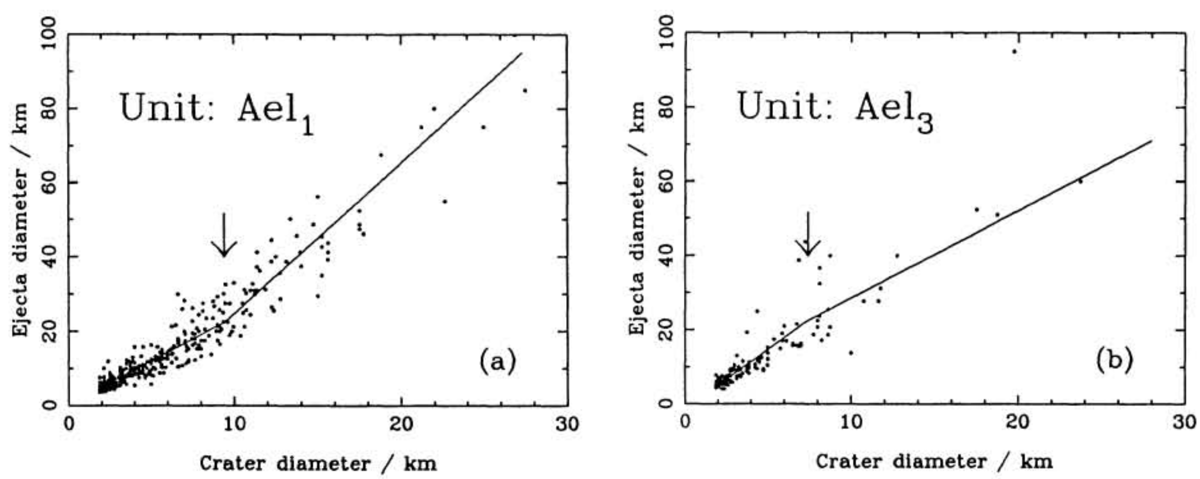

Figure 2: *Plots of ejecta vs. crater diameter*

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