DISTRIBUTION OF VOLATILES IN THE ELYSIUM REGION, MARS

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The Elysium region contains much morphological evidence of sub-surface ice (e.g. 1,2) including channels, fluidised craters and landforms that may have resulted from volcano-ice interactions (3). The dimensions and morphologies of impact craters and their ejecta may be used to investigate target and environmental characteristics (4,5). Preliminary mapping of the Elysium volcanic province indicated a diversity of crater types, and a detailed classification scheme (6) was devised to record the details of all craters over 1.875 km in diameter in the area shown in fig.1. The limits of the study area were chosen to include terrain which is cut by channels in the region peripheral to the Elysium rise. The transitional region and part of the highlands to the south of Elysium were included so that the characteristics of highland and lowland craters could be compared. The details of 7289 craters were incorporated into a database which is currently being analysed to determine the dominant factors that have influenced crater morphology.

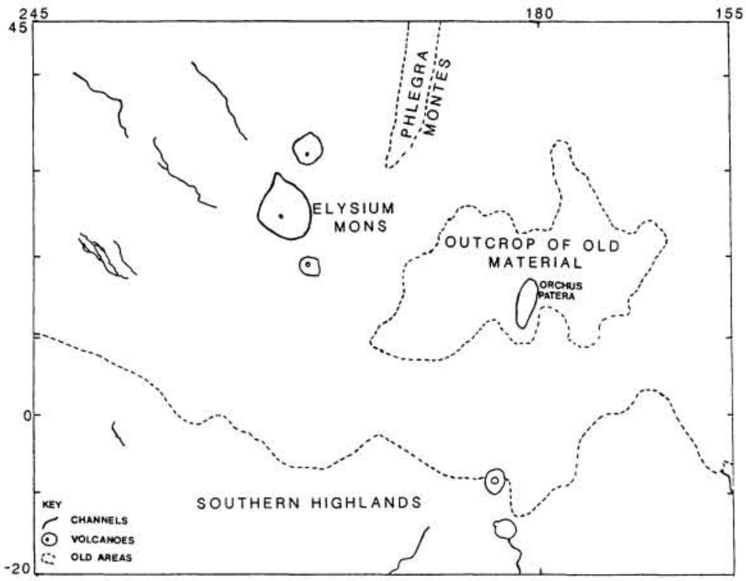

FIGURE 1: AREA COVERED BY THE CRATER DATABASE

The ratio of maximum ejecta diameter to crater diameter indicates the mobility of the ejecta which in turn reflects the degree of fluidisation (7,8,9). Therefore it is presumed that concentrations of sub-surface volatiles could be located by investigation of this ratio. There are many variables that could influence volatile location; the study area covers a range of latitude, altitude, geology and age. Initial studies of the variation of the mobility ratio with latitude revealed a substantial scatter of data with no obvious trends (10). Subsequent investigations of plots of ejecta diameter against crater diameter (hereafter EvsΦ) showed that there is a well-defined relationship between the two. The plot for all craters was of the form of a broad rising curve, indicating that larger craters are more strongly fluidised than smaller craters. Therefore the EvsΦ ratio cannot be used in isolation to chart volatile concentration since it is apparently strongly dependent on crater size and hence on depth of excavation. It is possible that this general increase in the ratio is due to the incorporation of volatile-rich material at depth.

The data were sorted into 5° bins from 20° S to 45° N and the EvsΦ graphs for each were examined to see if the depth at which the volatile-rich layer began could be ascertained. These plots indicated linear relationships, with gradient discontinuities designating the change in ratio between smaller and larger craters. In many cases the position of the discontinuity was clearly detectable by eye, but in order to reduce subjectivity and to maximise accuracy and repeatability, a statistical method was used to aid its determination. A program was constructed which, at successive increments in crater diameter, divided the data into two groups and calculated the resulting combined χ^2 for least square fits to the craters smaller and larger than each potential break-point. In theory, the optimum break-point occurs where χ^2 is minimised. In practise however, a clear minimum is not always apparent, and therefore the locations of the break-points were found from a visual examination of both the χ^2 and the resulting linear fits.

ELYSIUM VOLATILES: J. A. CAVE

A striking latitudinal trend was apparent in a plot of break-points and gradients, with the diameter of the discontinuity decreasing with increasing latitude in the northern hemisphere. A break-point was not obtained for the northernmost bin since no linear trend was observed here; the usual linear trend breaks down into a scatter, due to a high concentration of pedestal craters (10). In order to verify that this trend was not an artifact of the methodology of this study, the data were binned latitudinally once more but with the 5° bins starting at 17.5° S, and the process was repeated. A virtually identical plot was obtained (fig.2), again indicating a progressively smaller crater break-point with increasing latitude.

The one point (arrowed in fig.2) that lay far from the general trend was also evident in the second plot. It was noticed that a large outcrop of older material occurs at this latitude in the right half of the study area. All craters of latitudes 15° N to 25° N were selected for the left and right hand sides of the study area and the EvsΦ plots were analysed. Clearer correlations between the data were observed; the left half plot had a calculated break-point of 7.81 km and gradients 2.33±0.11, 3.85±0.16 which fit well with the general trend. The right half set had few large craters but indicated that the trend was linear until at least 13 km diameter, with a lower gradient which also corresponded well with the observed anomalous points. This would suggest that the dominant latitudinal trend has been influenced by the presence of this older material in this area. Other localised departures from the overall trend have been detected (11).

Summary

If the break-point reflects a transition with depth from volatile-poor to volatile-rich strata, this work indicates that the depth to volatile rich materials decreases progressively towards the north in the study region. This trend has been revealed in a latitudinal study, but it should be noted that there are also significant variations in altitude, age and geology across this region. The majority of craters that possess measured ejecta in the area show *some* indication of emplacement by flow, and so the calculated break-points probably reflect changes in the concentration or nature of sub-surface volatiles. The morphology of craters as a function of diameter and location is currently under study to see if morphological indications can be used to verify the suggestion of a variable volatile reservoir in the area. The indication of volatiles at depth in the southern materials and more shallow volatiles in the northern lowlands has important implications for the origin and distribution of volatiles on Mars as a whole. Continuing analysis of the database and comparison of the results to regional geology will place further constraints on the history of volatiles in the study area, which are needed to understand the martian water budget and surface evolution.

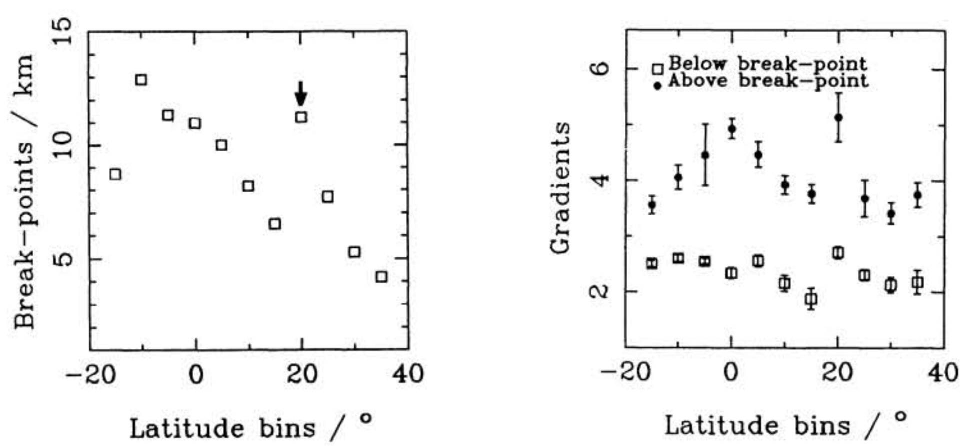

Fig.2

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