Possible temperature-related slope and surface roughness differences between the north and south walls of Coprates Chasma, Mars

DISSERTATION FOR DOCTOR PHILOSOPHIAE DEGREE

submitted by

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GENERAL EVALUATION

Jørn A. Jernsletten's dissertation has been written in the form of a monograph, which consists of more than 250 pages and is organized in nine main chapters that are followed by two appendices and a list of references.

The dissertation in concerned with the geomorphic processes that have shaped the walls of the largest canyon system on Mars, the Valles Marineris, which is more than 100 km wide, more than 3000 km in length, and typically 5-10 km deep. Although the origin of this canyon system was related to tectonic faulting, the canyon walls have undergone weathering and considerable erosion by mass-wasting processes, such as rockfalls and landslides, and have also been modified by the action of flowing water. The dissertation focuses on the role of ground ice in the evolution of Martian landscape, and – in particular – on how the differences in the thermal regime of the canyon walls facing the equator and the pole, respectively, are reflected in the canyon's morphology, especially in the steepness of the canyon-wall slopes.

The author demonstrates convincingly a strong relationship between the slope steepness and the slope orientation. He finds that the equator-facing canyon walls are significantly less steep than the pole-facing walls, which he correlates with the warmer average temperatures on these former walls. Other factors, such as differences in the canyon depth and rock properties, show no obvious correlation with the wall steepness. He concludes that it is the lower temperatures beneath of the pole-facing walls that increase the slope's mechanical strength and permit higher slope gradients, because of the strengthening role of ground ice in these walls. This explanation of the observed morphological differences, invoking ice-related differential strength, is itself plausible, but may not necessarily be the only possible interpretation; alternative explanations should have been discussed and possibly eliminated. Similarly, the equation used by the author for the calculation of average temperatures may not necessarily be correct (concerns can be raised that a closed-form solution of this type is not possible), and hence may require further justification or modification. However, it should be emphasized that the entire empirical analysis of canyon-wall slopes presented by the author is independent of this calculation.

Jernsletten's statistical study of the differences in canyon-wall steepness, with respect to the slope aspect and latitude, involves a well-conceived experimental design and is based on an original and extensive dataset, derived mainly from the NASA MGS mission. The statistical techniques used are straightforward and robust, revealing significant morphological patterns. The author's analytical approach as a whole is a commendable effort, worthy of a doctoral degree.

The dissertation in its most parts is lucidly written; the author's review of the literature on Martian slope processes, permafrost, geology, structure, and climate is thorough and up-to-date; and the figures are well drafted and informative. The range of topics summarized in the literature review addresses all the essential issues relevant to the author's study, including a comparative discussion of the geological and engineering knowledge on terrestrial slope stability and ground ice.

In conclusion, the committee considers Jørn Jernsletten's dissertation to be a significant contribution to the planetary literature and recommends that it is accepted for a public defense, towards the formal requirements for the Doctor Philosophiae degree.

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