Session: P059: Using Topography to Investigate the Evolution of Solar System Bodies

Title: Investigating the Formation of Noctis Labyrinthus, Mars

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Noctis Labyrinthus is a domical, highly faulted region on Mars situated west of Valles Marineris and southeast of the Tharsis Rise. The geomorphology of this region is complex, and the mechanism(s) responsible for the tectonic structures therein is not fully understood. Normal faults and graben complexes are widespread, and pit crater chains commonly coalesce and merge with the large troughs that dominate the central region of Noctis Labyrinthus. We combined detailed structural analysis with geophysical data to develop a relative formation sequence for this enigmatic region of Mars. We used fault displacement profile analyses as well as displacement–length scaling to characterize the populations of normal faults present. Our structural analyses show that there are two distinct populations of normal faults, one set with vertical displacements of ~375–500 m, and a second set with displacements of ~75–250 m. The geometric parameters of pit craters (major/minor axes, pit depth, and volume) were measured to determine their contribution to the geomorphology of the region. We find that individual pit crater chains increase in size, both in terms of diameter and volume, with increasing proximity to the central region of Noctis Labyrinthus. Importantly, we also find that the dimensions of the graben and pit crater systems within Noctis cannot be accounted for by tectonic deformation alone: they are simply too broad and too deep to have resulted solely from extensional tectonics. We propose that substantial volume loss has also occurred here, albeit perhaps enabled by crustal extension. For example, pit crater formation and normal faulting could expose subsurface volatiles (e.g., ground ice deposits) within the faulted sections, allowing for sublimation or melting and the opening of the troughs beyond that which is possible through faulting alone. Heat flux modeling for Mars shows that the Noctis Labyrinthus region has among the greatest present-day heat flux values, providing a basis by which volatile loss could have occurred here. The lack of large outflow channels in this region, however, suggests that sublimation, rather than large-volume melting, took place in this region. If so, then areas of comparatively little faulting with Noctis may still host substantial and as-yet unexposed deposits of subsurface ice.
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