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Insights into pitted cones at Isidis Planitia through synthesis of interior and surface

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The Isidis Planitia impact basin on Mars is located on the north-south dichotomy boundary, bordered by Utopia Planitia and the Syrtis Major volcanic province. The basin records a long geological history of global and regional events of impact-induced, volcanic and sedimentary processes. This is evident in the presence of a high-density subsurface mass concentration, the strongest on Mars outside the major volcanic provinces. The nature of this interior structure remains poorly understood despite modelling efforts (e.g., [1-3]). Isidis Planitia's surface also hosts the densest clustering of pitted cones [4,5]. The formation mechanism of these landforms, characterised by a conical mound with a central depression, remains debated as volcanic [6], sedimentary [4] or glacial [7].

We present an integrated approach to Isidis Planitia, showing that pitted cones are topographically constrained by surface wrinkle ridges driven by its subsurface structure. The subsurface is modelled using impact scaling laws combined with geological context to formulate a multi-layered model, which is fit to the local gravity field. Resultant structural elements are consistent with impact theory [8-10], estimated structures below Lunar basins [11,12], as well as mapped basins [13]. However, the gravity field cannot be constrained using infill, scaling laws and realistic density values. The models require mantle-like materials in the innermost parts of the basin. This element does not reconcile with expectations of impact theory nor basin infill, and is interpreted as significant post-impact plutonic intrusions.

This intrusive element is linked to a set of wrinkle ridge surface expressions with anomalous direction and dip. Two distinct formations of ridges are identified: an initial radial set of ridges and a latter concentric inward-dipping formation. This anomalous concentric set is not mirrored in Lunar basins [14,15] nor in Martian basins Utopia and Hellas [16,17]. The initial set is likely driven by regional compressive effects. The latter formation is driven by a stress field in the inner basin, which could be achieved during pluton inflation.

The pitted cones are shown to correlate with the basin topography dominated by the wrinkle ridges. The population conforms to both sets of pre-existing wrinkle ridges in distinct surface flow patterns. They are most consistent with volcanic rootless cones formed by lavas interacting with near-surface volatiles. The lava could be sourced from the intrusive magmatism, addressing the lack of other sources [6]. Overall, this study links Isidis Planitia's subsurface structure to surface morphology. It could redefine the complex and dynamic basin, offering new insights into the

active geological evolution of Mars.

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