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Tectonic structural complexity in Caloris basin, Mercury

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1. Introduction

Caloris basin is the largest young impact feature recognized on Mercury [1]. Its interior smooth plains host a variety of tectonic structures that were first described from Mariner 10 images [cf. 2, 3]. With MESSENGER Mercury Dual Imaging System (MDIS) data, at a resolution of 250 m/px or better (**Figure 1**), we document the nature, distributions, and cross-cutting relations of these structures, and we find that no single proposed formation mechanism satisfies all structural observations.

2. Caloris basin tectonic structures

Extensional faults appear as graben, whereas wrinkle ridges are the predominant form of contractional structures. We describe each structural type according to its orientation with respect to the basin center, e.g. radial, circumferential, or oblique.

2.1. Extensional structures

The most prominent graben set, Pantheon Fossae [4], originates from near the basin center and extends radially to ~0.55 of the radius of Caloris (r_C) (**Figure 1:1**). With more than 200 graben and graben segments, this set displays structural geometries typical of normal faulting, including tapered ends and relay ramps in stepover regions. Whereas radial graben occur almost axisymmetrically, those that lie sub-parallel to the mainly east-west illumination directions are difficult to discern. In addition, there is a dearth of radial graben at ~0.25–0.35 r_C along an azimuth of ~230°. A set of graben concentric to the basin center extend over ~0.45–0.55 r_C and generally bound their radial counterparts (**Figure 1:2**). Northern portions of this set form several distinct bands of graben, but elsewhere they define a more diffuse zone of circumferential extension. Finally, a third set of graben, with radial through intermediate to circumferential orientations, describe an annulus of polygonally patterned terrain that extends from ~0.55 r_C to the basin margins (**Figure 1:3**).

2.2. Contractional structures

Contractional landforms in Caloris are not as partitioned by orientation as extensional structures. Radial and circumferential wrinkle ridges occur together over ~0.1–0.7 r_C (**Figure 1:4**), rather than in discrete structure sets, though the latter orientation is somewhat more prevalent. Radial and circumferential ridges are often sinuous, and display fault linkage with neighboring structures. Where radial graben disappear at ~230° azimuth, radial ridges are particularly visible. From ~0.7 r_C to the basin margins, ridges define a polygonal pattern (**Figure 1:5**).

2.3. Cross-cutting relations

Earlier workers found a consistent relationship of extensional features superposed upon contractional structures [e.g., 5]. We note instances where concentric graben lie along the crests of circumferential ridges, and several sites where ridges appear seemingly offset laterally along the bounding faults of radial graben. Our observations generally support a relative age relationship of extension occurring after contraction of the basin's interior fill. However, targeted MDIS narrow angle camera (NAC) high-resolution (~50 m/px) images of graben-ridge intersection shows no definite structural offsets, so we regard this temporal sequence as equivocal.

2.4. Tectonic structures and topography

Topographic data for Caloris, derived from laser altimetry [6] and stereo photogrammetry [7, 8] reveals long-wavelength undulations of the basin floor (**Figure 1**). The northern and southern portions of the floor are elevated (to above the rim in parts), whereas an east-west-orientated trough crosses the basin's center. We attribute these undulations to lithospheric folding due to horizontal shortening as Mercury's interior cooled. With no obvious correlation between topography and tectonics, fold-induced strains may have been too low ($\sim10^{-5}$) to influence basin-localized deformation in Caloris [9].

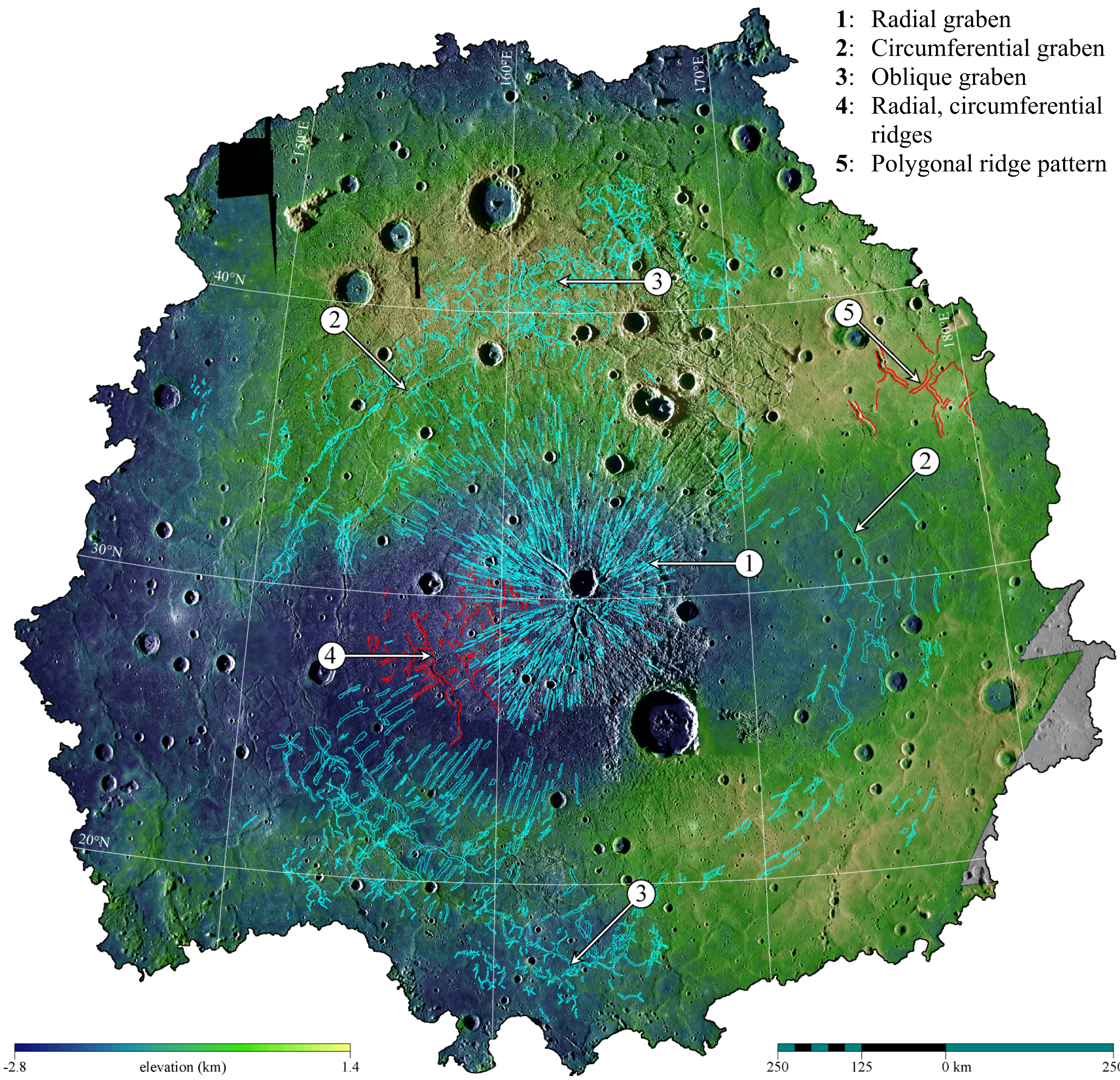

Figure 1. MDIS mosaic of Caloris, overlaid with stereo-derived topography (shown in an azimuthal projection, centred at 31.5°N, 162.7°E). Those extensional structures we have currently mapped are shown in cyan, and contractional landforms are in red.

3. Formation processes reappraised

Our observations allow for a renewed analysis of the tectonic history of Caloris basin. Previous studies of the suite of tectonic structures therein [e.g., 10, 11], or of specific structural sets such as Pantheon Fossae [e.g., 12, 13] do not account for the variety and complexity of structures within this basin. This ongoing study provides both a rationale and constraints for new hypotheses for the tectonic evolution of the Caloris basin.

References

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