Earth and Planetary Science Letters 285 (2009) 251–262

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

journal homepage: www.elsevier.com/locate/epsl

Evidence for intrusive activity on Mercury from the first MESSENGER flyby

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ARTICLE INFO

Article history:
Accepted 4 March 2009
Available online 21 April 2009

Editor: T. Spohn

Keywords:
Mercury
dikes
intrusion
graben
MESSENGER

ABSTRACT

Images from MESSENGER's first flyby of Mercury have shown convincing evidence for surface volcanism. Here we report on evidence in the new data for several features that are characterized by fractures and graben — rare features on a planet dominated by contractional deformation — that may be linked to intrusive activity. These features include: (1) A floor-fractured crater, interpreted to have been the site of laccolith-like sill intrusions; the feature is similar to some floor-fractured craters on the Moon and shows evidence for individual fractured dome-like uplifts on the floor. (2) A concentric complex of graben, observed inside the peak ring on the floor of the ~250-km-diameter Raditladi basin and associated with dark plains and possibly embayed by them; the feature may represent an unusual type of floor-fracturing associated with deeper intrusions and related ring dikes or cone sheets, or the graben may instead be the product of non-magmatic uplift of the basin floor. (3) A large radial graben swarm, Pantheon Fossae, located near the center of the Caloris basin, thus far unique on Mercury, and characterized by hundreds of individual graben segments ranging from ~5 km to ~110 km in length. In the nexus, graben crosscut one another and produce a local polygonal pattern; others curve away from the center as the nexus is approached. Two scales of graben length are observed; the radius of the dense radially symmetric plexus of graben is ~175 km, and a few graben extend to greater radial distances to the north and southwest out to distances that intersect with a ring of generally concentric graben around the outer basin floor. Two width scales of graben are observed; a large graben about 8 km wide emerges from the nexus and extends for ~100 km; most graben are less than half this width. Some graben walls appear cuspate, with convex-outward wall segments that resemble crater chain segments. One crater chain with distinctive raised rims parallels nearby graben. Locally, some graben appear in *en echelon* patterns, and smaller graben sometimes show cross-cutting (superposition) relationships. Abundant impact craters, the most prominent being Apollodorus, and secondary crater clusters and chains are superposed on the graben system; there is little evidence that craters greater than 5 km in diameter have been cut by a graben. This relation implies that the graben swarm formed soon after the emplacement of the Caloris floor plains. These graben are interpreted to be the surface expression of a radial dike swarm emanating from a subsurface magma reservoir. Similar features, in which the dikes contribute to a near-surface stress field that favors radial graben, are known on the Earth, Venus, and Mars. The location of Pantheon Fossae in the center of the Caloris basin suggests that formation of the radial graben structure is linked to basin evolution.

1. Introduction and background

Magmatism is the process of emplacement and solidification of igneous rock from molten material (magma) derived from a planetary interior. It is commonly subdivided into plutonic or intrusive processes, which involve magma movement and solidification in the subsurface, and volcanic or extrusive processes, which involve

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0012-821X/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsl.2009.03.008