numerous examples of asymmetrical graben development apparently related to heterogeneous regional stress fields are also seen there (Grosfils and Head, 1994a,b). The lateral extent of the dense Pantheon Fossae plexus of radial graben (~175 km radius) is similar to typical novae on Venus (up to ~175 km radius) and well within the range of radial dikes and graben associated with central magma reservoirs on Earth, Mars, and Venus (up to several thousand kilometers) (Parfitt and Head, 1993; Grosfils and Head, 1994b; Ernst et al., 1995; Wilson and Head, 2002).

Initial analyses of Pantheon Fossae (Murchie et al., 2008; Head et al., 2008; Watters et al., 2009a,b-this issue) indicate that some of the radial graben extend well past the central plexus of graben and intersect a concentric deformation system of ridges and graben (Fig. 7B, C). Illumination conditions during MESSENGER's first Mercury flyby were not optimal for confident detection of all of the extended radial features, but fewer and longer graben in some sectors would be consistent with periodic buffered dike emplacement conditions (Parfitt and Head, 1993). Some of the radial graben systems on Venus have vents and lava flows associated with individual graben (Krassilnikov and Head, 2003) (Fig. 10). No similar flow-like features or small edifices have yet been observed associated with Pantheon Fossae, although the illumination geometry, resolution, and homogeneous color properties of the volcanic fill (Murchie et al., 2008; Robinson et al., 2008; Watters et al., 2009a,b-this issue) make any such detection difficult with existing data.

Additional characteristics of Pantheon Fossae graben that suggest that they are related to dikes include some *en echelon* patterns (suggesting rotation of dikes to accommodate shallow near-surface stress fields), cross-cutting relationships (suggesting successive dike emplacement events), and cuspate walls and some crater-chain-like structures (observed in dike-related graben due to collapse and gas venting).

The details of novae on Venus provide important information to assess Pantheon Fossae (Fig. 9). These features have been interpreted to represent doming and fracturing of the surface accompanied by radial dike emplacement that creates graben (Fig. 9A–C) and associated volcanic flows (Fig. 10) (Krassilnikov and Head, 2003; Grindrod et al., 2005). The process interpreted to be responsible is the upwelling of mantle material and associated thermal and dynamic uplift to create locally high topography and some radial fractures. The creation of a shallow magma reservoir during this period results in overpressurization events and radial dike emplacement to produce near-surface stress fields resulting in radial graben. Depending on the relationship of the depths of these dikes to the surface, they can create graben with no associated effusion (Fig. 9A) or can produce surface eruptions often along the graben or at their termini (Fig. 10) (Wilson and Head, 2006). In many cases, these structures are close enough to the surface to produce topographic highs, ring structures, or depressions (Fig. 9A–B (Krassilnikov and Head, 2003). If the Pantheon Fossae complex indeed represents a radial dike swarm, the lack of apparent concentric structures and the paucity of evidence for effusive flows in the available data suggest relatively greater depths for the reservoir than for many of the novae on Venus (Fig. 10). Indeed, the structure of Pantheon Fossae is very similar to the Venus nova shown in Fig. 9. This nova has radial symmetry, two length and width populations, some curved elements, cross-cutting graben, some *en echelon* segments, large cross-cutting graben in the nexus, and many graben that are exposed as a series of short segments. Dissimilarities include the topographic high associated with the Venus nova (Fig. 9B) and the low number of superposed impact craters. Currently available

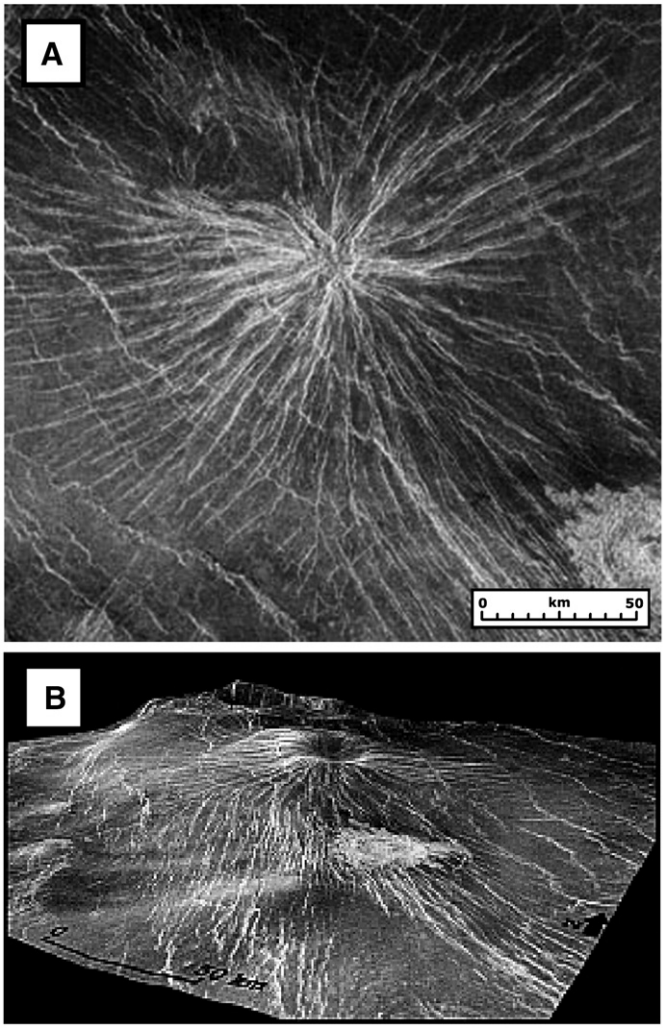

Fig. 9. Radial graben structures (novae) on Venus that are interpreted to be formed as radial dike swarms (e.g., Krassilnikov and Head, 2003). (A) Radar image of Becuma nova structure (34°N, 21.5°E), portion of Magellan image C1-MIDR 30N027.102. (B) Perspective view of radar image, looking north–northwest with 20× vertical exaggeration.

MESSENGER data do not permit the detection of any topography that might be associated with the nexus of Pantheon Fossae, and the superposition of Apollodorus crater further complicates the detection of any Pantheon topography. Altimetry data collected during the MESSENGER orbital mission will help to clarify these relationships.

The Pantheon Fossae complex is one of the few examples of extensional deformation yet seen on Mercury and the only radial graben structure observed thus far. The dominant global mode of deformation on Mercury is contractional, manifested in the form of tectonic ridges, scarps, and wrinkle ridges (Melosh and McKinnon, 1988; Solomon et al., 2008; Watters et al., 2009a,b-this issue), with the major exception being the concentric belt of graben inside the Caloris basin, observed in Mariner 10 data (Strom et al., 1975; Spudis and Guest, 1988; Melosh and McKinnon, 1988). A global contractional state of stress in the lithosphere is the product of a cooling interior (e.g., Solomon, 1977, 1978), which is also accompanied by a thickening

Fig. 8. Enlargements of portions of Pantheon Fossae, starting near the center (A), and then working generally clockwise from the south (B–H). Images and some of the characteristics of the radial graben swarm are described in more detail in the text. All images are subframes of MDIS NAC images. (A) EN0108826822M. (B) EN0108826822M. (C) EN0108826757M. (D) EN0108826757M. (E) EN0108826757M. (F) EN0108826757M. (G) EN0108826822M. (H) EN0108826822M.