TRANSMANTLE FLUX TECTONICS; V. J. Finn, Department of Geosciences, University of Arizona, Tucson, AZ 85721; A. Z. Dolginov, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058; V. R. Baker, Department of Geosciences and Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Venus, Earth, and Mars have surfaces that display topographic domes and depressions with quasi-circular planimetric shapes, relief of 0 to several km, and large spatial scales (10^2 to 10^4 km). Our morphostructural mapping reveals hierarchical arrangements of these features. They are explained by a model of long-acting mantle convection, as a particular case of convection in a stratified and random inhomogeneous medium, which develops the form of a hierarchy of different convective pattern scales, each arising from different levels in the mantle. The hypothesis of transmantle flux tectonics parsimoniously explains a diversity of seemingly unrelated terrestrial planetary phenomena, including Earth megaplumes, global resurfacing epochs on Venus, and cyclic ocean formation and global climate change for Mars.

Mars is a one-plate planet dominated by the Tharsis uplift, which is interpreted as a hot spot structure [1,2]. Earth is a multiplate planet on which the present oceanic lithospheric surfaces are well explained by the kinematic theory of plate tectonics [3,4,5]. The latter is presumably coupled to a dynamical theory of mantle convection [6,7], the details of which remain controversial [8]. A variety of second-order tectonic forms on Earth are theoretically explained by hot spots [9,10] and by mantle plumes [11,12]. The latter may be of importance in explaining various continental phenomena [13,14], many of which are anomalous with regard to the prevailing plate-tectonic paradigm [15].

Contrary to what might be predicted from its first-order geophysical similarities to Earth [16], Venus does not show plate-tectonic features, except perhaps at local scales [17,18]. Instead, the Venusian surface is dominated by quasi-circular global-hierarchical morphostructures (QGMs) at scales of 10^2 to 10^4 km [19,20]. Similar structures, though often eroded and/or deformed by lateral tectonic movements, can be recognized on Earth [21], using the morphostructural analytical procedures developed in the former USSR [22,23].

We hypothesize that all these phenomena may be parsimoniously explained by a process of transmantle flux tectonics in which long-acting mantle convection generates stresses in blocks of planetary lithosphere to produce distinctive QGM patterns. Transmantle flux tectonics differs from plume tectonics [15] in that individual plumes are not considered in isolation. Rather, a wholly interactive process is envisioned in which various spatial and temporal scales of convection operate contemporaneously and hierarchically within other scales. This process of continual change by hierarchical convective cells affects the surface at varying temporal and spatial scales, and its effects are discernable through their relic geological manifestations, the QGM patterns.

Transmantle flux tectonics derives from thermal energy released by core processes [24] and by radioactivity in the planetary mantle. The resulting convective fluxes in a stratified and randomly inhomogeneous mantle [25] will assume the form of a temporal/spatial hierarchy of convective structures in which the characteristic sizes are closely connected to the sizes of the stratification and to the correlated scales of the random inhomogeneities. Such a pattern is well exemplified by solar convection, which divides into giant cells, supergranules, mesogranules, and granules [26]. This hierarchy of surface cells corresponds to convective cells of different sizes that originate at different depths below the surface. Our preliminary calculations show that similar patterns, operating over much longer temporal scales, probably occur within terrestrial planetary mantles.

For Earth, where geophysical data provide constraints [27], it seems that temperature builds up for long periods at the core-mantle boundary (CMB) because of inner core formation.

Release of thermal energy from the CMB induces a highly energetic convective mode that alternates with a less energetic one after the core-mantle thermal gradient decreases. The process seems to be cyclic through Earth history, but characteristics of each cycle vary with the evolved state of inner core formation, compositional change in the mantle, and other factors. Temperature and chemical inhomogeneities at the CMB [28,29] may explain certain persistent magnetic anomalies that correlate to QGMs. Many more QGMs correlate to mantle inhomogeneities identified through seismic tomography [30,31].

While the above hypothesis differs in essential respects from dynamical scenarios developed to explain Earth-related plate-tectonic [27] and plume-tectonic [15] scenarios, we believe that it deserves serious consideration. It does not contradict known data; it has a theoretical basis; and it explains QGM patterns as a general phenomenon of the terrestrial planets. Moreover, it also explains some interesting quasi-cyclic phenomena, including (1) the superplume events [32] and continental flood basalt episodes [33] of Earth, (2) possible phases of global resurfacing of Venus [34] related to episodic thermal behavior of the planet [35], and (3) possible episodic, massive thermal events on Mars related to periodic outburst flooding, temporary ponding of massive water volumes, global climate change, and glaciation [36]. We hope that our preliminary hypothesis can provide a step toward the goal of identifying a unified basis for understanding these diverse phenomena.

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