TOPOGRAPHIC RISE IN THE NORTHERN SMOOTH PLAINS OF MERCURY: CHARACTERISTICS FROM MESSENGER IMAGE AND ALTIMETRY DATA AND CANDIDATE MODES OF ORIGIN.

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Introduction: MESSENGER observations from orbit around Mercury have revealed that a large contiguous area of smooth plains occupies much of the high northern latitudes and covers an area in excess of ~6% of the surface of the planet [1] (Fig. 1). Smooth surface morphology, embayment relationships, color data, candidate flow fronts, and a population of partly to wholly buried craters provide evidence for the volcanic origin of these plains and their emplacement in a flood lava mode to depths at least locally in excess of 1 km. The age of these plains is similar to that of plains associated with and postdating the Caloris impact basin, confirming that volcanism was a globally extensive process in the post-heavy bombardment history of Mercury [1]. No specific effusive vent structures, constructional volcanic edifices, or lava distributary features (leveed flow fronts or sinuous rilles) have been identified in the contiguous plains, although vent structures and evidence of high-effusion-rate flood eruptions are seen in adjacent areas [1]. Subsequent to the identification and mapping of the extensive north polar smooth plains, data from the Mercury Laser Altimeter (MLA) on MESSENGER revealed the presence of a broad topographic rise in the northern smooth plains that is ~1,000 km across and rises more than 1.5 km above the surrounding smooth plains [2] (Fig. 2). The purpose of this contribution is to characterize the northern plains rise and to outline a range of hypotheses for its origin.

Regional description: The part of the northern lowlands occupied by the topographic rise (Figs. 1-3) shows no evidence for any distinctive differences in albedo, color, density of buried craters, estimates of plains thickness, number of superposed craters, or slopes [1,2]. No regional normal faults or extensive linear graben have been observed [1], and wrinkle ridges are not oriented in a clear radial or circumferential pattern in relation to the rise [1] (Fig. 4). Individual topographic profiles (Fig. 5) show details of the rise; part of the rise extends as an isthmus to the surrounding more heavily cratered terrain (Fig. 4). The floors of some partly buried craters tilt away from the rise summit (Fig. 5, red arrows), and the floors and rim crests of some superposed craters also tilt away from the center (Fig. 5) [3,4].

Theories of Origin: We describe a range of scenarios for the origin of the rise (Fig. 6) and outline measurements and analyses that will help distinguish among them. (*1) Pre-plains emplacement:* In this scenario, a broad local rise existed prior to the extensive volcanic flooding, perhaps related to locally thick crust (basin rim topography? [5]); the large, partly flooded crater with exposed rim crest (Fig. 4,5) might favor the presence of pre-existing topography, but this scenario is not supported by gravity data [6]. (*2a) Syn-plains emplacement: Volcanic constructional rise:* In this scenario, the plains are due to volcanic construction at source regions. No evidence is seen, however, of radial flows, edifices, or calderas typical of these types of rises on other planetary bodies. Extensive localized lava flooding might, however, cause buildup of 1.5 km over 1000 km due to linear dike source regions in the subsurface (the flood basalt rise of [7,8]) or diffuse construction (Fig. 7), but this scenario is inconsistent with the gravity data because a thick lithosphere at the time of emplacement would be required [6]. *(2b) Syn-plains emplacement: Volcanic-thermal constructional rise:* Here the rise is similar to some "hot-spot" models of Tharsis on Mars, with combined thermal-dynamic and constructional contributions to the rise [9]; the rise lacks typical radial and concentric structures, however, but support might come from a mantle residuum [13]. (*3) Post-plains tectonic folding:* In this scenario, normal volcanic plains have participated in post-plains long-wavelength folding associated with a phase of global contraction [10]; regional thrusting visible in large thrust scarps and evidence of change in long-wavelength topography elsewhere supports this scenario [4,11]. (*4) Post-plains tectonic normal faulting:* Here, downfaulting of the edge of the rise would result in elevation of the plateau; however, no evidence is seen for circumferential normal faults characteristic of this mechanism.

Summary: A variety of explanations exist for the unusual topographic rise in the northern lowland plains. Currently the available geologic evidence and gravity data favor post-plains folding [10] or possibly syn-plains construction [9] on a thick lithosphere. Further mapping, gravity observations [6], and assessment of the character, deformation, and tilting of superposed and buried craters [3,4] will help to distinguish among these options.

References: [1] Head, J.W. et al. (2011) *Science* 333, 1853-1856. [2] Zuber, M.T. et al. (2012) *Science*, submitted. [3] Balcerski, J.A. et al. (2012) *LPS 43,* this mtg. [4] Solomon, S.C. et al. (2012) *LPS 43*, this mtg. [5] Fassett, C.I. et al. (2012) *LPS 43*, this mtg. [6] Smith, D.E. et al. (2012) *Science*, submitted. [7] Wilson, L. and Head, J.W. (2012) *LPS 43,* this mtg. [8] Coffin, M.F. and Eldholm, O. (1994) *Rev. Geophys*. 32, 1-36. [9] Banerdt, W.B. et al. (1992) in *Mars*, UofA, 249-297. [10] Dombard, A.J. et al. (2001) *LPS 32*, 2035. [11] Byrne, P. et al. (2012) *LPS 43*, this mtg. [12] Tye, A. et al. (2012) *LPS 43,* this mtg. [13] Phillips, R. J. et al., (1990) *JGR* 95, 5089.

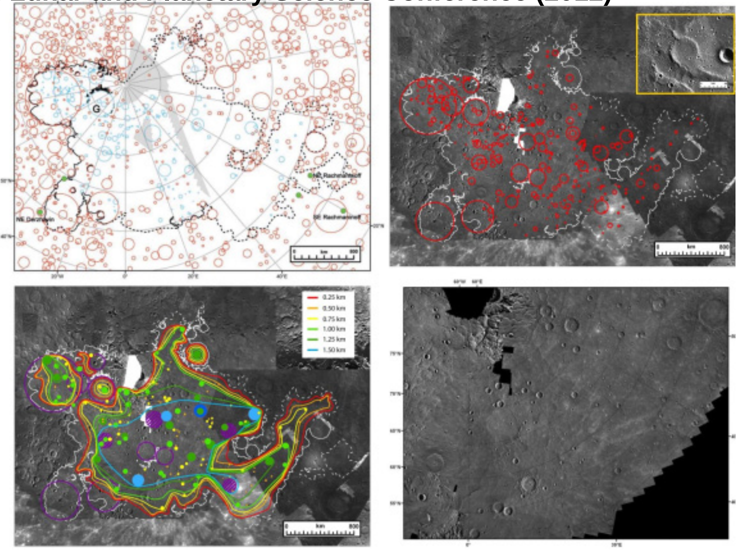

Fig. 1. Mercury's northern plains. (Upper left) Map showing the outline (black) of the northern plains, buried craters (blue), and superposed craters (red). (Upper right) Craters embayed or buried by the smooth plains (red). (Lower left) Isopach map of smooth plains infill compiled from contouring buried crater depths. (Lower right) MDIS image mosaic.

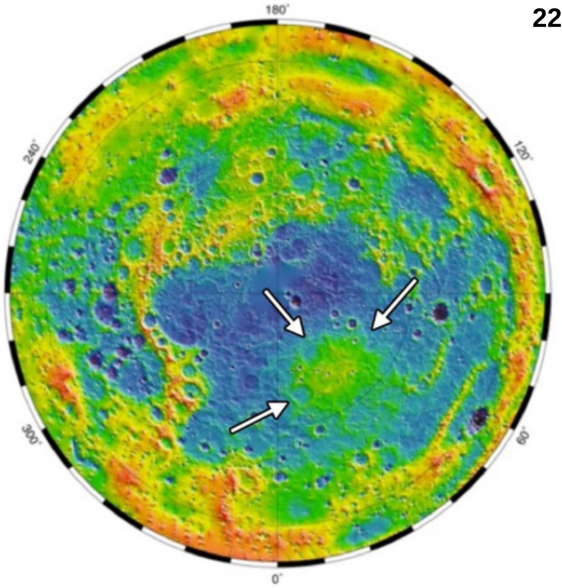

Fig. 2. MLA altimetry of northern high latitudes [2] showing the location of the smooth plains and the broad topographic rise (arrows).

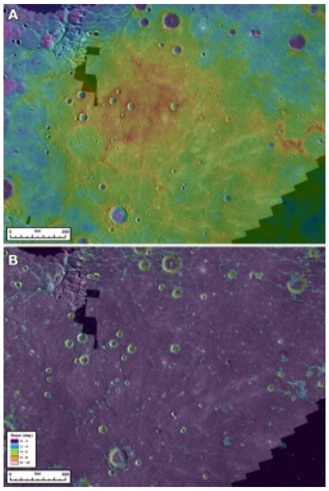

Fig. 3. (A) MLA topographic map of the rise overlaid on MDIS mosaic and (B) slope map from gridded MLA data (500 m baseline).

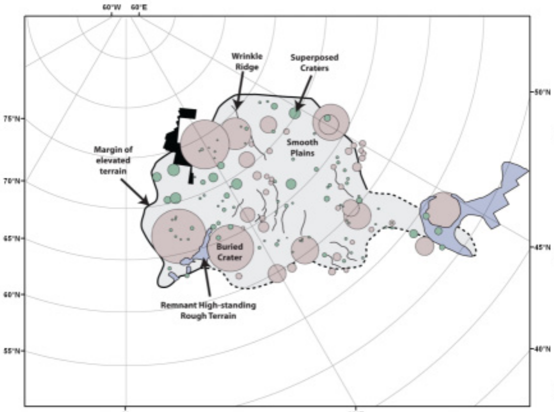

Fig. 4. Sketch map of the major features of the rise. Wavy lines are wrinkle ridges.

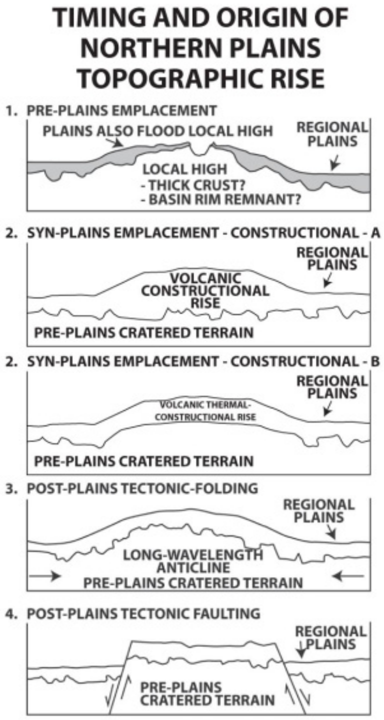

Fig. 6. Candidate modes of origin.

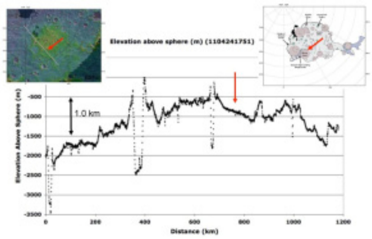

Fig. 5. MLA profile across the rise. Left inset, location; right, sketch map. Arrows show buried crater location (Fig. 4).

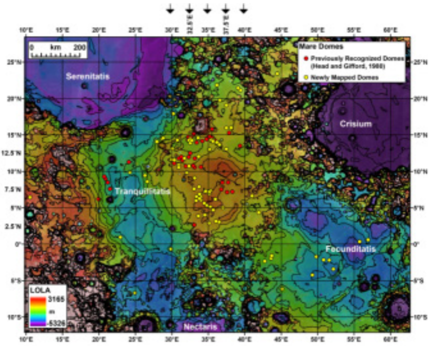

Fig. 7. Constructional rise (~1200 m) in Mare Tranquillitatis [12].