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Prolonged eruptive history of a compound volcano on Mercury: volcanic and tectonic implications

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Abstract

High resolution orbital imaging by MESSENGER under a variety of illuminations reveals that a 27 × 13 km rimless depression 100 km inside the southwest rim of the Caloris basin consists of at least nine overlapping volcanic vents, each individually up to 8 km in diameter. This is thus a 'compound' volcano, indicative of localised migration of the site of the active vent. The vent floors are at a least 1 km below their brinks, but lack the flat shape that is characteristically produced by piston-like subsidence of a caldera floor or by flooding of a crater bottom by a lava lake. They bear a closer resemblance to volcanic craters sculpted by explosive eruptions and/or modified by collapse into void spaces created by magma withdrawal back down into a conduit.

This complex of overlapping vents is at the summit of a subtle edifice at least 100 km across, with flank slopes of about 0.2 degrees, after correction for the regional slope. This is consistent with previous interpretation as a locus of pyroclastic eruptions. Construction of the edifice could have been contributed to by effusion of very low viscosity lava, but high resolution images show that the vent-facing rim of a nearby impact crater is not heavily embayed as previously supposed. Contrasts in morphology (sharpness versus blurredness of the texture) and different densities of superposed sub-km impact craters inside each vent suggest significant differences in the age of the most recent activity at each vent. This implies a long duration of episodic magmagenesis at a restricted locus. The age range is hard to quantify, but could be of the order of a billion years. If each vent was fed from the same source, geometric considerations suggest a source depth of at least 50 km.

The migration of the active vent may be partly controlled by a deep-seated fault that is radial to the Caloris basin. Other rimless depressions in this part of the Caloris basin fall on or close to radial lines, suggesting that elements of the Pantheon Fossae radial fracture system that dominates the surface of the central portion of the Caloris basin may continue at depth almost as far as the basin rim.

1. Introduction

The vent complex that we discuss here is located at 22.3° N, -31.7° E, situated about 100 km inside the southwestern rim of Mercury's Caloris basin. It was discovered [2] in images from MESSENGER's first flyby in 2008, and described as a 'kidney-shaped depression' surrounded by a relatively bright deposit with diffuse outer edges that they interpreted to be pyroclastic deposits erupted from the vent area. It is a 'rimless depression', lacking any trace of a rampart such as surrounds an impact crater. An inferred pyroclastic deposit centred on the vent was listed as Red Spot 3 (RS-03) by [2] in a preliminary analysis of colour trends, and investigated [3] as an example of evidence for unexpectedly high volatile content in the erupting magma (3600-13,000 ppm).

2. Figures

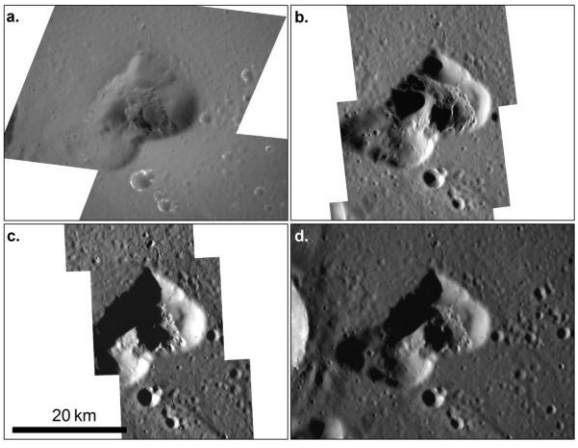

Figure 1: Mosaics of MESSENGER narrow angle camera (NAC) (a-c) and wide angle camera (WAC) (d) images of the vent area.

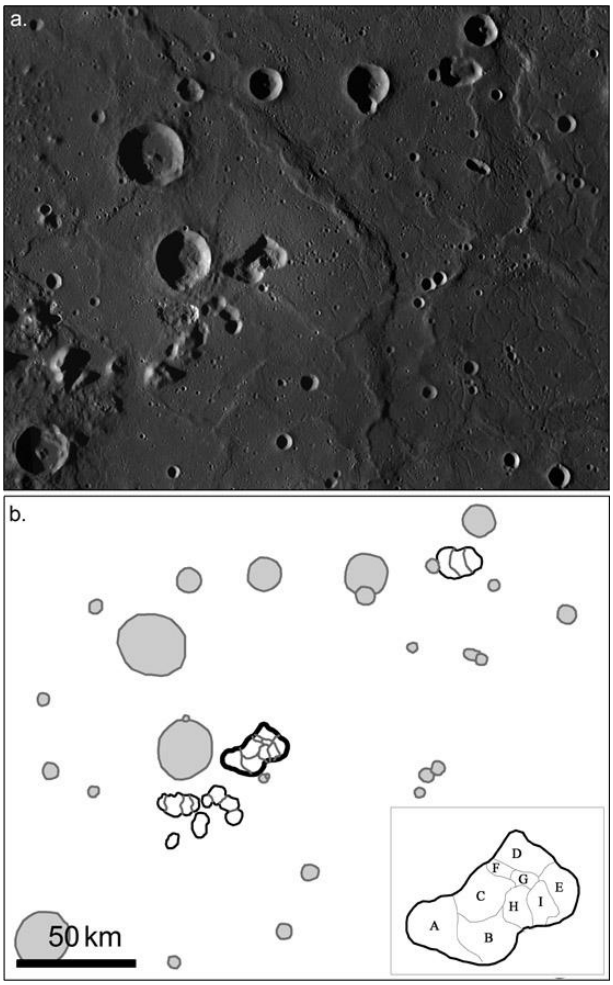

Figure 2: (a) Regional mosaic of WAC images mapped to a sinusoidal projection centred on the RS-03 vent complex. (b) Sketch map of the area shown in (a), based on NAC and WAC images. The main vent complex (RS-03) is shown with a heavy black outline. Other rimless depressions hosting possible vents are outlined with a finer black boundary. Septa marking the divides between individual vents marked by fine grey lines. Impact craters are shown with a grey fill. The inset shows the main vent complex enlarged, and with letters to identify each vent. The original description as 'kidney shaped' [1] was based on the outline around vents B-I only, because vent A was not apparent in the flyby image.

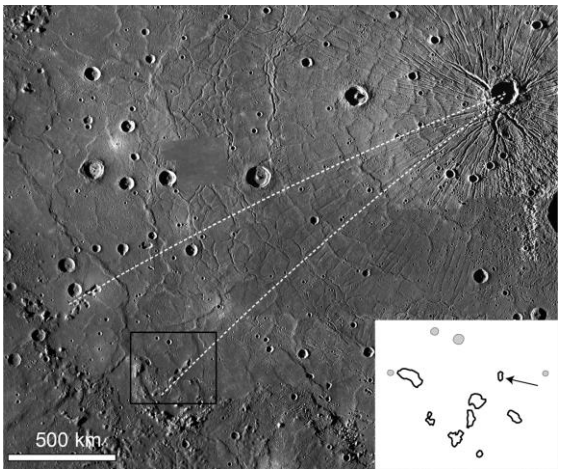

Figure 3: Cylindrical projection of part of the MDIS9 mosaic. The two dashed lines are geodesic lines (curved on this map projection) radial from the centre of the Pantheon Fossae radial graben system at the centre of the Caloris basin. The line trending approximately WSW passes through the long axis of the RS-03 vent and is close to all other vents identified in Figure 2b. The line trending approximately SW passes along a group of four candidate vents within the boxed area. Inset: sketch map of the boxed area. Candidate vents have black outlines, impact craters are shown with a grey fill. The northeasternmost of the candidate vents in the inset (arrowed) is centred within candidate pyroclastic deposit RS-03 SE of [2].

References

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[2] Head, J.W., Murchie, S.L., Prockter, L.M., Solomon, S.C., Chapman, C.R., Strom, R.G., Watters, T.R., Blewett, D.T., Gillis-Davis, J.J., Fassett, C.I., Dickson, J.L., Morgan, G.A., Kerber, L.: Volcanism on Mercury: Evidence from the first MESSENGER flyby for extrusive and explosive activity and the volcanic origin of plains, Earth. Planet. Sci. Lett. Vol. 285, pp. 227-242, 2009.

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