Mercury's "spider" – another giant caldera volcano?

G.J.H. McCall

44 Robert Franklin Way, South Cerney, Glos. GL7 5UD

joemccall@tiscali.co.uk

Dr Joe McCall, retired, is a former Reader (Associate Professor) of Geology at the University of Western Australia. He also curated the meteorites at the Western Australian Museum during his time in Perth. Besides his professional work on terrestrial geology he has long had an interest in the extraterrestrial extensions of geology, to the Moon, Mars, Mercury and other bodies in the Solar System. He was recently leading editor of a history of Meteoritics and key collections, published by the Geological Society of London, of which he is a Senior Fellow. He was awarded its prestigious Coke medal in 1994.

This letter reports the discovery, by means of comparison of a MESSENGER image of part of the Caloris Basin, Mercury, with images of Martian caldera volcanoes, of a very large caldera volcano. The structure, which has been called "the spider" informally by the MESSENGER team, and has hitherto been unexplained, is ~330 km in diameter and shows remarkable similarities to the giant Martian caldera volcanoes Ceraunius Tholus, Uranius Tholus and Tyrrhenia Patera.

I have long had an interest in Mercury and regretted its long neglect without follow-ups to the Mariner 10 visit[1]. I have also written about the giant caldera volcano of Olympus Mons on Mars[2]. Mercury's newly revealed and surprising image of a structure within the Caloris Basin, informally named "the spider" by the MESSENGER team, was recently discussed in *Science Daily*, as downloaded from the Web on 13.3.08[3] (Figure 1).

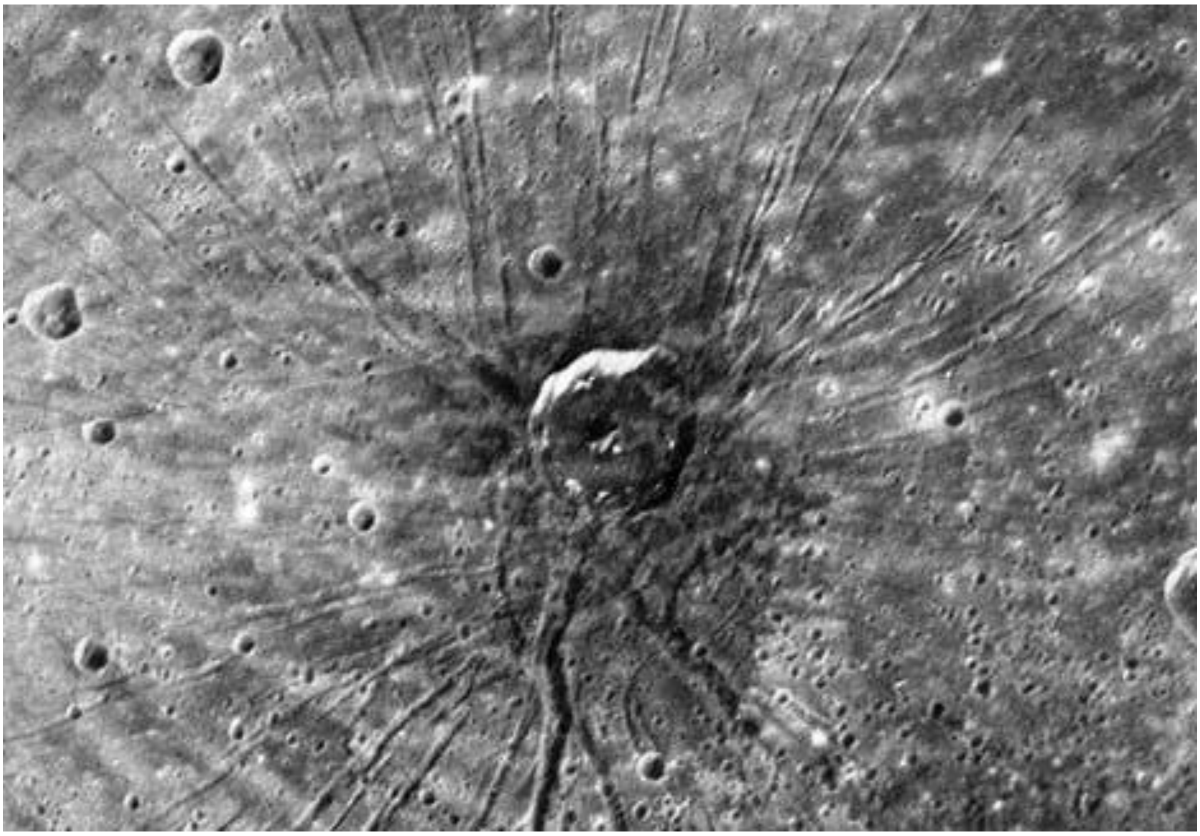

Figure 1: "The spider", revealed in an image sent back by MESSENGER, 14.1.2008. The volcano, circumscribed by a faint, white annular mark, is about 330 km in diameter (from ref. 3).

I quote from the above-mentioned webpage:

"MESSENGER obtained high-resolution images of the floor of the Caloris basin on January 14 2008. Near the center of this basin, this remarkable feature – named "the spider" by the science team – was revealed. A set of troughs radiating outward are interpreted to be the result of the breaking apart of the floor materials that filled the Caloris basin after its formation. Other troughs near the center form a polygonal pattern. An impact crater 40 km (25 miles) in diameter appears to be centered on "the spider" (Credit NASA/St Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington).

Figure 2: Uranius Tholus (top, ~ 60 km in diameter) and Ceraunius Tholus (bottom, ~ 130 km in diameter), both on Mars. The radial and later sinuous channels suggest that the material was easily erodable ash, rather than lavas. The steep conical piles support this inference (THEMIS MOSAIC).

I am familiar with calderas, having described Menengai[5], Suswa[6], Kilombe[7] and Silali[8] caldera volcanoes in the Kenya Rift Valley, and Ambrym caldera in Vanuatu[8]. Fortuitously, I recently reviewed Michael Carr's excellent re-issue of his book on Mars, with its superb images of Martian caldera volcanoes[4] – this review will be appearing shortly in *Geoscientist*. NASA interpreters have apparently neglected to study images of caldera volcanoes on Mars for comparison.

First, look at the Mars volcanoes Ceraunius Tholus and Uranius Tholus (Figure 2). These are ideal examples of caldera volcanoes ~60 and ~130 km across, with summit calderas ~12 and ~25 km across. The original volcanoes produced voluminous material in both cases and built up massive cones with well-defined circumferential margins. Both have radial fissures which I suggest were formed in the tumescent stage. Both have fewer and wider sinuous grooves or troughs, formed slightly later, and lastly they have summit calderas, formed in the relaxation stage. Uranius has two calderas, nested. Ceraunius has a single caldera.

Now look at the image of Tyrrhena Patera, which is a less ideal case (Figure 3). The volcano measures ~200 km across and the caldera 40 km across. The volcanic pile is flatter and wider, and there is less contrast with the surroundings because the output was of different material and had less colour contrast. Here there is a radial pattern of fissures but they are wider grooves or troughs. There are two later, sinuous grooves or troughs, both wider and one of these passes smoothly into the caldera floor. The caldera is complex (one could even suggest that there are two calderas interconnected). There is also a partial concentric narrow ring groove which is clearly cut off by the complex caldera. This partial annular groove was probaly formed early in the relaxation stage, prior to the subsidence of the caldera.

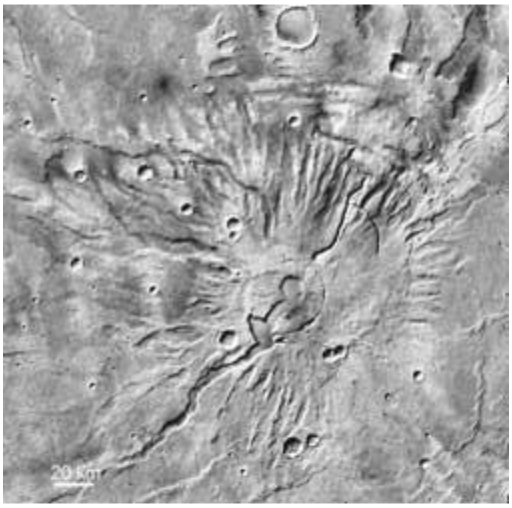

Figure 3: Tyrrhena Patera on Mars (~200 km in diameter). This is a flatter cone than Ceraunius and Uranius Tholus, but is thought to be composed of horizontally bedded ash deposits. The caldera and a flat-floored trough merge into one another (MOC WA).

Now look at "the spider" on Mercury. Again, as in the case of Tyrrhena, partial circumferential markings show up, here white and discontinuous. The image is chopped off, and the outer margin is barely seen, but at "two o'clock" the radial grooves seem to die out. This suggests a diameter of ~330 km, though it could be more. This structure is larger than the three Martian volcanoes I discuss here, though not the pile of Olympus Mons on Mars[2] which has a diameter ~550 km. Mercury is only 2/3 the diameter of Mars, but both these smaller-than-Earth planets apparently display volcanic giantism. Mt. Kenya and Kilimanjaro, among the largest terrestrial volcanoes, have diameters of only ~80 km. Mauna Loa, on Hawaii, is larger if one measures from the sea floor. It is probably the highest terrestrial volcanic pile, at about 200 km.

"The spider" displays almost straight radial fissures of the tumescence stage. in this it resembles Ceraunius and Uranius on Mars. There are wider, more irregular grooves that formed later than these, and one, as in the case of Tyrrhena, appears to run smoothly into the caldera floor. The wall of the caldera has the form of an irregular circle – this irregular, subpolygonal form is like that of many terrestrial calderas – only Ambrym of the calderas that I have mapped, and the caldera of Longonot, Kenya (with which I am familiar but did not map) is a neat, circular basin. The contrast of the material forming the volcanic pile with its surroundings is poor, but there is a darker, irregular area in the middle of the slopes. Flatter volcanic piles on Earth are produced by shield volcanoes made up of lava flows, but this might not apply to Mercury. The detail revealed by MESSENGER is far less than that revealed on the Martian images, and this structure will surely reveal much more interesting detail in the future, like Ceraunius, Uranius and Tyrrhena, when an Orbiter can get close enough to reveal comparable images.

I believe that "the spider" represents a huge caldera volcano of a relatively late stage in the moulding of Mercury's crust. Is it the first such giant volcano to be detected on this innermost planet? The presence of a huge caldera volcano in the centre of the Caloris basin is interesting. This vast basin, for which a diameter of 1550 km has been suggested[9], has been supposed to be an impact structure, produced by an impactor of asteroidal dimensions. However, the evidence for an impact origin of the huge Lunar Maria, Hellas basin on Mars, and Caloris Basin on Mercury, appears not to be very substantial.

*Reference*s

1. McCall, G.J.H. 2006. Mercury. In; Selley, RC, Cocks, L.R., Pilmer, I.R.; *Encyclopedia of Geology*, **5**, 235-244.
2. McCall, G.J.H. 2006. A caldera volcano of Brobdingnagian scale: Olympus Mons. *Geoscientist* **16**(4); 29-30..
3. Anon, 2008. "The Spider" on Mercury: MESSENGER spacecraft streams back surprises. Science Daily. http://www.sciencedaily.com/releases/2008/02/08201093149.htm
4. Carr, M.H.. 2006. The surface of Mars. Cambridge University Press; 307 pp
5. McCall, G.J.H. 1967. Geology of the Nakuru-Thomsons Falls-Lake Hannington Area. Report No. 78, Geological Survey of Kenya, 122 pp.
6. McCall, G.J.H. and Bristow, C.M. 1965. An introductory account of Suswa Volcano. *Bull. Volcanol*. **28**; 1-35
7. McCall, G.J.H. 1964. Kilombe caldera, Kenya. *Proc. Geologists' Association* **75**, 563-572.
8. Smith, M., Dunkley, P.N., Deino.A., Williams, L.A.J., and McCall, G.J.H. Geochronology, stratigraphy and structural evolution of Silali volcano, Gregory Rift, Kenya. *Journal of the Geological Society* **152**; 297-310.
9. Shiga, D. 2008. Bizarre spider scar foundon Marcury's surface. New Scientist. com news service 30 January.