Plumeless Venus preserves an ancient impact-accretionary surface

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ABSTRACT

Venus displays thousands of old circular structures, with topographic rims 5–2000 km in diameter, that have the morphology and cookie-cutter superposition required of impact craters and basins. Many structures have interior central or ring uplifts or broad, low volcanic constructs. Many are multiring. Old uplands are saturated with variably degraded structures, whereas lowland structures are variably buried by sediments. The youngest include three of the largest (rim diameters of 800–2000 km), for which analogy with the dated Imbrium impact basin on the Moon indicates likely ages of ca. 3.90 Ga. Venus is argued here to preserve much of its surface of late-stage main planetary accretion.

The Venus of conventional interpretation, by contrast, was wholly resurfaced, mostly by plume-driven processes, no earlier than 1 Ga, and preserves no ancient features. This speculation is extrapolated from terrestrial conjectures, and rationalizes away voluminous contrary evidence from Venus itself. Interpreters of early Venusian radar imagery accepted the possible impact origin and great age of the structures, but impact explanations were soon replaced, almost without analysis, by plume conjectures. Nearly all specialists now assume that Venus has internal mobility comparable to the exaggerated mobility assumed for Earth, and that the only Venusian impact structures are "pristine" small- to mid-size craters and basins with an age younger than 1.0 Ga. (Ages to 3.9 Ga for these are advocated here.) The older circular structures are conventionally attributed to mantle plumes and upwellings that deformed crust and upper mantle from beneath, with or without lava extrusion.

The "pristine" craters can be discriminated only arbitrarily from the best-preserved of the ancient circular structures. From the latter, there are all gradations back to the most heavily modified structures of the old family. Broad, low volcanic constructs (unlike any surviving terrestrial volcanoes) inside old impact basins are likely products of impact melts.

Transfer of plume conjecture to Venus from Earth has little merit. Terrestrial plume speculation is based on assumptions whose predictions have been consistently falsified. Not only do plumes probably not exist on Earth, but even the least-constrained attributions of geological and tectonic features to them do not include circular structures that in any way resemble those of Venus. Conversely, Venusian speculations neither address nor account for circularity and superpositions. The hot-mobile-Venus assumption behind young-surface conjectures is also dubious. Venus' lack of a magnetic field (its core is likely solid), its positive correlation of topography and geoid (outer Venus is far stiffer than Earth), its origin close to the Sun (less volatiles, including potassium, so much less early radiogenic heat, less weakening volatiles, and higher solidus temperature), and other factors indicate Venus to be much less mobile than Earth.

Venusian lowlands are floored not by young lava plains but by ancient sediments, possibly including deposits in a transient ocean, derived from uplands by processes still poorly defined. The plains are speckled with mud volcanoes (not lava cones) that, like minor deformations of the sediments, are due to top-down heating by the evolving atmosphere.