AN ALTERNATIVE VENUS – PLUME-FREE PLANET PRESERVES PRE-3.9 Ga ACCRETIONARY SURFACE

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The model for Venus accepted by most specialists assumes a radioactive composition similar to that assumed (wrongly?) in the standard model for the Earth. As Venus lacks bimodal topography and plate tectonics, common corollary speculation is that Venus sheds its assumed excess heat primarily by rise from deep mantle of large and small plumes and upwellings that spawn myriad plumelets and diapirs. In most variants of this general scheme, the rising material represents a mantle overturn that resurfaced the planet structurally and magmatically and that predated only bolide impacts younger than 1 or 0.5 Ga. The rising masses are manifested at the surface mostly by circular rimmed and multiring structures up to 2000 km in inner diameter, and by vast basalt-surfaced lowlands. Among hundreds of reports embellishing variants of such assumptions are Aittola and Kostama (2002), Basilevsky and Head (1998), Brown and Grimm (1999), and Smrekar and Stofan (1999).

The assumptions on which these rationales are based may be invalid. Venusian plume scenarios are imaginative extrapolations from conjectures, likely false, regarding existence of such structures on Earth (see last paragraph). Speculation that the lower mantles of Earth and Venus are fertile and unfractionated— prerequisites for whole-mantle convection and for plumes from deep mantle—descends from 1950s conjecture (e.g., Urey, 1951), reasonable then but not now, that these planets accreted cold and slowly from enriched material like that of meteorites from beyond Mars, then heated gradually and are still largely unfractionated. Cosmological, orbital, and other considerations require that the inner planets instead accreted fast, violently, and hot, from material much less volatile than those meteorites, and fractionated early and irreversibly (references in Anderson, 2002, and Hamilton, 2002, 2003). Observed heliocentric compositional zoning of the asteroids (coming sunward: ices + organics; carbonaceous chondrites and other volatile-rich compositions; ordinary chondrites etc.) continues through progressively-less-volatile Mars and Earth and, arguably, on through Venus. Direct indicators of a less volatile composition of Venus than Earth include Venus' probably lower uncompressed bulk density (more magnesian), lack of silicic crust as sampled by 7 landers, and its very low atmospheric ^{40}Ar (low planetary K_2O?). Earth itself is much less radioactive than commonly assumed, and has only about 2/3 the heat flow (Hofmeister and Criss, this symposium).

Venus commonly is postulated to have been magmatically resurfaced, and modified by extension and shortening, before ~1000 impact craters with little-modified ejecta blankets were blasted into it. These obvious impact craters have diameters <270 km, and mostly >50 km although only ~10 are >100 km, and are distributed randomly, or nearly so, on other units. The dense atmosphere retards all bolides; nearly all small bolides, and a great many mid-sized ones, are destroyed in transit. Conventional calculations of the maximum age of pristine craters are based on estimation of size distribution of the few bolides that produced the >100-km craters, with the critical assumptions that these craters represent all of the large impactors that reached the atmosphere and that these large bolides neither fragmented nor lost velocity in transit. A maximum age of ~800 Ma is inferred on this basis (McKinnon et al., 1997). This age limit likely overestimates atmospheric survival of large bolides, and it does not incorporate either atmospheric slowing or scaling of crater mechanics for the dense atmosphere, both of which markedly decrease crater dimensions for a given bolide. Integration of these neglected factors permits much of the pre-existing surface of Venus to be 3 or 4 Ga old (Schultz, 1993). The conventional young-age calculation assumes further that all young impact structures are visible and thus overlooks the possibility that the largest impacts (transient craters, say, >400 km diameter and >100 km deep) might have generated enough decompression melt, in addition to impact melt, to have buried the craters and produced large volcanic constructs (cf. Jones et al., 2002). In conventional explanations, Venusian uplands are regarded as saturated with products of pre-impact plumes, plumelets, and diapirs, and lowlands as vast fields of pre-impacts basalt.

A proposed alternative Venus is now internally much cooler than Earth (though graded to hot greenhouse surface temperature): its initial heat was all or mostly lost long ago, and its radiogenic replenishment is much less. Much of the surface of Venus has been little modified since main accretion ended -3.9 Ga ago. Uplands are saturated with small to huge ancient impact craters (not with young magmatic edifices), from which rubble was eroded and deposited in a transient ocean (unrecognized in consensus interpretations) in nonvolcanic lowlands whose floors also are saturated with impact structures.

The pre-pristine-craters upland surface of Venus is dominated by rimmed circular structures, variably superimposed, many of them multi-ringed, of widely varying degrees of preservation and interference. I see these as erosion-modified impact craters that had varying amounts and patterns of impact-related melt. (My first statement of this view was in Hamilton, 1993.) Well-defined inner rims range from 50 to 2000 km in diameter, and outer margins, beyond troughs and outer swells, reach 3000 km. The majority view of specialists is that these circles (most “coronae” and “arachnoids”, and many “novae” and “paterae”, in Venusian jargon), throughout their huge range of size, formed atop plumes and plumelets that spread, sublithospherically in some schemes and extrusively in others, into circular shapes no matter where, or against what, they formed. This widely-accepted conjecture lacks discussion of bases or alternatives, or of such critical problems as lack of the lobate shapes required by the speculation.

To me, large rimmed circles on a solid-surface planet require gigantic explosions, and only impacts are plausible sources. (Earthbound geologists went through this in the 1960s and 1970s, when circular “crypto-volcanic structures” were proved to be ancient impact craters.) Volcanic explosions are trivial by comparison; indeed, the obvious volcanic constructs on Venus have, at most, small calderas. Many of the older large Venusian circles are moderately deformed, and stresses, and their relaxation, related to impacts may account for much of the modest early deformation of the planet’s surface. Correlation of gravity with topography indicates great strength—thick lithosphere—in outer Venus. (Contrary inference that topography is supported dynamically by rising plumes or cells, that lithosphere is thin, and that high upper mantle is near solidus temperature, is circular rationalization.) The young nearly-pristine impact structures retain obvious ejecta blankets that distinguish them from older rimmed circles of similar to larger size, assigned to plumes. Inner rims of large Venusian circles, as exposed in uplands, are eroded to bedrock, so particulate ejecta have been removed from rims, although perhaps only smoothed on outer slopes. In the broad lowland plains, hundreds of small to large buried impact craters appear as rimmed depressions ("ghost coronae") where plains surficial material is compressed into them, and huge circles (mostly-buried impact maria?) may be defined by partly-exposed rims, to ~4000 km in diameter. This printing-through of subjacent structures shows plains material to be weak and thin.

Lunar analogy indicates giant impact craters to be older than 3.9 Ga. Venusian uplands, like the lunar highlands, are saturated with craters that include such great terminal impacts of main accretion. The surface of Venus is an eroded accretionary landscape mostly older than 3.9 Ga. The weak Venusian heat engine has been incapable of much modifying the surface throughout most of geologic time.

The resurfacing prior to formation of little-modified impact craters was not planet-wide magmatism, but instead was a brief era of erosion that removed and smoothed ejecta blankets in the uplands, and of mostly-marine sedimentation that buried impact structures in the lowlands (Jones and Pickering, 2003). Timing is constrained primarily to be younger than 3.9 Ga, but the aqueous era was brief—subaerial valley systems are poorly integrated (Baker et al., 1997), and marine deposits are thin. (Subsequent eolian erosion and deposition have probably been minor: Greeley et al., 1997.) The atmospheric deuterium/hydrogen ratio, ~150_ that of Earth, may indicate that Venus once had an ocean equivalent to ~270 bars of water (Hunten, 2002). Erosional river valleys enter the lowland plains, into which channels ("canali") extend, one possibly 6800 km long but all others shorter than 500 km. The channels were made by debris-carrying fluid and some have cutoff meanders, braids, point bars, and deltas (Williams-Jones et al., 1998). Jones and Pickering (2003) recognized that the uniform-cross-section lowland channels dimensionally and morphologically resemble terrestrial submarine density-current channels, and hence that the lowlands likely are formed mostly of turbidites. (See Habgood et al., 2003, for further description of terrestrial analogs.) A transient early ocean apparently was present, perhaps more than once and perhaps hot, and disappeared as the atmosphere heated because of increasing solar radiation and increasing greenhouse gas. Mass, temperature, and composition of the Venusian greenhouse atmosphere—now 93 bars, surface T ~475EC, ~96.5% CO_2, 3.5% N_2, traces of other gases—must have changed greatly over time, importantly by loss of water by oxidation of CO to CO_2 and escape of H_2.

Radar properties of the gentle and mostly radar-dark Venusian plains accord with sedimentary character (Cochrane and Ghail, 2002). Soviet landers showed plains materials to be soft, porous, low in density, and horizontally layered—all consistent with sedimentary deposits—and vaguely basaltic in semiquantitative partial chemical composition (e.g., Basilevsky et al., 1985). Nearly all Venusian geologists, however, assume that liquid water cannot have existed during the planet's geologically recorded history, so they devise ad hoc explanations, devoid of actualistic analogs, of the plains and channels in terms of volcanism. For example, the superabundant small, low shields, mostly 0.1-5 km in diameter, that speckle many lowland regions are termed, without evaluation, basalt volcanoes. Their distribution makes no sense in this context, and I presume them to be mud volcanoes.

The plains sediments and channels predate broad, open deformation (Stewart and Head, 2000). Smaller-scale surficial deformation of the plains—wrinkle ridges, and gridded and polygonal patterns—is likely a product of secular changes in post-oceanic atmospheric temperature (e.g., Anderson and Smrekar, 1999), and not of global tectonics or volcanism (cf. Banerdt et al., 1997). Relative fluid pressurization responsible for mud volcanoes presumably also relates to atmospheric change.

The surface of Venus may have been modified since late in the era of main planetary accretion primarily by early aqueous erosion and deposition. Internally-driven tectonism and volcanism have been minor. The change, likely before 3 Ga, from aqueous modification to pristine preservation of impact craters, represents thresholds in evolution of atmosphere and hydrosphere, and not an internal turnover of the planet.

Widespread acceptance of feebly-based conjecture that plumes from deep mantle profoundly influence evolution of Earth's crust and upper mantle has retarded consideration of alternatives (Anderson, 2000; Hamilton, 2002, 2003; various authors in this symposium). Terrestrial plumology is based on bad assumptions of planetary composition and evolution. Geophysical rationales and purported evidence do not withstand scrutiny and improved data, but as fast as their plume predictions are falsified, proponents make their conjectures more convoluted, untestable, and unique to each example. After early speculation that earthly plumes are fixed in the mantle was disproved by plate-kinematic and paleomagnetic data, and after it was learned that ridge and island basalts largely overlap in composition, evidence-evading salvage notions of gyrating and squirting plumes were made ever wilder. Pro-plume geochemical rationales display unawareness of thermodynamics, phase petrology, and much more. Export of dubious terrestrial plume conjectures, with unconstrained modifications, retards comprehension of very-different Venus.

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