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Evidences for recent plume-induced subduction, microplates and localized lateral plate motions on Venus

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Using laboratory experiments and theoretical modeling, we recently showed that plumes could induce roll-back subduction around large coronae. When a hot plume rises under a brittle and visco-elasto-plastic skin/lithosphere, the latter undergoes a flexural deformation which puts it under tension. Radial cracks and rifting of the skin then develop, sometimes using pre-existing weaknesses. Plume material upwells through the cracks (because it is more buoyant) and spreads as a axisymmetric gravity current above the broken denser skin. The latter bends and sinks under the combined force of its own weight and that of the plume gravity current. However, due to the brittle character of the upper part of the experimental lithosphere, it cannot deform viscously to accomodate the sinking motions. Instead, the plate continues to tear, as a sheet of paper would do upon intrusion. Several slabs are therefore produced, associated with trenches localized along partial circles on the plume, and strong roll-back is always observed. Depending on the lithospheric strength, roll-back can continue and triggers a complete resurfacing, or it stops when the plume stops spreading. Two types of microplates are also observed. First, the upwelling plume material creates a set of new plates interior to the trench segments. These plates move rapidly and expand through time, but do not subduct.. In a few cases, we also observe additional microplates exterior to the trenches. This happens when the subducting plate contains preexisting heterogeneities (e.g. fractures) and the subducted slab is massive enough for slab pull to become efficient and induce horizontal plate motions.

Scalings derived from the experiments suggest that Venus lithosphere is soft enough to undergo such a regime. And indeed, at least two candidates can be identified on Venus, where plume-induced subduction could have operated. (1) Artemis Coronae is the largest (2300 km across) coronae on Venus and is bounded over 270° of arc by a trench and outer rise, which is proposed to be a subduction zone based on its morphologic similiarity to several terrestrial features. Its interior is cut by a rift and several shear zones. (2) Lada Terra is a ∼1000 km diameter topographic rise centered near 65°S, 10°E. The 800 km diameter Quetzelpetlatl Corona (QC) defines its western margin. The western edge of QC is defined by a trench and outer rise. As at Artemis, the latter presents also graben and fractures similar to the extensional features seen in the laboratory. The subsurface density variations inferred from modeling the gravity and topography data at both coronae are compatible with the existence of a slab at depth. Moreover, the interior of Artemis looks like the system of growing microplates inside the coronae described in the laboratory. While the second type is probably occuring in the Lada Terra region, where the presence of an extension zone to the north (Kalaipahoa Linea) could mark the edge of a microplate currently subducting at QC. Moreover, evidence for geologically recent volcanism at Quetzelpetlatl suggests that subduction may be currently active on Venus.