PULSATING CONTINENTS ON VENUS. I. Romeo[1] and D. L. Turcotte[2], [1] Department of Geology, University of California Davis, One Shields Avenue, Davis, CA USA 95616-8605, romeo@geology.ucdavis.edu, [2] Department of Geology, University of California Davis, One Shields Avenue, Davis, CA USA 95616-8605, turcotte@geology.ucdavis.edu.

Introduction:

The origin and evolution of crustal plateaus on Venus, subcircular areas with diameters in the range of 1500 to 2500 km, and elevations of 0.5 to 4 km above the surrounding plains, has been a controversial topic since high-resolution radar images were obtained by the Magellan mission. The plateaus are made up of intensely deformed terrain, known as tessera, characterized by different cross-cutting sets of structures indicating a complex tectonic history. Tessera terrain also outcrops in the volcanic plains showing inlier textures.

Different models for crustal plateau formation have been proposed, but no consensus has been reached. The two principle models consider crustal plateaus as either the surface expression of downwelling [1] or plumes [2] on an ancient thin lithosphere. Both hypotheses have problems in explaining all the characteristics of plateaus. On the one hand, the downwelling model needs too much time for the thickening by crustal flow (1– 4 billion years) [3]. On the other hand, the plume model has no explanation for the high tectonic contraction observed [4]. A catastrophic model where crustal plateaus were formed by huge lava ponds generated by massive mantle melting due to large bolide impacts on a thin ancient lithosphere has been recently proposed [5].

In this contribution we suggest that tessera terrains, forming both crustal plateaus and tessera inliers represent Venusian continental crust that does not participate in the periodic recycling of the lithosphere through global subduction events [6,7]. In this context crustal plateaus would represent continents and the tessera inliers, collapsed continents.

Model description and results:

We have studied the force balance on the boundary of a continental area that survives a global subduction event using an analytical model. Our results for the force equilibrium (Fig.1) show that the ratio between the crustal and lithospheric mantle thicknesses controls the force balance. If the crust thickness is less than ~2/5 of the lithospheric mantle thickness then the continental area will be compressed generating a plateau, but if the crustal thickness is higher than ~2/5 of the lithospheric mantle thickness it will spread out and collapse froming tessera inliers.

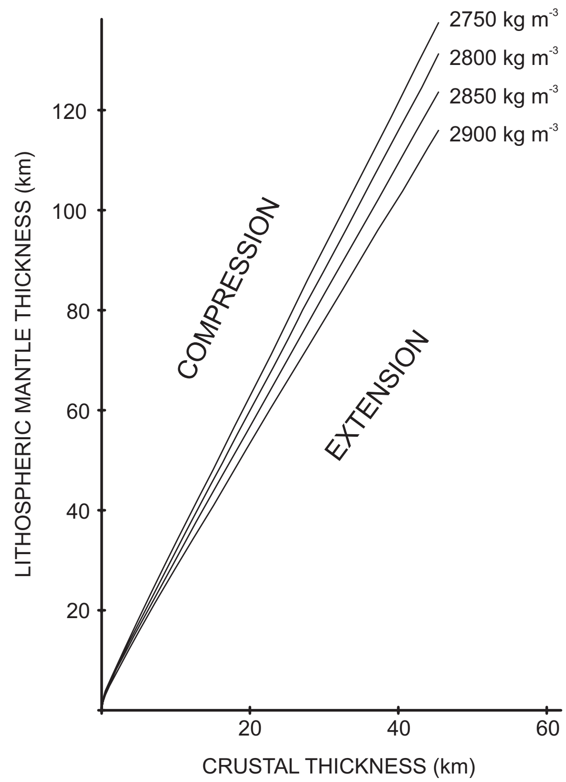

Figure 1. Relation of crustal and lithospheric mantle thicknesses of a continental area in force equilibrium with a surrounding mantle with a density, ρ=3300 Kgm^{-3}. The relation is given for different continental crust densities.

We have modelled the thickening of a continental area by tectonic contraction after a subduction event using a thin viscous sheet approach with a Newtonian viscosity for the continental crust. The force from a hot mantle raised in a global subduction event is enough to build up a plateau by compression in ~50 Ma using a viscosity for the continental crust of $\eta=10^{21}$ Pa s and ~200 Ma for $\eta=5\cdot10^{21}$ Pa s. During this compressional stage concentric fold and thrust belts are generated in the plateau-continent, erasing any previous impact craters. The subsequent stabilization of a new crust and lithosphere in the surrounding mantle would change the force balance allowing a moderate gravitational collapse of the plateau-continent accommodated by radial grabens.

Our model links for the first time the generation of crustal plateaus by crustal shortening and the origin of the volcanic plains predicting the observed equivalent effective crater density for both terrains.

Our proposal of idealized cyclic behavior for the continental crust on Venus is outlined in Fig.2. During the deformation and thickening of the plateau from b to c the crust becomes partially mechanically decoupled with respect to the lithospheric mantle. The growing of a new lithosphere in the surrounding region produces moderate gravitational collapse (Fig.2d). The mechanical decoupling between the crust and the lithospheric mantle allows the delamination of the lithospheric mantle during the next global subduction event (Fig.2f). The plateau then collapses gravitationally by extension in a very hot mantle environment (Fig.2g). Contemporary with plateau collapse, the extensive volcanism generated by the superficial hot mantle produces a partial flooding of the collapsed plateau-continent generating the observed tessera inliers mainly characterized by extensional tectonics. A new lithosphere grows by heat conduction (Fig.2h), blocking the collapse process. This new lithosphere generated by cooling under the collapsed plateau is mechanically coupled to the continental crust because the crust is thin and therefore the upper lithospheric mantle is relatively cold when the new lithosphere gets thick (Fig.2a). Thus, the next global resurfacing process does not delaminate the lithosphere under the continent, yielding the initial conditions for plateau thickening (Fig.2b). Thus, controlled by the periodic subduction events, the Venusian continents can suffer cycles of thickening events driven by tectonic compression and subsequent extensional collapse events. Therefore we propose the term pulsating continents to describe this cyclic behavior that links crustal plateaus and tessera inliers.

References:

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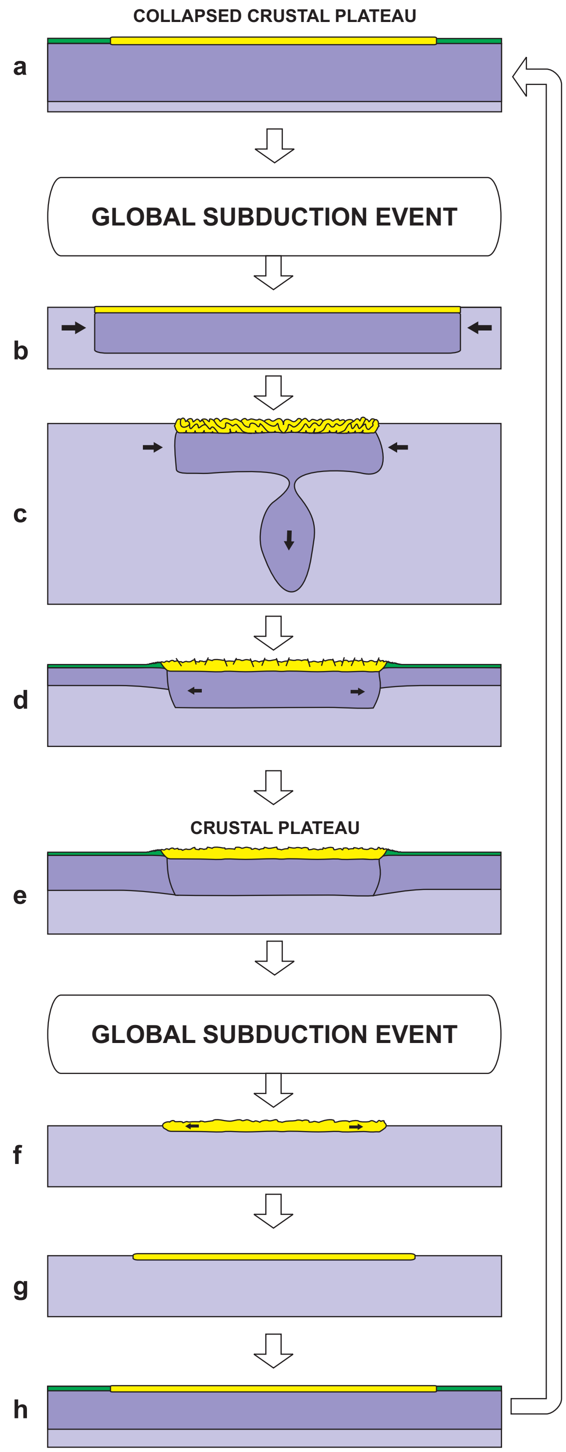

Figure 2. Model of cyclic evolution of the continental crust of Venus, relating crustal plateaus and tessera inliers (remants of collapsed crustal plateaus). Yellow: continental crust. Green: basaltic crust. Dark blue: lithospheric mantle. Light blue: hot matle.