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How Venus' young surface came to be: New insights from 2D and 3D modelling

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Venus is similar to Earth in size, composition and bulk density. Nevertheless, Venus seems to lose its heat much differently than Earth. Venus currently convects beneath a stagnant lid without continuous rejuvenation of its surface as occurs for plate tectonics on Earth. According to observed crater retention statistics, the Venusian surface age is estimated to range between 500 and 1000 Ma, and is nearly uniform globally. This is commonly explained as the result of a global event that catastrophically recycled the Venusian surface. More information about Venus' thermal evolution may be gleaned by examining its surface, which is geologically complex with extensive compressional and extensional tectonics. These complex geologic structures are likely the result of dynamic mantle processes occurring within Venus' interior. In particular, we find that 72% of Venus' surface is covered by lava plains associated with another 20% of surface area that features volcanic and tectonic structures. The remaining 8% has been identified as an intensely deformed thick crustal terrain and relatively older termed as Tesserae, which is said to have survived the last episodic overturn event. The distribution and sizes of impact craters used to determine the surface age are random across the different geological units, limiting the possibility to distinguish the above described interpretation of sequence of events. In this study, we developed 2D and 3D numerical convection models of Venus' thermal evolution that predict Venusian surface characteristics. Using these models, we constrain the effect of physical parameters for example mantle viscosity and melt eruption efficiency on observable characteristics such as the distribution of similar aged surfaces and crustal thickness values. We compared purely stagnant lid cases to episodic models in order to characterize them after considering their predictions of Venus' resurfacing history. Our models suggest that most stagnant lid cases produced results with much thicker crust and very young surface age when compared to the episodic models. We find that episodic overturn models produce surface age distributions and crustal thicknesses that are in better agreement with the observed values.