

**VENUSIAN IMPACT: STARTING A MOBILE LID.** G. T. Euen<sup>1</sup> and S. D. King<sup>1</sup>, <sup>1</sup>Department of Geosciences, Virginia Tech, 926 W Campus Dr, Blacksburg, VA 24061 (egrant93@vt.edu)

**Introduction:** Earth and Venus are often called sister planets; however, their surfaces bear almost no resemblance to each other. Despite the heat within Venus, which we postulate would be similar to Earth, we do not see any form of a dynamic, mobile lid as we do on Earth. The surface of Venus is hypothesized to be in a stagnant lid regime. Based on crater distribution, the surface age could be uniform or variable with an average age of approximately 500 million years [1]. The implication is that the entire crust may have melted and re-solidified roughly 500 million years ago.

There are two prevailing hypotheses for this resurfacing: a progressive process similar to hotspot volcanism on Earth and a cataclysmic event which triggers melting and resurfacing. Recent work has shown that the mobile lid regime requires a component of degree-1 density structure [2]. Without this, models remain in a plume-dominated, stagnant lid regime. This suggests the need for a mechanism to introduce the degree-1 structure in order to trigger mobile lid behavior. It has also been proposed that a large planetary impact was the trigger that initiated plate tectonics on the early Earth [3]. Here we investigate the role of impacts on the development of mobile lid convection on Venus and whether an impact that initiates mobile lid convection would produce a degree-1 center of mass, center of figure offset.

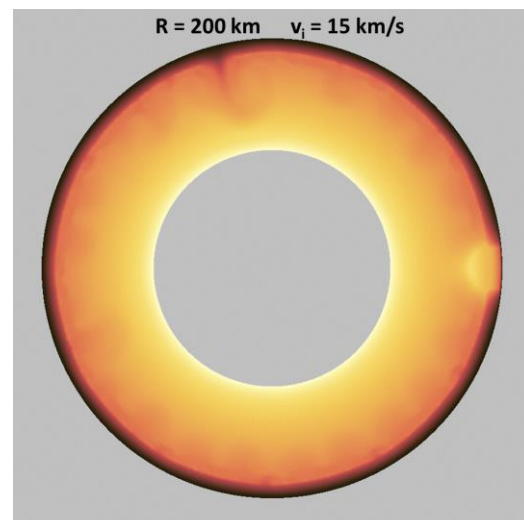
**Methods:** Models were run using the geodynamics code ASPECT, Advanced Solver for Problems in Earth's ConvecTion, based on previous work done by [3]. Impacts are modeled based on the methods outlined in [4]. Heating of the mantle caused by the impacting body is calculated as a function of pressure due to the shock waves caused by the impact. The pressure of the impact is parameterized as a function of radius from the impact site. The interior of the impact crater, the isobaric core, is set to at a constant peak pressure. Outside this radius the pressure decays exponentially according to  $P_s(r) = P_s(r_c) * (r_c/r)^{l-a} + b * \log(v_i)$ , where  $P_s(r)$  is the pressure due to impact,  $P_s(r_c)$  is the peak pressure within the isobaric core,  $r_c$  is the radius of the isobaric core,  $r$  is distance from the impact,  $a$  and  $b$  are decay law exponents, and  $v_i$  is velocity of the impacting body.

The decay law for calculating the pressure outside of the isobaric core relies on the two exponent values  $a$  and  $b$  shown above. Numerical experiments done by [5] found values of  $1.84 \pm 0.17$  and  $2.61 \pm 0.14$  for

these values respectively. Using the hydrocode iSALE, [3] refined these values to 1.68 and 2.74 respectively.

**Conclusion:** Based on these models, a planet in stagnant lid conditions, can evolve into one of three states after an impact. If the impacting body is less than 75 km in radius, the stagnant lid is unbroken and continues to be the dominant regime across the planet. If the impacting body is greater than 75 km in radius, the stagnant lid is broken in the area near the impact, triggering transient localized melting and subduction (Figure 1). Over geologic time lithospheric overturn occurs as viscosity becomes dominated by yielding. If the impacting body is greater than 500 km in radius, the stagnant lid is broken with large-scale heating of the mantle causing buoyant uplift that drives melting, subduction, and lithospheric overturn soon after impact. It should be noted that here even the “small” category are very large impacting bodies, especially by present standards. This agrees with the findings of [3] who showed that Hadean Earth requires a large impact to initiate plate tectonics.

**References:** [1] Simons M. et al. (1994) *Science*, 264(5160), 798-803. [2] King S. D. (2018) *JGR*, 123, 10.1002/2017JE005475. [3] O'Neill C. et al. (2017) *Nature Geoscience*, 10, 10.1038/NGEO3029. [4] Watters W. A. et al. (2009) *JGR*, 114, E02001. [5] Pierazzo E. et al. (1997) *Icarus*, 127, 408-423.



**Figure 1:** Stagnant lid case impacted by body of radius 200 km. Downwelling, melting, and subduction begin around the impact location. Through geologic time, these effects spread to initiate lithospheric overturn.