VENUS: COULD RESURFACING EVENTS BE TRIGGERED BY SUN'S OSCILLATION THROUGH THE GALACTIC MID-PLANE? Steven M. Battaglia[1], [1]Northern Illinois University, Department of Geology and Environmental Geosciences, 1425 W. Lincoln Hwy., Davis Hall, DeKalb, IL, 60115 (Email: battagls1@gmail.com).

Introduction: The following discussion proposes an alternative hypothesis for the initiation of a planetary resurfacing event on Venus. Specifically, a dialogue is developed to consider the vertical oscillation of the Sun through the galactic mid-plane of the Milky Way galaxy as a possible triggering source for the revitalization of the Venusian crust.

Earth's Sister: Venus is essentially Earth's sister in mass and radius, and is our nearest neighbor in proximity to the Sun. The surficial conditions are inhospitable from a lack of water and a dense CO_2-dominant atmosphere comprised of mean surface temperatures of ~730 K [1]. The hot, dry surface establishes a flexible non-rigid crust that is less dense than Earth's crust and therefore resists subduction from the increased buoyancy [2]. Although signs of Earth-like tectonic processes have not been detected, there is evidence of deformation of the malleable lithospheric lid from mantle-originated convection currents [3]. Observations of the surface estimate the majority (>80%) of its age to be ~300–700 Ma [3-4].

The leading supposition for the relatively uniform surface age on Venus is a planetary resurfacing event [4-5]. Radioactive decay in the mantle is the primary source for internal heating and, because of a stagnant lid, it warms the mantle over time [5]. The eventual swelling of low density mantle material (from the temperature increase) can ascend toward the surface and inundate the crust by fracturing the lower lithosphere. Once the mantle temperature is warm enough, localized decompression melting is, at first, conditional. The regional volcanism then becomes widespread over the bulk of the surface as the planet releases built-up interior heat. The resurfacing process is estimated to last no more than ~100–150 Myr before the planet reenters an, or another, era with a stagnant lid [6].

Despite the proposal that radioactivity alone produces the eventual mantle temperature necessary to begin a crustal overturn episode, resurfacing on Venus may also be triggered by an extraterrestrial occurrence.

SS Crossing the GMP: The solar system (SS) vertically oscillates through the galactic-mid plane (GMP) once every ~30–35 Myr [7-8]. This circumgalactic ring is composed of visible matter (VM) and a thin disc of concentrated dark matter (DM) [9]. The DM is most likely composed of weakly interacting massive particles (WIMPs). The Sun's periodic crossing of the GMP increases potential VM and DM (and thus WIMP) interactions with SS-orbiting celestials.

Two processes may follow from the SS cutting across the GMP. First, comet-like objects that make up the Oort cloud may be gravitationally vexed by galactic VM and DM tidal forces that could give forth to increased comet showers in the inner SS [10-11]. Second, WIMPs (from DM heaps) can be captured by planetary gravitational wells [12-14]. The WIMPs scatter off nucleons that comprise a planet and lose energy. The particle speed from decreased energy can become subordinate to the escape velocity of the planetary body and drift towards the core. The total WIMP densities could be considerable for mutual annihilation of individual particles and may result in the expulsion of substantial energy within the core. The generous energy may increase the core temperature when encountering dense DM clumps in the GMP [14]. This ample surplus of energy to a planetary core is expected for Earth- and Venus-sized bodies or larger, and therefore Mercury and Mars, because of their relative sizes, are less probable for DM interactions.

Outcomes from GMP Crossing: A few potential outcomes for Earth and Venus can result from increased comet showers and capture of WIMP wads. A surge of comets may increase the number of impacts that could transform the geodynamic structures of the planetary crusts. The increased core temperature from WIMP eradication can produce an excess of magma plumes along the core-mantle boundary if the energy supplied is larger than the present planetary heat flow. The temperature of the core may increase by a few hundred Kelvin compared to the planetary cooling rate and is therefore prone to yield populous low density mantle material [14-15].

On Earth, the proposed cause of the K-T mass extinction ~66 Ma was by one or both of these outcomes [15-16]. The gravitational perturbations of Oort cloud objects could have sent a large comet (or asteroid-size rock) on a collision course with the Earth that may have led to an impact event. The capture of dense clumps of DM could have induced a surplus of upwelling mantle plumes from the core-mantle boundary. This may have caused the initiation of the Deccan Traps flood basalts believed to have originated from the lower mantle. In either scenario, the K-T impact and the Deccan Traps floods are estimated to have occurred within 100 kyr of each other [17] and are thought to have both contributed to the mass extinction ~66 Ma. It can be implied that, if these aftereffects are indeed from the SS crossing the GMP, the crust of inner SS planetary bodies can undergo a significant modification from extraterrestrial processes.

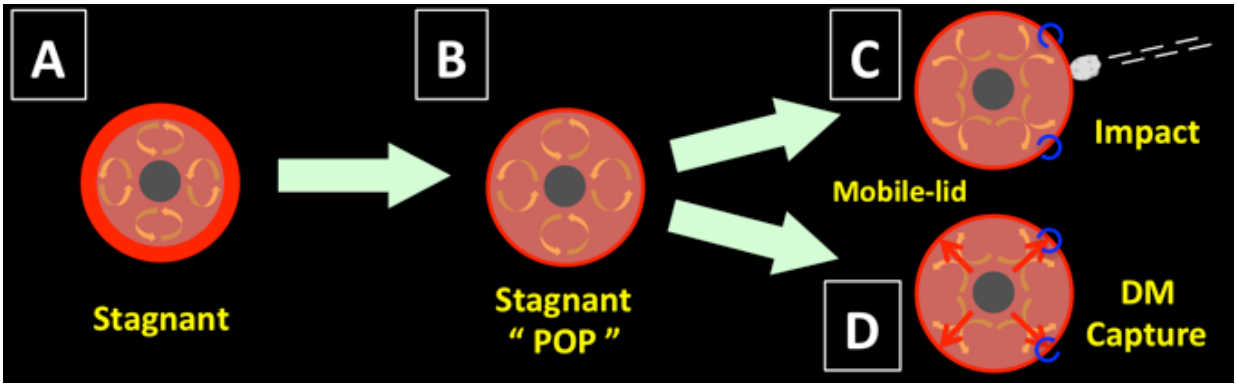

Fig. 1: Sequence of proposed initiation of a Venus resurfacing event from extraterrestrial forces caused by the SS crossing the GMP. [A] Radioactive decay in the mantle (indicated by circular orange arrows) generates internal heat with a planetary stagnant lid. [B] The interior temperature increases and mantle material inundates the lower lithosphere creating a POP for Venus. Once the POP is established, the mobile-lid regime (indicated by blue circular arrows and non-circular orange arrows) may trigger from [C] a planetary impact from increased comet showers or [D] excessive core warming from capture of dense DM.

Resurfacing the Venusian Crust: It is assumed here that similar external and internal processes from the Sun's vertical oscillation through the GMP can result on Venus as they do on Earth. However, how can these extraterrestrial means initiate a mobile crust on Venus? Fig. 1 is an illustration of the proposed hypothesis.

With a stagnant-lid regime, an amplification of temperature within the interior of Venus is acquired over time. The mantle temperature increase is produced by both radioactive decay and core warming from captured DM by successive GMP crossings. The increase in interior temperature can deluge the lower lithosphere (i.e. crustal thinning) and eventually set the stage for a resurfacing event. This stretch, in which a triggered mechanism can initiate the mobile lid because of excessive interior heat, is dubbed the *potential overturn period*, or POP. [The ambiguous use of the term POP is used only for the purpose of describing the generally warmed interior of Venus prior to crustal resurfacing.]

The extraterrestrial processes from the SS crossing the GMP may spark the resurfacing event when Venus is in its POP. An impact event, caused by a dismay of gravitational forces between the GMP and Oort cloud objects, can fracture the Venusian crust with enormous energy. The immense energy generated could produce an environment favorable for increased magmatism from the numerous low density mantle plumes (as has been historically documented on Earth [17]). The glut of plume ascents can be further assisted from an increase in core temperature from the gravitational capture of WIMPs. A localized volcanic eruption at the surface during a POP can induce widespread volcanism at multiple locations whereby excessive plumes, from the interior temperature escalation, may escape the lower lithosphere through further crustal fracturing and form new surficial melts. The stagnant- to mobile-lid regime could also be triggered by a contribution of both external and internal processes analogous to the suggested cause for the K-T mass extinction on Earth.

Summary: The current model introduces an alternative perspective on the initiation of a global resurfacing event on Venus. The build-up of interior heat in the mantle arises from two processes: (1) from radioactive decay and (2) core warming by successive capture of dense DM clumps. From the mantle warming, Venus eventually attains a POP—a potential overturn period for its crust.

A GMP crossing by the Sun while Venus is in its POP may lead to the rejuvenation of the upper lithosphere. This could occur by an impact event from Oort cloud gravitational perturbations with the circumgalactic disc or by excess swelling of low density mantle material from capture of a surplus of WIMPs. If this conjecture is correct, then a greater understanding of the geological and evolutionary history of Venus may be better determined.

References: [1] Carroll and Ostlie (2007), *An Intro. To Modern Astrophys.*, Pearson Pub., 740. [2] Taylor and McLennan (2009), *Planet. Crusts*, Camb. Univ. Press., 181. [3] Nimmo and McKenzie (1998), *Annu. Rev. EPS*, *26*, 23. [4] Schaber et al. (1992), *J. Geophys. Res.*, *97*, 13257. [5] Strom et al. (1994), *J. Geophys. Res.*, *99*, 10899. [6] Armann and Tackley (2012), *J. Geophys. Res.*, *117*, E12003. [7] Bahcall and Bahcall (1985), *Nature*, *308*, 706. [8] Holmberg and Flynn (2000), *MNRAS*, *313*, 209. [9] Randall and Reece (2014), *Phys. Rev. Lett.*, *112*, 161301. [10] Matese et al. (1995), *Icarus*, *116*, 255. [11] Nurmi et al. (2001), *MNRAS*, *327*, 1357. [12] Krauss et al. (1986), *Phys. Rev. D.*, *33*, 2079. [13] Gould (1987), *ApJ*, *321*, 571. [14] Abbas and Abbas (1998), *Astropart. Phys.*, *8*, 317. [15] Rampino (2015), *MNRAS*, *448*, 1816. [16] Randall (2015), *DM and the Dinosaurs*, Ecco Pub. [17] Richards et al. (2015), *GSA Bull.*, *127*, 1507.