THE IMPLICATIONS OF APPLYING A LARGE IGNEOUS PROVINCE (LIP) CONTEXT FOR VOLCANISM, TECTONICS AND ATMOSPHERIC EVOLUTION ON VENUS. R. E. Ernst[1,2], K. L. Buchan[3], H. El Bilali[1,2] and J. W. Head[4], [1]Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada; richard.ernst@ernstgeosciences.com; [2]Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia; [3]273 Fifth Ave., Ottawa, Canada; [4]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, Rhode Island, USA.

Introduction: Voluminous Venusian magmatism may be analogous to Large Igneous Provinces (LIPs) on Earth [1-3]. We consider implications of the terrestrial LIP paradigm for the Venusian geological record, and for the evolution of the Venusian atmosphere over time through input of CO_2 and SO_2 from LIP-style volcanism.

Grouping Magmatic Units and Tectonic Aspects into LIPs: On Earth, each LIP event comprises multiple magmatic units (flows, dykes, sills, intrusions, magmatic underplate) and tectonic features (uplift, associated rifting). Different LIP events (with distinct ages) can spatially overlap. For Venus we are assessing strategies to group units into discrete events, using stratigraphic and cross-cutting relationships [4] in the absence of an absolute geochronology.

Graben-Fissure Systems as the Surface Expression of Underlying Dyke Swarms: An important consideration is whether radiating and circumferential graben-fissure systems on Venus overlie radiating and circumferential dyke swarms. A related question is how best to distinguishing grabens overlying dykes from purely extension graben in Venusian rift systems. Another issue is whether Venusian coronae are analogues to terrestrial circumferential dyke swarms [5].

Link to Mantle Plumes: For Venusian LIPs (by comparison with Earth), we can distinguish three magmato-tectonic regions: the plume centre, a broader plume head region, and a beyond-plume head region. Each has a distinctive magmatic and tectonic expression.

Plume head size on Venus (like on Earth) can be assessed from the distance at which a radiating swarm transitions outward to a linear trend controlled by a regional stress field [6]. The maximum size of a circumferential swarm could also mark the outer boundary of the plume head [5].

The characteristics of terrestrial plume tail volcanism, including smaller volume pulses and shorter dyke swarms, represent criteria for testing for plume tail magmatism on Venus.

Given the absence of plate tectonics [7], Venus provides an opportunity to assess the natural size distribution of mantle plumes based on the sizes of radiating and circumferential swarms, uncoupled from any influence by plate tectonics.

Triple Junction Rifting: On Earth plume/LIP events are often associated with triple junction rifting [3,8]. There is an opportunity for systematic comparison of such rifting on Earth (prior to the ocean opening stage) with the extensive triple junction rift systems on Venus that are associated with major plume-related magmatic centres [9-12].

Locating Magma Reservoirs: On Earth, erosion and geophysical data reveal the distribution of magma reservoirs of LIP plumbing systems [5, 13]. On Venus (given the absence of erosion), we assess evidence for the presence of magma reservoirs in at least three indirect ways: a) local uplifts, b) central depressions within coronae, which may indicate down-sag caldera collapse associated with expulsion of magma; and c) surface depressions which can be interpreted to mark roof collapse above sill-like and dyke-like layered intrusions [14].

Identifying Sources of Lava Flows: Terrestrial lava flows can be fed from fractures along the edge of a caldera, from lateral injection of radiating dykes intersecting surface topography and from circumferential dykes [15]. Given the absence of erosion, Venus provides a remarkable opportunity for linking specific lava flows to specific sources, thus providing insight into the distribution of buffered vs unbuffered magma reservoirs [16] within an overall magmatic system.

Effect on Climate: Terrestrial LIPs are responsible for dramatic climate change and mass extinctions [17]. The proposed Great Climate Transition on Venus, from habitable to present day hyper-warm with high CO_2 [18-20], may be associated with stochastic overlap of multiple LIPs [21].

The post-climate change atmosphere of Venus will have ongoingly received additional input of CO_2 and SO_2 from Venusian LIP style basaltic volcanism. This contribution will come from different sources including the older mafic plains (planitia) and the younger plume-related magmatic centres [4] such as Atla Regio which are likely currently active [22, 23]. Detailed flow and graben (dyke) mapping of both planitia and younger volcanic centres and determination of relative ages from cross-cutting relationships [4] can constrain the volume vs time release of CO_2 and SO_2 and thus provide parameters for improved modelling of the evolution of the Venusian atmosphere. and testing the model of the presence of an earlier Earth-like atmosphere and the hypothesis of a "Great Climate Transition" to today's observed decidedly "un-Earth-like" atmosphere.

References:

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