The geologically recent areas as one key target for identifying active volcanism on Venus.

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Abstract

The recently selected NASA VERITAS and DAVINCI missions, the ESA EnVision, the Roscosmos Venera-D will open a new era in the exploration of Venus. One of the key targets of the future orbiting and in-situ investigations of Venus is the identification of volcanically active areas on the planet. The study of the areas characterized by recent or ongoing volcano-tectonic activity can inform us on how volcanism and tectonism are currently evolving on Venus. Following this key target, the manuscript by Brossier et al. (2022) (https://doi.org/10.1029/2022GL099765) extends the successful approach and methodology used by previous works to Ganis Chasma in Atla Regio. We comment here on the main results of the manuscript published by Brossier et al. (2022) (https://doi.org/10.1029/2022GL099765) and discuss the important implications of their work for the future orbiting and in-situ investigations of Venus. Their results add further lines of evidence indicating possibly recent volcanism on Venus.

The importance of identifying volcanically active areas in the future exploration of Venus

The exploration of Venus will go through a new golden era thanks to the recently selected NASA Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy (VERITAS) (Smrekar et al., 2020) and Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (DAVINCI) (Garvin et al., 2022) missions, the ESA EnVision mission (Ghail et al., 2020), and the Roscosmos Venera-D mission (Zasova et al., 2019). Moreover, other two missions are currently being evaluated for selection: the ISRO Shukrayaan-1 mission (i.e., Haider et al., 2018; Sundararajan, 2021) and the Chinese VOICE mission (e.g., Wang et al. 2022). These missions will focus on the analysis of the chemical composition of the atmosphere and the geologic features of Venus.

One of the main targets of the future missions to Venus will be the identification of potentially volcanically active areas on Venus (i.e., Smrekar et al., 2010; Filiberto et al., 2020). Identifying the locations of possibly active volcanism with its related composition is crucial to estimate energy and volatile budget on Venus, that is of great importance to understand the geodynamic evolution of

Venus and the terrestrial planets. Evidence of ongoing volcanism can give us clues in the debate between catastrophic (i.e., Schaber et al., 1992; Basilevsky and Head, 1998; Romeo and Turcotte, 2010) and equilibrium resurfacing (i.e., Phillips et al., 1992; Guest and Stofan, 1999; O'Rourke et al., 2014), indicating how volcanic and tectonic activity is currently evolving on Venus (e.g., Weller and Kiefer 2020). The analysis of recently erupted (chemically unweathered) lava flows will also provide useful information about the volatile content of the mantle of Venus (e.g., Filiberto 2014). We comment here the results of the work by Brossier et al. (2022) (https://doi.org/10.1029/2022GL099765) and the related implications for the future orbiting and in-situ investigations of Venus.

As observed by previous studies (e.g., Pettengill et al., 1992), the presence of high dielectric (ferroelectric) minerals can increase the radar reflectivity and lower the radar emissivity on Venus. It is observed that some minerals (e.g., perovskite oxides and chlorapatite) can lower the emissivity even at anomalously low altitudes (Brossier et al., 2021). Theoretical studies indicate that the high dielectric minerals can be formed over the time by the interactions between the surface and lower atmosphere, also known as chemical weathering (e.g., Zolotov 2019). In this way, dielectric measurements on Venus can be used as a potential chronometer to constrain the age of surface materials.

Brossier et al. (2022) (https://doi.org/10.1029/2022GL099765) analyze the radar emissivity excursions of seven different sites at Ganis Chasma, four of which already studied by Shalygin et al. (2015) using Venus Monitoring Camera (VMC) data of the Venus Express, while other three sites were selected separately for comparison (Fig. 1). Their results show that for a given (range of) altitude and temperature, the emissivity excursions do not occur uniformly over all the analyzed surface materials (Fig.2). This implies that, in the study area, the observed emissivity excursions are mainly controlled by the presence (or absence) of distinct ferroelectric minerals with high dieletric constant. Based on the magnitude of the observed radar emissivity excursions of the seven different sites, the authors conclude that sites 1, 3, and 4 may be characterized by unweathered and thus extremely young surface materials where high dielectric minerals have not yet been formed.
Similarly, using a holistic approach, other recent studies have combined laboratory results, geologic interpretation, and Venus Express VIRTIS 1 micron surface emissivity data to provide additional lines of evidence for recently or possibly ongoing volcano-tectonic activity at Idunn Mons, the major volcanic structure of Imdr Regio on Venus (D'Incecco et al., 2017, 2021a,b,c; Filiberto et al., 2020., 2021; Cutler et al., 2020; López et al., 2022). Combining this new work with previous studies by Brossier et al., (2020) and Brossier et al. (2021), this demonstrates that the Magellan dataset is able to provide important clues about the materials on the surface, which can be used as a potential chronometer for the surface age of Venus. The results of this manuscript are extremely relevant to our understanding of how volcanic processes are currently acting on Venus. Further, these models can be tested with the upcoming fleet of missions expected to arrive at Venus in the next decade.

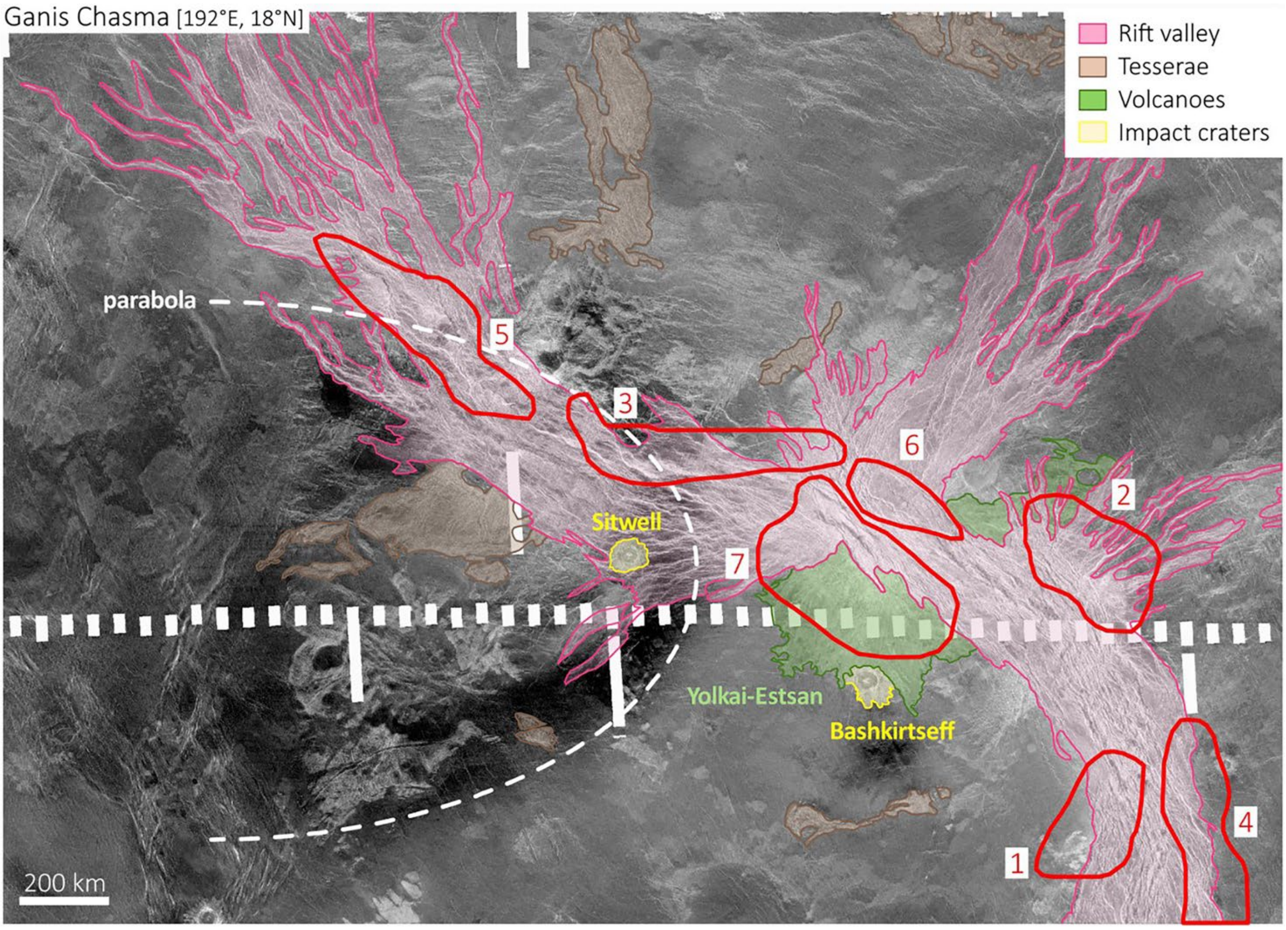

Figure 1: Ganis Chasma (192°E, 18°N) showing Magellan Synthetic Aperture Radar image (gray scale) and the main morphologic features. The seven sites of interest are outlined in red. Morphologic features are mapped after Ivanov and Head (2011): Ganis Chasma (rift zone), Sitwell crater (with its parabola), Bashkirtseff crater, Yolkai-Estsan Mons, and surrounding tesserae. Maps have a simple cylindrical projection and north is up. *From Brossier et al., 2022*.

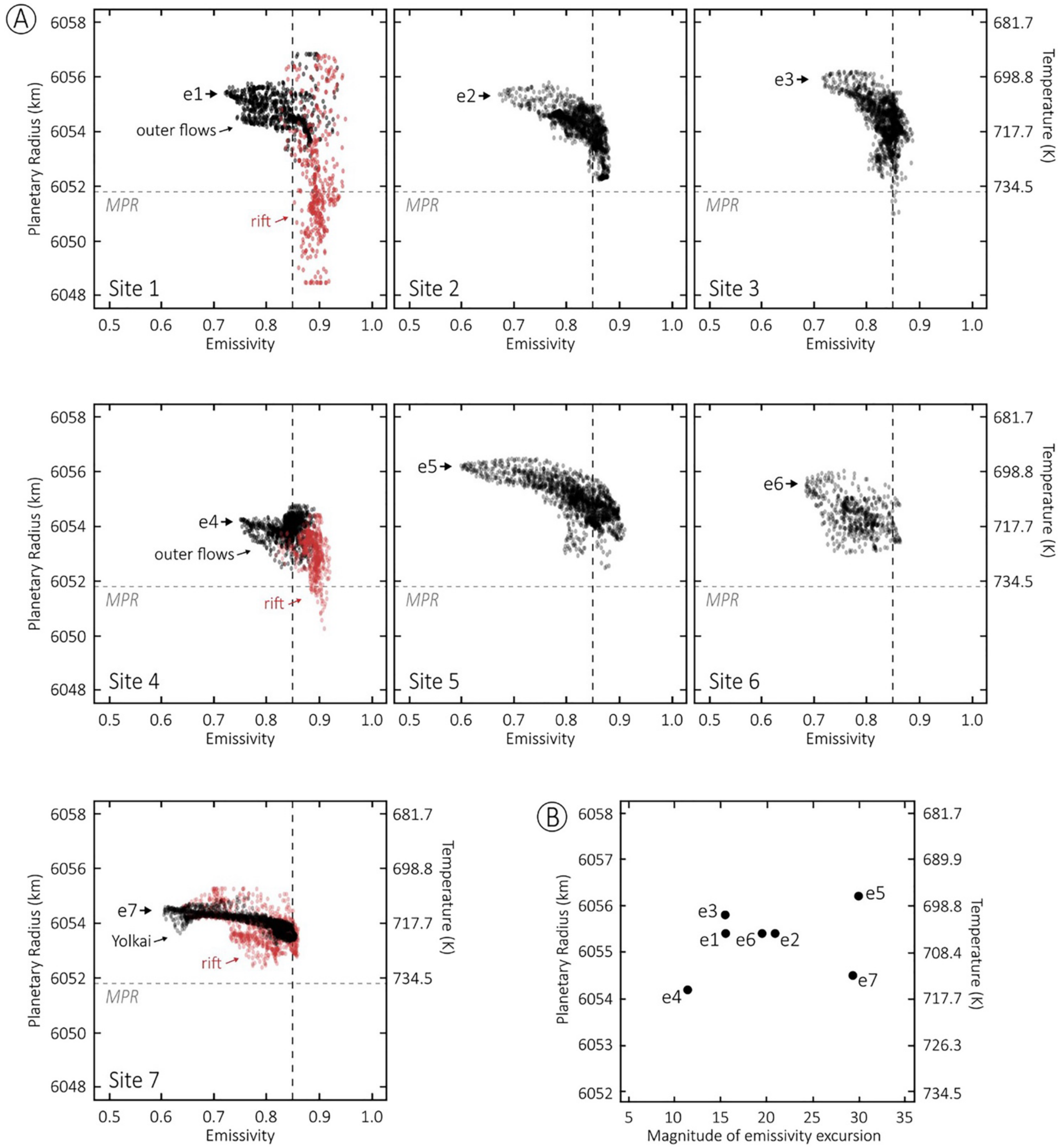

Figure 2: (a) Elevation versus emissivity plots obtained for the studied sites. Dashed lines in plots are mean global values of emissivity at 0.85 (vertical, black), and planetary radius at 6,051.8 km (horizontal, gray). (b) Magnitude of emissivity excursions (percent change from global average value of 0.85) detected in each site versus corresponding altitude and temperature. Temperatures are given by the Vega 2 lander data (Brossier et al., 2020; Lorenz et al., 2018; Seiff, 1987). *From Brossier et al., 2022*.

The wealth of data to be provided by the future missions will tell us more about ongoing volcanic activity on Venus. For this reason, it is crucial to select a number of relevant volcanically and tectonically active areas on Earth as suitable Venus's analogues. To this regard, Project "Analogues for VENus's GEologically Recent Surfaces" (AVENGERS) aims to create a list of suitable analogue volcanic sites on Earth, which can help us to: i) collect spectral signatures from lava flow samples on Earth, whose chemical composition is known, to compare with the spectra to be provided by the future investigations of Venus; ii) analyze radar backscattering over volcanically active areas on Earth to check how to evaluate changes in the areal extent of the lava flows in short amounts of time due to the effect of possibly ongoing eruptions; and iii) use easily accessible volcanic sites on Earth as test areas for drilling operations and in-situ elemental analyses. As a first analogue site for Project AVENGERS, preliminary studies are currently being conducted on Mount Etna (D'Incecco et al., 2022; Eggers et al., 2022), one of the most active and well monitored volcanoes on Earth. Building off this, studying active and recently active volcanism on the Earth is vital to test models for Venus exploration, such as Brossier et al. (2022) in order to be able to constrain potentially active volcanism and tectonism on Venus with the future missions due to arrive and make repeated measurements over the same surface previously measured by Magellan.

Data Availability Statement

For this commentary article, no new data were used. The data we commented in this article come from the previously published research by Brossier et al. (2022), on this journal.

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