DISTINCT MINERALOGY ASSOCIATED WITH INDIVIDUAL LAVA FLOWS IN ATLA REGIO, VENUS. J. Brossier, M. S. Gilmore, and K. Toner. Dept. of Earth and Environmental Sciences, Wesleyan University, Planetary Science Group, 265 Church St., Middletown CT 06459, USA (jbrossier@wesleyan.edu).

Introduction. A decline in radar emissivity at many Venus mountaintops [1,2] is thought to be the result of atmosphere-surface interactions in the highlands, where temperatures are lower [3-5]. These reactions are a function of rock composition, atmospheric composition, and degree of weathering. Recent analysis of NASA's Magellan radar data [6,7] reveal that some large volcanoes on Venus exhibit multiple, often sharp declines in radar emissivity values over a range of altitudes. This phenomenon was also reported in earlier studies [8]. Here we perform detailed mapping of these volcanoes and examine any correlations between their location and stratigraphic position and emissivity signature; this may yield insight into the evolution of the volcanic system. Here we focus on Sapas, Maat and Ozza montes, located in Atla Regio.

Data & Methods. We mapped the lava flow units of the volcanoes with the Magellan Synthetic Aperture Radar (SAR) images at 75 m per pixel. Mapping of the flow units is primarily based on morphology, radar backscatter, and stratigraphic relationships, e.g., [9]. Magellan elevation and emissivity data are extracted to produce scatterplots of the variation of emissivity with altitude [1,6]. Both datasets are oversampled to 4.6 km per pixel. The elevation data are given in planetary radius with a mean value of 6051.8 km [10]. We retrieved temperatures by correlation to the Vega 2 lander entry profile [11]. We derived permittivity from emissivity after [12], as described in [13].

Geologic Mapping and Emissivity Excursions. Emissivity excursions are defined as a reduction of radar emissivity below a value of 0.7 on an elevation vs. emissivity plot. The shape and elevation of these excursions can be seen in Fig. 1, plotted as permittivity, which is considered as the inverse of emissivity.

We identified 6 lava flow units on Sapas (S1-6 units). Most flow units participate in the same emissivity excursion (e1) and reach their minimum values at around 6054 km. The radiating bright flows (S5 unit) display a more gradual decline above this altitude until 6054.6 km with an emissivity low of ~0.4, before returning to slightly higher emissivity values at the summit features (S6 unit). The summit region comprises the two scalloped-margins domes and dark materials exposed on their flanks [9].

Then, we identified 5 lava flow units on Maat (M1-5 units). The southwest bright flows (M2 unit) are the main source of the emissivity excursions at 6056.2 km (e1), 6055.4 km (e2) and 6053.9 km (e3). The northwestern flows (M1 unit) are the main source for the excursion at 6052.7 km (e4). The SAR dark materials identified in the north flank (M3 unit) and in the sum-

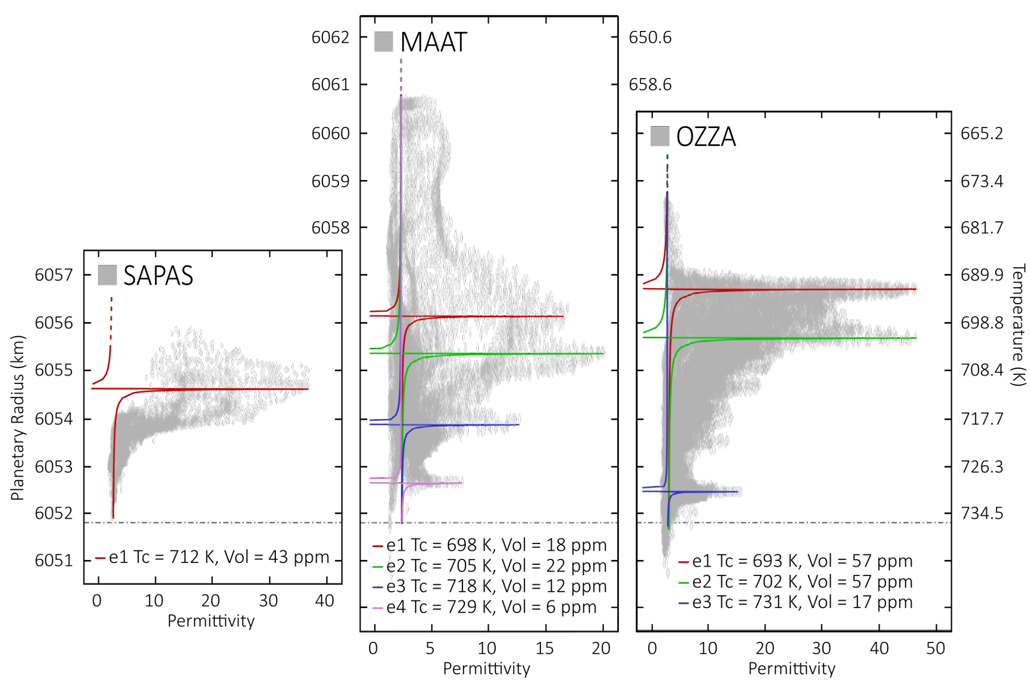

Figure 1 - Derived permittivity vs elevation plots with modeled excursions for each volcano.

mit region (M4 unit) of Maat have mostly high emissivity values. The eastern flows (M5 unit) extending from the summit also have high emissivity for the entire elevation range of the volcano.

Finally, we identified 8 lava flow units on Ozza (O1-8 units, see Fig. 2), however stratigraphic relations among them remain ambiguous. The tectonized caldera (O3 unit) is the main source of the emissivity excursions at 6056.7 km (e1) and 6055.7 km (e2), before returning to higher values at elevations above 6057 km (i.e. SAR dark plateau). Another set of flows (O4 unit) is stratigraphically above the caldera and may contribute in the previous excursions (e1-2). The field of shield volcanoes found near the dark plateau (O5 unit) has an average emissivity of 0.55. The hummocky flow field (O2 unit) surrounding the summit is the main source for the excursion at 6052.5 km (e3) and participates in the high elevated excursions (e1-2). We also include two large flow fields (O7-8 units) identified near Atla Regio and Parga Chasma that are possibly associated to Ozza's activity. They both participate in the low elevated excursion at 6052.5 km (e3).

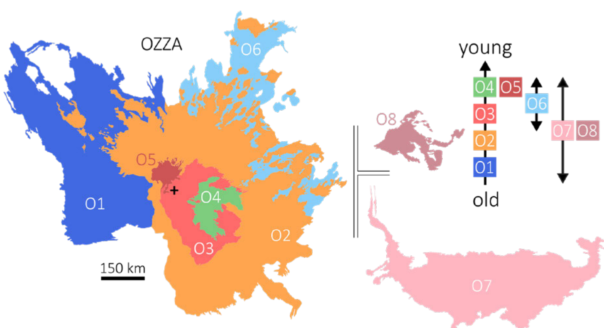

Figure 2 - Ozza flow units.

Ferroelectric Model. The shape of the emissivity variations seen in these volcanoes are consistent with the presence of ferroelectric minerals in the rocks undergoing a phase change at a specific temperature (Curie temperature, Tc) [14] (see also Ovda Regio [15]). If we assume that the elevation of the major excursions represent their Curie point temperature, we can estimate the volume of the ferroelectric mineral present in the rocks. We first converted the emissivity to dielectric constant after [12] (also [13]), and then applied the ferroelectric model after [4] for a mineral with a given Curie constant ($C = 10^5$). From this we can derive the volume of the ferroelectric assuming a constant mineral shape (see Fig. 1).

Discussion & Conclusion. Emissivity excursions in the studied volcanoes are spatially correlated to specific flows, ensuring that they are related to rock composition rather than atmospheric conditions (composition, temperature). The low elevated excursions are consistent with ferroelectric minerals at higher Curie temperature than for the excursions previously considered on Venus.

There are multiple excursions in one volcanic system, suggesting there are multiple minerals in that system. Flow events with similar excursions in emissivity with altitude are not always contiguous or sequential. Sapas flows are consistent in dielectric composition through its history, unlike Maat and Ozza. Only the two oldest flows of Maat have undergone the weathering, while all of the flows of Ozza have had enough time, implying much of Maat is younger than Ozza. This is supported by the volumes of ferroelectrics in Ozza modeled to be greater than in Maat, indicating more time to produce them.

The temperature and altitude of the emissivity excursion are functions of composition, while the magnitude of the excursion is a function of volume of the ferroelectric [4].The existence of emissivity excursions at the same altitude across several flow events provides an opportunity to study the evolution of the reactions creating these excursions. Some excursion elevations are shared between volcanoes, implying that similar common minerals are turning on within these volcanoes, particularly Maat and Ozza montes, while Sapas has its own distinct mineralogy.

References: [1] Klose et al. (1992) *JGR* 97, 16353. [2] Pettengill et al. (1992) *JGR* 97, 13091. [3] Arvidson et al. (1994) *Icarus* 112, 171. [4] Shepard et al. (1994) *GRL* 21, 469. [5] Brackett et al. (1995) *JGR* 100, 1553. [6] Brossier et al., *under review*. [7] Toner et al. (2019) *50^{th} LPSC*, 3153. [8] Robinson and Wood (1993) *Icarus* 102, 26. [9] Keddie and Head (1994) *EMP* 65, 129. [10] Ford and Pettengill (1992) *JGR* 97, 13103. [11] Seiff et al. (1987) *ASR* 7, 323; Lorenz et al. (2018) *Icarus* 305, 277. [12] Campbell (1995) USGS Open-File Report 95-519. [13] Stein and Gilmore (2017) 48^{th} LPSC, 1183. [14] Palazzari et al. (1995) *26^{th} LPSC*, 1089; Campbell et al. (1999) *JGR* 104, 1897. [15] Treiman et al. (2016) *Icarus* 280, 172.