TOPOGRAPHIC CHANGES ON THE SURFACE OF VENUS OBSERVED ALONG LAVA CHANNELS.

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Introduction: In first order characteristics, Venus and Earth are similar, yet the surface of Venus experiences much higher temperatures and pressures. Thick clouds made of sulfuric acid prevent visible light imaging and analyses, making radar the only method that can image the surface. NASA's Magellan mission succeeded in this task in the early 90s, imaging 97% of the surface with synthetic aperture radar (SAR) [1].

Around 80% of the surface of Venus is covered by volcanic plains [2]. One of the most prominent and widespread features on the surface of Venus are sinuous, canali-like channels called valles (sg., vallis) that can extend hundreds to thousands of kilometers in length (Fig. 1). These channels maintain constant width of several kilometers and are currently interpreted as channelized lava flows [3]. Along these channels, the topography has changed after their formation, which has been reported along Baltis Vallis caused by both large-scale (long-wavelength) and small-scale (short-wavelength) topographic undulations due to regional uplift, subsidence, or faulting (Fig. 1, red line) [3].

Any topographic undulations along channels other than Baltis Vallis remain mostly unexplored; but a systematic study of the topography along these channels would provide insight into the nature and abundance of topographic undulations, with implications for the geologic, tectonic, and thermal histories of Venus—topics that are heavily debated in the planetary science community [4, 5]. Here we conduct a global survey of the Venusian channels, using a systematic mapping approach to extract geologic observations, topography, and dynamic topography to study the commonality and nature of these topographic undulations [6].

Methodology:

Data. For our mapping and data collection, we created a GIS with the Venus Magellan SAR Left and Right Look Global Mosaics with pixel resolutions of 75 m, the Venus Magellan Global Topography at a 4641 m pixel resolution, and the gravity-derived global dynamic topography [6]. For reference, we also use the global geological map of Venus [7].

Methods. In our GIS, we located all known channels from the IAU-named valles. Of those, we selected 34 channels based on length and quality of data, and traced each of them with equally spaced vertices of 1 km. To assure consistent data sampling and to minimize distortions from the map projection, we reprojected the channels along their length using a ten-by-ten decimal degree grid using a stereographic projection with the Venus 2000 datum. The mapping was carried out at a 1:100,000 map scale. When both channel walls were clearly visible, we mapped in the center of the channel floor; otherwise, the visible wall was traced. The map traces were used to extract the pixel values of the topography and gravity-derived datasets at each vertex.

To study the topographic changes along the length of the channels and the tectonic processes causing them, we describe the geology and extracted information on topography and dynamic topography along each of the 34 channels, comparing them in a profile view along their length. We describe structures that interact with the channels and quantify the wavelengths and amplitudes of the topographic undulations, where present.

Findings: The lengths of our mapped channels (Fig. 1) range from ~200 km to ~7000 km. We identify almost 50 topographic undulations in a total of 29 channels. The wavelengths of the undulations range from 30 to 2500 km, with an average of ~340 km. The amplitudes of the undulations range from 50 to 2500 m, with an average of ~370 m. Because the locations of the channels likely do not coincide with the maximum topographic changes, the extracted values on amplitude and wavelength represent a minimum estimate of the topographic changes. Nevertheless, our findings indicate that marked topographic changes are widespread and common across the surface of Venus.

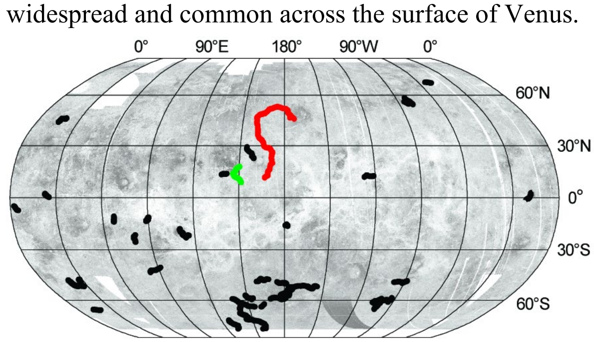

Fig 1: *Global map of channels on Magellan mosaic projected to 180°E, 0°N in Robinson projection. Baltis Vallis is shown in red, Ikhwezi Vallis is green.*

Geologic observations. One intriguing lava channel is Ikhwezi Vallis (IV, Fig. 1, green line), which is well observable in the left-look Magellan SAR mosaic (Fig. 2). The observable parts of IV total a length of 1836 km, but considering data gaps it may exceed 1919 km. From A to A', the straight-line distance is 1005 km, resulting in an overall sinuosity of ~1.91.

Following the channel from A to A', the southern terminus of IV is in an area with abundant lava flows in a highly fractured region. The origin and flow direction were not apparent in the radar data, so any reference to directionality is only descriptive. Near point A, IV shows a cross-cutting relationship with a fracture without any indication of relative age. IV then crosses featureless plains. IV curves around a topographically elevated region called Urutonga Colles that is mapped as shield plains [7]. That IV curves to avoid the shield plains indicates that the shield plains were a preexisting topographic high when the channel formed. IV then crosses a topographically elevated region mapped as ridged plains, where it increases in sinuosity. This region contains Olena crater and the channel curves around the ridged plain but still crosses a topographically elevated region that extends beyond the ridged plains (Fig. 2, label a). This indicates that the ridged plains already were a topographic high while the channel formed but that topographic changes continued after channel formation. Then the channel curves around the topographically elevated Barbale Dorsa groove belt, which has a NW/SE orientation. The grove belt thus was already a topographic high when the channel formed. The channel then changes orientation from a primary NW/SE to a NE/SW direction, notably perpendicular to Barbale Dorsa. Then, IV is directly located on an elongated topographic elevated region until encountering more groove belts, through which the channel tightly curves with a markedly increased sinuosity, until it enters a region of wrinkle-ridged plains (Fig. 2, label b). These observations indicate that this groove belt formed first, followed by the channel flowing sinuously through the grooves, with this area being topographically further modified after the channel formed. IV is no longer observable beyond radar-bright regional plains near Escoda crater (Fig. 2 label c).

Extracted Profiles. We extracted topography and dynamic topography from the mapped channel in Fig. 2 and plotted them as profiles (Fig. 3). The topography (black curve) shows highs at the start and end of the profile with a low in the profile center. The short-wavelength topographic undulations (e.g., Fig. 2, 3 labels a and b) indicate that ridges continued to build topography after the channel formed, increasing elevations by hundreds of meters on wavelengths of a few hundred kilometers. This profile also shows one prominent long-wavelength topographic change of at least 1000 m over a wavelength of ~1600 km. The dynamic topography (Fig. 3, green curve), a calculated measure of mantle convection, broadly mimics that of the topography, indicating that the observed topographic changes may be representative of dynamic topography. Taken together with the relative timing information from our geologic observations, this dynamic topography is one of the most recent tectonic phenomena found in this region of Venus. Additional topographic observations along channels on Venus will bring insight into how common, how widespread, and over what scales dynamic topography on Venus can be detected.

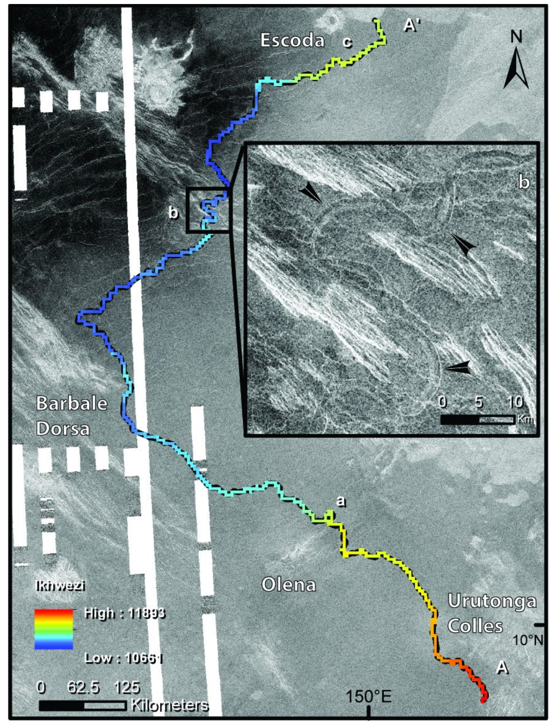

Fig 2: *Ikhwezi Vallis (see black arrows on inset) is shown as color coded topography on top of the left-look Magellan mosaic projected to 150°E, 14°N in an orthographic projection.*

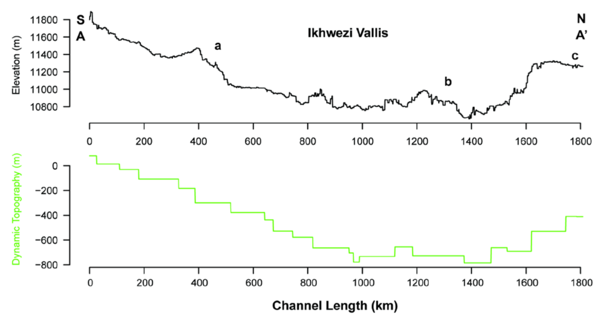

Fig 3: *Topography and dynamic topography plotted along the length of IV from A to A'.*

References: [1] Saunders, R. S. et al. (1992) *JGR, 97,* 13067–13090. [2] Basilevsky, A. T. & Head, J. W. (2003) *Rep. Prog. Phys., 66,* 1699-1734. [3] Baker, V. R. et al. (1997) *Venus II, University of Arizona Press.* [4] Komatsu, G. & Baker, V. R. (1994) *Icarus 110, 2,* 275-286. [5] Solomon, S. C. et al. (1992) *JGR, 97*, 13199-13255. [6] James, P. B. et al. (2013) *JGR, 118*, 859-875. [7] Ivanov, M. A. & Head, J. W. (2011) *PSS, 59,* 1559-1600.