

Cross-sectional profile of Baltis Vallis channel on Venus: Reconstruction from Magellan SAR brightness data. S. Oshigami and N. Namiki, Department of Earth and Planetary Sciences, 33 Kyushu University.

Introduction: Baltis Vallis is a 6800-km long canali-type lava channel on Venus. Channels of this type meander locally and are distinguished by their length extending from several hundreds to several thousands km. The width is nearly constant and is between 1 and 3 km over their entire length [1]. Some canali show characteristics similar to terrestrial fluvial channels. For example, cut-off meanders, point-bars, and deltas are frequently observed on radar images [2, 3]. These morphologic features imply that canali may have formed by low viscosity lava with high discharge rate. These lavas are likely to have chemical composition such as carbonatite, sulfur, and mafic or ultramafic lavas [1, 2, 4, 5, 6, 7, 8].

Formation process of canali has proposed to be either constructional [1, 7] or erosional [3, 8, 9]. Construction is the process that lava flow on the surface develop embankment by gravel and soil of the flow path or solidifying part of the fluid. The levee structure is characteristic of constructional channel. The majority of channels on Venus have well-defined levee [2], however, the Magellan SAR images of Baltis Vallis and other canali do not reveal obvious levees. On the other hand, erosion is the process that channel forming fluid incise the surface thermally or mechanically.

The depth of Baltis Vallis is significant in investigating its origin, but is not accurately measured yet. From the radar foreshortening, or image distortion, the depth has been estimated to be several 10s meters. However, this estimate is subject to 75-m resolution of Magellan SAR images.

Spacial resolution of Magellan altimetry data is ranging from several km to ten km. Because the width of canali is only a few km, it is impossible to reconstruct cross-sectional profile from altimetry data. Instead, a new method of precise reconstruction of small scale topography from brightness data of SAR image is developed in this study. We discuss the formation process of Baltis Vallis from the point of view of geomorphology.

Backscattering model: We apply Muhleman's backscattering function (Equation 1) [10] to brightness data of the Magellan FMAP images,

$$\sigma_0 = \frac{\beta \cos I_0}{(\sin I_0 + \alpha \cos I_0)^3} \quad (1)$$

where σ_0 is backscattering coefficient, that is, intensity of backscattering. The I_0 is radar incidence angle, and

α and β are constants that represent reflectance properties of the surface.

Magellan FMAP images are produced by the U. S. Geological Survey [11]. Pixel values of these images can be translated into backscattering coefficient [12]. It is well known that an intensity of the backscattering of the SAR image depends on slope, roughness, and dielectric constant of surface. Apparently, equation (1) relates an intensity of the backscattering only with radar incidence angle. Roughness and dielectric constant of planetary surface are included in two local parameters α and β in this function.

Reconstruction of cross-sectional profile from I_0 : Radar incidence angle in Muhleman's backscattering function consists of an incidence angle with respect to the mean surface, tilt angle from the mean surface both parallel and perpendicular to the direction of the flow, and average slope. Average slope is estimated from altimetry data. The Magellan space craft have orbited from the north pole to the south pole and transmitted radar pulses to east (left-looking) or west (right-looking) in the direction perpendicular to the line of flight [12, 13]. We can therefore consider that each FMAP image is illuminated from nearly due west (left-looking) or due east (right-looking). The Magellan SAR incidence angle for the mean surface is given as a function of latitude [12].

We take 120 sites of about 10-km by 1.5-km square region across Baltis Vallis. We construct average profile in each region. Roughness and dielectric constant are different every site. We therefore determine α and β in equation (1) on each site where both left- and stereo-looking FMAP images are available. We assume that surface properties are uniform in each site regardless of inside or outside of the channel.

Brightness data are stacked over 20-pixels, namely 1.5-km, along the channel. Stacking cancels random noises of radar images and minor variation of slope in the flow direction. Finally, we correct image distortion resulting from radar foreshortening.

Results: We reconstruct the cross-sectional profiles at 120 sites over about 6000-km reaches of Baltis Vallis. The reaches lower than 6000-km are not examined because flow track is hardly identified on the radar images. Cross-sectional profile at 49.0N and 165.5E is shown in Figure 1 as an example of our reconstruction. Figure 2 shows 3D image of Baltis Vallis at 47N and 161E. This figure adopt 4 cross-sectional profiles and average surface slopes. Altim-

etry data both parallel and perpendicular to the flow direction are used.

In summary, the 120 profiles of the channel reveal average depth and width of $53 \text{ m} \pm 18 \text{ m}$ and $2.6 \text{ km} \pm 0.5 \text{ km}$, respectively. The depth profile along the flow (Figure 3) is highly undulatory. In contrast, the variation of the width is small.

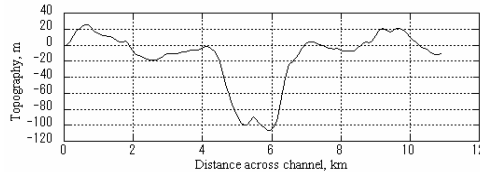


Figure 1. Cross-sectional profile of Baltis Vallis at 49.0N and 165.5E. The vertical axis is a height from average surface.

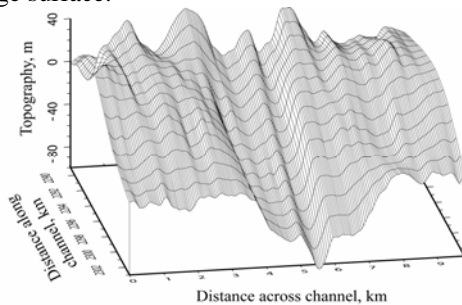


Figure 2. 3D image of Baltis Vallis at 47N and 161E. Levee-like structure can be recognized at upper reach side.

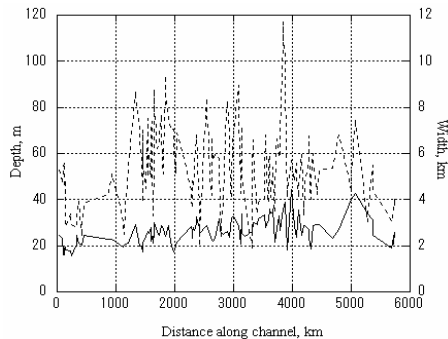


Figure 3. The depth and width of Baltis Vallis from the estimated source of lava flow to the terminal. Dashed line is the depth and solid line is the width.

Discussions: We evaluate the error included in cross-sectional profile such as Figure 1 in order to examine the accuracy of the profile. We compare average surface slope obtained from the profile and that estimated from altimetry data. Then, we have defined the difference of these two slopes as an error of the reconstructed profile. The evaluation at 3 sites (30.9N and 165.8E, 40.2N and 161.1E, 42.7N and 160.2E) results in an uncertainty less than 10-m per km along the cross section. The results are considered to be sufficiently reliable to discuss quantitatively cross-sectional morphology.

It is demonstrated that a clear levee structure can be recognized at only 31 % among the all 120 sites. And the bottom surfaces of the channel are lower than the surrounding plains by several 10s meters at 86 % of these sites. The groove-like morphology as well as the lack of levee structure indicate that Baltis Vallis is likely erosional in origin. The channel formed by thermal erosion is expected to decrease depth with the increasing flow distance. However, such decreasing trend of depth is not observed in Figure 3. Therefore we conclude that Baltis Vallis is most likely to have been formed by not thermal but mechanical erosion in general. It is noteworthy, however, that ratio of the sites with levee structure is about 70 % and higher than the average at upper reaches between 0 and 1500 km from the source, while erosion of the bottom surface is limited to 63 % in this reach. This observation suggests that not only erosion but also construction plays an important role in the formation process of Baltis Vallis at upper reach.

Conclusions: We develop a new method to reconstruct small scale topography from brightness data of SAR images. The accuracy of the reconstructed profile is estimated to be about 10 m/km by comparing the average slope of the profiles with altimetry data. Using this method, we reconstruct cross-sectional profile at 120 sites. It is shown that the depth and width of the channel are $53 \text{ m} \pm 18 \text{ m}$ and $2.6 \text{ km} \pm 0.5 \text{ km}$, respectively. The paucity of levee structure and the absence of decreasing trend of the depth with increasing distance as well as the erosion into the surrounding plains at most sites indicate that Baltis Vallis is likely to have been formed by not thermal but mechanical erosion in general. At upper reach, construction plays an additional roles in channel formation.

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