Cross-sectional profile of Baltis Vallis channel on Venus estimated from Magellan SAR images

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Baltis Vallis is a 6800-km long canali-type lava channel on Venus. In general, a formation process of lava channel has been proposed to be either constructional, erosional, or a combination of these two [Baker et al., 1997]. While canali-type is supposed to be constructional in origin, the Magellan SAR images of Baltis Vallis don't show characteristics of the constructional lava channel such as levees or lateral flow deposits. The depth of Baltis Vallis has been estimated to be several 10s meters using the effect of radar foreshortening. However, this estimate is smaller than 75-m resolution of Magellan FMAP images. Therefore the estimate is likely to include significant uncertainty [Komatsu et al., 1992]. In this study, we adopt the Muhleman backscattering function [Muhleman, 1964] to construct cross-sectional profile of Baltis Vallis from brightness data (pixel values) of the Magellan images, and to discuss the formation process.

It is well known that an intensity of the backscattering of the SAR depends on slope, roughness, and dielectric constant of surface. The Magellan FMAP images are normalized by the Muhleman backscattering function and an incidence angle that changes with altitude of the Magellan space craft. The coefficients in the backscattering function are derived by fitting radar reflectance data obtained by Pioneer Venus [Pettengill et al., 1988] to analytical form of the back scattering function.

The Magellan space craft orbited from north to south and transmitted radar pulses to east in the direction perpendicular to the line of flight. Therefore in the region where the channel flows from north to south, a true incidence angle for a local surface is taken as a sum of an incidence angle with respect to the mean surface and eastward tilt angle from the mean surface. Then, by taking the Muhleman backscattering function and under the assumption that the dielectric constant and surface roughness of the region are constant, we can calculate a surface slope with respect to an average eastward tilt at each pixel from a deviation of pixel value from the average brightness. While the average eastward tilt is unknown, the tilt less than a few degrees has little effect on our results. And northward tilt has even less effect. Thus, a cross-sectional profile can be obtained by integrating the surface slope from east to west.

We have tested the above method by calculating the cross-sectional profiles at several sites around 40 degrees N and 160 degrees E with the two different radar incidence angles of both left-looking and stereo-looking images. Further, in order to reduce a random noise of SAR, the brightness is averaged over 20 pixels from north to south. Then we find that the cross-sectional profiles obtained from both left-looking and stereo-looking images are consistent. The depth of the channel is thus estimated to be between 40 and 80 m. Besides, a clear levee structure can not be recognized in the profiles. Such lack of levee structure as well as the bottom face lower than the surrounding plains by several 10s meters indicate that Baltis Vallis may be formed mainly by thermal or mechanical erosion of lava flows.