

CAN VENUSIAN CHANNELS FORM BY SUBSURFACE THERMAL EROSION? N.P. Lang¹, V.L. Hansen¹, J.B. Swenson¹, and R.A. Bannister¹, ¹Department of Geological Sciences, University of Minnesota Duluth, Duluth, MN 55812; lang0604@tc.umn.edu.

Introduction: Channel formation is a unique puzzle in Venus' rock record. Channels, open passages believed to have transported fluid [1], occur in presumed volcanic regions [2], which together with current Venus surface conditions (~450° C [3] and ~100 bars surface pressure [4]), has led many workers, including us, to infer a volcanic origin for venusian channels, although an origin involving liquid water cannot be fully excluded [1, 5; *see also*, 6-7]. Any hypothesis regarding the formation of venusian channels must explain channel characteristics that include the apparent incision of a substrate with mostly consistent widths of 1-3 km for distances of up to 1000s of km [1], large apparent width to depth ratios, the general absence of levees [8] and extensive lateral flow deposits, and the lack of tributaries and cut-off meanders. Although it is likely that venusian channels form by more than one process, the processes remain largely speculative. Proposed mechanisms of venusian channel formation range from constructional processes [9] to mechanical [5, 10-11] and/or thermal erosion [8]. Fluids proposed to carve the channels range from water to basalt to komatiite to carbonatite. The proposed processes and fluids vary based on assumptions regarding the interface and/or substrate in which channels form [e.g., 1-2, 5, 8-12].

The purpose of this contribution is to continue investigating processes of venusian channel formation. We focus our work by presenting our first steps in numerically modeling venusian channels forming through thermal erosion in the subsurface. We explore the possibility and implications that some venusian channels form by lava flowing along a subsurface boundary where lava thermally erodes overlying materials.

Background: This study builds on the work of [12] who analyzed three widely separate study areas on Venus with the explicit goal of delineating the geologic history of specific venusian channels. Based largely on the observation that channels in the three study areas dissect pre-existing topographic highs (wrinkle ridges and small shield edifices) with no deflection in the channel course, [12] argues that at least some channels on Venus are carved from below in a process similar to piping [13] instead of at the surface as assumed in earlier hypotheses. Termed the stoping hypothesis [12], venusian channels may form by fluid (likely lava) that flows along a shallow subsurface interface between two geologic units. The flowing

lava erodes surrounding materials to initially create a subsurface conduit. Continual fluid movement in the conduit may cause erosion and stoping that eventually reaches the surface independent of pre-existing topographic highs to create a continuous channel. Based on mapping relations, the interface along which the lava flows may reflect the boundary between local basal materials and overlying low backscatter materials; channels traces are carved into the low backscatter materials.

Large abundances of small shield edifices characterize the low backscatter material in the three study areas. The occurrence and distribution of shields in each study area resembles that of shield terrain [14], regions that may reflect *in situ* partial melting of basaltic crust. Partial melting of basalt will produce a melt product that is more felsic and, hence has a lower melting temperature than basalt; melt residuum may then have a higher melting temperature than basalt inferring that the melted byproducts represent a more siliceous material than the basaltic crust. If the low backscatter materials in which the channels occur represents a felsic (i.e. andesite or dacite) partial melt of basalt, then lava more mafic than the low backscatter materials should be able to thermally erode the overlying materials. Thermal erosion may therefore be responsible for the formation of the subsurface conduit and subsequent channel. Hence, basalt could theoretically carve the conduits that evolve into the channels in the stoping hypothesis. If the basal layer has a basaltic composition (as presumed), then basalt lava could thermally erode the low backscatter materials, but not extensively erode the basal materials [e.g., 15-17]; thermal erosion would be limited to the low backscatter materials.

Numerically modeling the stoping hypothesis:

We are beginning to numerically model the stoping hypothesis as a 1-D thermal erosive process. We model the channel-conduit system as evolving from a laminar, non-isothermal stream of basalt flowing along the interface between mafic basal materials and felsic (either andesitic or dacitic) surface materials (Fig. 1). We assume that all heat is transferred conductively to the surrounding felsic surface materials; the mafic base serves as an insulating layer that does not conduct heat. We assume that the center of the basalt stream maintains a constant temperature of 1200° C; the lava temperature decreases in all directions towards the

surrounding felsic surface materials. We argue that the heat flux supplied by the basalt stream to the wall is sufficient to induce thermal erosion of surrounding felsic materials. The conductive heat flux supplied to the surrounding felsic materials is dependent, however on the diameter of the basalt stream. As thermal erosion occurs and conduit width increases, the conductive heat flux from the center of the basalt stream will decrease. We postulate that it is this decrease in heat flux that creates the consistent widths of venusian channels. Once the basalt stream has eroded up to the surface, it is exposed to Venus' CO₂-rich atmosphere, which serves as an insulating layer that impedes lava heat loss by facilitating conductive heat transfer [18]. A slower rate of heat loss to Venus' atmosphere infers that lava flows will travel further on Venus compared to Earth and suggests that the basalt stream may continue to flow significant distances in the channel-conduit system once it exposed at the surface. However, conductive heat loss to Venus' atmosphere will still be greater than to the felsic surface materials, which may result in the arresting of channel formation and widening ultimately 'locking of the channel shape in place'.

Discussion: Although we are only in the initial stages of numerically modeling the stoping hypothesis, it seems likely that thermal erosion should play a role in channel formation. In fact, following the methodology of [8; *see also*, 19], we calculated temperature profiles in possible felsic surface materials with andesitic and dacitic compositions as a function of time and distance. Our results, illustrated in Figure 2, suggest that significant thermal erosion should occur in geologically reasonable periods. However, we do not suggest that all venusian channels form by thermal erosion. Instead, it may be just one of many ways to create a channel.

References: [1] Baker, V.R. et al. (1992) *JGR*, 97, 13421-13444. [2] Komatsu, G. et al. (1993) *Icarus*, 102, 1-25. [3] Crisp, D. and Titov, D. (1997) *Venus II*, 352-384. [4] Fegley, Jr. B.G. et al. (1997) *Venus II*, 591-636. [5] Jones, A.P. and Pickering, K.T. (2003) *J. Geol. Soc. Lon.*, 160, 319-327. [6] Donahue, T.M. et al. (1982) *Science*, 216, 630-633. [7] Donahue, T.M. et al. (1997) *Venus II*, 385-414. [8] Bussey, D.B.J. et al. (1995) *JGR*, 100, 16941-16948. [9] Gregg, T.K.P. and Greeley, R. (1993) *JGR*, 98, 10873-10882. [10] Komatsu, G. et al. (1992) *GRL*, 19, 1415-1418. [11] Williams-Jones, G. et al. (1998) *JGR*, 103, 8545-8555. [12] Lang, N.P. and Hansen, V.L. (in review) *JGR*. [13] Parker, G.G. et al. (1990) *GSA Sp. Ppr.* 252, 77-110. [14] Hansen, V.L. (2005) *GSA Bull.*, 117, 808-822. [15] Keszthelyi, L. (1995) *JGR*, 100, 20411-20420. [16] Sakimoto, S.E.H. and Zuber, M.T. (1998),

JGR, 103, 27465-27487. [17] Fagents, S.A. and Greeley, R. (2001), *Bull. Volc.*, 62, 519-532. [18] Snyder, D. (2002) *JGR*, 10.1029/2001JE001501. [19] Turcotte, D.L. and G. Schubert (1982), *Geodynamics*, 450 pp. [20] Winter, J.D. (2001), *Intro to ig and met petrology*, 697 pp.

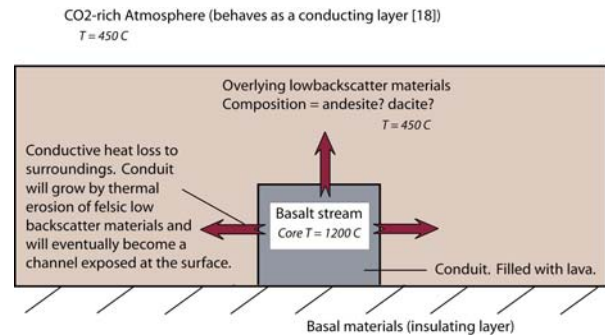


Figure 1: Cartoon diagram illustrating our 1-D model of the stoping hypothesis as a thermal erosive process.

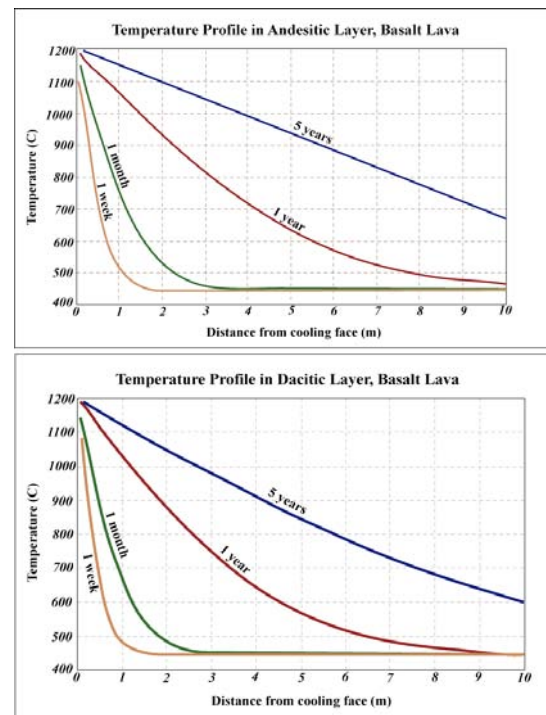


Figure 2: Temperature profiles within felsic surface materials with andesitic (top) and dacitic (bottom) compositions. Temperature profiles are for 1 week, 1 month, 1 year, and 5 years. Melting temperature for andesite is ~1000° C and melting temperature for dacite is ~900° C [20]. Ultimately, melting temperatures will vary depending upon water content [20].