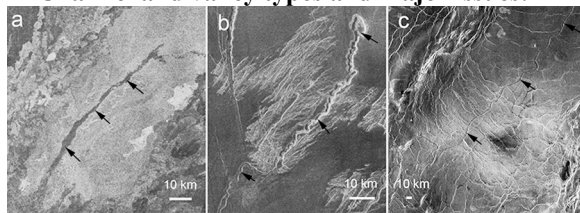


**REVISITING CHANNELS AND VALLEYS ON VENUS: ISSUES IN THE ERA OF RENEWED VENUS EXPLORATION.** G. Komatsu<sup>1</sup>, V. R. Baker<sup>2</sup>, and J. S. Kargel<sup>3</sup>, <sup>1</sup>International Research School of Planetary Sciences, Università d'Annunzio, Viale Pindaro 42, 65127 Pescara, Italy (goro@irsps.unich.it), <sup>2</sup>Department of Hydrology and Atmospheric Sciences, University of Arizona, <sup>3</sup>Planetary Science Institute, Tucson, Arizona.

**Introduction:** Channel and valley landforms on Venus were discovered in the early 1990s through global studies of ~100-m spatial resolution images generated by the SAR instrument onboard the Magellan spacecraft [1,2,3]. More than 200 channels have been identified on the images [4,5,6], and they exhibit a wide variety of morphological characteristics. In light of the new era of Venus exploration, it is timely to summarize the scientific issues regarding these enigmatic landforms.

#### Channel and valley types and major issues:



**Fig. 1.** Examples of representative channel types on Venus: a. simple channel with flow margin; b. sinuous rille; and c. canali-type channel (Baltis Vallis).

*Channels in association with clear lava flow units:* The Magellan imagery revealed many channels occurring on clearly observable lava flow units (**Fig. 1a**), and they are classified as channels with flow margins [4,5,6]. They are interpreted to be lava channels commonly known with terrestrial volcanic systems. These channels exhibit simple or complex (e.g., braided, distributary) flow path patterns. Individual channel widths range from a few km down to the limit of resolution. Because these channels have formed on lava flows and do not seem to have incised surrounding terrain, they appear to be similar to their terrestrial counterparts in having mostly constructional origins. In general, these simple channels lack distinctive source regions. New data will shed light on their role in long distance transportation of lava.

*Venusian sinuous rilles:* Many Venusian channels, mostly single threads, are identified to be analogous to lunar sinuous rilles (**Fig. 1b**) [4,5,6]. Sinuous rilles emanate from distinct, circular, or elongated regions of collapse (generally several kilometers in diameter), and they form channels up to several kilometers wide and tens to hundreds of kilometers long. As with lunar sinuous rilles, these Venus counterparts become narrower and shallower in a downstream direction. Most sinuous rilles on Venus are not associated with detectable lava flow margins. The similarities in morphology and size to lunar sinuous rilles may imply

that thermo-mechanical erosion by high-discharge, highly fluid lava was also an important channel-forming process on Venus [6,7,8]. Some of the Venusian sinuous rilles are associated with networks of valleys or depressions [8,9] or with coronae and corona-like features [6] implying genetic links among these landforms. New data will offer opportunities for understanding the possibly common mechanism of formation applicable to both the Venusian and lunar sinuous rilles.

*Canali-type channels and Baltis Vallis:* Canali are unique to Venus. Unlike other channels they have generally constant width and depth over their entire flow path (**Fig. 1c**) [4,5,6,10]. These channels generally have widths ranging up to 3 km and lengths exceeding 500 km. However, some canali may be up to 10 km wide; and a few have enormous lengths, likely exceeding 6800 km in the case of Baltis Vallis (**Fig. 2**) [4,5,6,10]. Canali may locally exhibit numerous abandoned channel segments, cutoff meander bends, levees, and radar dark terminal deposits [4,5,6,11]. Sources and termini are normally indistinct. Canali are generally located on topographic plains [6], considered to be volcanic in origin and mafic in composition [12], and they are tectonically deformed along their longitudinal profiles [13,14]. The extraordinary length and a relatively short formation time scale (i.e., geologically speaking) of Baltis Vallis allowed this feature to be used to correlate distant geological units on Venus plains to understand their sequential relationships [15]. The morphology of these channels suggests that they probably formed by continuously conveyed large discharges of low viscosity fluids to distant regions over prolonged periods [4,5,6,10,16]. Both erosional and constructional origins have been proposed [10,17,18,19,20,21]. The formative fluids have been hypothesized to be a wide range of silicate lava varieties, as well as low-viscosity flows of sulfur or carbonatite lava [4,5,6,10,11,17]. More speculative hypotheses invoke the role of nonvolcanic fluids, including turbidity currents that would have had to occur at a time when an ocean existed on the Venusian surface [22], or it is envisioned that particulate gravity currents resulting from the suspension of fine particulate matter in the dense Venusian atmosphere moved downslope to travel long distances and formed canali [23]. The origin of the Venusian canali remains poorly understood.

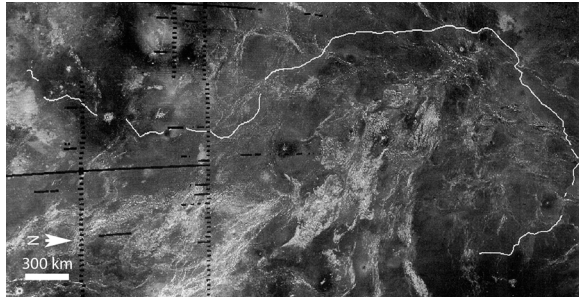


Fig. 2. The traceable stretch of > 6800 km long Baltis Vallis.

*Venusian “outflow channel” Kallistos Vallis:* Kallistos Vallis (Fig. 3) is a compound channel, containing simple and complex segments as it extends about 1200 km [4,5,6]. It emanates from a distinct collapse region that is leading to a linear trough about 400 km long. Beyond the trough, the channeled fluid is inferred to have spilled out to create the distinctive anastomosing subchannels. Deflected eastward, the flows were impounded upstream of a north–south ridge, eroding through that obstacle to create streamlined hills in the divide crossing. Downstream of this divide the system displays a distinctive distributary pattern of radar-bright channels that feed into an immense area of lobate deposits, the likely solidified flows that traversed the channel. Some morphologic characteristics of Kallistos Vallis, in particular the collapsed source region and anastomosing segment, bear a resemblance to some aspects of Martian outflow channels [1,2,3,4,5,6]. Leverington [24] drew particular attention to these features of Kallistos Vallis and applied the outflow designation much more generally to lunar and Venusian sinuous rills and various other volcanic channel forms sourced at fissures, vents, collapse areas, and other types of depressions; Leverington further proposed that these all share a common volcanic origin with the Martian outflow channels, which others primarily associate with water outbursts or possibly erosion by ice. New data are expected to reveal more detailed morphological properties of Kallistos Vallis, enabling an assessment of the validity of the comparison with Martian outflow channels.

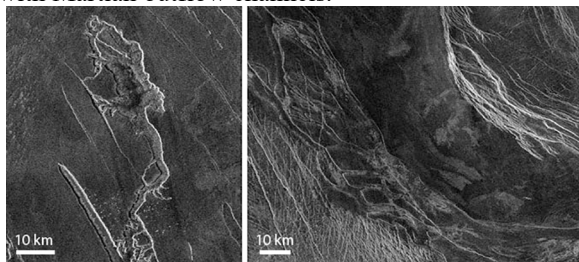


Fig. 3. Kallistos Vallis: (left) collapsed source region; (right) anastomosing reach.

*Valley networks:* Venusian valley networks (Fig. 4) are classified as rectangular, labyrinthic and pitted, or irregular [4,5,6,9]. The Venusian valley networks are structurally controlled, as shown by morphological patterns of valley branches, consistency between valley and fracture orientations, and associations with the deformed terrains. The morphologies resemble those of terrestrial and Martian sapping valleys. Valley networks on Venus probably formed initially from fracture systems and became enlarged by sapping, possibly by low-viscosity lava of unknown composition. Subsurface flow of lava may locally have been assisted by surface flows. Valley networks are often associated with corona and similar features and may be related. The process of valley network formation remains speculative. Tessera-hosted valley networks recently were interpreted as due to ancient fluvial erosion during a period of cooler and wetter conditions [25].

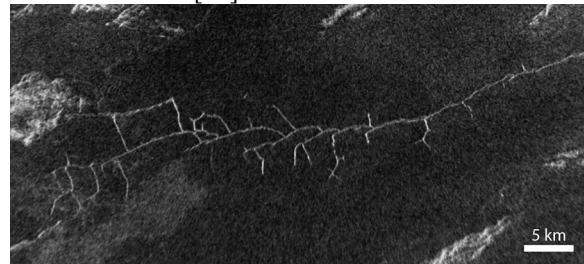


Fig. 4. A typical rectangular valley network in Ovda Regio.

**References:** [1] Komatsu G., Baker V. R. (1996) *PSS*, 44, 801–815. [2] Komatsu G. (2007) *Geogr. Compass*, 1(3), 480–502. [3] Baker V. R. et al. (2015) *Geomorphology*, 245, 149–182. [4] Baker V. R. et al. (1992) *JGR*, 97, 13421–13444. [5] Baker V. R. et al. (1997) In: *Venus II*, Univ. of Arizona Press, Tucson, p. 757–793. [6] Komatsu G. et al. (1993) *Icarus*, 102, 1–25. [7] Komatsu G., Baker V. R. (1994) *Geology*, 22, 67–70. [8] Oshigami S. et al. (2009) *Icarus*, 199, 250–263. [9] Komatsu G. et al. (2001) *Geomorphology*, 37, 225–240. [10] Komatsu G. et al. (1992) *GRL*, 19, 1415–1418. [11] Kargel J. S. et al. (1994) *Icarus*, 112, 219–252. [12] Kargel J. S. et al. (1993) *Icarus*, 103, 253–275. [13] Komatsu G., Baker V. R. (1994) *Icarus*, 110, 275–286. [14] Langdon J. C. et al. (1996) *LPS XXVII*, 721–722. [15] Basilevsky A. T., Head J. W. (1996) *GRL*, 23, 1497–1500. [16] Bray V. J. et al. (2007) *JGR*, 112, E04S05. [17] Gregg T. K. P., Greeley R. (1993) *JGR*, 98, 10,873–10,882. [18] Bussey D. B. J. et al. (1995) *JGR*, 100(16) (941–16,948). [19] Williams-Jones G. et al. (1998) *JGR*, 103, 8545–8555. [20] Lang N. P., Hansen V. L. (2006) *JGR*, 111(E4), E04001. [21] Oshigami S., Namiki N. (2007) *Icarus*, 190, 1–14. [22] Jones A. P., Pickering K. T. (2003) *J. Geol. Soc. Lond.*, 160, 319–327. [23] Waltham D. et al. (2008) *JGR*, 113, E02012. [24] Leverington D. W. (2011) *Geomorphology*, 132, 51–75. [25] Khawja S. et al. (2020) *Nature Com.*, 11, 5789.