

**SOURCE AND EMPLACEMENT HISTORY OF NEAGO FLUCTUS, VENUS.** R. Stark<sup>1</sup>, R.E. Ernst<sup>1,2</sup>, H. El Bilali<sup>1,2</sup>, J.W. Head<sup>3</sup>, <sup>1</sup>Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada; robinstark@cmail.carleton.ca, <sup>2</sup>Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia, <sup>4</sup>Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, Rhode Island, USA

**Introduction:** There are approximately 208 major basaltic lava flow fields (flucti) (defined to cover at least 50,000 km<sup>2</sup>) on Venus and these are considered analogous to terrestrial flood basalts associated with Large Igneous Provinces (LIPs) [1]. They have been classified and analyzed at the regional scale. However, in many cases, the exact source of these flows and potential link with other magmatic components of LIP events remain enigmatic.

An important example is Neago Fluctus (Fig.1), which is located in northern Sedna Planitia, spanning the border of Quadrangles V-7 (Lakshmi Planum; mapped by [2] and V-19 (Sedna Planitia; initial mapping of this quadrangle reported in [3]). In [1] Neago Fluctus corresponds to entry 14 in Table 1 with the following characteristics: transitional (between sheet and digitate types), with a flow field area of 744,000 km<sup>2</sup> and a maximum flow length of 1900 km. According to [4] it was erupted from a source in the southern portion of Clotho Tessera. Lancaster et al. [4] described four flow units F1-F4 (flow units originally recognized by [5]). Byrnes and Crown [6] characterized lava flow fields (flucti), including Neago Fluctus, in terms of morphology, stratigraphy and surface roughness.

We reexamined Neago Fluctus with a particular focus on considering the source location and setting of such flood basalts in the context of LIPs, given our improved understanding of terrestrial LIP plumbing system architecture [7] and with significant improvements in our understanding of lava flow patterns on Venus [8, 9].

#### **Detailed 1:500,000 scale Mapping of Neago Fluctus:**

*Flow distribution and ages:* We recognize two major flows (with interpreted flow patterns shown in Fig. 2). These two flows broadly correspond to F2 (radar bright) and F3 (radar grey) of [4]. The inferred age order (youngest to oldest) is F1-F4, which would make F2 younger than F3. However, our mapping suggests that the radar dark flows are younger, since they can be traced back to their source (Fig. 2) and the radar bright flows have a fragmented distribution due to superposition by the radar dark flows.

*Source caldera:* Another finding from our work is that the source area is spatially linked to an elliptical depression located at 58.1 N, 344.3 E (Fig. 2) about 130 km by 120 km, with the longer axis trending ENE-WSW. The depth is 800 m in an E-W profile direction

and about 400 m in a N-S profile (where the southern rim is lower, and where the flow appears to have spilled out onto the SE side. Using these dimensions, an approximate minimum volume of the depression using semi-axis values of 65 and 60 km and 400 m depth, yields a volume of 5000 km<sup>3</sup>). We infer that the depression represents subsidence above an underlying magma reservoir and that the volume of the magma expelled from the reservoir corresponds to the 5000 km<sup>3</sup> volume of the depression. We next compare this number to the estimated volume of Neago Fluctus.

The outline in Figure 1 shows our mapped extent of the flow field; the areal extent of the flow field is obtained using the Calculate Geometry feature in ArcGIS. Our estimated areal extent is 1,140,000 km<sup>2</sup> which is slightly larger than the 744,000 km<sup>2</sup> estimate of [1].

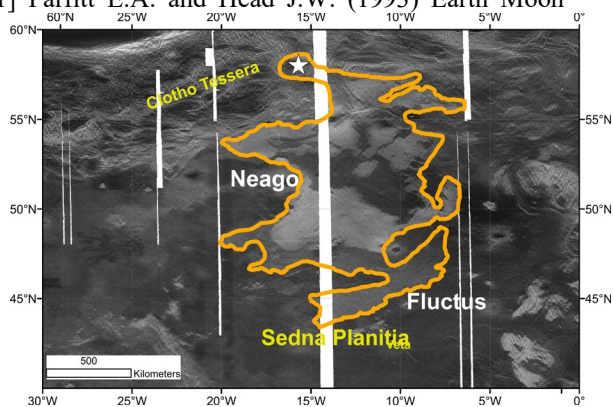
Assuming a flow thickness of 25 m per flow (cf. [10] and discussion within) then a minimum volume is given by the maximum areal extent, yielding a minimum volume of is 28,500 km<sup>3</sup>. This value can be compared against the volume of the inferred magma reservoir (approx.. 5000 km<sup>3</sup>), suggesting that emplacement of the flow field would require approximately 6 cycles of refilling and emptying of the magma reservoir. Given the recognition of two major flow units (and perhaps four in total [4]), this would require the source to have been buffered through continued input from deeper reservoirs [11].

**Future Work:** We will continue detailed mapping of the flow units of Neago Fluctus, and also that of a separate large digitate (E-W) flow system located to the east, which we provisionally interpret to be younger. These E-W digitate flows may be linked to (and fed from) a major E-W graben system, which we are also mapping in detail. Broader questions to be addressed include: 1) identifying whether there is any radiating or circumferential graben system associated with this Neago Fluctus event, and 2) where this event fits in the global stratigraphy [12]

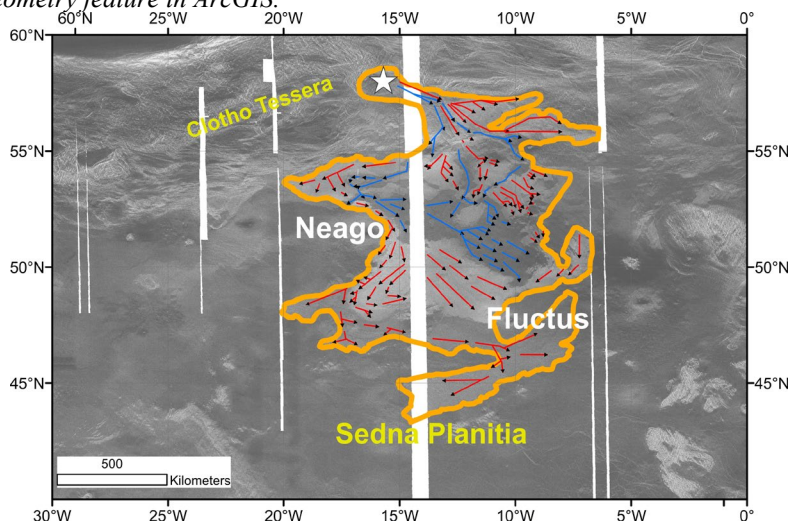
**References:** [1] Magee K.P. and Head J.W. (2001) in Geol. Soc. Amer. Spec. Pap. 352. [2] Ivanov M.A. and Head J.W. (2010) USGS SIM 3116. [3] Martin P, Stofan E.R., Guest J.E. (2009) Abstr. Ann. Mtg. Planet. Geol. Mappers. [4] Lancaster M.G. et al. (1995) Icarus, 118, 69– 86. [5] Arvidson R.E. et al (1992) JGR, 97, 13303-13317. [6] Byrnes J.M. and Crown D.A. (2002). JGR, 107, E10, 5079. [7] Ernst R.E. et al (2019) J. Volc. Geotherm. Res., 384, 75–84.

[8] Head J.W. et al. (1992) JGR, 97, 13153-13197. [9] Crumpler L.S. and Aubelle J.C. (2000) In: Encyclopedia of Volcanoes. Academic Press. [10] MacLellan L. et al. (2021) E-Sci. Rev., 220, 103619. [11] Parfitt E.A. and Head J.W. (1993) Earth Moon

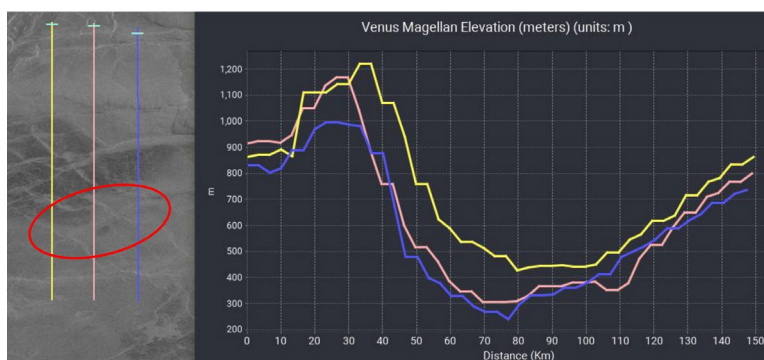
Planets, 61, 249-261. [12] Ivanov M.A. and Head J.W. (2015). Planet. Space Sci., 113-114, 10–32.



**Figure 1.** Overall distribution of Neago Fluctus. Outline used to calculate areal extent using Calculate Geometry feature in ArcGIS.



**Figure 2.** Flow lines superimposed on distribution of older radar bright (red lines) and younger radar intermediate (blue lines).



**Figure 3.** Profiles across source depression (caldera?) centred at 58.1 N, 344.3 E, and located by white star in Fig. 2.