THE EVOLUTION OF VOLCANISM IN SYRTIS MAJOR PLANUM (MARS): DRAWING INSIGHT FROM TERRESTRIAL ANALOGUES. P. Fawdon[1] M. R. Balme[1], C. L. Vye-Brown[2], D, A, Rothery[1] and C.J. Jordan[3] [1]Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, UK. MK7 6AA; peter.fawdon@open.ac.uk, [2]British Geological Survey, Murchison House, West Mains Road, Edinburgh, UK. EH9 3LA. [3]British Geological Survery, Nicker Hill, Keyworth, Nottingham, NG12 5GG

Introduction: The Syrtis Major Planum, originally mapped as unit Hs in the Greeley and Guest 1987 map [1], is a Hesperian (3.7 – 3.0 Ga) age, low-angle basaltic plains volcano on Mars covering ~1 % of the martian surface. The 1500 km by 1100 km edifice is composed of basaltic lava plain with a total lava thickness of ~500 m. Extensional and compressional fault systems orientated concentrically and radially from the central caldera complex dissect the flanks. There are two distinct central calderas whose floors are believed to contain evolved volcanic products. Syrtis Major has been little studied relative to other large martian volcanic terrains. Since a summary of MGS data in 2004 [2] its evolution has not been holistically investigated.

We investigate the volcanic evolution of Syrtis Major Planum using the 3D visualisation software Geovisionary™ and aim to build an architectural model of the evolution of the Syrtis Major volcanic complex. We are using volcanological studies of terrestrial analogues in Krafla, Iceland and the Manda-Hararo rift segment Afar, Ethiopia, to help understand the volcanology of Syrtis Major.

We apply a remote sensing data collection approach using modern NASA and ESA datasets. For Mars we have used THEMIS Mosaic (100 m/pix), HRSC (12.5 m/pix) and gridded MOLA elevation data. For terrestrial sites we have utilized LiDAR data at 1 m/pix and accompanying aerial photographs for Krafla and Afar, provided by UK NERC ARSF (Airborne Research and Survey Facility) and the British Geological Survey.

Lava flow mapping: From our ongoing mapping and differentiation of the unit Hs, we find lava flows 1-6 km wide, 5-30 m thick with flow field lengths up to 300 km that are distributed radially with respect to the central caldera complex. Both simple and complex lava flows commonly display medial channel and levee structures (*figure 1a, b*).

We present initial results of our investigation into the rheological properties of the observed lava flows on the flanks of Syrtis Major (1) and use similar data

from terrestrial lavas from Dabbahu (Afar) and Krafla (Iceland) to demonstrate the validity of the method.

a)

b)

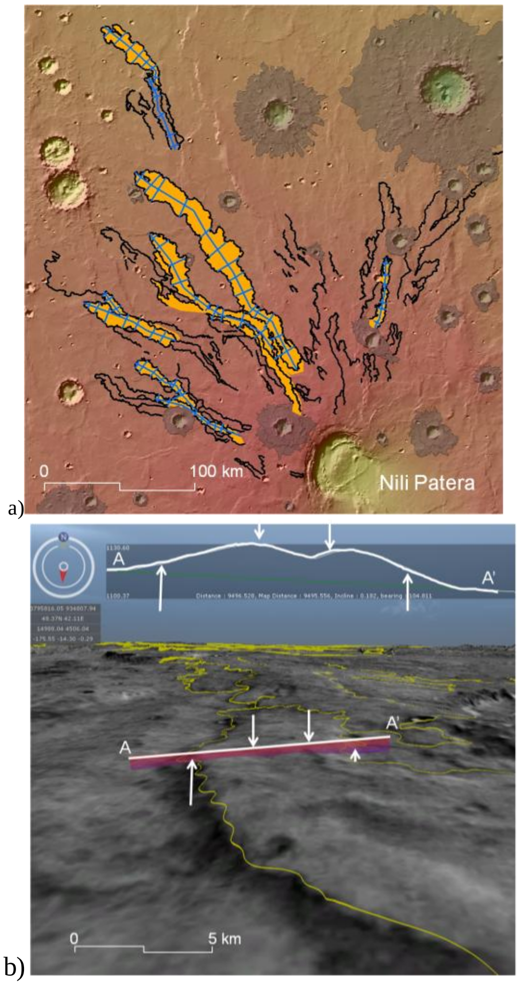

Figure 1: a. (top) Shaded MOLA topography showing lava flows radiating from the Syrtis Major central caldera complex. b. (bottom) Perspective view of a flow with medial channel cross-section visualised in Geovisionary™

Based on these data we report the results from two simple rheological models [3, 4]. Firstly [3] a cooling limited relationship linking final flow dimensions and assumed properties of a cooling basaltic lava to the time taken for a flow to stop extending. Secondly [4] an emperical relationship linking final flow dimensions to eruption duration.

Results: From an initial data set of 11 martian and 4 terrestrial flows we calculate inferred mean effusion

rate and modelled durations from which we then calculate minimum mean effusion rates. Using these

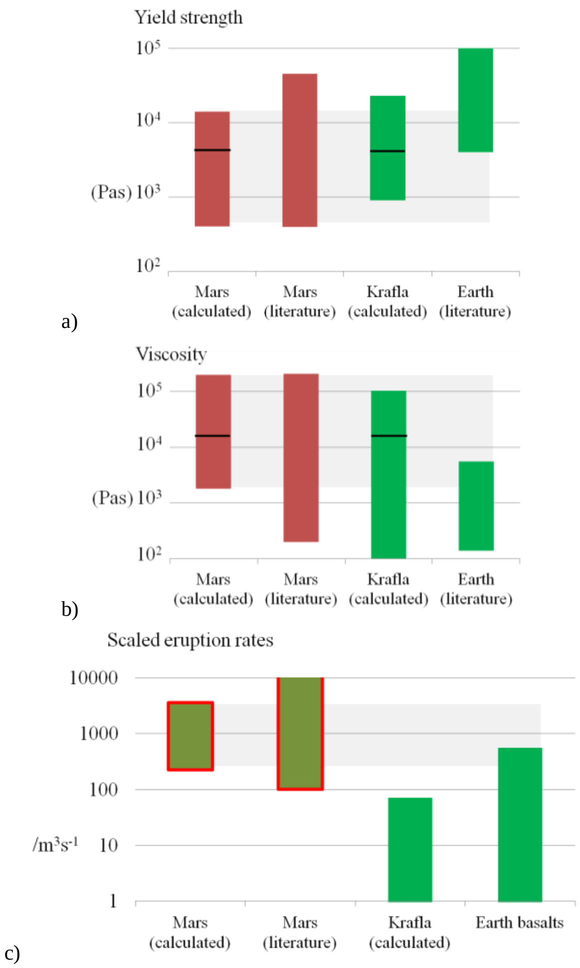

Figure 2 a) comparison of yield strength values. b) comparision of viscosity. c) comparison of scaled effusion rates to terrestrial rates.

eruption parameters we go on to infer yield strength [5] and maximum viscosity for flows at Syrtis Major, Krafla and Dabbahu.

Eruption parameters. Inferred minimum eruption rates range from 1100 m^3s^{-1} to 5100 m^3s^{-1} from the cooling limited model at Syrtis Major and from 6 m^3s^{-1} to 30 m^3s^{-1} at Krafla. Durations calculated from the empirical model range from 3 to 90 days on Syrtis Major and between 0.1 and 1 day at Krafla. Corresponding minimum mean effusion rates are 320 m^3s^{-1} to 36000 m^3s^{-1} at Syrtis Major and between 14 m^3s^{-1} and 70 m^3s^{-1} at Krafla.

Rheological parameters. Using the inferred eruption parameters and reasonable assumed values for density and thermal conductivity, we calculate yield strength and minimum viscosity. Yield strengths range from 4×10^2 Pa to 3×10^4 Pa at Syrtis Major and between 9×10^2 and 2×10^4 at Krafla. Inferred maximum viscosities are from 2×10^5 Pas to 1×10^3 Pas at Syrtis Major and from 1×10^5 Pas to 1×10^2 Pas at Krafla.

Discussion: These initial results demonstrate the similarity between erupted material on Earth and Mars. Similarities in yield strength and viscosity with terrestrial basalts provide confidence about our inferences about composition, although the calculated viscosities are higher than nominal terrestrial values. Our calculated values are reguarded as maxima (*figure 2a, b*) because the flow lengths used in the mean effusion calculations are possible underestimated, as only observable flow lengths were measuredm, rather than a longer inferred flow length from proposed vent location to the flow front.

Wilson and Head 1994 [7] calculated scaling parameters for a martian eruptive environment relative to terrestrial conditions. Using the results of these calculations we can draw a compassion between our calculated martian eruption rates and contemporary terrestrial basaltic eruptions rates from the literature. Here we find that, despite the inferred rheological similarities, the scaled eruption conditions for lavas erupted in this style on Syrtis Major lavas are significantly higher than contemporary terrestrial lavas although there is some coincidence in mean eruption rate (*figure 2c*). The calculated values for Syrtis Major eruption rates are minima as previously discussed. This suggests that the formation of Syrits Major may have progressed at similar rates to terrestrial large igneous provinces.

Conclusion: These comparative results contribute to the investigation into the evolution of volcanism at Syrtis Major by justifying the method and therefore allowing us to consider sources of melt and thermal regime in the martian upper mantle. These results add to the body of data for martian as well as terrestrial eruptive processes. We will expand the dataset by including more Syrtis Major flows, and add a temporal aspect using crater counting of each flow. Hence we hope to build a model of the evolution of Syrtis Major Planum.

References: [1] Greeley, R. Guest, J. E. : *Geologic Map of the Eastern Equatorial Region of Mars, Map I-1802-B, U.S. Geol. Surv., 1987* [2] Hiesinger, H., and Head III, J. W. (2004) *J. Geophys. Res., 109* [3] Hiesinger, H., Head III, J. W. and Neukum, G. (2007) *J. Geophys. Res., 112* [4] Lopéz, R. M. C., Kilburn, C. R. J. (1990) *JGR 95 14,383 – 14,397* [5] Moore, H. J., et, al., (1987) *Proc. 9th Lunar planet, Sci. Conf. 3351-3378* [6] Wilson, L. and Head III, J. W. (1983) *Nature Vol. 302 21* [7] Wilson, L. and Head III, J. W. (1994) *Rev. Geophys. 32 (3): 221–263*