

INVESTIGATING MULTIPLE LAVA FLOWS NEAR MANGALA FOSSA WITH SHARAD. R. R. Bharti¹ and I. B. Smith², ¹Physical Research Laboratory, Navrangpura, Ahmedabad 380009, rajiv@prl.res.in, ²Planetary Science Institute, Lakewood, Colorado 80401.

Introduction: Mangala Fossa region is situated South-West of Arsia Mons, one of the three large shield volcanoes located on the Tharsis rise, the most extensive volcanic province on Mars. Mangala Fossa is source of Mangala Valles, a major outflow channel system. This area shows geomorphic evidence for catastrophic release of water and lava possibly in the Late Hesperian to Early Amazonian age. Apart from the outflow channel, lava-infilled craters are evident in this area. One example is an unnamed crater we informally call “Mangala Crater”. Mangala fossa was played an important role in formation of Mangala outflow channel, but the formation sequence of the outflow channel is still debated. Some research argued that these channel formed from catastrophic water flow. [1,2,3] urged that the geomorphological traces of fluvial or lacustrine processes within Mangala Valles can be better explained by fluid lava flooding the channels and filling pre-existing impact craters. There is also no consensus about the number of flow episodes that occurred in the Mangala region. [4] found that the morphology of the channels could be explained by a single flood episode, whereas by considering the morphology of the source graben, [5] argued specifically for two events.

We present new evidences from the Shallow Radar (SHARAD) sounding experiment on Mars Reconnaissance Orbiter (MRO) [9] that lava played an important role in formation of the Mangala out flow channel. SHARAD is well suited to determining the dielectric properties of lava flows, provided that it can detect a subsurface interface [2]. We also try to explain of extent of infilling of lava in this region by conducting radar based subsurface analysis.

SHARAD Data Set and Methodology: SHARAD operates with a 20 MHz center frequency and a 10 MHz bandwidth, which translates to a vertical resolution of 15 m in free-space and $15/\sqrt{\epsilon}$ in a medium of relative permittivity ϵ . Horizontal surface resolution depends on surface roughness characteristics, but for most Mars surfaces the cross-track footprint is 3–6 km and the along-track footprint, narrowed by synthetic aperture processing on the ground, is 0.3–1 km [6].

Observations and Interpretations: Radargrams in our study area show that SHARAD penetrates through these flows in three distinct areas: symmetrically across the fossa, in Mangala Crater, and farther north, near to the outflow channel (Fig. 1). There is a general trend that subsurface reflections increase in time-delay (depth) towards the north.

Inside Mangala Crater the subsurface reflections are

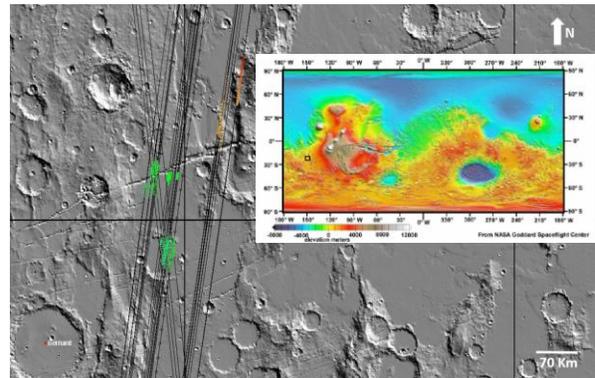


Figure 1: Map displaying locations of sub-surface reflections near Mangala Fossa

horizontal, and some locations exhibit two reflections, implying that there are at least two subsurface interfaces and three units within the crater (Figs. 2 and 3). We propose a simple heuristic model for the infilling events at Mangala Crater (Fig. 4)

Surface observations indicate that the entire region is covered by dust, and wind streaks are common.

Measurement of Dielectric Properties: We can estimate the real relative permittivity of the flows by comparing the measured time delay of returns from the subsurface with altimetry measurements of the flow heights relative to the surrounding plains. The real permittivity denoted by ϵ' can be calculated from

$$\epsilon' = \left(\frac{c\Delta t}{2h} \right)^2$$

Where h is the height of surrounding plane measured from using data CTX and HRSC DTMs. The dielectric value of lava flow near the fossa is around 9. South of the fossa is approx. 8, and north of the fossa is also

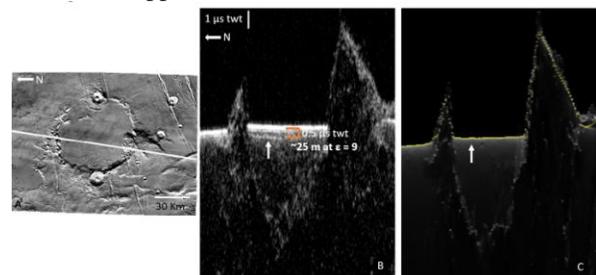


Figure 2 (A) SHARAD ground track passing through Mangala Crater (B) SHARAD radargram with time delay and arrow indicate the subsurface reflection (C) Simulated radargram showing the off-nadir topographic clutter echoes

approx. 8. Previous studies suggested that the dielectric value of lava flows near Ascraeus Mons were between

6.2 and 17.3 in the north and between 7.0 and 14.0 in

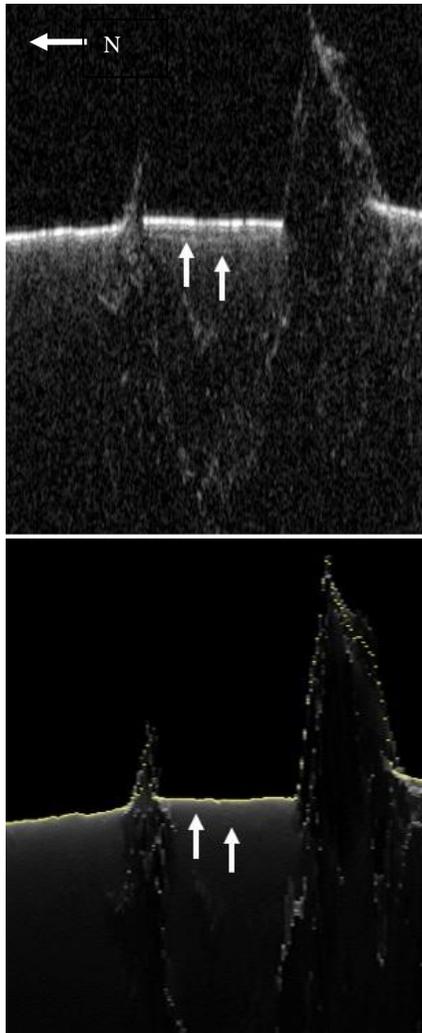


Figure 3: SHARAD observation 3667301. Two subsurface reflectors inside the Mangala crater indicate multiple periods of lava flow with contrasting dielectric material in between

the south [7]. The range of measured dielectric constants in Mangala is between 8.0 and 9.0, on the lower side of the range near Ascreaus.

For dry materials, the permittivity is primarily influenced by density [7]. Empirical studies have yielded a relationship of:

$$\epsilon' = 1.96^{\rho}$$

where ρ is the density in g cm^{-3} [8]. Inverting this equation for density, we find values of 3.09 to 3.26 g cm^{-3} from the measured permittivities. Since basalts commonly have densities greater than 3 g cm^{-3} , whereas most granitic rocks have densities between 2.5 and 3.0 g cm^{-3} [9], the measured permittivity values for the Mangala flows are more consistent with low density basalt.

Conclusions: Radar evidence suggests that a minimum of two successive infilling events happened (Fig. 3)

into the Mangala crater and separated by sufficient time to allow the rim craters to form and partially bury the first lava infill.

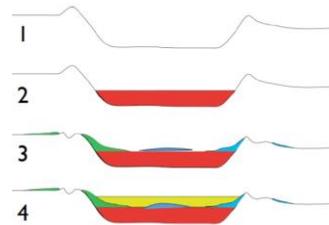


Figure 4: Heuristic model of crater infill.

1. Impact formation of Mangala crater.
2. Partial infill either sediments or lava
3. Two crater rim impacts deposit ejecta within and over previous infill
4. Final infilling; lava embays ejecta

Assuming a constant thickness (~25 m) and constant radius (~32 km), the volume of top unit of lava is ~81 km^3 . The consistent dielectric value between the north and south lava flows do not rule out the possibility that they happened at the same time. Later, the north lava flow was eroded at the formation of the Mangala outflow channel. A paucity of overlying craters suggests that the final lava flow was emplaced recently in geologic time. Ejecta from the formation of Mangala crater appears to be submerged in the same lava that fills it, so the age should be the same. Finally, the outflow channel that eroded the lava beds indicates that Mangala Fossa was active in some capacity even after the formation of the uppermost lava bed. By comparing the relative ages of Mangala Crater, the successive lava beds, the outflow channel, and the superimposed craters on Mangala Crater, we can begin to put a timeline on the history of events in this region.

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Acknowledgments: Special thanks to the CO SHARPS and SHARAD teams for providing SHARAD data and processing and to SeisWare™ for sharing an academic license. THEMIS IR and MOLA data were very helpful in this study.