EMPLACEMENT OF ATHABASCA VALLES FLOOD LAVAS. W. L. Jaeger[1], L. P. Keszthelyi[1], A. S. McEwen[2] and the HiRISE Team, [1]Astrogeology Team, U.S. Geological Survey, Flagstaff, AZ 86001 (wjaeger@usgs.gov), [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Introduction: Athabasca Valles is thought to be the youngest outflow channel system on Mars. Both the floodwaters inferred to have carved its branching network of channels and the low-viscosity lava that subsequently resurfaced them appear to have issued from localized points along the Cerberus Fossae fissure system [1-4]. Our previous work showed that the emplacement of this lava flow was atypical. Generally, flood lavas inflate, filling in topographic lows to level (and locally invert) the terrain [5]. However, in Athabasca Valles the molten flow deflated 50-80 m, leaving the channels coated with only a thin veneer of solidified lava and preserving the flood-carved morphology of the substrate [4]. Here we present preliminary results from our continuing investigation of this unusual lava flow.

Extent and Volume of the Lava Flow: Earth-based radar and photogeology show that pristine lavas cover most of Elysium Planitia and Marte Vallis [3, 6-9]. However, impact crater size-frequency distributions indicate that the flows in Marte Vallis and northeastern Elysium Planitia are probably older than the Athabasca Valles flood lavas (AVFLs) [2]. New HiRISE and CTX images are helping to trace the extent of this youngest lava flow (Fig 1).

The flows that comprise the AVFLs emanated from four discrete locations along the Cerberus Fossae: two feed into the main branch of Athabasca Valles (B and C on Fig. 1) and the other two feed tributaries to either side (A and D on Fig. 1). The westernmost tributary is the smallest. It flows due south and joins the main branch of Athabasca Valles midway down the channel. The larger eastern tributary embays ejecta from Persbo crater then extends between two wrinkle ridges to parallel the main channel. Numerous distributaries connect the main channel with this parallel channel.

At its distal end, Athabasca Valles empties into Cerberus Palus, a holding basin with an estimated volume of 0.5-3 x 10^4 km^3 [8, 10]. After filling the basin, some lava flowed out of Cerberus Palus to both the east and west, eventually lowering its level by ~12 m, which is the equivalent of ~10^3 km^3 of lava [8]. The lava that exited Cerberus Palus to the west occupies a valley ~25 km wide and ~450 km long that runs along the northeastern side of Aeolis Planum. Beyond the end of this valley, the AVFLs spread out for an additional ~100 km. The far western terminus of the AVFLs is defined by lobate margins seen in HiRISE images and is clearly visible in other data sets such as THEMIS IR. The lava that exited Cerberus Palus to the east flowed through Lethe Vallis, leaving that channel system draped with lava. At its distal end, the lavas from Lethe Vallis merge with those from the eastern reaches of Athabasca Valles, and the combined flow extends to the east and southeast. The eastern edge of the AVFLs is difficult to map because of the complex interfingering of young lavas from various sources (e.g., the Cerberus Fossae and the Cerberus Tholi). Our effort to map this boundary is ongoing. While there is still about a factor of 2 uncertainty, our preliminary analysis suggests that the volume of the AVFLs is ~5x10^3 km^3. This is comparable to the volume of typical terrestrial flood basalt flows, which is ~10^3 km^3 [11].

Flow Rate and Duration: The peak flux of lava that passed through Athabasca Valles can be estimated using the channel dimensions and the methodology detailed in [12]. The average flow depth through Athabasca Valles was 60-80 m, and the average slope is 0.063±0.007%. Even using conservative values of 100 Pa·s for viscosity, 2700 kg/m^3 for lava density, and 70% bubble content, the flow is expected to be fully turbulent.

Turbulent flow velocities are calculated using the simple formula $v^2 = g\ H\ a\ /\ C_f$. The difficulty is in estimating the friction coefficient (C_f), but typical values are in the range of 0.01-0.001 [13]. A study of rapidly emplaced Hawaiian lava flows calculated values between 0.0057 and 0.11 [14], but it is not clear that these flows were actually turbulent. An alternative method, applicable to moderately turbulent flow, was obtained empirically by Goncharov [15]. Because the flow is only moderately turbulent in these laboratory experiments, viscosity does play a weak role in the estimated flow velocity. Table 1 shows the values of C_f calculated using the Goncharov method.

Table 1. Model input and output values for lava flowing through Athabasca Valles. The three columns correspond to minimum, nominal, and maximum flow velocities.

Flow Depth (m)	60	70	80
Gravity (m/s^2)	3.92	3.92	3.92
Viscosity (Pa·s)	100	20	10
Vesicularity (%)	70	40	10
Bulk Density (kg/m^3)	810	1620	2520
Slope (%)	0.056	0.063	0.070
Friction Coefficient	0.0042	0.0021	0.0016
Velocity (m/s)	5.6	9.1	11.8
Reynolds Number	2700	53000	240000

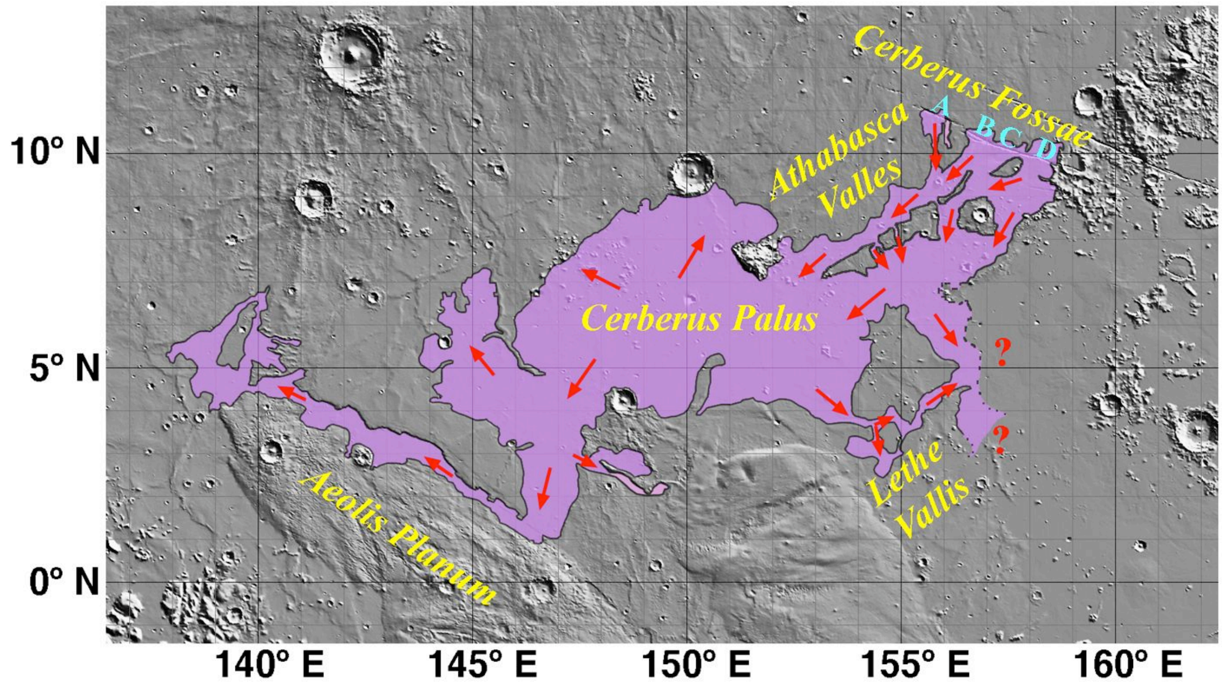

Figure 1. Mapped extent of the Athabasca Valles flood lavas (AVFLs). Red arrows indicate flow direction. The four discrete source regions along the Cerberus Fossae are labeled A-D.

Goncharov used relatively smooth surfaces, which may marginally underestimate C_f for lava flows. However, even for a C_f of 0.01, the flow velocity will be 5-6 m/s. We conclude that the flow velocity for the lava passing through Athabasca Valles was probably between 5-10 m/s. The main channel is 10-15 km wide so the estimated flux of lava is between 3-12 $x10^6$ m^3/s. Not surprisingly, since turbulent flow is quite insensitive to the fluid viscosity, these results are similar to the estimates of the flux of water that fits within the current topography of the Athabasca Valles [2,16].

At this rate, it would have taken 5-20 days to erupt the ~$5x10^3$ km^3 of the AVFLs. For most terrestrial fissure eruptions, the average eruption rate is nearly an order of magnitude less than the peak discharge [17], suggesting that an eruption duration of 2-7 months might be likely. However, we find no morphologic features indicative of a long eruption at low eruption rates (e.g., lava tubes, lava inflation, compound flow lobes) within Athabasca Valles. Moreover, the fact that lava from all four AVFL sources along the Cerberus Fossae merge together (rather than crosscutting one another) suggests that the eruption took place as a single event, rather than as a series of distinct episodes fed from separate segments of the fissure system. We therefore favor an eruption duration of a few to several weeks.

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