RHEOLOGICAL INVESTIGATIONS OF LAVA FLOWS ON ARSIA MONS, MARS: J.K. Lanz, DLR-Institute of Space Sensor Technology and Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany, Julia.Lanz@dlr.de

Introduction: The rheological investigation of lava flows on Mars is restricted to remote sensing methods as in situ data are obviously not available. Several models have been developed and applied to martian lava flows. As, even on Earth, we are still far from understanding fully all the relationships between lava composition, temperature, shear rate, viscosity and crystallinity, and how these parameters control the final shape of a lava flow, these models are bound to suffer from severe insufficiencies [e.g. 1]. Currently, though, they represent the only way to assess the rheology of planetary lava flows.

Arsia Mons, the southernmost of the three Tharsis Volcanos in the Tharsis Region of Mars, was examined to determine the yield strengths and effusion rates of 30 lava flows in the summit region of the volcano.

Methods: From the various models using spatial data (i.e. flow dimensions) to determine parameters like yield strength (Sy) or effusion rate (E) of Martian lava flows [2], we adopted a widely used yield stress or Bingham-fluid model [3] which requires the knowledge of topographic slope, the thickness of the lava flow and the width of the leveés confining the flow (Method III, see below).

To obtain the required data, several image mosaics of Arsia Mons and a digital elevation model (DEM) were derived from high resolution Viking Orbiter imagery. Photoclinometric methods were employed to determine the thickness of the lava flows. We used the FCMT-software (Fotoclinometria Marte) developed 1995 especially for Mars by PAOLO in cooperation with MOSANGINI & GARAGNANI at the University of Bologna. This software is based on the Minnaert photometric function. Input parameters (like subsolar lat/lon, subspacecraft lat/lon, azimuth etc.) were taken from the Mars Navigator data base maintained by the PDS (Planetary Data System).

Three methods have been applied to determine the yield strength Sy [3 and 4]:

Method I: $Sy = \rho g \sin \alpha H$
Method II: $Sy = \rho g H^2 / w_f$
Method III: $Sy = \rho g \sin^2 \alpha \, 2 w_b$

From the resulting yield strength (assuming a viscosity of terrestrial lavas with comparable yield strength) it is possible to calculate the effusion rate E by the following relationship [5]:

$$E = F (Sy / \alpha)^4 / (g \rho)^3 \eta$$

where:

ρ density (we adopted a value of 2.6×10^3 kg/m^3 [6])
η viscosity (1.7×10^5 N sec m^{-2} [5])
g gravity (on Mars surface: 3.73 m sec^{-2})
α topographic slope
H thickness of the lava flow
w_f width of flow
w_b width of leveés
F w_f / w_b

Results: The measured yield strengths for the lava flows show values between 0.8×10^4 and 2×10^4 N/m^2. These values are slightly higher than those measured for the lavas of typical shield volcanos on Earth but are comparable with yield strengths of Etnean lavas which have a basaltic to andesitic composition [6]. The effusion rates lie between 10^4 and 2×10^6 m^3/sec where the lowest values were measured for lava flows close to the crater region of Arsia Mons. These high values, compared to Earth, are consistent with results of previous authors for lava flows on Mars [e.g 7, 8, 9, 10,11] and are due to the different environmental conditions on Mars.

The derived values of yield strength support a basaltic-andesitic composition of the investigated lava flows which might be consistent with geochemical measurements made at the Mars Pathfinder landing site. There, the examined rocks showed higher silica contents and lower magnesium values as is typical for pure basalts [12]. That could hint to a more complex development of martian lava.

Discussion: As mentioned above, the results of such investigations have to be treated with care. Even though they offer reasonable results the uncertainties are high and the possibilities are limited by insufficient data. Our knowledge concerning the emplacement of planetary lava flows will certainly be improved by new and more accurate data, especially stereo data, from current and future camera experiments as they will give more detailed topographic information. The Mars Observer Laser Altimeter (MOLA) on Mars Global Surveyor is already providing excellent local topographic profiles which are precise enough to reveal the thickness of single lava flows. New camera systems like the High Resolution Stereo Camera (HRSC) to be flown on the Mars Express Mission in 2003 will provide a near global stereo coverage of Mars and will thus offer a strongly enhanced topographic view of the planet.

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