SEARCH FOR CLIMATIC SIGNAL IN PAVONIS MONS FAN DEPOSITS. B.H. Foing, A. Orsi, A. Cord, T. Zegers, A. Rossi and HRSC Co-I team , c/o SCI-S, postbus 299, 2200 AG Noordwijk, The Netherlands, Europe, Bernard.Foing@esa.int

Introduction: Mars has experienced large variations in its orbital parameters throughout its history. They are calculable for the last 10 million years, with periodicity of 120 000 years for its obliquity, 95 to 100 000 years for its excentricity, and 51 000 years for its precession, however they become undetermined beyond 20 Myr [1]. Laskar et al [2] define a standard model of Mars' insolation parameters over 4 Gyr with the most probable values 0.068 for the eccentricity and 41.80° for the obliquity.

Climatic consequences: At high obliquity, significant amount of ice can be deposited as ice at low latitudes. General circulation models predict an annual net accumulation rate of ice on the west of Tharsis volcanoes.

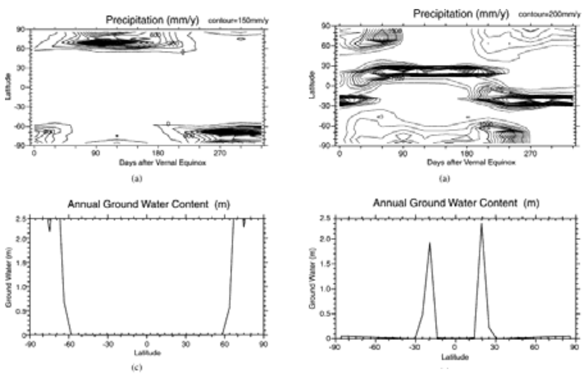

Fig. 1: precipitation for low obliquity 23.5 deg (left) and high obliquity 60 deg (right).

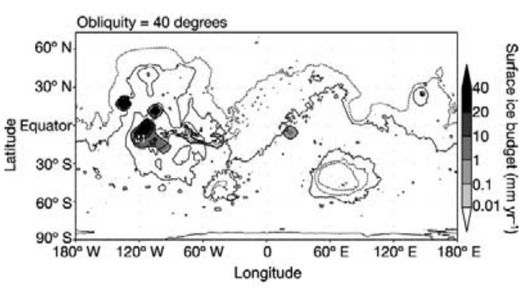

Fig. 2: precipitation map for average obliquity 40 deg. This predicts significant precipitation over Tharsis volcanoes.

Pavonis fan shaped deposits: We analysed Mars Express images obtained over orbit 946, of the west fan deposit at Pavonis Mons. The analysis of the HRSC images shows around 15 ridges, with interval 0.5 – 4.5 km. The interaction with the underlying surface can be seen , indicating the overlap of different episodes. The ridges are interpreted as drop debris on the front edge of a cold glaciar during its slow retreat.

On the other hand isotropic knobbies , circular sub-km-scale hills are interpreted as results of fast glaciar sublimation. By texture analysis we could distinguish ridges, knobbies from various episodes and relate them with geological studies [3].

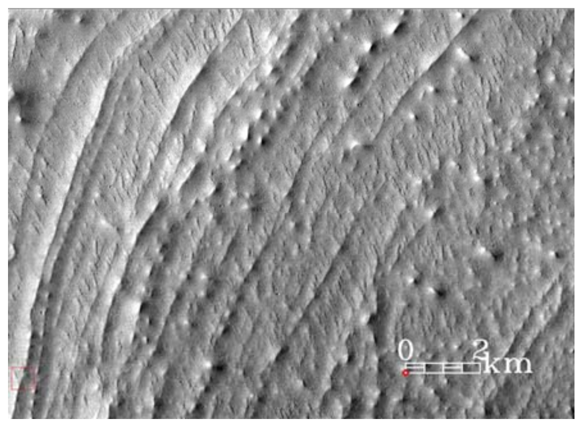

Fig. 3 a: HRSC observations of ridges in Pavonis Mons deposits.

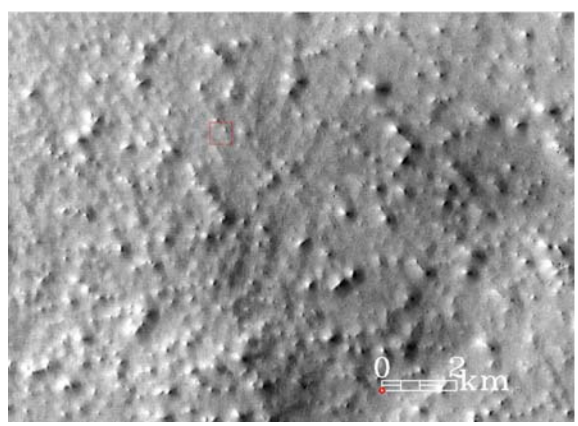

Fig. 3 b HRSC observations of Knobbies, sometimes overlying ridge episodes

Glaciar model: For this basic study, we choose the simplest model of glacier. The bed is believed to be horizontal, and does not interfere with the glacier. Assuming that the ice is perfectly plastic, we can drive a parabolic profile $H=\sqrt{\lambda}L$, where the height of the glacier H is proportional to the square root of its length L, with a dimensional coefficient $\lambda=4/3*\tau/(\rho*g)$ where τ is the sheer stress at the bottom of the ice sheet, ρ = 0.917kg/m^3 the density of ice and g=3.72m/s^2 the gravitation constant on Mars. We choose τ = 10 Bar, which is a medium value. A higher value like 15 Bar would be that of a harder ice, a smaller value like 5 Bar that of a softer ice, which would trigger to a larger extent of the glacier.
For a volume V of ice, its variation throughout the time $dV/Dt=\alpha(\theta)*L$, the volume is $2\sqrt{\lambda}*L^{3/2}$,
we therefore have $dL/dt=\alpha/(2\lambda)*L$.

Glaciar model and ridges data: If the ridges are due to obliquity oscillation, the rate of snow fall and sublimation must depend slightly on obliquity. Indeed, with accumulation rates and ablation rates at the same order, we are able to find oscillation of the glacier extent. We consider an annual ablation/accumulation rate $\alpha(\theta)$ depending on the obliquity, by quadratic interpolation from the values derived from GCM simulations at different angles we interpolate we have, we infer $(\theta)= 15.10^{-3}*((\theta-\theta o)/10)^2$ expressed in meters per year, where θo is the threshold value where the ice accumulation/ablation net rate takes off.

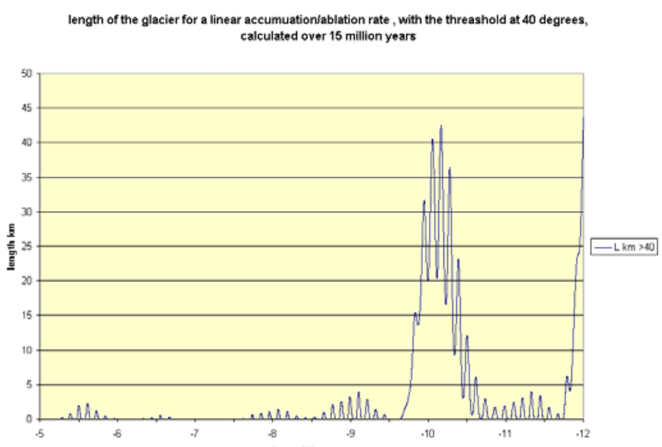

Fig. 4 Modelling Pavonis Fan glaciar extent as a function of time due to the variations of linear accumulation/ablation vs obliquity in the last 12 Myr.

We can see oscillations of the glacier extent from the beginning. It is interesting to notice that this shape is consistent with the observation of older outer sets of ridges, and young inner ones. The maximum extents, which we intent to link to the position of the ridges are organized by groups of 4 or 5.

The outer ridges we see on Pavonis Mons date back to 10-200 million years ago. We know that the obliquity raised 5 million years ago. The recent lowering of the obliquity could have triggered inner ridges too, but the outer ones we see look older. To account for their formation, we have to find an area of great variation in obliquity, allowing the glacier to form and retreat, before 10 millions years ago. A threshold higher than 35 is needed to account for a glacier older than 10 million years.

Threshold obliquity value for snow fall: The obliquity variation are chaotic, there is no certainty about their values, however, the mean obliquity is most probably over 30 degrees. The GCM simulation gave a value of θo =35 for the beginning of accumulation. The simulation of glacier extent show that these value are not consistent with the ridges of Pavonis. In this case, whatever the snow accumulation and ablation rate, there is always abrupt length decrease later than 5 million years ago. The age and structure of Pavonis fan shaped deposit is not consistent with the threshold θo at 35 given by the GCM.

Conclusions and Perspectives: Ridges in Pavonis Mons Fan deposits could be interpreted as cold glaciar debris tracing climate changes. Texture analysis to distinguish units and episodes from different obliquity and climate variations. We developed a simple qualitative glaciar progression/recession model. One needs to better quantify ice deposition/ablation net rates vs obliquity. We find that a 45 deg obliquity deposition threshold could better describe the Pavonis Mons Fan deposits data. Next steps in modeling should include the effect of topography, slopes, orientation. The geologic stratigraphy can constrain the evolution of fan deposits [3], in conjunction with crater counts dating and chronology . The climatic signal imprinted as ridges could be determined over the period of large extend of glaciar, and could permit to constrain the undetermined obliquity variations beyond 15 Myr [2].

References: [1] Laskar et al 2002 Nature 419, 375, [2] Laskar et al (2004, Icarus, Volume 170, Issue 2, p. 343-364. [3] Shean, D.E., Head, J.W., Marchant, D.R. 2005, JGR, 110, E5