SIMULATIONS OF GEYSER-TYPE ERUPTIONS IN CRYPTIC REGION OF MARTIAN SOUTH POLAR CAP. G. Portyankina[1], W.J. Markiewicz[1], M. Garcia-Comas[1], H.U. Keller[1], J.-P. Bibring[2], and G. Neukum[3], [1]Max-Planck Institut für Sonnensystemforschung, Max-Planck-Str.2, 37191, Katlenburg-Lindau, Germany, [2]Institut d'Astrophysique Spatiale, Univ. Paris-Sud, Orsay, France, [3]Freie Universität Berlin, Institut für Geologie, Geophysik und Geoinformatik, Berlin, Germany.

Introduction: The name "martian spiders" was introduced by the MOC team to describe structures that show several branches diverging from one common center. Soon after the first detection, they were discovered to be negative topographical features (depressions) - i.e. radial troughs or channels. This unusual shape and appearance of spiders caused a lot of speculation about their origin ranging from carving by running fluid to explanations involving biological species. Here we will try to argue in a favor of a model proposed by H.H. Kieffer [1]. It builds on the specific optical properties of CO_2 ice.

Model description: According to the model proposed by H.H. Kieffer spider patterns can be formed during eruption caused by rapid pressure growth under the CO_2 ice plate. Spiders were detected by MOC in the so-called cryptic region. It is defined as area that simultaneously has low temperature and low albedo. It is located inside South Polar cap. It is believed to be covered with CO_2 ice until the middle of Southern spring. One possible solution to the paradox of low albedo together with low temperatures observed in the cryptic region is to assume that the surface with the albedo of approximately 0.3 is covered by transparent CO_2 ice (slab ice) with the temperature of 160K. The reasons for geographic distribution of cryptic material is still unknown. The boundary of cryptic region does not correlate with any other properties of the surface such as elevation, geological structure, chemical composition or thermal properties. The High Resolution Stereo Camera (HRSC) together with OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) onboard of Mars express (MEX) observed Martian South Pole during southern spring 2004. Fig. 1 shows data from OMEGA aquired over South Pole area at L_s=225°. These observations show that cryptic region stays covered with CO_2 ice at least untill this time and that at the same time CO_2 ice in this area shows properties different from the rest of polar cap. In addition, after sublimation of CO_2 ice cryptic region shows no traces of water ice, while other areas of polar cap still do even at lower latitudes.

According to Kieffer's model, formation process of spiders is divided into 3 stages:

1. Formation of CO_2 ice with dust.
2. CO_2 ice cleaning due to solar insolation.

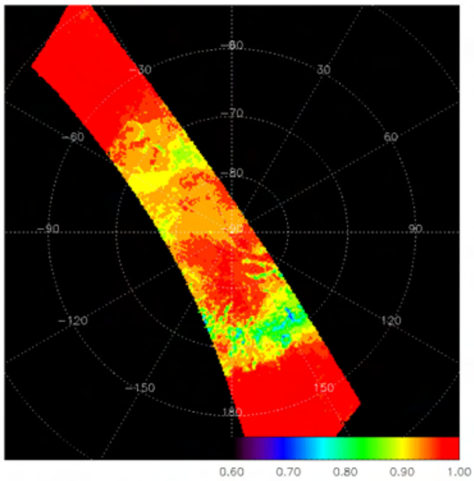

Figure 2 Transmittance at 1.5 µm relative to a local continium chosen at 1.3 and 1.71 µm.

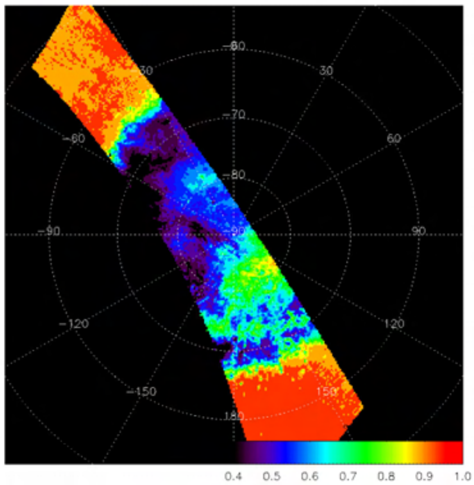

Figure 1 Transmittance at 1.43 µm relative to a local continium chosen at 1.3 and 1.71 µm.

3. Breaking the ice by sub-glacial pressure and formation of channels.

After the two first stages which take place during southern spring CO_2 ice becomes so transparent that the surface at the bottom of the slab receives enough energy to start subliming the CO_2 ice from the bottom. This CO_2 vapor accumulates under the slab rapidly increasing pressure. How long can the slab of ice resist the growing pressure underneath?

Consider an ice plate under the load of gas pressure from below. We will assume the plate to be circular supported at the edges. The pressure is uniformly distributed over the circular area in the plate's center. The plate is initially flat with a thickness that is much smaller than any other dimensions. The dimensions of our ice plate are chosen based on measurements of spiders and thicknesses of ice sheets. The latter depends on time during spring season as the slab ice sublimates from top and bottom. The diameter of the plate is chosen to be mean spiders' diameter which is 300 m.

Discussion of material strength: A significant area of uncertainty in our calculations is related to mechanical properties of CO_2 ice. We would like to know at what pressure below it the ice plate breaks. For this we need to know mechanical characteristics of material under the stress, namely: yield stress, Young's modulus and Poisson's ratio for CO_2 ice. Unfortunately these values are not known. In this work we used Young's modulus and Poisson's ratio measured for water slab ice. Another difficulty is yield stress which has to be compared to the stress produced by gas pressure under the plate. From coring experiments [2] it is known that coring of CO_2 slab ice needs more power than coring of H_2O ice. This implies that CO_2 ice is stronger than water ice, but even so it can still be more fragile for fracturing. Since we have no experimental data for CO_2 ice, we compared stresses produced in our CO_2 ice plate to yield stresses of different materials (Fig.2). We assume that CO_2 slab ice yield stress should be at least weaker than steel, but stronger than water ice.

Conclusions: With the above assumptions and following our calculation of pressure under the ice we can conclude that at latitude 75°S pressure will grow fast enough to break the ice plate in 1 to 20 days. The fracture of plate should happen before L_s=175° (Figure 2). This is before the CO_2 ice is sublimed away at this latitude and hence consistent with Kieffer's model of formation of spyders.

References: [1] Kieffer, Hugh H. (2003) Journal of Geophysical Research, 6'th International conference on Mars, Behavior of solid CO_2 on Mars: a real zoo. [2] Garry, J.R.C. and Wright, I.P. (2004) Planetary and Space Science, Vol. 52, Coring experiment with cryogenic water and carbon dioxide ices - toward planetary surface operations.

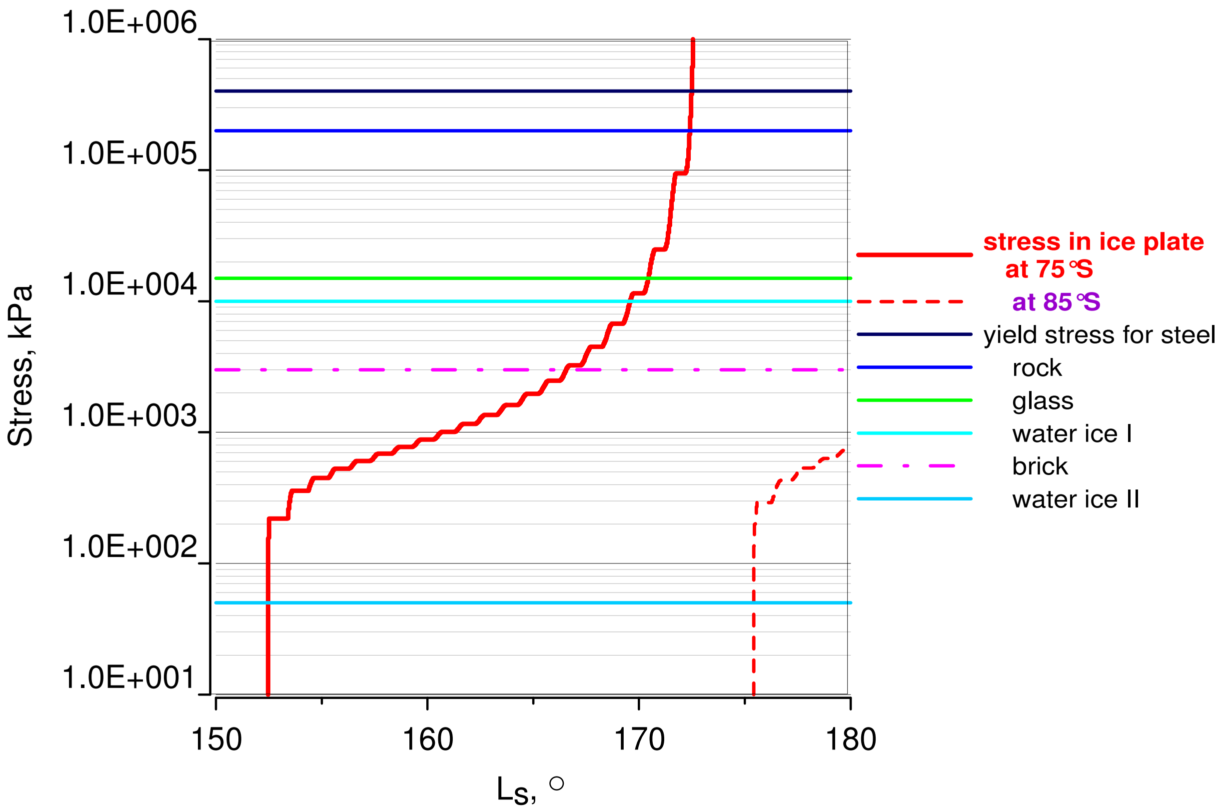

Figure 3 Comparison of stresses inside ice plate that are produced by growing pressure below it to the yield stresses of different materials