POSSIBLE ICE LENSES ON MARS. J. Raitala[1], M. Aittola[1], J. Korteniemi[1], T. Öhman[2], T. Törmänen[1] and S. Kukkonen[1], [1]Astronomy, Dept. of Physics, P.O. Box 3000, FIN-90014 University of Oulu, Finland (jouko.raitala@oulu.fi, marko.aittola@oulu.fi), [2]Dept. of Geosciences, FIN-90014 University of Oulu, Finland.

Introduction: The central part of Noachis Terra (36-47°S, 20-30°E; Figure 1) is located to the west of the Hellas Basin. This ancient highland has peaks that rise 2 to 3 kilometres higher than wide basins and large eroded impact craters in the area. In several places, the slopes have chanels that indicate ancient fluvial processes. Inside one of the craters (45.98°S, 24.41°E) there are numerous mounds that are located within a narrow unit that forms a 500 to 800 meters wide band on the crater floor beside the inner crater wall. These small domes (diam. 20-120 m) are located strictly within the unit and they do not exist anywhere else on the crater floor. The unit is connected to a channel that breaches the SW rim and runs into the crater (Figure 2A; white arrow). Being an apparent accumulation material, the narrow unit has most probably been placed through the channel. In this study we discuss of a possible pingo-like formation of the domes.

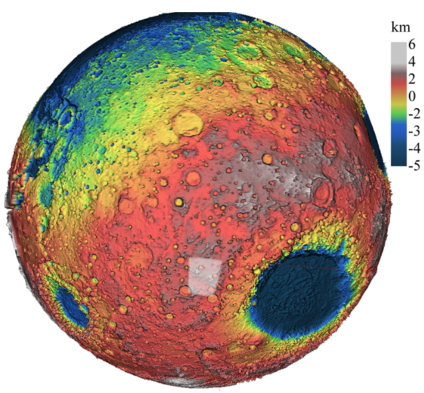

Figure 1. Noachis Terra has some of the highest topographic peaks on its latitude and hemisphere. The study area is indicated by a grayish box.

Bakcground: A number of articles have described periglacial polygonal terrains, pingos and pingo groups on Mars [1-3] connected to groundwater [4] and lake beds [5-7]. The MOC images allowed to identify details of pingo fields [8-15]. Recent HiRISE images have increased many substantial details to the observations of such structures [16, 17] – even if there still is a debate if they are pseudocraters, small volcanoes or even modified impact craters [18, 19].

Polygons and pingos on Mars: The Mars Phoenix lander studied a northern frost-wedge polygon terrain and discovered ice a few centimeters below the surface. In some favourable conditions this subsurface ice may have been more active and resulted in frost heave processes [1-7]. MOC [8-15] and HiRISE [16-17: cf. http://hirise.lpl.arizona.edu/results.php?keyword=Pingo&order=release_date&submit=Search] images show rather symmetrical dome-like structures on various locations on polygonal terrains on Mars. Of course, prosesses related to pseudocrater explosion, small-scale volcanism and even impact crater deformation [18-19] have to be taken into the account in dome formation. If – and in environments where - these other formation mechanisms can be excluded we have a strong case to postulate a pingo-like formation of small dome structures. The case is still stronger if the dome or dome group bears characteristics found in other structures that have been identified as pingos.

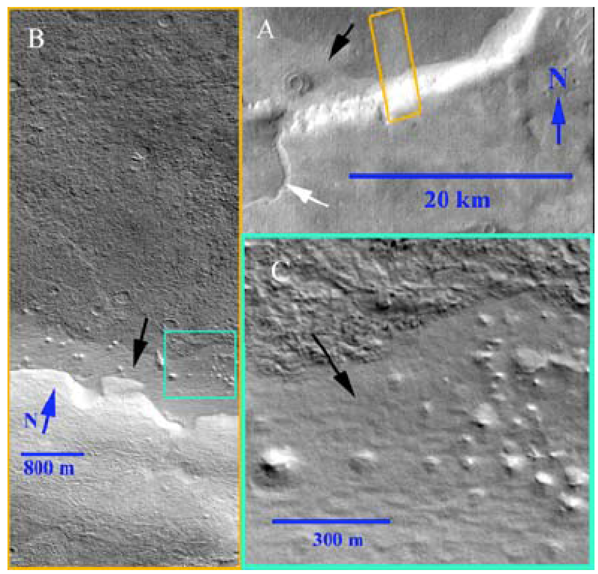

Figure 1. A) A channel (white arrow) runs from the highlands into the crater. It has an associated deposit of relatively smooth material (black arrows; THEMIS I06466002). B) The deposit along the inner crater wall has numerous small mounds (MOC R1900276). C) A close-up shows details of the mounds. The underlying older, darker and rougher unit has the crater count age of 900 ± 500 million years. The bright and smooth deposit was placed over it and is thus youger.

Pingo-likeness of the studied domes: We studied the surrounding terrain, the actual dome environment and details of the small hilly structures (Figure 2B,C). After detailed studies of these domes (unfortunately there are not any HiRISE images over them) we were able to exclude other processes that are proposed for the formation of similar small mounds: (A) They do not bear any signs of pseudocrater or hydrovolcanic explosion. (B) The wider surroungins included, they do not display any evidences of being cinder cones, volcanic domes or small volcanic edifices. (C) The mounds do not have any indications of being modified impact craters.

There are strong evidences only for the pingo-like characteristics of the domes. The environment - as a whole - has numerous signs of water activity in the past and the mounds have all the necessary characteristics that are needed to claim that they have developed under conditions and by the processes that are usually connected to pingos and their ice-lens core formation.

Terrestrial pingos: In order to cast more light on the prosesses involved in pingo formation, we took a look over terrestrial pingos. On the Earth, pingos are found in arctic permafrost environments in Alaska, Canada, Greenland, Siberia and Spitsbergen. Collapsed paleopingos of England and Holland indicate previous permafrost conditions. Arctic pingos are laccolithic ice lenses - actually ice cumulates that exist together with polygonal wedge-ice terrains. Earth-covered ice-lens pingos may be meter-size but some grow over 50 m high and more than 500 m in diameter. Being periglacial, the pingo formation processes are linked to extended ground ice accumulation in long-term cold season environment without any signs of glaciation.

Pingo types: Water injection and freezing close to the pingo surface in extended cold season conditions are essential for the pingo growth. Outward dipping soil strata indicates ice core accumulation. A palsa is a smallish ice-lens covered by peat and soil while the group of pingos consists of regular rounded small hills to larger domes with an icy core. Larger or more evolved pingos often display depressions and fractures on their upper slopes due to a partial ice lens melting.

Local pingo. Closed-system (hydrostatic) local pingos form in drained ponds where annually increasing permafrost rises the sediments. Porous material draws water up to freeze during the cold season resulting an ice core growth and an additional rise of the surface layers [cf. 20]. A hydrostatic pingo assumes the shape of drained circular to elongated pond.

Feeded pingo. Open-system (hydraulic) pingos are aquifer-feeded. In an extreme case, water is pushed up to freeze close to the surface. Freezing adds mass to the expanding ice lens that pushes the soil up. Existing slope may increase aquifer activity and subsequent pingo growth. An aquifer-feeded pingo may reach a larger size than a closed-system pingo. Open-system pingo depends on the aquifer geometry and activity.

Pingo growth. Estimations of terrestrial pingo growth rate count on water intrusion and frost heaving. A reasonable estimate is that a terrestrial pingo grows a few centimetres per year. Assuming a growth rate of 2 cm/year it formally takes 2500 years for a pingo to grow 50 meters high. A growth rate of 1 cm/year gives 5000 years. A large pingo may last up to a few thousands years before it declines and collapses. For a smaller pingo or for a pingo in not-so-frendly environment it may take decades or centuries only to reach the mature phase and to begin to decline.

Pingos on Noachis Terra: The mounds are strictly connected to the flow unit emplaced out of the channel. Ice-lens formation and accumulation controlled the pingo growth but we have, however, not been able to identify if the structures were caused by a closed (hydrostatic) or open (hydraulic) system. If the pingo formation took place after the channel flow was deceased, the pingos would be the closed ones [20] grown by local cycles of groundwater and permafrost activity. If the channel still offered additional water, the mounds may have formed as open system pingos feeded by aquifer-supplied water. Topography of the actual pingo group area favours the alternative that their growth was, at least partly, supported by an amount of aquifer-feeded water. A closed-system formation is favoured by their rather regular form and wide distribution within the unit they are located on.

The channel-associated unit, pingo-like features on it and nearby crater floor collapses indicate that there was, and probably still is, some water/ice/permafrost below the surface. The pingo characteristics exhibit that water was active in the region in the past. Loss of water, permafrost melting and ice lens sublimation deformed pingos, especially their upper elevations. The area should be of great interest to studies by the HRSC, HiRISE and SHARAD instruments.

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