PINGOS ON SPITSBERGEN AND ON MARS AS ASTROBIOLOGICAL TARGET

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Introduction:
Low temperature and pressure on the surface of modern Mars complicate presence of liquid water and life forms based on it. At the same time, microorganisms which could originate during warm and wet Noachian time potentially still exist in deep aquifers under permafrost. Deep biosphere of Earth colonized by chemolithotrophs may be considered as analog of this econiche. This is the only econiche where life could survive all history of Mars regardless to changing conditions on the surface [1]. However, great depth of burial makes them inaccessible for investigation. Young volcanism was considered as a possible way to transport biomarkers from the depth [2]. Another geological process which may result in transport of material from the depth to the surface is ground water seepage with formation of frost mound called pingo (in English literature) or bulgunyakh (in Russian).

Pingos on Earth, Spitsbergen:

Two pingo types are commonly distinguished on Earth, which are closed system and open system pingos. Closed system pyngos usually form after drainage of lakes and following freezing of underlake talik. Open system pingos, unlike closed system pingos, gravitate toward mountain relief and do not need presence of standing bodies of water on the surface. They form when freezing from the surface is accomplished by inflow of pressurized water from within or below permafrost. Both processes result in a massive ice body that heaves the surface and form conical elevations. Using logistic facilities of Russian scientific center on Spitsbergen we studied group of seven pingos in Grondalen valley in the vicinity of Barentsburg settlement on island Western Spitsbergen (Fig.1). Pingos Fili and Nori were entirely drilled through ice body to underlying permafrost; upper boundary of ice was sampled in Kili pingo. Hydrochemical measurments of ions Cl, SO_4, HCO_3, Na, Ca, Mg, K and measurements of isotopes δD and δ18O in ice body showed composition similar to nearby spring [3]. This data allows us to reconstruct history of pingo formation in Grondalen as follows: after retreat of the sea from Grondalen freezing from the surface took place and open system pingos grew on tectonic fissure controlling seepage of groundwater fed by subglacial melt. Ground based georadar and noncontact electrical survey were performed on pingos to test geophysical methods for mapping underground ice bodies. Georadar with low frequency antennas (40 MHz) was unable to detect ice on Nori and Kili pingo (upper ice boundary according to drilling is located at depth 4,5 and 13 m, respectively) and all other pingos expect Fili, where due to degradational crater upper ice boundary is located at 1,5 m. Near-field transient electromagnetic sounding (NTES method) with square antenna (25, 50 and 100 m quarter) showed

valid data only on Kili, Oin and Gloin pingo. On geoelectrical crossections (fig. 2) taliks with ground water are seen but, unfortunately, ice was indistinguishable from permafrost. On other pingos measurements were non-liquid due to absence of conductors in the section and polarization effect.

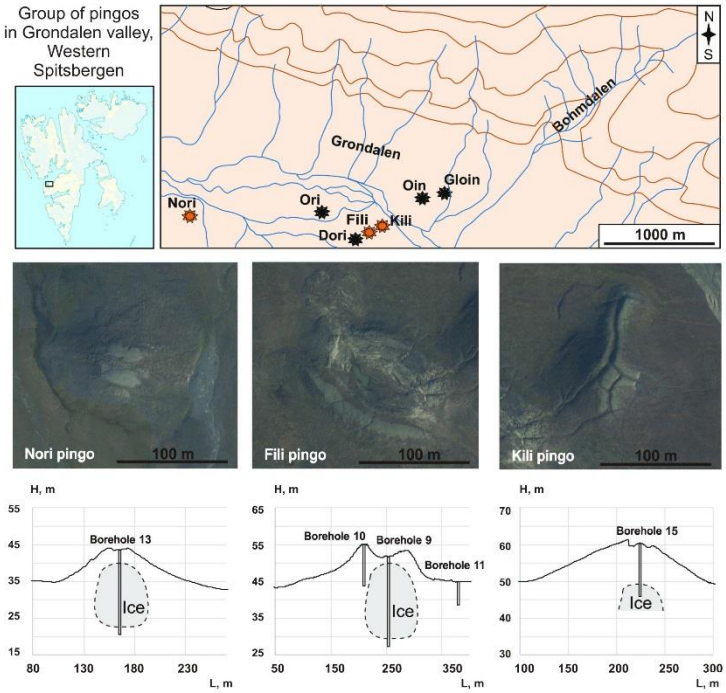

Fig. 1. Location, space images and crossections of pingos in Grondalen, Western Spitsbergen.

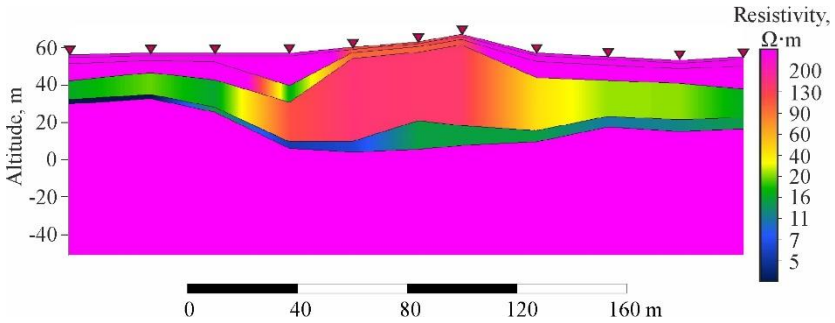

Fig. 2. Geoelectrical crossection of Gloin pingo.

Pingos on Mars:

Discussion about presence of pingos on Mars has a long history. Mechanism of formation of frost mounds on Mars may be quite different from what we know on Earth. At the same time, it was proposed [4] that there should be no systematic difference between pingo heights and diameters on Earth and Mars. Using HiRISE images, we found several locations on Mars (fig.3) with mounds having identical morphometry to open system pingos studied in Grondalen, Western Spitsbergen. Next step was to understand how Martian mounds comply with geomorphological diagnostic characters of Spitsbergen pingos, which are: correlation with glacier-like ice bodies, negative relief forms and tectonic faults, the source of pressurized ground water flow, presence of degradational crater and cracks on the top of mound.

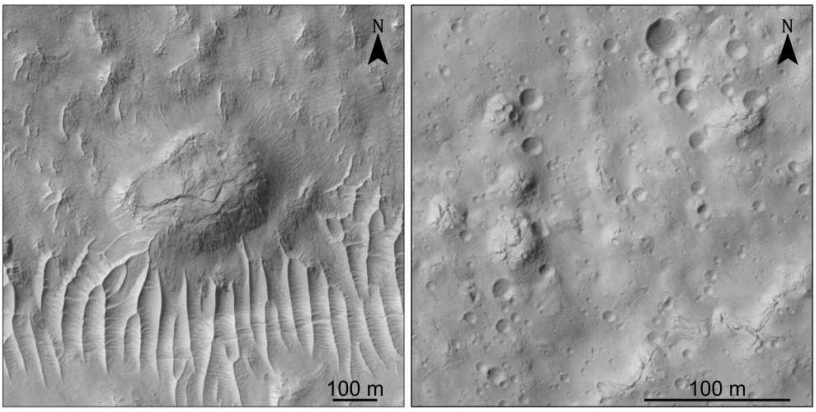

Fig. 3. HiRISE images of Mars' pingos-like features on the bottom of mid-latitudes craters. Left - 37°S 203°E (PSP_001578_1425), right - 33°S 131°E (PSP_002135_1460).

Discussion:

Presence of mounds on Mars that match geomorphological criteria's for being pingo-like frost mounds drums up interest to potential presence of liquid water under the surface. Near surface massive pingo ice may be considered as the best resource of water for human exploration of Mars. It must be taken into account, that even on Earth detection of ice body and its geometry under pingo cone is complicated when using only geophysical survey without drilling. In next expeditions we plan to test detailed gravimetric measurements in combination with laser altimetry for mapping of pingos' massive ice. Spitsbergens pingos allow us to investigate processes of microbial life transport from deep biosphere to the surface and preservation of viable forms in ice. Results of microbiological studies of pingo ice, permafrost and spring water available for the conference date are going to be presented in the talk. Terrestrial pingo life refuge model may be useful for choosing candidate targets for astrobiological missions to Mars with shallow drilling and search for water and biomarkers.

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