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Are pre-crater mounds gas-inflated?

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Gas-emission craters (GEC) on Yamal peninsula, which occupied minds of researches for the last couple of years since first discovered in 2014, appeared to form on the place of specifically shaped mounds. There was a number of hypotheses involving pingo as an origin of these mounds. This arouse an interest in mapping pingo thus marking the areas of GEC formation risk. Our field research allows us to suggest that remote-sensing-based mapping of pingo may result in mix up of mounds of various origin. Thus, we started with classification of the mounds based on remote-sensing, field observations and survey from helicopter. Then we compared indicators of mounds of various classes to the properties of pre-crater mounds to conclude on their origin.

Summarizing field experience, there are three main mound types on Yamal. (1) Outliers (remnant hills), separated from the main geomorphic landform by erosion. Often these mounds comprise polygonal blocks, kind of “bay-dzherakh”. Their indicators are asymmetry (short gentle slope towards the main landform, and steep slope often descending into a small pond of thermokarst-nivation origin), often quadrangle or conic shape, and large size. (2) Pingo, appear within the khasyrei (drain lake basin); often are characterized by open cracks resulting from expansion of polygonal network formed when re-freezing of lake talik prior to pingo formation; old pingo may bear traces of collapse on the top, with depression which differs from the GEC by absence of parapet. (3) Frost-heave mounds (excluding pingo) may form on deep active layer, reducing due to moss-peat formation and forming ice lenses from an active layer water, usually they appear in the drainage hollows, valley bottoms, drain-lake basins periphery. These features are smaller than the first two types of mounds. Their tops as a rule are well vegetated.

We were unable to find a single or a set of indicators unequivocally defining any specific mound type, thus indicators of pre-crater mounds are still debatable.

Our hypothesis initially does not involve pingo origin of pre-crater mounds for several reasons, among which were the initial depth (70 m) and width (18 m) of the crater void, frozen walls and bottom, no traces of sub-lake talik, an important control for pingo formation, and more. Pre-crater mounds are closer to frost-heave mounds in size (4-7 m high and 30-60 m in diameter). Yet frost-heave mounds like palsa or lithalsa have segregated ice lenses closer to the surface, total thickness of these lenses is equal to the height of the mound. Pre-crater mounds have at least 20 m of tabular ground ice in the section that has no manifestation in the mound height or diameter.

All above-mentioned leads to the conclusion that pre-crater mounds form because of gas inflation rather than regular frost heave process involving moisture migration towards the freezing front.

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