GIS of the gas-emission crater area (Yamal peninsula, Russia)

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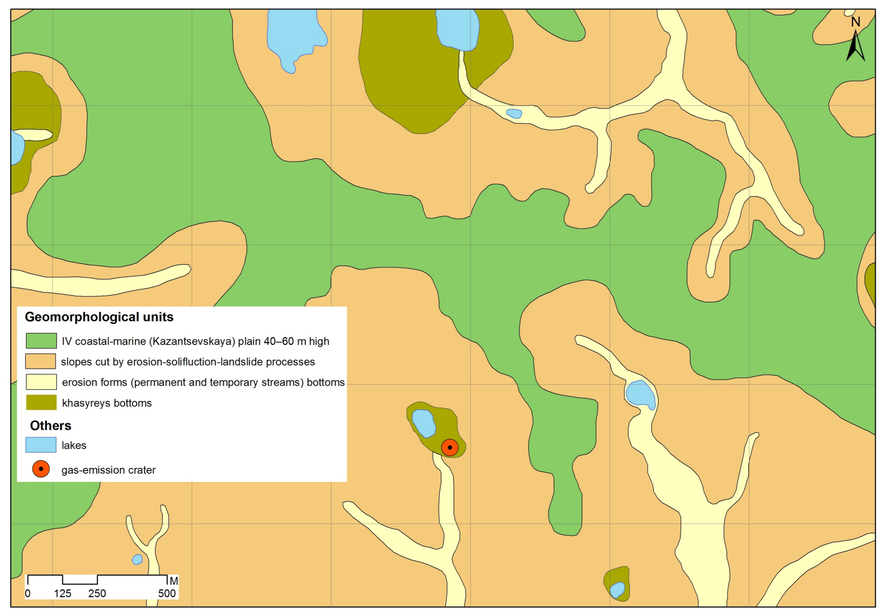
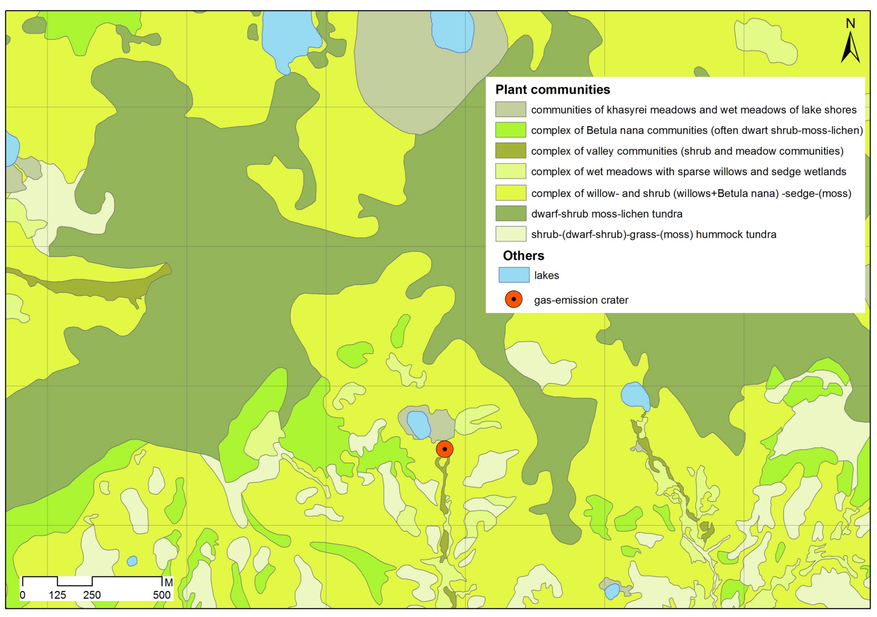
GIS of the area was developed in order to study a phenomenon of the gas-emission crater in the Central Yamal. Formation of gas-emission craters is a newly discovered cryogenic phenomenon which may pose a hazard for economic facilities in permafrost zone.
GIS methods which were used enabled to collect, visualize and analyze spatial data. Development of the GIS is intended for - 1) systematization and organization of existing information on geocryological, geomorphological and landscape structure of the area for joint analysis; 2) reveal of environmental conditions and estimation of the factors (or composition of factors) which led to gas-emission crater formation.

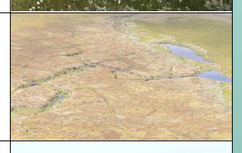
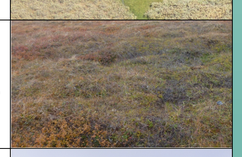
Fieldwork was carried out since 2014 (Leibman et al., 2014). The most efforts were put on study of the exposed sections in the crater walls and thermocirque (which is located nearby), assessment of relief dynamics and investigation of landscape structure of the key site.



Mapping of relief and relief-forming processes, preliminary landscape mapping were carried out during the fieldwork. Field data was analyzed jointly with satellite images for estimation of relief features before and after the crater formation (Kizyakov et al., 2015). A digital elevation model (DEM) of the relief was developed by processing of satellite image stereo pair (WorldView-1). This provided an opportunity to get quantitative specifications of the relief change. Joint processing of the field landscape descriptions and satellite data led to landscape typification which was used as a base for landscape mapping of larger than a key site territory.

Narrow elongated watershed surfaces (42-48 m, evaluated by EGM96) dissected by erosion and thermokarst landforms are found in the north of the area. Those are supposed to be the surface of the Middle or Upper Pleistocene Marine plain. Polygonal microrelief could be found locally here as well.
Small lakes (diameter 80-230 m) are located in the upper parts of valleys which are dissecting watershed surface in all directions. Round shape of these valleys' openings (in plan view) is associated with lakes and drain lake depressions (hasyreis). Cryogenic landslides are widely distributed on slopes and lake shores. Gas-emission crater is situated to the south of a hill on the peripheral side of khasyrei formed in the upper section of erosion valley.
Along with relief, the other main GIS layer is vegetation which is the main land surface feature well seen on the images and rather well understood in environments of Yamal Peninsula.



Plant communities	Main species	Horizontal structure (% of cover)	Photograph
complex of wet meadows with sparse willows and sedge wetlands	*Salix glauca, Carex aquatilis, C. rotundata, C. rariflora, Eriophorum polystachion, E. scheuchzeri,* Sphagnum spp.	Total = 55-95% shrub layer < 5% dwarf shrubs and grasses layer = 45-95% moss-lichenous layer = 0-35%	
dwarf-shrub moss-lichen tundra	*Vaccinium vitis-idaea subsp. minus, Salix nummularia, Carex arctisibirica, Poa arctica, Hierochloe alpina,* Alectoria nigricans, Cetraria islandica, Cladina arbuscula, Aulacomnium turgidum, Dicranum elongatum	Total = 90-100% shrub layer = 0% dwarf shrubs and grasses layer = 60-70% moss-lichenous layer = 90-100%	
communities of khasyrei meadows and wet meadows of lake shores	*Arctophila fulva, Carex aquatilis, C. concolor, Eriophorum scheuchzeri, Calamagrostis neglecta, Dupontia fisheri, Comarum palustre, Nardosmia frigida, Saxifraga cernua,* Drepanocladus spp., Mnium spp.	Total = 80-100% shrub layer = 0% dwarf shrubs and grasses layer = 65-75% moss-lichenous layer = 0-90%	
complex of valley communities (shrub and meadow communities)	*Salix lanata, S. glauca, Equisetum boreale, Carex concolor, Eriophorum scheuchzeri, Calamagrostis langsdorffii*	Total = 90-100% shrub layer = 0-40% dwarf shrubs and grasses layer = 50-100% moss-lichenous layer = 0-80%	
shrub-(dwarf-shrub)-grass-(moss) hummock tundra	*Betula nana, Salix lanata, S. glauca, Carex arctisibirica, C. concolor, Rubus chamaemorus, Vaccinium vitis-idaea subsp. minus, Luzula multiflora,* Aulacomnium turgidum, A. palustre, Pleurozium schreberi, Sphagnum lenense	Total = 100% shrub layer = 50-60% dwarf shrubs and grasses layer = 30-50% moss-lichenous layer = 60-100%	
complex of willow- and shrub (willows+Betula nana) -grass-(moss) communities	*Salix lanata, S. glauca, Betula nana, Carex concolor, Pedicularis lapponica, Nardosmia frigida, Polemonium acutiflorum, Ranunculus borealis, Equisetum boreale, Calamagrostis langsdorffii,* Hylocomnium splendens, Dicranum angustum, Sanionia uncinata	Total = 100% shrub layer = 40-100% dwarf shrubs and grasses layer = 30-70% moss-lichenous layer = 30-100%	
complex of Betula nana communities (often dwarf shrub - moss-lichen)	*Betula nana, Empetrum subholarcticum, Ledum decumbens, Vaccinium vitis-idaea subsp. minus, Carex arctisibirica, Equisetum boreale, Calamagrostis lapponica,* Pleurozium schreberi, Dicranum spp., Flavocetraria cucullata, Cladina rangiferina, C. arbuscula, Ochrolechia frigida	Total = 90-100% shrub layer = 30-70% dwarf shrubs and grasses layer = 30-60% moss-lichenous layer = 60-100%	

Horizontal structure of vegetation cover reflects the main features of relief and geomorphological processes. Dwarf-shrub moss-lichen tundra occupies about ¼ of study area (well-drained ecotopes) and is tightly associated with watershed surfaces. More than the half of the area (including significant sections of slopes and valleys) is covered by complex of willow- and shrub (willows+Betula nana) -grass-(moss) communities. Identifiable vegetation types are found on the khasyreis, low lake shores, wider sections of flood plains and relief depressions (in total about 9% of the study area). In contrast to above-mentioned vegetation types these are more fragmented and occupy ecotopes of far lesser area. Shrub-(dwarf-shrub)-grass-(moss) hummock tundra is often developed on wet gentle slopes. Complex of Betula nana communities (often dwarf shrub -moss-lichen) is associated with relatively dry ecotopes of hilltops.

Developed system of data accumulation, storage and processing of this unique cryogenic phenomenon serves as a basis for analysis of environmental conditions leading to its occurrence. The next planned step of the research is establishing ranking criteria (i.e. combination of natural settings) to predict the phenomenon. As a result, the methodological possibility for assessment of territory in connection to gas-emission craters hazard appears.
GIS of the area is an open system suitable for uploading new information sources of all types.