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DECODING AND INDICATION OF CURRENT EXOGENOUS PROCESSES UNDER GEOCRYOLOGIC MONITORING OF PERMAFROST AREA (THE CASE OF WESTERN YAMAL PENINSULA)

SUMMARY. This article indicates the importance of permafrost geocryological monitoring as a means of ecological design (eliminating failure of information security, reduction of accidents at the production sites, preparation and transportation, detail information about the permafrost processes, based on engineering and permafrost studies).

The concepts of decoding and landscape indication are viewed as subsystems of modern mapping technology of cycle exogenous processes on the territory of Kharasaveyskoye and Kruzenshternovskoye gas fields.

The article briefly describes the basic physical and geographical characteristics, spatial organization, landscape displays and decoding features of modern exogenous processes at the studied area, among which there are frost cracking and ice-wedge casts, long-term cryogenic heave, thermokarst units, cryo solifluction, thermal abrasion and thermal erosion.

It has been found that the decoding signs and landscape indication properties of the studied modern exogenous processes are complex and require further study, as well as improvement and standardization.

The paper benefited large-scale, highly detailed panchromatic aerial photographs and highly detailed multispectral imagery (World View 2, Geo Eye 2) of 2012.

KEY WORDS. Decoding, indication, exogenous, geocryological, monitoring.

Errors in the design of gas-producing infrastructure facilities are related to the lack of data support and they specify the majority of emergency situations, making it necessary to detail information about the processes occurring in the permafrost zone. The geocryological monitoring as a means of greening design, forecasting changes in permafrost conditions for gas field facilities and construction control is of particular importance in this research.

The first reference to the geocryological monitoring appeared in 1974 in the classification of monitoring systems by Yu.A. Izrael [1]. The problems of geocryological monitoring as a particular form of geological monitoring are developed in the late 80s. According to P.I. Melnikov, R.M. Kamensky and A.V. Pavlov, *geocryological monitoring* is a system of research, assessment and control of geocryological environment. It is a system of assessment of the changes of permafrost, geotechnical and hydrogeological conditions in the North under the influence of natural factors and human activities [2].

A wide range of issues, included into the subject area of geocryological monitoring, requires a considerable amount of geological survey, geotechnical and hydrogeological works for short periods of time.

The absence of transport infrastructure, difficult terrain conditions, short field period on the Yamal Peninsula limit the spatial and temporal ranges of this complex kind of monitoring.

The problem can be solved through the use of new technology works, the essence of which is the aggregation of more specific methods (decoding and landscape indication), hardware (remote sensing of the Earth) and modern means of providing information (geographic information systems (GIS)).

Each of the subsystems of the technological cycle solves its own problem:

Decoding of remote sensing data (DRSD) allows obtaining the information about the ecosystems according to their photos, based on the laws of replication of their optical and geometrical properties. In this study, good results were obtained by means of World View 2, Geo Eye 2 remote sensing satellite systems.

Landscape indication during the geocryological monitoring is focused on the study of permafrost conditions, modern exogenous processes (internal content), reflected in the physiognomic (visible, external) components of the environmental systems. It is based on the correlation ratio of the externals of the elements and components of the landscape with their internal structure, followed by the interpretation based on reliable indicators [3], [4]. The basis of the landscape indication is the idea that all components of the environment within a specific genetically homogeneous part of the Earth's surface, are in close relationship and interdependence to form a single natural entity—landscape [5], [6], [7].

Modern exogenous processes, being the objects of geocryological monitoring, are complex and require a qualitative field study. In the study, the field data, including the results of verification decoding and overall descriptions at the after field office period are supplemented by the cartometry data, obtained while processing the landscape, geological and geomorphological maps, using GIS modeling.

The landscape–indicator research is the most labor-intensive within the technological cycle of geocryological monitoring, especially in its processor part. The spatial organization of six current geodynamic processes is studied: frost cracking and ice-wedge casts, long-term cryogenic heave, thermokarst units cryo solifluction, thermal abrasion and thermal erosion.

The geodynamic processes were decoded and analyzed as a part of tracts' types, mapped according to the location (a form of the relief, the composition and thermal properties of the soils, drainage, geodynamic process), phytocoenotic properties and soil covers. While mapping, qualitative results are obtained with the use of GIS (MapInfo 10, ArcGIS 10, ENVI).

1. *Frost cracking and re-wire ice formation* [8], [9], [10] in many ways form the current look of the researched area. These processes are the most active in the territories of the prevalence of modern accumulation of earth cover: in laids, bottom lands and peat lands of all geomorphological levels. This process is decoded by feeble, sometimes disappearing network of thin frost cracks, forming peat land loops. On large scale

panchromatic aerial photographs (Figure 1) the general photo color varies from light gray to dark gray. They are characterized by a network of feeble dark lines of a polygonal reticulate pattern, fine-grained structure (homogeneous).

Figure 1: Frost cracking and re-wire ice formation.

2. *The long-term cryogenic heave* [8], [9], [10] leads to injection-segregation mineral and mineral-peat mounds, ridges and areas of heaving, as well as injecting mounds—frost mounds. Mounds of heaving (Figure 2) are composed of hard icy clay loams, clays, sandy loams (rarely). The process indicators are the mounds, up to 8–10 meters high, within a fully or partially deflated lake basin. Usually, the diameter of the base of perennial mounds of heaving was of several tens of meters. The borders of lake basins are set by the preserved shape of the coastline. On the panchromatic aerial photographs of a large and medium size, the mounds of heaving are represented by round or oval spots, usually of a lighter or darker photo color than the surrounding surface of the lake basin, decoded by a loop circuit of the cliff (Figure 2).

3. *Thermokarst units* [8], [9], [10] are abundant on all geomorphological levels except the sandy lower laid. The main part of thermokarst units—lakes, hasyreyes and extensive marshy low areas—are ancient formations. Modern thermokarst is poorly developed and forms a flat-sinkholes and crack-polygonal surfaces. According to the data from the cartometry studies, the degree of thermokarst infestation is 57%, 91% accounts for the lakes and hasyreyes, and 9% accounts for the developing forms. The most commonly thermokarst affects flat smooth surfaces of watershed parts of marine terraces, undrained with raw grass-moss polygonal tundra and a dense network of thermokarst depressions. Flat-kettle surfaces (Figure 3) are decoded by the spotty pattern, homogeneous structure of a dark photo color. The location of spots is chaotic.

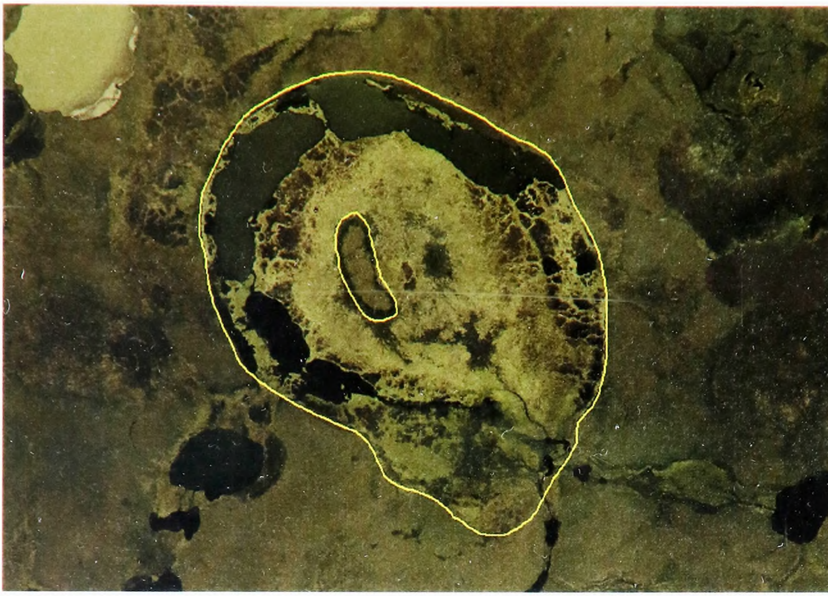

Figure 2: Hasyrey (large outline) and the mound of heaving (small enclosed outline).

Figure 3: Thermokarst units.

4. *Cryo solifluction* is developed on the terraces slopes in the areas where perennial permafrost contains hard icy clay loams and clays. The reason of slip outs may be abnormally high summer temperatures and violation of vegetation [8], [9], [10].

On the aerial and satellite photos, cryo solifluction, as a process, can be identified by cryo solifluction walls and ridges, which are arranged in a perpendicular direction to the slope. On large-scale panchromatic photos they look blurry-banded, "corrugated", bend over backwards to the middle of the slope pattern, of gray photo color (Figure 4).

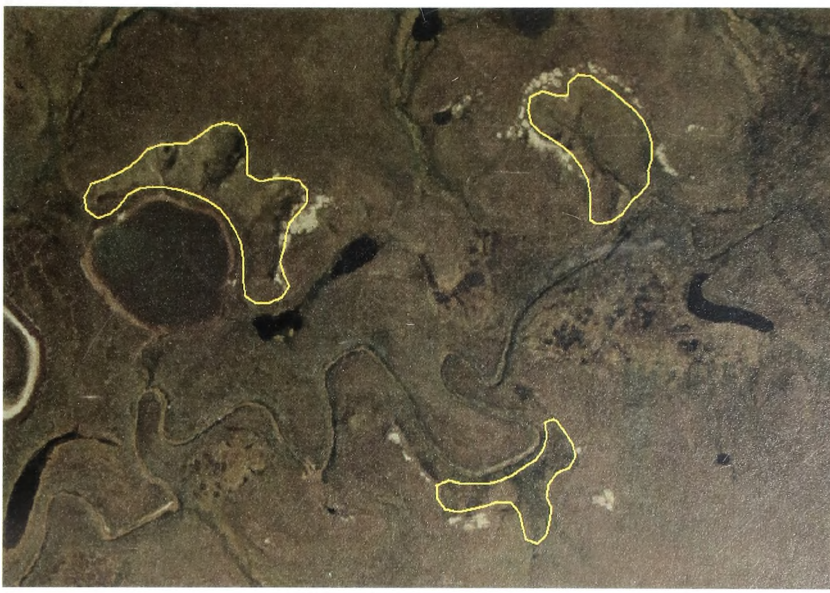

Figure 4: Cryo solifluction.

5. *Thermal abrasion* is developed along the banks of lakes where mono-mineral deposits of ice (stratal ice and ice-wedge casts) are exposed. Within the studied area, thermal abrasion is developed almost everywhere, indicating a high ice content of the soil [8], [9], [10]. Thermal abrasion is decoded fairly easily based on large-scale panchromatic aerial photos and satellite imagery. An indirect indication of this decoding process is the confinement to the banks of lakes and seas. The banks take the form of parallel-oriented bands of a light (to white) photo color, different thickness, there may be spots of a light photo color among them (Figure 5).

6. *Thermal erosion*. Its specific characteristics of the development on the studied area are conditioned by the active heave of the area at Late Quaternary, the proximity of erosion basis, the lack of thick vegetation and general development of hard icy strata, containing stratal ice and ice-wedge casts.

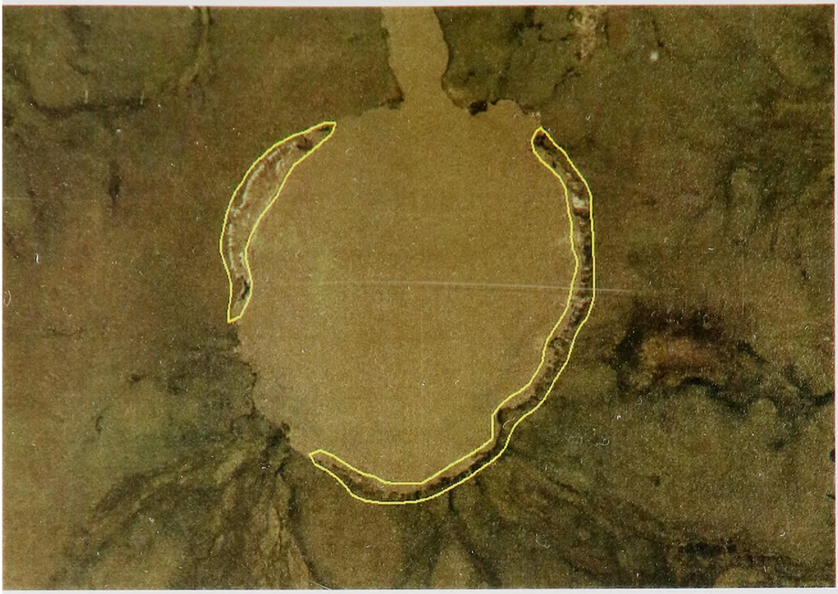

Figure 5: Thermal abrasion.

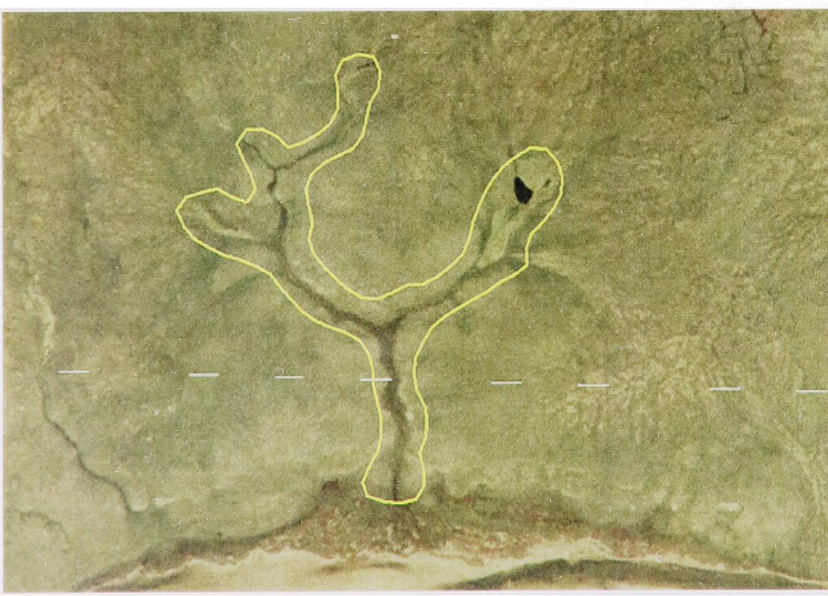

Figure 6: Thermal erosion.

The highest degree of thermal erosion compartmentalization is peculiar to the sites, directly adjacent to the sea coast, as well as to the river valleys and lake shores [8], [9], [10]. The thermal erosion gulley network is decoded from a tree (full of branches) graph, dark gray photo color in the center and a light gray photo color at the edges (Figure 6). It is necessary to use a large or medium-scale aerial photos and satellite imagery.

The use of decoding and landscape indication significantly reduces the time of field research, offers the opportunity to accumulate labor-intensive drilling and other works on the typical key areas, significantly increases the quality of engineering and mapping the geocryological territories.

The conducted landscape indication study of the western Yamal peninsular (within Kharasaveyskoye and Kruzenshternovskoye gas fields) showed a significant variety of types and forms of contemporary exogenous processes. Inventoried interpretive signs and landscape–indicator properties of the test geodynamic processes are complex and require further improvement and standardization.

REFERENCES

1. Izrael, Yu.A. Ecology and Environmental Control. Leningrad: Gidrometeoizdat (1984): 560.

2. Melnikov, P.I., Kamensky, R.M., Pavlov, A.V. Monitoring of Permafrost. *Proceedings of the Russian Academy of Sciences. Vol. 63. № 12.* (1993): 1090–1095.

3. Akovetsky, V.I. Photo Interpretation. *Textbook for Higher Education Institutions.* Moscow: Nedra (1983): 374.

4. Viktorov, S.V., Chikishev, A.G. Landscape Indication and its Practical Application. Moscow: Moscow State University Publishing (1990): 200.

5. Geo-ecology and Environmental Management. *Conceptual and Terminological Dictionary.* Kozin V.V., Petrovsky V.A. Smolensk: Oykumena (2005): 576.

6. Kozin, V.V. Levchenko, V.S. Landscape Mapping of the Yamal Peninsula Based on Space Photo Information. *Geodesy, Aerial Photography, Cartography. Issue 9. Engineering and Technology.* Moscow (1984): 20–22.

7. Kozin, V.V., Levchenko, V.S., Shlakhov, A.F. Medium–landscape Map of the Yamal Peninsula. *Landscapes of Western Siberia.* Irkutsk: Institute of Geography of Siberian Department of the USSR Academy of Sciences (1985): 34–39.

8. Baulin, V.V., Dubikov, G.I., Aksyonov, V.I. and all. Permafrost Conditions of Kharasaveyskoye and Kruzenshternovskoye gas fields (the Yamal Peninsula). Moscow: GEOS (2003): 180.

9. Dubikov, G.I. Composition and Cryogenic Structure of Permafrost of Western Siberia. Moscow: GEOS (2002): 246.

10. Kozin, V.V. Landscape and Ecological Environment of Western Siberia. *Study Guide. Part I. Yamal–Gidansky Region.* Tyumen: Tyumen State University Publishing (2007): 144.