Permafrost researchs report of Russia 2013

*****The results of the most fundamental and advanced investigations have been published in the journal "Earth's Cryosphere" ("Kriosfera Zemli").

1) Russian Academy of Science earth cryosphere Institute of Siberian Branch RAS (ECI SB RAS)

V.S. Sheinkman, V.P. Melnikov. Siberian glaciers as a component of cryolithogenic-glacial geosystems

Cold continental climate in Siberia determines peculiar conditions of glacier formation and dynamics. Interacting with permafrost, they become a new element of cryodiversity, i.e. a set of objects and phenomena produced by cold, and differ greatly from the glaciers which used to be considered from the positions of the Alpine glaciation model. Being cooled down to quite low temperature (much below 0ºC), the glaciers in Siberia acquire traits which are more inherent for the cryolithozone rather than for Alpine-type glaciers. The acquired feature calls for regarding the formed aggregation of glaciers and permafrost as a peculiar geosystems; we name them cryolithogenic-glacial systems.

2) Russian Academy of Science earth cryosphere Institute of Siberian Branch RAS (ECI SB RAS)

S.M.Fotiev. Underground waters of cryogenic area of Russia (classification)

During the cryogenic period (the last 3.1 million years) the geothermal and hydrogeological conditions inside the geological structures have essentially changed all over the vast circumpolar area of Russia. As a result of perennial freezing of rocks the thick low-temperature cryogenic aquicludes had formed inside the structures. They had changed considerably the conditions of water-exchange, the hydrochemical zonality and the capacity of hydrogeological structures. Basing on the contemporary scientific researches in the fields of hydrogeology and geocryology, the enormous but utterly irregular (in time and space) influence of the process of cryogenic metamorphism of rocks on the transformation of the hydrogeological conditions inside the hydrogeological structures situated in various geocryological zones has been revealed.
Elaborating the classification of the underground waters of cryogenic area, the author has proceeded from the assumption that the geological structures and the accumulation of the main types of the underground waters inside them had formed before the beginning of the cryogenic period. During the cryogenic period the underground waters had maintained the active thermal resistance to the perennial freezing of rocks. Just therefore, the classification of the underground waters of the cryogenic area has been founded on the key hydrogeological feature of the rocks – their water-permeability.

3) Russian Academy of Science earth cryosphere Institute of Siberian Branch RAS (ECI SB RAS)

F.E. Are. Thermal aspects of N.A. Tsytovich principle of water and ice equilibrium state in frozen ground

The applicability of the Stephen problem solutions for permafrost dynamics modeling is discussed using N.A. Tsytovich principle of water and ice equilibrium state in frozen grounds.

The main external impacts controlling equilibrium, relationships between equilibrium dynamics and thermal processes in ground, possibilities of mathematical modeling of permafrost dynamics are reviewed. The dynamics of equilibrium state in saline ground is discussed using results of permafrost investigations on Yamal Peninsula and Laptev Sea shelf. It is revealed that the cryopeg temperature in equilibrium state is equal to its initial freezing point, the ice-bonded permafrost may contain cryopeg and preserve permeability, the cryopeg boundary may not coincide with the phase boundary. Free-salined permafrost on the shelf flooded by the sea undergoes fast salinization and physicochemical thawing at negative temperature. The thawing is accompanied by temperature lowering due to latent heat absorption. The ice content in salined permafrost on shelf is changing in space gradually without a clear phase boundary. It is revealed that solutions of Stephen problem are unacceptable for shelf permafrost modeling.

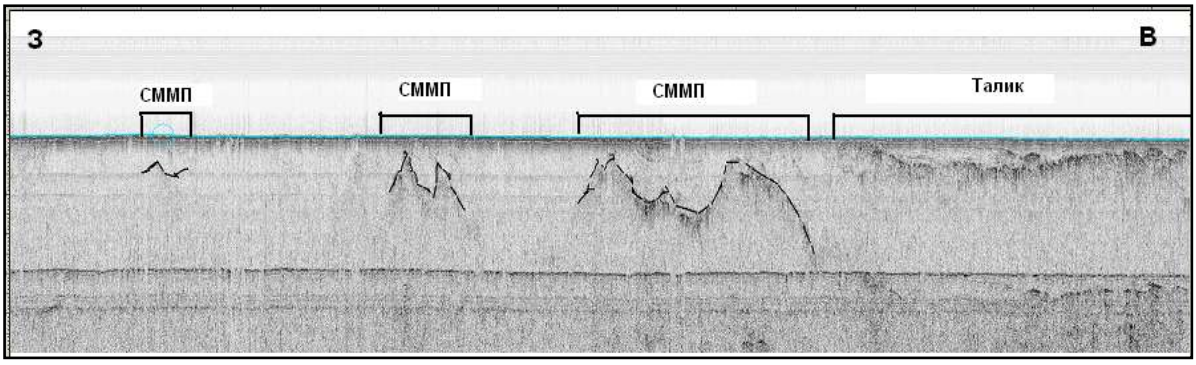
4) The Department of Cryolithology and Glaciology, Geographical Faculty, Lomonosov Moscow State University

V.N. Konishchev. Nature of the cyclic structure of ice complex, East Siberia

The features of cyclic structure in the Karga-Sartan Ice Complex deposits have been researched for coastal lowlands in the Northern Yakutia. The cycles of different genesis (cryolithological, structural, lithological, soil-vegetational) and duration have been analyzed. It has been demonstrated that the climate fluctuation had been the major factor of cyclic structure in the Ice Complex deposits. It has been revealed that the cyclic characteristics of the Ice Complex can become apparent both in subaqueous and in subaerial facies of Ice Complex. The conclusion has been made about the crucial role of the cryogenic weathering and subsequent re-deposition of eroded soils in river valleys and alas depressions in the formation of the Ice Complex.

*****Important results on the programs of Earth Cryosphere Institute (Russian Academy of Science earth cryosphere Institute of Siberian Branch RAS (ECI SB RAS)

1) Complex researches in the sea-coastal area have been carried out, including a) the ground investigations of the structure, composition and salinity of the dispersed sediments, b) the ground investigations of the dependence of the phase transition temperature upon the water-soluble salts, upon the temperature regime of the rocks and sea water in the shallow zone, c) the high-resolution seismic investigations. These researches have allowed elaborating the conceptual structural model of the correlation between the continental and subaqual permafrost in the sea-coastal area. The successive replacement of the continental permafrost by the frozen ground of the transit zone occurs in the direction from the land towards the sea, then the continuous talik takes place, and at last there is the subaqual permafrost of the island type.

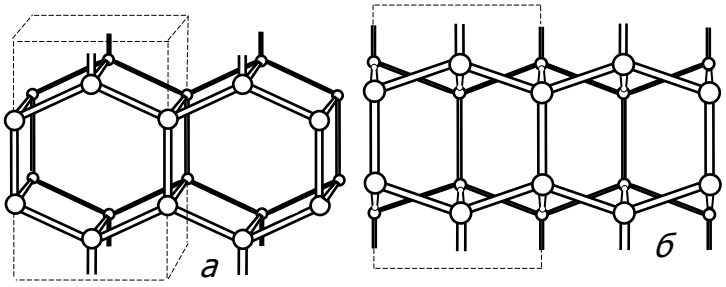


Interpretation of the seismogram of the high-resolution seismo-profiling(Western Yamal)

The proper technique of the shallow seismic investigations for detection and identification of the hard-frozen rocks at the offshore strips including the saline geological profile have been worked out. The technique of bottom seismic investigations allow solving engineering-geological problems in shallow waters. Assumed is the using of P- and SH-waves at the same time.

2) It has been revealed that the aggregative stability of the "dry water" dispersion in the formation/dissociation cycles of the gas hydrates is reached when the concentration of the water-repelling nanoparticles of the silicon dioxide Aerosil® R202 is rising up to 10 wt%. This fact improves the opportunities of "dry water" application in the gas hydrate production technology.

3) The studying of the ice bilayer features have resulted in the pioneer determination of the new property of the hydrogen-bond net: the noninvariance of its characteristics towards the change of direction of all hydrogen bonds. As opposed to the ice-like water clasters, the external free atoms of hydrogen are absent in the ice bilayers. That's why there we mark out quite new property of the hydrogen-bond net itself but not its peculiarities as in the case of water clasters. The founded invariance implies the presence of the asymmetry in the ice structures.



Ice bilayers without external atoms of hydrogen: a – "usual" hexagonal bilayer, b – displaced hexagonal bilayer. The rectangular unit cells are shown by the dotted line.

4) The score of the climate parameters have been carried out and the map of the meteorological hasards of the Russian Federation have been plotted using the developed (Earth Cryosphere

Institute SB RAS) technology of the cartographic modeling for the description of the complex impact of the current climate change on the permafrost. The overlaying of this map on the landscape and geological maps permits to zone the territories according to the degree of heat inertia, and then to specify the spatial distribution of the meteorological hazards of permafrost (look at the map).

Map of zoning of the Russian territory according to the meteorological hazard for permafrost (red colour – maximal risk, violet colour – minimal risk)

In the conditions of the changing climate the low-temperature permafrost is warming up quickly whereas the warm-up of the ground strata at the temperatures close to 0^0C is retarding due to the constant phase transitions. This fact is especially considerable for the zone of discontinuous permafrost in taiga and forest-tundra.

The technique of calculation and nature verification of the wind redistribution of the snow depending on territory morphology, landscape structure and pattern, biota peculiarities has been worked out for the woodless tundra and forest-tundra regions. This technique allows lateral differentiating of the value of the winter heat exchange and the time of the snow thawing.

It has been established that the evidence of the relic thermokarst in the profiles of saline frozen sea-coastal and subaeral deposits are remained as taberal complexes. The taberal complexes of the marginal North of the Western Siberia (Belyi island) are similar to the thawed ice complex of the Eastern Arctic: the pseudomorph-type and postcryogenic-structure-type macrofeatures, and the microstructure stipulated by the initial sincryolithogenesis, thawing and secondary frozing. The relicts of singenetic cryogenesis are not observed southward (Central Yamal).

*****Melnikov Permafrost Institute (MPI SB RAS), Yakutsk

In 2013, the Melnikov Permafrost Institute (MPI) celebrated the 140th birthday of the pioneer of fundamental permafrost research and founder of geocryology, Mikhail Sumgin (1873-1942),

with a Forum for Young Permafrost Scientists held from June 24 to July 13. This event, third in the series, consisted of a geocryological conference attended by 76 students and early career scientists from Moscow, Novosibirsk, Tyumen, Tomsk, Chita, St-Petersburg, Lensk and Chernyshevsky, and a field trip to the southern Verkhoyansk Range focusing on mountain permafrost. A biography of Mikhail Sumgin was published in "Permafrost Researchers" book series [Alekseev V.R. 2013. Sumgin Mikhail Ivanovich. Yakutsk: Permafrost Institute Press, 138 pp.].

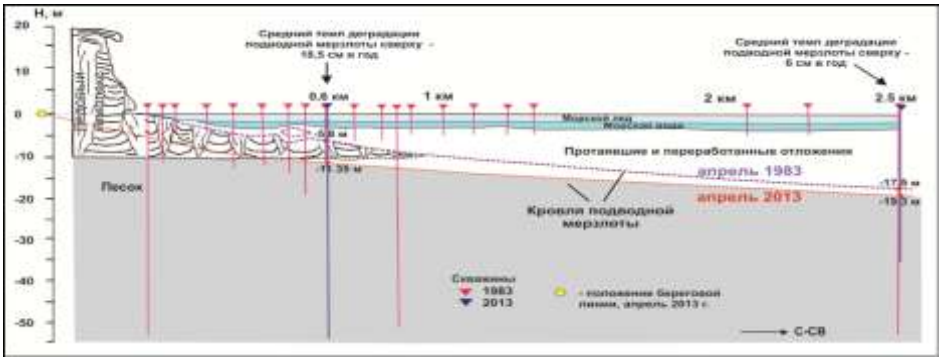
Third Forum for Young Permafrost Scientists: Conference participants.

Third Forum for Young Permafrost Scientists: On a field trip.

Main research results

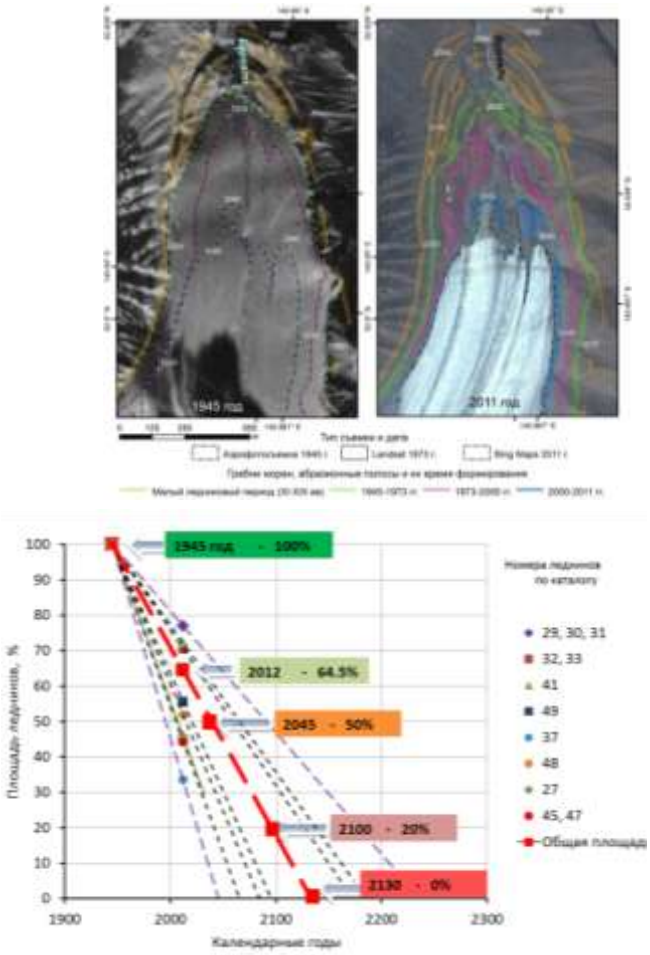
A 1:1,500,000-scale engineering-geological map of the Republic of Sakha/Yakutia was completed. The map compiled in ArcGis version 10 provides systematized data on soil/rock type, cryolithology, suprapermafrost water chemistry and properties, and permafrost-related landforms and surficial processes.

In April 2013, research groups from MPI, Pacific Oceanological Institute in Vladivostok and Moscow State University drilled two boreholes in the Buor-Khaya Gulf, Laptev Sea to determine rates of subsea permafrost degradation. Comparison with the borehole data obtained by MPI in April 1983 indicates that over the last 30 years the subsea permafrost table has lowered at an average rate of 18.5 cm/yr at a distance of 0.6 km and approximately 6 cm/yr at a distance of 2.5 km from the coastline.



Subsea permafrost degradation between April 1983 and April 2013 in Buor-Khaya Gulf, Laptev Sea, north of Muostakh Island

Glaciological studies provided data on the structure, isotopic composition and age of glaciers in the Suntar-Khayata Range, north-eastern Yakutia. Glacier sizes were reconstructed for different periods of glacial retreat.



Position of the Glacier 31 terminus derived from time lapse series of aerial and satellite images (a) and shrinkage of Mus-Khaya Mt glaciers predicted from GIS-based analysis of aerial and satellite images (b).

Samoylov Station

On 23 September 2013, the Presidium of the Siberian Branch of Russian Academy of Sciences (SB RAS) and the Government of the Republic of Sakha/Yakutia held a joint session to officially open the new Arctic research station on Samoylov Island.

New Samoylov Station, April 2013.

International projects

MPI continued investigations within a number of international projects and programs. One is the POLARIS Project which aims at understanding how terrestrial, aquatic and permafrost conditions in the Kolyma River watershed are changing in response to changes in climate. Observations in the northern Tien-Shan undertaken as part of the Global Terrestrial Network-Permafrost (GTNet-P) program have resulted in a database of permafrost and seasonal frost temperatures in different landscapes and evaluation of thermal response to climate change. Studies were initiated jointly with EcoLab – Laboratoire d'écologie fonctionnelle (UMR 5245 CNRS-UPS-INPT), Toulouse, France as part of a EUFP7 project, TOMCAR-Permafrost: Terrestrial organic matter characterization in Arctic River through molecular and isotopic analyses. Bilateral agreements for scientific and educational cooperation were concluded with the Woods Hole Research Center (USA) and the Department of Earth Sciences, University of Oxford (UK).

Publications

Eleven monographs authored by MPI researchers were published, including: (1) Mikhailov V.M. 2013. Floodplain Taliks in the Russian North-East. Novosibirsk: Geo, 244 pp. (2) Goncharov Y.M., Popovich A.P. 2013. Surface Spatial Ventilated Foundations on Permafrost. Yakutsk: Melnikov Permafrost Institute Press. (3) Gavriliev R.I. 2013. Thermophysical Properties of Rocks in the Russian North-East: A Catalogue. Melnikov Permafrost Institute Press. (4) Efremov V.N. 2013. Radioimpedance Sounding of Frozen Ground. Melnikov Permafrost Institute Press.

Completed Degrees

In 2013, two MPI researchers received Kandidat Nauk (Ph.D. equivalent) degrees in geology and mineralogy: Felix Zavadsky (Dissertation: Climate Change Driven Changes in the Geocryological and Hydrogeological Conditions in Southern Yakutia) and Leonid Gagarin (Dissertation: Dynamics of Thermosuffosional Processes in Permafrost, with Special Reference to Central Yakutia)

*****Cryolithology and Glaciology Department, Geographical Faculty, Lomonosov Moscow State University

Cyclic pattern of Ice Complex (type 3) is shown to be formed under the climatic variations of different periodicity during the Karginsky and Sartan periods. Guidelines were developed for the regulation of the permafrost conditions of the urban areas, taking into account the peculiarities of the nature-technical geocryological complexes, the latter varying by the scale and timing of changes and dominant permafrost dynamics trend. For the Norilsk area, 17 such complexes were localized, while there are 11 of them for the Yamburg area, 32 – for the linear in the north of Western Siberia. Permafrost degradation occurs nowadays within the majority of the Russian.

We also kept tracking the changes, taking place in the area of the glacial catastrophe of September 20th 2002, in the Northern Ossetia (Alaniya). Total ice accumulation in the Kolka glacial cirque exceeded since 2004, during the extended period of unfavourable climatic conditions. Former inflows ('tributaries') of the Kolka glacier are now separate glacial bodies; one of them has extended its terminus by 500 m during these times. It is by now the unique evidence of the glacial surge/extension in century. The recurrence probability of the 2002 glacial catastrophe is insignificant. Contemporary glaciation of the Polar Ural Mountains is shown to include 76 minor glaciers of the cirque and protalus types; 5 glaciers are newly described and 20 had ceased its existence since 1966. International Field Courses in Geocryology were organized

and held by the Department in July, 2013, in the north of Middle Siberia (Igarka and Norilsk districts), attracting the participants from Russian, Canadian and U.S. universities.

*****Geocryology Department, Geology Faculty, Lomonosov Moscow State University

Conference "Geocryologic mapping: problems and prospects" was held June 5-6, 2013 at the Faculty of Geology of Lomonosov Moscow State University (Chairman: Brouchkov A.V., co-chairmen: Sergeyev V. I.& Laurier I.K.). 66 reports, including 3 foreign ones were presented. Participants were presenting 35 institutions and organizations from Moscow, St. Petersburg, Tyumen, Yakutsk, Irkutsk, Magadan, Ukhta, Nizhnevartovsk, Pushchino, Edmonton, Calgary (Canada), Alma-Ata, Anadyr and Krasnodar. A part of reports was devoted to transfer to an electronic version and the updating of the 1:2 500 000 scale Geocryologic Map made for the USSR territory in the eighties of the XX century. A.V. Gavrilov (MSU) presented updates within the east Arctic shelf. M.V.Zimin (SCANEX) reviewed new remote-sensing instruments and opportunities for the permafrost mapping. A technique and results of multi-scale mapping of permafrost conditions were reported by Yu.B. Badu, L.N. Kritsuk, A. Matiukhin, I. Streletskaya, E.V. Seversky and others. Maps of glaciers, snow fields (N. V. Kachurina, E.K. Serov) and stocks of organic carbon (P.A.Shary) were presented. The dynamic aspect of the phenomena, such as change of the area of glaciers and snow fields of Antarctica was reported by I.S. Yozhikov (AANII). Development of landscapes and indicator approach was considered in the report of N. V. Tumel and N. A. Koroleva. T.Yu. Zengina with co-authors reported use of various software products for mapping. Reports on constantly operating cartographical model of a thermal condition of soils of the Urengoy gas field (D. S. Drozdov with co-authors), on mapping of taliks in the northeast of the Russia (B. M. Sedov), and on landscape indication of distribution of massive ice in Yamal (A.V. Homutov, M. O. Leybman, M. V. Andreyeva) were of the great interest.

Geocryology department (head – Dr. A.Brouchkov) of Lomonosov Moscow State University has finished the project on a new software for thermal calculations of soil freezing and thawing – TUNDRA instead the older one TEPLO (or HEAT) which is widely used in the Russian research and design institutions. The new program works with latest Windows software and applicable for permafrost forecast in natural conditions and for bases of engineering structures on permafrost, including thermosiphon calculations.

*****Sergeev Institute of Environmental Geoscience, RAS (Moscow)

GTN-P observations program has been continued with expanding for two CALM sites in Chara Region (Fig.). They were developed in cooperation with Moscow state university geologists. The national GTN-P mirror data base was started to be installed in IEG RAS and in Yakutsk permafrost Institute.

The experimental and modeling results were obtained on the effectiveness estimation of Solar Water Heating Systems in cryolithozone.

Aerovisual observation of the CALM site landscape from small radiocontrol helicopter (Chara Region).

******Joint-Stock Company "Funadmentproekt"**

JSC "Funadmentproekt" carried out complex research for correlation laboratory methods of frozen ground testing made by international standards (ASTM) and Russian standards (GOST). Based on the analysis of the results of laboratory tests of grounds, correlation indicators of frozen ground properties obtained by uniaxial compression test and the compression are defined. Conducted research and defined limits of the comparability of methods for the determination of frozen grounds salinity. Results convergence of the different methods of assessment defined.

*****Mining-Geological Joint-Stock Company MIREKO**

Komi Center of the Public Monitoring of the State of Bowels (KC PMSB) continued 30-45-year permafrost monitoring at five stations covering the majority of basic landscapes of European North-East of Russia. The main result in 2013 – preservation of long-term trend of degradation of permafrost and accompanying thermokarst.

The greatest thickness of cryolithozone for Subpolar Urals was determined. In its axial zone at mark 1300 m the geothermal gradient within depths 174-435 m is 0.69^{o}C/100 m, and estimated thickness of the cryolithozone – 660 m. This value is more than twice as large as the value suggested by I. Ya. Baranov (1977). The stage thickness of the frost rocks is up to 160 m; the crack ice was determined to the depth of 300 m. The border of continuous permafrost and non-continuous permafrost was traced at mark near 1100 m.

*****Soil Cryology Laboratory, Institute of Physicochemical and Biological Problems in Soil Science, RAS

1. In the period from September 29 to October 3, 2013 Soil Cryology laboratory has successfully held the International conference «Earth Cryology: XXI century», which was attended by 130 scientists representing the leading scientific organizations from Russia, USA, Germany and Brazil.

2. The gas seeps in Kolyma lowland are associated with methane inclusions in permafrost. These inclusions are formed by methane squeezed by epigenetic freezing of methane saturated deposits. This is proved by the biological genesis of the methane, by the isotopic data and the lower radiocarbon age of the methane from the gas seep in comparison with the radiocarbon age of the host deposits. The experimental data and observations of methane distribution in permafrost indicate that the methane distribution in the stratum of frozen deposits is a result of methane migration during cryolithogenesis. The regularities of methane distribution in the deposits and formation of methane inclusions may change the idea of the character and volumes of emission of greenhouse gases into the atmosphere upon degradation of permafrost.

3. The database of total carbon, bulk density, and iciness of permafrost in North-Eastern Yakutia was compiled. Basing on the State Geological map of Quaternary Deposits (2000) and original drilling data on the main Quaternary stratigraphic units occurrence in Kolyma Lowland the total carbon (TC) storages of the upper 25 m have been estimated. Taking the morphology into account, the TC pool assessed is 38.0 ± 22.5 Gt at near 150 000 km^2 area. In our calculation system of ice wedges are not included, what can reduce the total carbon pool. Mean specific carbon content is around 9.5 $kg*m^{-3}$ in Kolyma Lowland permafrost. The stratigraphic unit-

based approach used to compile the database and its analysis provides detailed study of carbon storage in Arctic permafrost. It is well organized for adequately forecasting of permafrost degradation consequences for carbon cycle, including activation of microbiological processes and greenhouse gases emissions.

4. The study resulted in creation of a collection of 16 bacterial strains from Arctic cryopegs actively producing lipolytic enzymes. Two cold-active lipases and esterase from the *P.cryohalolentis* strain K5^{T} have been obtained as pure proteins and characterized. Unlike most cold-active enzymes, EstPc LipPc exhibit a rather high level of thermostability.