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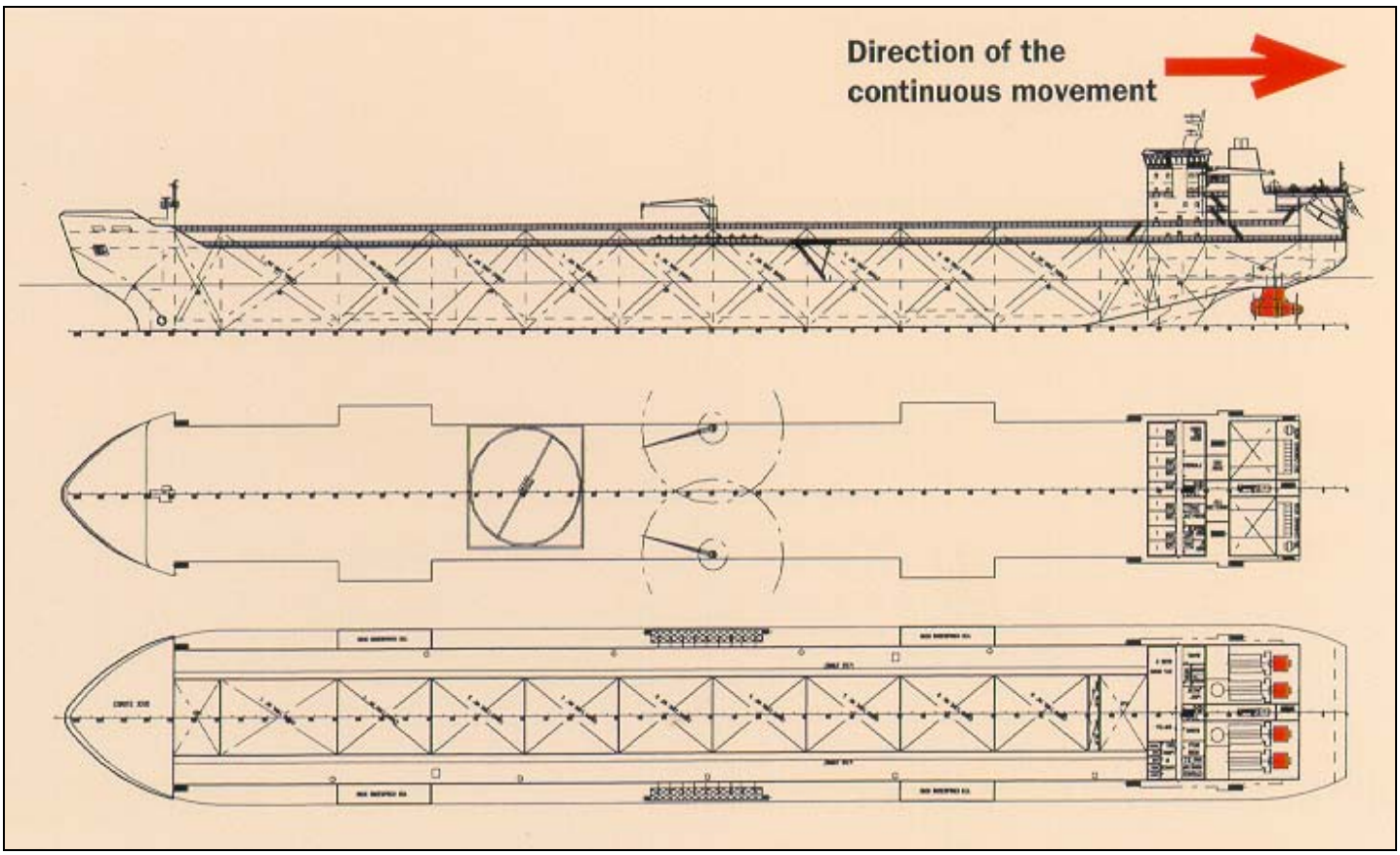

TRANSPORTATION SYSTEM FOR THE EXPORT OF GAS-CONDENSATE FROM OB BAY, WESTERN SIBERIA,

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ABSTRACT

Ob Bay is located in the northwestern Siberia of Russian Federation. Perhaps, the biggest gas fields in the world are located in this region. Furthermore, in the area of Yamal and Tazov peninsulas as well under the Ob and Taz Bays there are a number of big oil fields. Today the production of the gigantic gas fields of Yamburg and Urengoi flows to the south through pipelines or are transported by railway (gas-condensate). Export through the northern ship route has not been considered, except a few experimental voyages. The transport potential is millions of tons of gas-condensate.

In Yamal peninsula there has been plans to build giant terminals in Kharasavay and Novy Port. At present, these multi-billion dollar projects are far to be realized.

In order to get started, there has been going on an effort to develop a simple solution with small capital investment. The paper describes the work done around different alternatives, environmental conditions and infrastructure in the area to promote the ability to analyze the feasibility of gas-condensate export through the northern route.

INTRODUCTION

The Ob River/Bay is one of the major waterways in the Arctic Russia and thus has remarkable potential to be used for export of oil and gas. The reserves exploited today are located mostly to the east of the Ob Bay and the products are transported to the south-east either through pipelines or railroad.

Recently oil and gas deposits have been discovered more to the north and these findings when utilized will need new thinking in production methods as well as transportation questions.

The whole area is very vulnerable and environmental hazards are a threat. All actions require more careful planning as for instance traces on the tundra never disappear. However the area is of big interest. The projects are long and one never knows how many ups and downs appear during a project. Everything is dependent on oil price.

Ob Bay is located in the north-western Siberia east of Yamal Peninsula between latitudes 66 and 73 North and between longitudes 72 and 74 East. The Bay collects the wasters of Ob River (Irtysh) and Taz River and flows towards the north to the Kara Sea. The Ob Bay is ice bound from October to July. The ice cover comprises of up to 2 m thick flat level ice and ridges (rubble) up to 12 m in total thickness. The bay is shallow (generally under 12 m) and wide (30-50 km).

The discovered oil and gas reserves in the area are considered huge. The Yamburg gas field is one of the biggest in the world and new discoveries are made every year. The map in Figure 1 shows the location of some of the reserves.

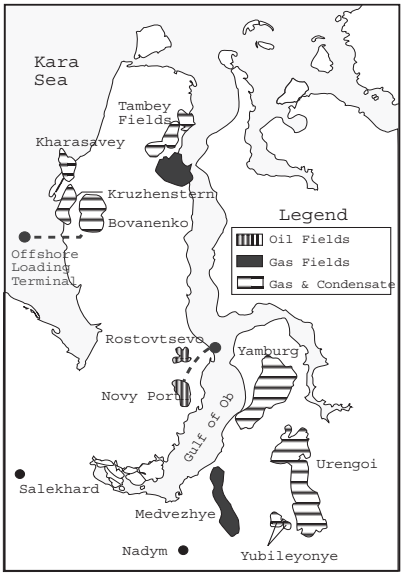

Figure 1, OB Bay area, oil and gas discoveries /1/.

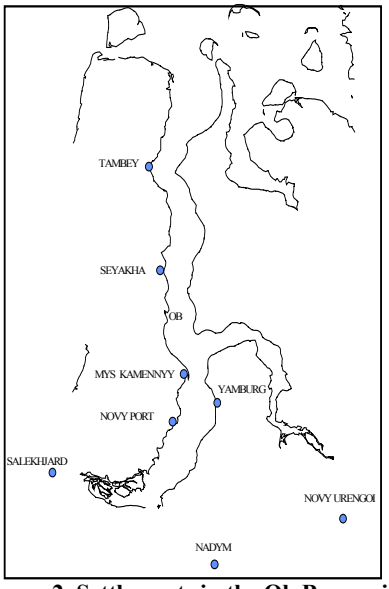

Figure 2, Settlements in the Ob Bay region.

Infrastructure in the Ob Bay is not well developed. On the west bank of the bay there are several villages where a few thousand people live. The nearest bigger town is Salekhard that is in the delta area where river gradually changes to bay. On the East bank the only remarkable settlement is the Yamburg gas combinate which was build to its present extent in 1987. Yamburg in connected by a road and railroad to Novy Urengoi from where there are is regular flights to Moscow. Also from Salekhard, as well as Mys Kamennyy, there are regular connections to elsewhere in the country. Figure 2 shows the location of the important settlements. In the summertime the most important way of moving around is the bay and

river itself. The connections to the nearby villages are handled using helicopters (MI 8) and small (AN 2) planes.

PLANS FOR DEVELOPING THE OB BAY AREA

The preliminary plans to develop the area have been very diverse. There have been plans to build one giant terminal on the west coast of Yamal peninsula. Also smaller terminals have been planned in many locations as well as pipelines across the Baidaradskaya Bay on the western side of the Yamal Peninsula. The plans are also related to the development in the Yenisei River area. It could happen that the whole area will be developed together. The map in Figure 3 illustrates the locations of the terminals.

The development in the area has in fact already started by organizing test shipping in the summertime as well as during winter.

In summertime ship loads have been carried out from Mys Kamennyy, Tambey and Kharasavey. In winter time, two exploratory voyages (1995 and 1998) have been arranged to transport condensate out from Tambey. The 1998 trip, called ARCDEV (Arctic Demonstration Exploratory Voyage), was made as an international European Union supported effort. Parties involved in ARCDEV were from different European countries and Russia.

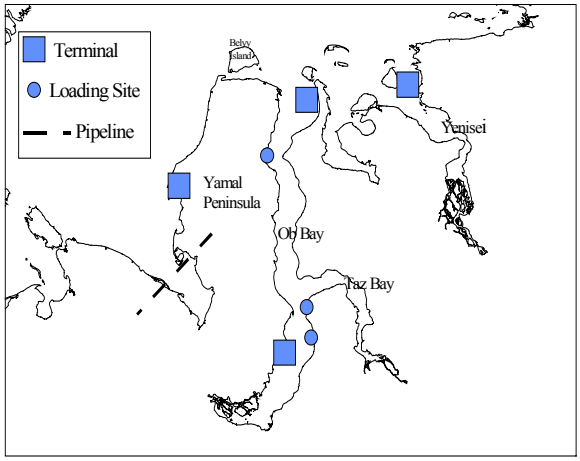

Figure 3, Some of the proposed terminal sites

STEPS NEEDED FOR SUCCESSFUL OPERATION

ENVIRONMENTAL RESEARCH

In every area, where oil and gas exploitation is considered the first steps before the production starts should include studies for clarifying the state of the environment. During the construction and production phases, the condition of the environment should be monitored to ensure that the operation is kept safe.

DESIGN BASES

In oil and gas industry, the system may include the following components in the chain of transporting the production out from the drilling sites:

- onshore pipelines
- onshore tank farms
- loading piers
- offshore pipelines, terminals
- production platforms,offloading sites
- supply vessels
- tankers
- icebreakers

Each item mentioned above, require a design base of its own. A design basis is typically a list of parameters and their values that are affecting the design. For instance a list of parameters for a design basis can look the following:

- maximum thickness of level ice
- maximum size of ice ridges
- consolidation degree of ice ridges
- minimum air temperature
- maximum wave height
- minimum water depth
- maximum current velocity
- etc.

Values for these parameters must be known before any efficient and economic structure can be designed and built. Conditions may vary from year to year and thus long-term patient studies are needed.

INNOVATIVE DESIGN SOLUTIONS

TRANSPORTATION CHAIN

The principal idea is to transport the condensate from the area by ships through the north via Kara Sea to the European market.

To be able successfully carry out a project in an environment were no such activity has been tried, requires both creativity and admiration to the nature. We are dealing with extremely sensitive nature. Also proceeding step by step gives a possibility to start with a small investment and learning by doing increases the knowledge of the possibilities in said conditions. During the past couple of years at the same time with environmental studies and exploratory voyages, different alternatives for arranging condensate export facilities in the Ob Bay have been studied:

- The condensate is either produced locally or transported from a distance (200-300 km) by train.
- The condensate is stored in an onshore tank farm
- The condensate is lead to the loading site through a pipeline (onshore/offshore)
- The loading site could be either an offshore SPM or a several kilometres long pier

The principle scheme of the arrangement is shown in figure 4.

The main source of condensate is Novy Urengoi fields. The storage area is planned to be in Yamburg. The loading site for this condensate flow has been studied at three alternative main locations, see Figure 5. In the area there are a number of new hydrocarbon discoveries offshore Mys Kamennyy and also in the Taz Bay area. The export of these new field could be handled in a similar way as the condensate in question.

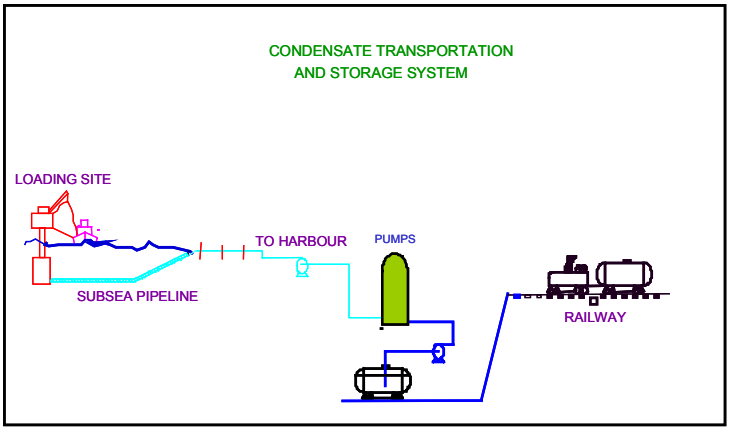

Figure 4, Condensate export scheme

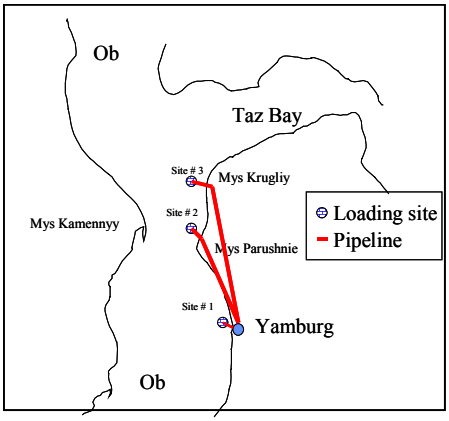

Figure 5, Possible loading sites

SHIPS

Presently the ships available are 16-17000 TDW product tankers, which can load condensate up to 12000tonnes, see MT Uikku in Figures 6 and 7. The Ob Bay is shallow. At Mys Kamennyy level the water depth is 10-12 m, which restricts the draft of the vessel to 9 m. Offshore Yamburg the water depth is even less. Some 3 km offshore the bay is 7-8 m deep. This means that ships need to be loaded only in part or the condensate is to be transported on river tankers further north.

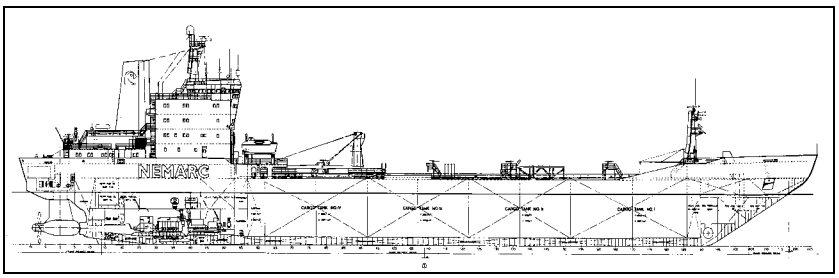

Figure 6, MT Uikku

Figure 7, MT Uikku loading in Tambey.

The transportation is planned to begin with existing ships. However designs for future ships have been done and model tests in ice performed.

One of the restricting factors is the water depth in the bay. For instance the water depth is 10-12 m at Mys Kamennyy level and if Yamburg will be the loading site the water depth is even less, 7-8 m. In Yamburg the vessels are either smaller or are loaded only in part. An alternative is to load the condensate to river-sea vessels and transfer the cargo into bigger vessels in further north.

Another affecting parameter is the length of the season; should the most severe part of the winter be non-trafficked? or what the final concept will be. In case the traffic will be year-round, then the vessel could look like the concept illustrated in Figure 8, the OB MAX 40000.

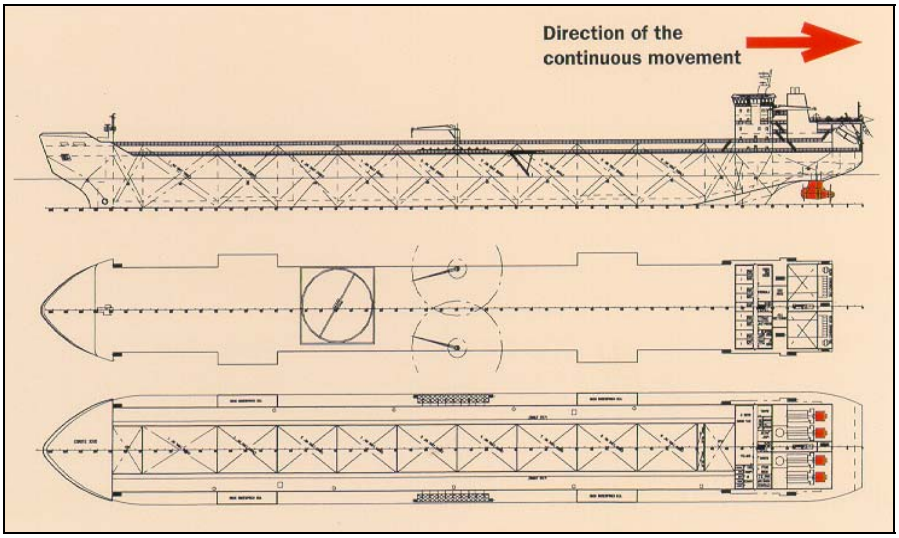

Figure 8, OB Max, 40000 tdw Arctic Tanker

The vessel can break with continuous motion level ice that is over 2 m thick when running astern. Of course the final size of the vessel is dependent on the overall concept(s) selected.

ENVIRONMENTAL RESEARCH CARRIED OUT

The Finnish -Russian Offshore Working Group started operation already in early eighties in order to mutually develop offshore capabilities in the two countries. The idea is, that all the research activity expenses are paid equally. The work done so far has concentrated in three geographical areas: Sea of Okhotsk (Offshore Sakhalin Island), Pechora/Kara Sea and Ob Bay. The actual field work under the Finnish -Russian co-operation agreement started in 1990.

The data collection expeditions arranged in year 2000 are the following:

- March, Ice expedition to map conditions offshore Yamburg Nefte Base and Mys Kamennyy. Lines on ice were marked with poles for further studies. Measurements on Ice thickness, surface roughness were made.
- May/June, Ice expedition/geotechnical drilling. The expedition was directed to the same locations as in March.

The previous studies (1995-98) are described in references /1/, /2/ and /3/.

HYDROMETEOROLOGICAL STUDIES

The hydrometeorological studies in the Ob Bay consist mainly of ice conditions, bathymetry, weather, current and tide measurements. Bondarev & al, /1/, have described the basics of the main characteristics of hydrometeorological research. The June/July 1998 studied are described by Golovin & al in reference /3/.

The main emphasis in the studies during winter 2000 was put on the following parameters:

- Ice thickness
- Ice movement
- Composition of ice ridges
- Distribution of ridge

Two separate expeditions were done. Two main sites, **Offshore Yamburg** and **Offshore Mys Kamennyy** were selected for detailed studies.

At the Yamburg site a 12 km line was marked with poles. Similar way a 2.6 km line was marked at Mys Kamennyy. In figures 9 and 10 the both sites can be seen.

Figure 9, Ice surface/Yamburg

Figure 10, Ice surface/Mys Kamennyy

The winter 1999/2000 was considered as an average winter. The thickness of level ice was around 1.5 m. As an example the profile surveyed and studied offshore Mys Kamenny is presented in Figure 11.

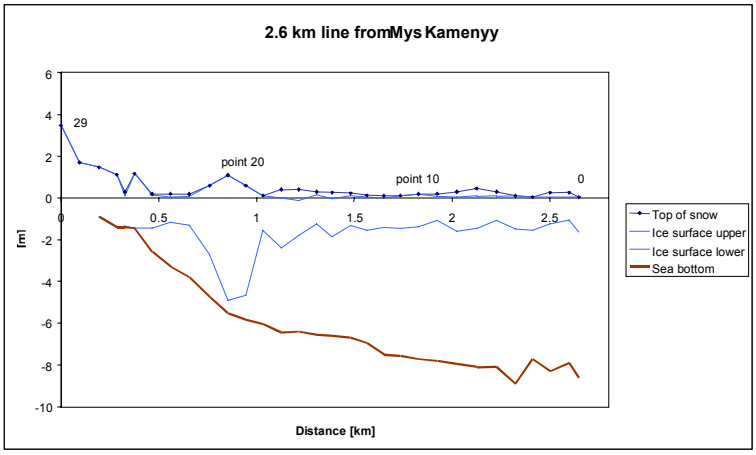

Figure 11, Profiles, Mys Kamenny

ENGINEERING-GEOLOGICAL STUDIES

Within the framework of complex environmental investigations, also engineering-geological and geo-ecological studies have been carried out. These include shallow seismic profiling in combination with side-scan sonar survey and echo sounding, as well as soil sampling

with the aid of grabsampler have carried out in the central part of the Ob Bay. The main target of these first investigations in the Ob region was to obtain a general estimation of environmental and engineering-geological conditions of the study area, /2/.

More in detail, ground penetrating radar was applied to obtain seabed topography profiles at several locations close to shoreline and to record stratigraphical and geocryological data at the onshore part of the coast line (Figure 12). Moreover, a gravity sampler was designed for sediment sampling through slim holes in ice cover. Besides, a dynamic probe was designed to test soil stratigraphy in association with ice studies. Furthermore, onshore soil sampling with a hand auger has been conducted to collect ecological, engineering-geological and geocryological information.

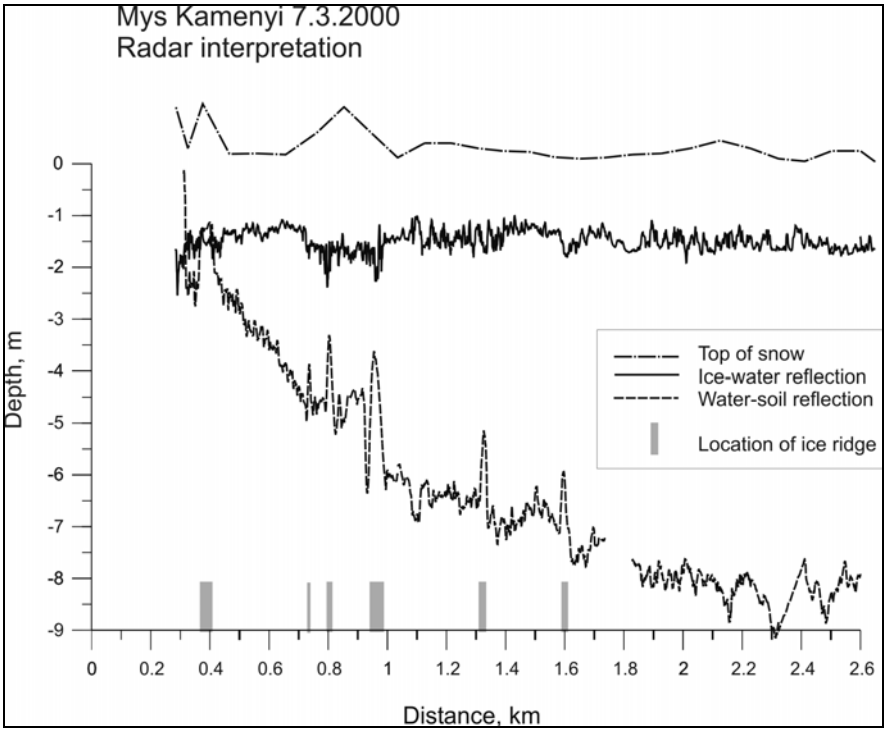

Figure 12. The interpreted depth sections for the reflectors related to ice thickness on the 400 MHz records and for seabed on the 100 MHz records along the georadar profile offshore Mys Kamennyy, March 2000. Anomalies owing to ice ridges are marked below the profiles

As a result these first investigations the following main features in engineering-geological conditions have been established:

- The bottom relief within the study area is rather flat, the water depth varies from 7 m to 16 m;
- Ice scour marks of different ages occur commonly in the Ob Bay;
- Sand banks and dunes are located at the near-shore seafloor;
- Bottom soils are partly gas-saturated, probably owing to degraded sub-bottom frozen soils;
- Most of the soil samples show clayey-loamy character at the seafloor;
- The degree of heavy metal and hydrocarbon pollution is minimal in the limited number of samples;
- The onshore silts are strongly frost-susceptible;
- The thickness and the temperature of the active layer are measured only occasionally.

At the seafloor, the ice-scour marks show typically 2 - 3 main ice drift directions. The intensity of the ice-scours highest at the sandy banks, but it is not limited to a known isobath. Although the first study proved the ice-scouring effect at the seafloor, it is suggested to re-run the side-scan surveys in order to evaluate the annual variations in the intensity, width and depth of the scours using statistical methods.

The evidence of free gas on the seismic time series in shallow arctic shelf is often related to the processes of relict sub-sea permafrost degradation. Because of free gas is observed both in areas with totally thawed permafrost and in areas, where frozen soils are remained, it will be necessary to continue detailed investigations in order to analyze the state of the subsurface. These investigation are supposed to include indirect geophysical sounding techniques, i.e., sub-bottom resistivity profiling and seismo-acoustic profiling and direct shallow drilling and soil sampling to a depth of 50 - 100 m with adjoining laboratory tests as well as cone penetration tests with measurement of soil temperature profile.

The conditions at the shoreline play a very important role when planning and designing pipelines and harbours. The engineering-geological data is this far limited to only a few ground penetrating radar profiles and very shallow soil sampling. This radar data is fitted to ice drilling profiles, which gives a reasonable estimate of the seafloor slope and locations of sand dynes near the shoreline. These investigations are to be adjusted for deeper penetration in soils by both means, sounding and drilling. The follow-up procedure should also be focused on the stability of the seafloor.

On the onshore, permafrost is observed immediately at the shoreline. The extent of frozen ground towards offshore should be investigated prior to any further planning of harbours, loading terminals or pipelines. On the other hand side, the thickness of the onshore active layer should be monitored over time. Moreover, the stability of the permafrost terrain should be evaluated using temperature sensors and tilt meters in boreholes to allow thermal and mechanical calculations for onshore constructions.

ECOLOGICAL STUDIES

The research done until 1997 are described by Bondarev & al, /2/. In summer (ice break-up) the studies were continued along with other research. It was then, June/July, the first time when ecological studies were made during ice break-up and the interesting aspect was how the seasonal changes affect the results.

The studies included the following:

- hydrography
- water chemistry
- phytoplankton biomass, abundance and species composition
- oil concentration in the surface water

The highest concentration of chlorophyll was found close to open water spots. The highest concentrations of nutrients were measured in the area where Ob and Taz bays meet. The species abundance and chlorophyll a concentrations indicated that the spring bloom already had reached its peak in the area. These measurements indicate clearly that more systematic measurements need to be done.

The heavy metal and polycyclic aromatic hydrocarbon concentrations in sediment samples are analysed in two sets of soil samples collected in connection with engineering-geological studies in 1996 and 2000. Also, these studies should be widened to cover the Ob Bay more systematically.

FUTURE

The continuation of the programme in the Ob Bay is presently mainly dependent on the interests of companies RAO Gasprom and Fortum. The possibility of getting the condensate flow to the market started with minimum investment and start learning along the activity is very tempting. The research of environment and preparation of the designs will hopefully continue.

ACKNOWLEDGEMENTS

The different studies in the Ob Bay have been funded by Gazprom, Fortum, Ministry of Trade and Industry of Finland, Aker Rauma Offshore and Kvaerner Masa-Yards. All these organizations have shown also in other areas perspective activities promoting the exploration of the unknown. The help of the local organizations: Yamburg Gasdobitcha and Yamal Neftegas Geologiya as well as Fundament project has been highly appreciated, and we hope that the fruitful co-operation can be deepened. Also all the personnel of the participating organizations are acknowledged for their outstanding work and co-operation.

REFERENCES

/1/ Blanchet D., Bhat S., Wilkman G., 1995 Ice Conditions in the Ob Bay in Western Siberia, IAHR 98, Potsdam, NY, U.S.A..

/2/ Bondarev V., Denisenko, S. Golovin N., Grönlund L., Okko O., Rokos S., Sandler H., Wilkman G., Environmental Studies in the Ob Bay During 1995-97, RAO 97, St. Petersburg, Russia.

/3/ Golovin N., Grönlund L., Namjatov A., Okko O., Wilkman G., Recent activities in the Ob Bay development, RAO 99, St. Petersburg, Russia.