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Sedimentary Cover Thickness Map – Sedimentary Basins in the Arctic

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THEME 15: Geodynamics of the Arctic Region

Summary: A Sedimentary Cover Thickness Map of the Arctic Ocean at a scale of 1 : 6 000 000 has been produced using all available Russian and international drilling, seismic and potential fields information. Earlier regional maps of specific shelf areas amended with recent data have been incorporated. The map shows a set of sedimentary basins, the West Arctic, North Siberian, New Siberian-Alaskan, and North Canadian sedimentary provinces, which constitute a Circum Arctic belt. The structural pattern within each sedimentary province displays a dominating influence of rift controlled depocenters. The age of individual sedimentary basin varies from Paleozoic to Recent from one province to the other, showing the migration of the geodynamic activity around the Arctic Ocean region through the Phanerozoic.

The sedimentary cover taken as a whole constitutes a single gigantic Arctic Superbasin dominated by the concentric tectonic zonation of the Arctic Geodepression. With respect to the base of the sedimentary cover, the zonation is manifested as an almost continuous belt of shelf and peri-oceanic sedimentary basins rimming the deep-water oceanic area with much thinner sedimentary cover.

This sedimentary assemblage is bounded by an orogenic belt on the outside. The belt separates the Arctic Geodepression from adjacent planetary-scale structures (GRAMBERG 1984, 1989, GABRIELYANTZ 1990).

INTRODUCTION

The Arctic Ocean and adjacent continental margins of Eurasia and North America constitute a tremendous sedimentary Superbasin, which is considered a part of the Arctic Geodynamic System (POGREBITSKY 1976). Despite prominent differences, the constituent parts of the Superbasin have a number of similar characteristics which link them. The first Sedimentary Cover Thickness Map of the Arctic Superbasin compiled by All-Russia Research Institute for Geology and Mineral Resources of the World Ocean (VNIIOkeangeologia) allows these linkages to be recognised.

The map was compiled using data from Russian and foreign geophysical surveys and the results of scientific and offshore exploration drilling (HINZ & SCHLÜTER 1978, JOKAT et al. 1992, KARASIK 1980).

TYPES AND METHODS OF SEISMIC STUDIES

The deep-water Arctic basin portion of the map was compiled from the results of systematic areal seismo-hydrographic surveys performed by aircraft supporting high latitude „SEVER" expeditions of the Soviet Navy in 1961-1989. The bulk of this research consisted of seismic reflection measurements from ice with a spacing 10-20 km. The surveys covered an area of 4,1 million km^2 which comprises about 80 % of the Arctic deep water basin (KISELEV 1996). Long – term reflection seismic observations along the drift of the Soviet „Severny Polyus" ice camp (GRAMBERG 1991, ASHIKHMINA et al. 1986) were also carried out.

Geophysical data obtained by the Polar Expedition (PMGRE) in 1989 and 1992 along two geotransects in the central part of the Arctic Ocean provided key information (GRAMBERG et al. 1993, KRUKOV 1996). This input allowed us to minimize the uncertainties of previous interpretations. Deep refraction seismic data along geotransects indicated that the base of the sedimentary cover in Amundsen Basin, on Lomonosov Ridge and in Podvodnikov and Makarov basins is much deeper than was previously estimated by KISELEV (1986) on the basis of seismic reflection data (Sweeney et al. 1982).

The sedimentary cover thickness within the Arctic Ocean has been determined with different levels of reliability. Most reliable results are derived from direct observations along geotransects, and less reliable results are based on data beyond geotransect zones. At a considerable distance from geotransects the sedimentary cover thickness was estimated by the position of „acoustic basement" and such estimates are next to speculation (SOBCZAK 1990, VERBA et al. 1986, 1990).

The map reflects the unevenness of the Arctic geophysical survey network. The best studied area is the western part, especially the Barents Sea. The major part of the Barents Sea was covered by reflection seismic, CDP and deep refraction seismic profiling. The Kara and Laptev seas have much poorer reflection seismic-CDP coverage, with few reflection deep seismic and refraction profiles providing most of the data. The East Arctic Russian shelf was studied by scarce reflection seismic profiles with the exception of eastern part of the Chukchi Sea where the seismic coverage produced by Soyuzmorgeo is more complete. These seismic results have been recently summarized and coordinated with American seismic data on the Alaskan shelf (YASHIN 1994). On the rest of the East Arctic shelf the depth to basement has been estimated on the basis of correlation between seismically defined depth and the values of Bouger gravity anomalies. Sedimentary cover thickness data for the Beaufort Sea, Canada Arctic Islands and deep-water part of Canada basin were taken from JACKSON (1988).

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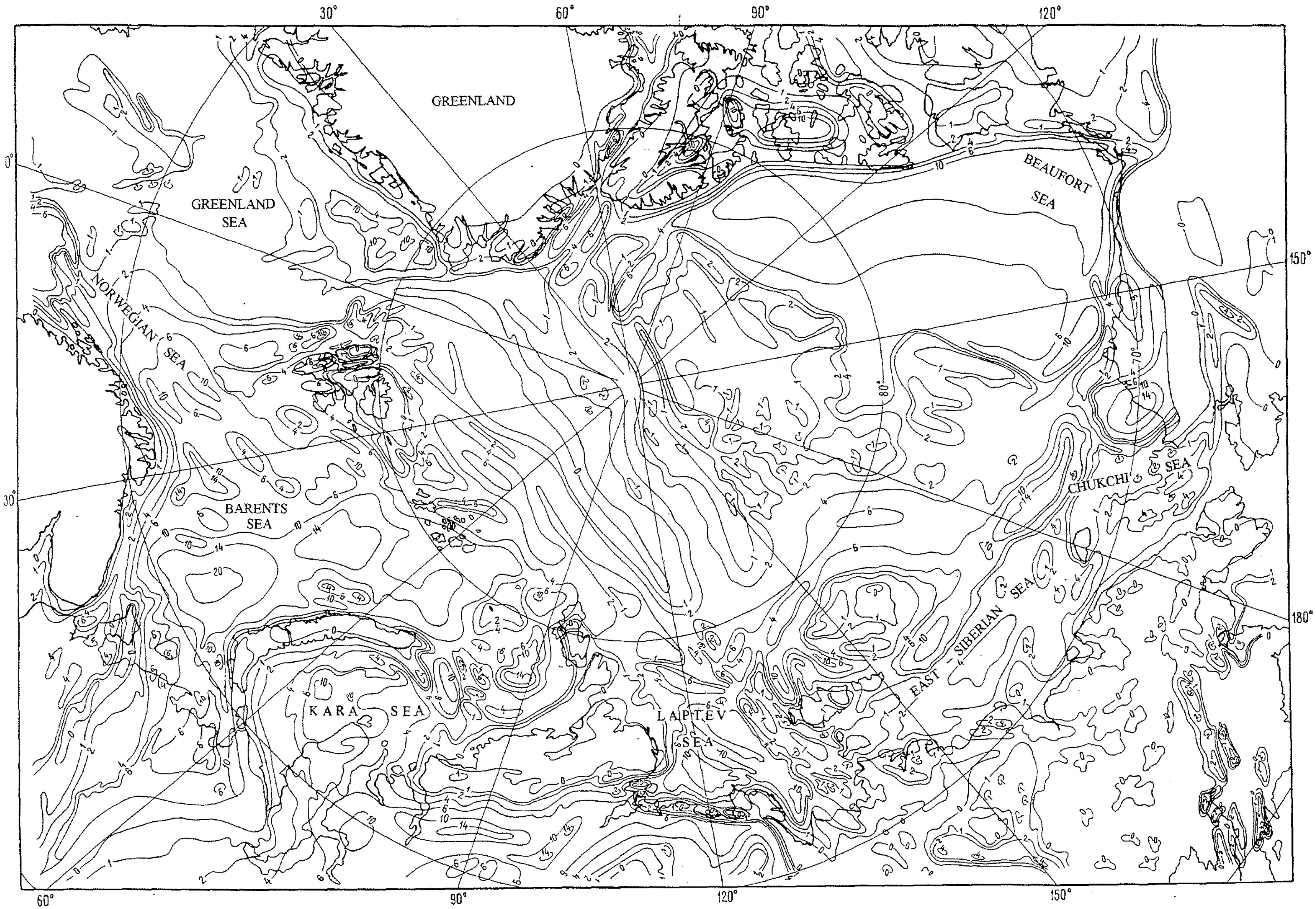

Fig. 1: Sedimentary cover thickness map.

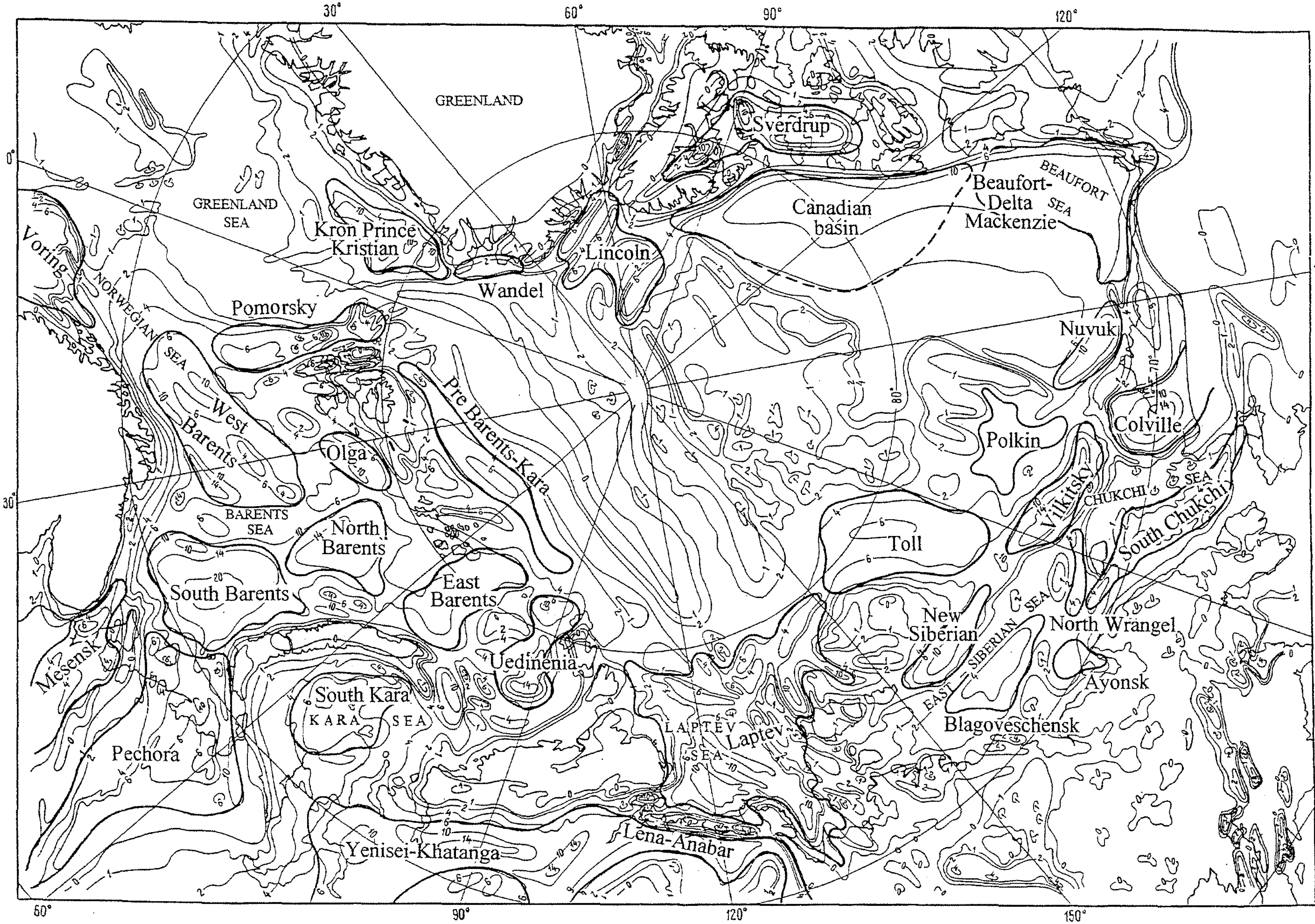

Fig. 2: Arctic sedimentary basins.

SEDIMENTARY BASINS IN THE ARCTIC

The Sedimentary Cover Thickness Map unlike previous maps shows the total thickness of stratified successions with no regard to the composition and age of the constituent units. The sedimentary cover comprises upper undeformed deposits, as well as deformed sedimentary and volcano-sedimentary assemblages, not affected by intense compressional folding and regional metamorphism.

Despite the above constraints the Sedimentary Cover Thickness Map highlights some of the most general characteristics of sedimentation in the Arctic Geodynamic System. The major constituent parts of this system are the starved deep-water basin and the bordering continental margins of North Europe, Asia, and North America. Each one of these areas has its own specific features. A distinct circum-polar zonation in the distribution of the sedimentary basins is the most prominent feature. The zonation is manifested in an almost continuous belt of large marginal sedimentary basins which surround the oceanic Eurasian and Amerasian basins. A series of regional structural highs borders this belt on the seaward side. The highs supplied clastic sediment to the basins. A modern starved depocenter occurs on the inner side with the thickness of Cenozoic sediments usually less than 1-3 km.

Four major areas of sedimentation were distinguished within the belt of depocenters. They are connected to each other and comparable in size and sediment thickness, but they substantially vary in age and genesis.

The West Arctic sedimentary province is the largest one with the greatest thickness of undeformed sedimentary deposits – which reaches 20-22 km within the Barents - North Kara megabasin. Along with relatively small basins on the northeast Kara shelf, it covers an area of 1.5 106 km^2.

The North Siberian province is the second largest in size and sedimentary cover thickness. It is almost 2000 km in length and has an area of about 600 000 km^2. Sedimentary cover thickness reaches 14-16 km. The Yenisei-Khatanga megabasin appears to be the main element of this province and together with a number of adjacent smaller basins in the Kara and Laptev shelves, forms a continuous belt traced from Novaya Zemlya to the New Siberian Islands.

A complicated and specific assemblage unique to the Arctic adjoins the province from the east. It consists of narrow linear basins of the New Siberian - Alaskan sedimentary province. Together with the West Alaskan depressions its length reaches 2200 km, its width about 500 km, and its sedimentary cover thickness about 10-15 km.

The North Canada sedimentary province closes the circumpolar sedimentary ring. It has slightly lesser thickness, not exceeding 14 km. The Canada Basin appears to be the main part of the province and with the Sverdrup Basin, it forms a belt which is about 2000 km long and 600 km wide.

Each of the above provinces has its own system of depocenters which are usually extensional in origin. Present day structural patterns and the tectonic histories of the provinces vary dramatically depending on the age of local depocenters, sedimentary environments, rate and volume of clastic material, igneous activity and on the impact of tectonism in adjacent regions.

West Arctic province

Four large structural depressions on the south, west, north and east Barents shelf are the main depocenters of the West Arctic province. They constitute the Barents - North Kara rift-type megabaisn (BNKM). The megabasin is surrounded by large fragments of the ancient East European platform which were separated during middle to late Paleozoic rifting and partly buried under synrift sediments of the BNKM.

The oldest segments of the West Arctic province are the Pechora syneclise, Svalbard anteclise, and Central Barents and Admiralty highs. They have a nearly uniform sedimentary cover thickness of 4-6 km, typical for platforms. Sedimentary cover starts with Upper Riphean to Vendian strata within the oldest blocks, includes strata from the whole Paleozoic in most blocks, and commonly includes relatively thin Mesozoic strata (VERBA et al. 1990).

Rifts in the BNKM are dominated by a north-northeast trend and formed between the Late Devonian and the end of the Triassic. The total thickness of the synrift strata is about 15-17 km and it consists mostly of siliciclastic deposits with a considerable amount of volcanics in the lower part. Rifting started in the Permian in the West Barents basin with the appearance of Permian evaporite. The thickness of synrift strata which are mainly terrigenous deposits is 7-9 km. Platform type post-rift deposits are represented by a Jurassic to Cretaceous terrigenous succession that is about 2.5-3.5 km thick and overlaps the entire BNKM and adjacent structures.

Continuous accumulation of thick, mostly terrigenous sediments throughout much of the Phanerozoic is characteristic of the West Arctic sedimentary province.

North-Siberian province

The core of the North-Siberian sedimentary province appears to be the regional Yenisei-Khatanga megabasin, which forms a link between the West-Siberian and Laptev structural domains. Two alternative concepts for the rift-type origin of the megabasin have been the subject for debate since the 1970s. One group (VERBA 1969) maintained that the first manifestation of rifting occurred during the end of the Permian with the formation of the megabasin completed in the Triassic. According to this concept the older, lower to middle Paleozoic sedimentary sequences of the Siberian platform sedimentary cover are developed only on the borders of the megabasin and do not contribute much to the fill of the rift. MURZIN (1985) and others believed this area of sedimentation joined with the BNKM in the north Kara shelf through the North Siberian arch with a set of rifts. The origin of these structures can be related to formation of rift troughs in the north of the West Siberian basin (APLONOV et al. 1996).

The Yenisei - Khatanga megabasin is shown on the Sedimentary Cover Map as a relatively homogeneous structure with several local depocenters (VERBA et al. 1969). Shelf structures of the Laptev Sea and Lena-Anabar depression join them on the east. The rift fill comprises a Lower Triassic tuff-argillaceous unit over 1 km thick. It is overlapped by relatively monotonous, terrigenous Middle and Upper Triassic, Jurassic and Cretaceous deposits with a total thickness of up to 7-8 km.

The Laptev megabasin is the eastern link of the North Siberian province. It is a continuation of the Eurasian oceanic basin on the shelf and appears to open to the central ocean. Following the shape of the Laptev Sea, the megabasin is broadly isometric and has dimensions of 600 km by latitude and 900 km by longitude. The basin-forming succession is terrigenous and is dated as Late Mesozoic-Cenozoic. The age of the base of the oldest local depocentres is apparently Aptian. The megabasin exhibits extreme variability in thickness, structural character, age, and composition of sedimentary fill as well in basement structure and relief. In areas of the megabasin underlain by pre-Riphean basement, the sedimentary cover is increased by the addition of mostly carbonate Paleozoic and early Mesozoic strata of the intermediate structural stage. The total thickness of the sedimentary cover in such areas exceeds 10 km. The web of branching grabens in the basement and sedimentary cover is characteristic of the internal structure of the Laptev megabasin. The lower units of the basin are mainly confined to grabens. Laptev Sea grabens are usually regarded as a projection of the Gakkel Ridge spreading zone on to the shelf and a link between the Eurasian and North American plates.

Sedimentary basins of the North Siberian province tend to generally have developed as a continuation of the basins of the West Arctic province. Principal features of the North Siberian basins were apparently formed at the beginning of the Triassic slightly later than in the BNKM. Pre-Permian sedimentary succesions are not that thick compared to the West Arctic province. The main depocenters of the Yenisei-Khatanga megabasin, as well as in BNKM, are attached to the rifts, and trend from west to east along the megabasin. Sedimentary fills of the BNKM and of the Yenisei - Khatanga megabasin are similar in age, composition and thickness. However, the ratio of Cenozoic strata in the sedimentary cover increases eastward (POLKIN 1976).

New Siberian – Alaskan province

The province comprises elongated basins which constitute a belt which is 2200 km long extending from the Laptev Sea to the Beaufort Sea and 500 km wide. The maximum thickness of sediments in basins is usually 10-12 km sometimes exceeding 15 km. The southern zone of the province is intensely affected by late Mesozoic tectonism of the north Pacific mobile belt. The influence of Pacific tectonics weakens northward and the features inherited from earlier tectonic eras become more prominent, along with manifestations of geodynamic settings related to the development of the oceanic basin.

The Ayonsk, South Chukchi and perhaps North Wrangel basins are located within the Mesozoic deformation belts of Northeast Russia. The basement consists of variable successions which are intensely deformed and penetrated by middle Cretaceous granites. The lower unit of sedimentary cover is a mid Cretaceous molasse. The upper unit consists of Late Cretaceous to Cenozoic terrigenous sediments.

Colville basin is a foredeep of the North Alaskan foldbelt. It is filled with Late Jurassic to Early Cretaceous molasse and overlapped by Late Cretaceous to Cenozoic sedimentary cover with a total thickness of up to 11 km (GRANTZ et al. 1990). The western extension of Colville basin to Chukchi Sea is often regarded as the Chukchi basin with the sublongitudinal Hanna trough in the west. The sedimentary cover increases at the base with the inclusion of gently deformed lower Mesozoic and Paleozoic terrigeneous and carbonate units. Consequently the total thickness of the sedimentary cover is more than 15 km.

The Blagoveschensk basin is believed to be similar to the Colville basin with respect to its position at the front of late Mesozoic foldbelt. It is hypothesized that it started as a foredeep filled with Aptian to Albian molasse and evolved to a shelf synclinal basin. (GRAMBERG 1984, KOS'KO 1988). Pre-Aptian strata of the intermediate structural stage may be present within the Blagoveschensk basin, but the 4 km sedimentary cover thickness indicated on the map includes only Aptian and later sediments.

The New Siberian and Vil'kitsky basins are outer shelf basins in the north part of the East Siberian and Chukchi Seas. New Siberian basin strikes east-west and Vil'kitsky basin trends west-northwest. The basins form extensions of each other but are divided by a saddle in the basement. They form a stripe 1500 km long and up to 200 km wide. Both basins are beyond the impact of late Mesozoic Pacific orogeny. The age of the basement is most likely early and middle Paleozoic. Paleozoic carbonates and siliciclastics may be present in the lower part of the sedimentary fill of the basins. The upper part of the basin fill are siliciclastic deposits. The total thickness of the sedimentry cover exceeds 16 km in Vil'kitsky basin.

The Toll', Pol'kin and Nuwuk basins are located within the continental slope and rise, within the Chukchi borderland, and within the Podvodnikov depression on transitional and suboceanic crust. The basins constitute a belt 1800 km long and 350 km wide from Lomonosov Ridge on the west to the Beaufort Sea on the east. The presence of Paleozoic and early Mesozoic terrigenous and carbonate successions in the sedimentary cover of the basins has been ascertained by seismic data in the Nuwuk basin and supported by discovery of Paleozoic and Mesozoic microfauna on Northwind Ridge (GRANTZ et al. 1990).

North Canada province

The North Canada sedimentary province comprises the Beaufort Sea - Mackenzie Delta basin in the west and Canada basin, Sverdrup basin, and Lincoln Sea basin farther to the east. The extent of the province is 2000 km with the width of up to 600 km. The province is a part of the passive continental margin separated from the Eurasian basin by the Central Arctic highs and the Canada bathyal plain.

The Beaufort Sea - Mackenzie Delta basin is situated mainly on the shelf of the Beaufort Sea. It encompasses areas of the continental slope in the north and the onland and shallow water Mackenzie Delta in the south. The northwest part of the basin is known as the Kaktovik basin. Small basins of ramp and graben type are recognizable on the west in conjuction with Nuwuk basin. The Beaufort Sea - Mackenzie Delta basin is 700 km by 700 km in size. The basement consists of Precambrian metamorphic units of the Canadian shield in the southwest, and of highly deformed lower Paleozoic rocks in the northwest. Over the major part of the basin the crust is continental. In the north the crust is an intermediate type. The sedimentary cover is subdivided into the pre-basin and the basin-forming stages. The pre-basin stage consists of terrigenous and carbonate formations of Paleozoic and early Mesozoic age with a diachronous lower boundary within the early to middle Paleozoic. The upper basinal stage started in the Jurassic when a provenance area formed in the south and the northward transportation and deposition of eroded clastic material was established. From the Cretaceous, the basin was filled by clinoformal units, which prograded northward. The inner structure of the basin is complex, where individual troughs and rises are deformed by a variety of folds, including diapiric ones, that can be distinguished. The thickness of the sedimentary cover exceeds 12 KM (EITTREIN & GRANTZ 1979).

The Sverdrup basin is the best studied of the basins bordering the Amerasian basin. It is located within the Canada Arctic Archipelago and is 900 km long, extending northeast from Melville Island to northern Ellesmere Island. The width of the basin reaches 300 km. On the north and northwest the basin is bordered by structural highs with exposed Precambrian and highly deformed early to middle Paleozoic deep water strata of the Innuit foldbelt. In the southeast the basin is bordered by the Franklinian foldbelt. Those assemblages comprise a basement in the basin. The lower part of the basin fill is late Paleozoic in age. Carboniferous to Permian carbonates and siliciclastics with evaporites overlie late Devonian orogenic formations on the boundaries of the basin. Mesozoic and Cenozoic units are mostly siliciclastic. Sediments are penetrated by basic dykes. Compressional folding and faulting took place in the Cenozoic in the eastern part of the basin. The total subsidence of the basin is over 12 km.

The Canada basin strikes from Cape Richards 83 °N to the Amundsen Gulf 72 °N. Its northeast boundary is a basement structural high. Its southwest boundary with the Beaufort Sea - Mackenzie Delta basin parallels continental slope. The basin extends 1200 km with a maximum width of up to 600 km. Terrigenous and carbonate successions of Carboniferous to Jurassic age may exist in the lower portion of the basin sedimentary cover. Succession coeval with basin formation started no earlier than the Middle Jurassic. These are terrigenous sediments which prograded basinward. The structural pattern of the upper units of the sedimentary fill of the basin is correlated with the present day relief of Amerasian Basin. Maximum sedimentary thickness exceeds 10 km.

The Lincoln Sea basin is located north of Ellesmere Island and Greenland within the part of the province where structural and topographic highs separate Canada basin from Eurasian basin. Lincoln Sea basin has dimensions of 600 by 600 km. The lower portion of the sedimentary cover within the basin may comprise terrigenous and carbonate sediments of Carboniferous to pre-Middle Jurassic age. The basin forming succession is most likely late Mesozoic to Cenozoic in age with a predominance of terrigenous units. Maximum subsidence in the basin perhaps exceeds 8 km.

The Wandel Sea basin connects the Arctic sedimentary basins with the basins of the North Atlantic. It is located on the narrow shelf and slope of northern Greenland, and is separated from the Lincoln Sea basin by the aseismic volcanic Morris Jesup Rise. The basin is probably connected to east Greenland basins. The dimensions of the basin are 350 km by 150 km. The sedimentary cover of the basin is represented by terrigenous and carbonate formations from late Paleozoic to Tertiary in age resting on Caledonian basement. Maximum thickness of the sedimentary cover in the basin exceeds 8 km.

CONCLUSIONS

The Sedimentary Cover Map supports the concept of a giant Arctic Sedimentary Superbasin. Distribution of sediments within the Superbasin was dominated by a concentric zonation of the Arctic geodepression comprising nearshore areas, shelf, continental slope and ocean abyssal plain. At the base of the sedimentary cover the zonation is manifested as an almost continuous belt of shelf and perioceanic sedimentary basins rimming the Arctic Ocean deep-water area. All identified sedimentary provinces possess a number of common features. They are confined to epicontinental rifts and in consequence accumulated extremely thick, mostly siliciclastic sediments with some basal volcanics. The Arctic Geodepression was not subjected to large scale collisions, and the sediments were not intensely folded. The combination of these factors results in the absence of sharply defined unconformities within the sedimentary section of rift troughs. The gradual increase in rock density with depth and illusive boundaries between sequences, including the base of the sedimentary cover, are characteristics of the Arctic Geodepression (POGREBITSKY et al. 1993, ROEST et al. 1996, ROWLEY 1988). These characteristics are also favorable for petroleum generation.

The Arctic Sedimentary Superbasin is a planetary scale hydrocarbon reservoir with discovered oil and gas fields, and a very large undiscovered resourse potential.

References

Aplonov, S.V., Shmelev, D.K., Krasnov, A.A. & Trunin (1996): New geodynamic model of the Barents-Kara shelf and adjacent mainland.- DAN RF 351/5: 652-655 (in Russian).

Ashikhmina, E.A., Dik, G.G. & Konovalov, V.V. (1986): Seismic research along the drift route of scientific polar station «NP–26» in 1988–84 years.- Bull. Sevmorgeologia 68-71 (in Russian).

Eittrein, S. & Grantz, A. (1979): CDP seismic sections of the western Beaufort continental margin.- Tectonophysics 59: 251-262

Gabrielyantz, G.A. (ed.) (1990): Map of oil and gas geological zonation of USSR. Scale 1: 2500 000.- Mingeo USSR, Minneftprom, Mingasprom.

Gramberg, I.S. (ed.) (1989): Map of the relief of the different in age heterogenetic basement of Arctic and adjacent areas. Scale 1:10000000.- Mingeo USSSR .

Gramberg, I.S., Kiselev, Ju.G. & Konovalov, V.V. (1991): Seismic research on ice camp drift station „Severny Polyus".- Sov.Geologia, 3: 45–54 (in Russian).

Gramberg, I.S. & Pogrebitsky, Yu.E. (eds.) (1984): Seas of the Soviet Arctic, Geology of the USSR and Regularities of the Distribution of Economic Minerals 9, „Nedra", Leningrad, VNIIOkeangeologia, 280 (in Russian).

Gramberg, I.S., Verba V.V. & Kudrjavtsev, G.A. (1993): The structure of the Arctic Ocean Earth crust along geotraverse of De Long Island - Makarov Basin.- DAN 328/4: 484-486 (in Russian).

*Grantz, A., Johnson, L. & Sweeney, J.F. (*eds.). (1990): The Arctic Ocean region. Geological Society of America, 626 pp.
Hinz,K. & Schlüter, H-U. (1978): The geological structure of the western Barents Sea.- Marine Geol. 26: 199-230.
Jackson, H.R. & Oakey, G.H. (1988): Sedimentary thickness map of the Arctic Ocean.- The Geological Society of America.
Jokat, W., Weidelt, I., Kristofferssen, J., Rasmussen, T. & Schone, T. (1995): New geophysical result from the south-western Eurasian Basin (Morris–Jesup, Gakkel Ridge, Yermak Plateau) and the Fram Strait.- Geophys. J. Int. 123: 601–610
Jokat, W., Uenzelmann–Neben, G., Kristofferssen, J. & Rasmussen, T.M. (1992): Lomonosov ridge – a double–sided continental margin.- Geology 20: 887–890.
Karasik, A.M. (1980): General peculiarities of the evolution history and structure of the Arctic Basin floor by aeromagnetic data.- Marine geology, sedimentology sedimentary petrography and ocean geology. „Nedra", Leningrad: 178-193 (in Russian).
Kiselev, Ju. G. (1986): Geology and lithoshere structure of the Arctic Basin. M., „Nedra" : 223 (in Russian).
Kiselev, Ju. G. (1996): Russian seismic research on ice camp drift in Arctic Ocean.- GUNiO MORF, 32, St. Petersburg.
*Kos'ko, M.*K. (1988): Sedimentary basins of the East Siberian and Chukchi Seas: relation to the basement, lateral connection, and evolution.- Geology of the Seas and Oceans, Leningrad: 188-195.
Krukov, V.D., Sorokin, M.Yu., Lipilin, A.V. & Poselov, V.A. (1996): Geological and geophysical aspects of determination of Russian continental shelf outer boundary in the Arctic Ocean..- Exploration and Protection of Mineral Resources, „Nedra" 12: 25-27.
Murzin, R.R., Yunov, A.Yu., Bogolepov, A.K &, Svistunov, Yu.I. (1985): General features of tectonics for north-eastern part of the Barents-Kara shelf (in Russian).- Geological Structure of the Barents-Kara shelf. Leningrad, Bull. „Sevmorgeologia", 5-10.
Pogrebitsky, Ju.E., Shimaraev, V.N., Verba, V.V., Verhoef, J., Macnab, R., Kisabeth, J. & Jorgensen, G. (eds) (1993): Magnetic anomaly map of Russia and adjacent land and marine areas. Scale 1:10 000 000.-Compiled by Sevmorgeologia, Geol. Surv. Canada, CONOCO.
Pogrebitsky, Ju.E. (1976): Geodynamic System of Arctic Ocean and its structural evolution.- Sov. Geology 12: 3–22 (in Russian).
Polkin, Ya.I. (1986): The composition and structure of the sedimentary cover of Norwegian-Greenland and Arctic basins of the Arctic Ocean.- Heterogeneity of Deep Geology of the Oceanic Earth Crust, Sevmorgeologia 56-67.
Roest,R., Verhoev J. & MacNab, R. (1996): Magnetic anomaly map of the Arctic north of 64° Scale 1: 6 000 000.- Geol. Surv. Canada.
Rowley, D.B. & Lotters, A.L. (1988): Plate-kinematic reconstruction of the North Atlantic and Arctic: Late Jurassic to Present.- Tectonophysics 155: 73-120.
Sobczak, L.W. & Haepenny, L.W. (1990): Isostatic and enhanced isostatic gravity anomaly maps of the Arctic.- Energy Mines Resourses Canada.
Sweeney, J.F., Weber, J.R. & Blasko S.V. (1982): Continental ridges in the Arctic Ocean: Lorex constrains.- Tectonophysics 89: 217-237.
Verba, M.L. (1969): West–Siberian plate and Yenisei–Khatanga trough - zones of extension of Early Mesozoic Earth crust.- Mesozoic tectogenesis.- Magadan, Publish. SO AN USSR: 56-62 (in Russian).
Verba, M.L., Daragan–Suschova, L.A. & Pavlenkin, A.D. (1990): Riftogeneous structures of the West Arctic shelf from Deep Refraction Seismic Profiling.- Sov. Geol. 12: 37–47 (in Russian).
Verba, V.V., Volk, V.E. & Gubernov, A.P. (1990): Multidisciplinary geophysical model of the Arctic basin earth crust.- Dokl. AN USSR, 12: 441–446 in Russian).
Verba, V.V., Volk, V.E. et.al. (1986): Deep geology of the Arctic Ocean by geophysical data.- Structure and history of evolution of the Arctic Ocean.- PGO Sevmorgeologia, 54-71 (in Russian).
Yashin, D.S., Kim, B.I. & Reinin I.V. (1994): Petroleum-geological zonation of Chukchi - Alaskan shelf based on introdisciplinary geological and geochemical analyses of sedimentary cover.- VNIIOkeangeologia Internal report, St. Petersburg, 266 (in Russian).