EUG XI

Symposium RCM7

Tectonics and Sedimentation Associated with Arctic Margins

Convenors

Vicky Pease
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RCM7
Tectonics and Sedimentation Associated with Arctic Margins

Wednesday PO Session

RCM7 : WEpo01 : PO
Tectonics of the Arctic Shelf of Russia

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The analysis of the tectonic structure of the Arctic shelf of Russia was done in connection with the preparation of tectonic maps of the Russian Arctic margins, at a scale of 1:2 500 000. The shelf extends from west to east for more than 10 000 km. Over its entire extent it is composed of tectonic terranes: microplates, massives, blocks, and single accretionary lenses. At the shelf western part, the East European craton, from the north, through the Timan fold-overthrust belt (Baikalian in age) is adjacent to the Svalbard microplate with the Grenville metamorphic basement. The Nordkappe riftogenic valley extends along the boundary of the plate and Baikalides with the Caledonian front of Scandinavia, over the collision suture.Farther east, a system of grabens framed by listric faults occurs within the Pechora epi-Baikalian plate. In the east, the Svalbard and Pechora microplates come into contact with the Early Mesozoic Pai Hoi-Novaya Zemlya folded belt. The East Barents trough (its sedimentary cover is more than 18 km thick) lies over that collision zone. Thickest sediments accumulated in Permian-Triassic time. East of Novaya Zemlya, the front of Hercynian deformations is divided into several grabens by a series of listric dislocations oriented from south to north. The Late Triassic and Jurassic sediments are the thickest within the South Kara trough. In the east, the South Kara block borders on the Kara microplate. At the beginning of the Triassic, the Kara microplate through the Central Taymyr belt of Baikalides collided with the Siberian craton. The eastern boundary of the microplate is oriented along the Khatanga-Lomonosov transform fault. The Enisey-Khatanga trough is traced by the collisional suture and is mostly filled with Jurassic and Lower Miocene sediments. A system of young rifts, filled, just like the East Siberian trough, with Upper Cretaceous-Cenozoic deposits, developed, in the Laptev Sea between Taymyr and the dome. The trough is traced from west to east along the coast line of the continent, inheriting the collisional suture in the acoustic basement, along which the Hyperborean microplate with Precambrian basement get conjugated with the accretionary-collision structural mosaic structures of northeastern Asia. In conclusion, we should note that the troughs in the Arctic shelf inherit the position of collision sutures, and from west to east, the age of sediments in troughs is increasingly younger, from Upper Proterozoic to Upper Cretaceous.

RCM7 : WEpo02 : PO
Structural Evolution of the Mesozoic Accretionary Prism on the NW Pacific-Asia Convergent Margin, Southern Taigonos Peninsular, Okhotsk Sea Coast, NE of Asia (Results from the INTAS Project 96-1880)

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The Taigonos Peninsular is a segment of the large Late Mesozoic Uda-Murgal convergent margin between the Pacific oceanic plates and Siberia continent. We recognized the following main elements of paleo island arc structure: metamorphic terranes of Asia basement, back-arc, axial island arc, forearc and accretionary prism terranes. Taigonos segment of Uda-Murgal island arc from north to south consists of Avekov metamorphic terrane, Central Taigonos island arc and forearc terranes and complicate accretionary prism of Beregovoy terrane. The latter is bounded from north by suprasubduction granitoid multistage pluton. Accretionary structure consists of some south vergent tectonic slices composed of Mz oceanic and island arc ophiolite sequences (‘Kingiveem’ and ‘Lagerniy’ type of sequences), serpentinite melange, turbidite and accretionary melange sequences, and metamorphic rocks.

We can recognize three main stages of deformation in the accretionary structure. First deformational stage (Late Jurassic to earliest Cretaceous) is characterized by sinistral transpressional strike slip faults, folds, cleavage and metamorphic schistosity. Metamorphism of this stage took place 140-170 Ma, ^{40}Ar-^{39}Ar data (Bondarenko et al., 1999) and is characterized by P=8-12 Kbar and T=450-820° (Silantyev et al., 2000). This metamorphic conditions are typically for ‘hot subduction’. The accretionary event of first stage is accompanied by C-S mylonite forming in the deep level of the crust; by large scale folds and duplex structure forming in the medium crust level, and terrigenous accretionary melange forming with ‘broken formation’, ‘block-in-matrix’, etc. structural shapes in the upper crust level. Second deformational stage (Early Cretaceous, 120-130 Ma, ^{40}Ar-^{39}Ar data) is characterized by extensional conditions, dextral strike slip faults forming and active volcanism in the axial part of the island arc. Third deformational stage (latest Early Cretaceous to Late Cretaceous, 100-105 Ma, ^{40}Ar-^{39}Ar data) is characterized by collisional condition, lateral crust shortening, sinistral strike slip fault formation and diorite-tonalite, gabbro-diorite plutonism in the forearc region and accretionary prism. The retro duplex faults, folds and final metamorphism took place during this stage too. This deformational stage was a result of collision process between Uda-Murgal ensialic island arc and ensimatic island arc.

The collisional event of the third deformational stage is characterized by the final of the Uda-Murgal convergent margin existence. The next convergent margin between Pacific and Siberia is marked by Okhotsk-Chukotka suprasubduction volcanic belt.

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RCM7 : WEpo03 : PO
The Palaeozoic-Mesozoic Evolution of the Hyperborean Craton Southern Margin: Evidence from New Siberian Islands

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The Hyperborean Platform was recognized by N. Shatsky in 1932 (Shatsky, 1932) proceeding from the occurrence of Lower Palaeozoic shelf deposits on New Siberian Islands. At present, the Precambrian Arctic continent is still identified, though designated and boundered differently. In 2000, fieldwork was done in Bol’shoy (Bigger) Lyakhov Is., where a southern margin of Hyperborean continent is exposed.

We have studied the southeastern part of the island with outcrops of Permian-Triassic flysch, including serpentinite and pillow lava blocks and metamorphic rocks. The flysch is presented by moderately sorted sandstone with siltstone interbeds, showing occasional graded bedding, cross-bedding and ripple marks. The predominant quartz-plagioclase fragments indicate a continental source. The Formation has accumulated within the distal delta in the outer shelf of Hyperborean craton. This inference is supported by correlation with Triassic terrigenous rocks of Chukotka foldbelt.

The low-K - low-Ti pillow basalt resembles the MORB (Drachev et al, 1993). It is associated with dolerite, gabbro and serpentinized harzburgite. We beleive these rocks to be fragments of the oceanic plate, located south of Hyperborean craton in Late Palaeozoic - Early Mesozoic.

As show the preliminary studies, the metamorphic unit is a mafic-ultramafic layered magmatic series. Ultramafic cumulates are actually non-serpentinized. Their metamorphic alteration is manifested by recrystallization of olivine and partial replacement of pyroxenes by amphibole. They were metamorphozed in wet conditions above the temperature stability of serpentine and talc (>690C at 10 kbar) (Schmidt et al, 1998). Metabasites are composed of amphibole and epidote-zoisite, they sometimes contain white mica or garnet. Lower metagabbroic unit has altered to flaser gabbro showing lineation and pegmatoid schlieren. The upper gabbroic unit displays thin-banded fabric formed by late magmatic flow. At the late stage of magmatic evolution these rocks were recrystallized under high temperature and high pressure hydrous conditions. Preliminary estimated pressure is about 10 kbar. Such conditions are realized in suprsubduction environments. The island arc lower crust is the most favourable setting for this magmatic chamber (DeBari et al, 1989). We have a good chance to determine the age of crystallization and metamorphism of these rocks.

At present, the oceanic and island-arc rocks are overthrusting the Hyperborean craton margin as a result of the craton’s collision with the Anuy-Svyatoi Nos island arc. The arc’s andesites and basalts are exposed on the mainland south of our island. The postcollision granites that discordantly intrude all the above units are dated as 120±1.7 Ma (Dorofeev et al, 1999). We have grounds to beleive that dating of layered gabbro and of Permian sandstone clastic minerals will reveal another collision event of assumably Middle Palaeozoic age.

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RCM7 : WEpo04 : PO
The Mamont-Shrenk Neoproterozoic Granitoids (Central Taimyr): Geochemistry, Petrology and Geodynamics

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New geochemical and isotopic (U-Pb, Sm-Nd, Sr-Sr, Ar-Ar) data from Mamont-Shrenk terrane granitoids in the Neoproterozoic Central Taimyr accretionary belt are presented. For the first time, we are able to define the melt sources and age of these granitoids. Their comparison with those from Faddey terrane provide new analogies. S-type granites (low-alkaline granite and granite with normal alkalinity) are P_2O_5 - poor (phophorus oxide less 0.1 wt.%), characteristic of weakly differentiated rocks (Chappell, 1999). Low Rb, Ta, Th and high Hf support this. More differentiated granites that have negative Eu anomalies possess higher absolute REE contents in comparison to weakly differentiated granites with positive Eu anomalies. These granites have the same crustal source with Sr-enriched and Nd-depleted initial ratios: 0,71206 < $^{87}Sr/^{86}Sr_i$ < 0.72163 and -7.14 < εNd (885-940 Ma)< -4.48. TDM ages vary from 1.8 to 2.0 Ga. Some of the granitoids (leucogranites) display hybrid mantle-crustal characteristics (H-type granites): 0.70977 < $^{87}Sr/^{86}Sr_i$< 0.71920 and -2.1 < εNd (879-894 Ma) < +0.04. They have Mesoproterozoic Sm-Nd model ages (TDM between 1.5-1.6 Ga). In contrast to the S-type granites, leucogranites do not have high Al_2O_3 and have lower REE contents. More differentiated low-alkaline granites and leucogranites were formed between 879 and 894 Ma (U-Pb zircon; Cameca IMS 1270 ion-microprobe). For a weakly differentiated, low-alkaline granite, the U-Pb age is 940 Ma. In addition, separate zircon xenocrysts dated between 1.2 and 1.4 Ga were observed in most samples. A single zircon was dated at 2.2 Ga. This allows us to suppose that Mesoproterozoic and Paleoproterozoic crust took part in granitoid formation. The ^{40}Ar/^{39}Ar method on muscovite from the low-alkaline granite yielded a date of 815,7 ±2,4 Ma, similar to K-Ar ages for muscovite from the granite of the same magmatic complex in the northern area of the Mamont-Shrenk terrane (803 ±23 and 813 ±26 Ma; Zacharov et al. 1993). This event we connect with metamorphism of these rocks, resulting from uplift of the intrusive formations to upper crustal levels. Our investigations confirm a common genesis for the granitoids from Mamont-Shrenk and Faddey terranes, which formed as a result of collision-accretional events (continent-continent or continent-island-arc) within a single tectonic block. Subsequently, these terranes were separated and both incorporated in the Neoproterozoic accretionary belt.

RCM7 : WEpo05 : PO
Timanides of Northwest Russia and Part of Northeast Norway: Vendian Orogenic Deformation and Linkages with Peri-Gondwanan, Avalonian-Cadomian Terranes

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Terrigenous sedimentary successions of Meso- to Neoproterozoic age and low metamorphic grade drape the northern periphery of Baltica (E.European Craton) adjacent to the Barents and Pechora Seas, forming the 1800 km-long, NW-SE-trending, Timan-Varanger Belt (TVB). Distinction is made between pericratonic and basinal regimes. Comparable successions occur in the Urals, but there also with variable developments of subalkaline basalts, bimodal volcanite units, diverse plutonic arc complexes, and a fragmented ophiolite of latest Riphean age. Such rocks, in strongly deformed condition, have been encountered beneath the adjacent Pechora Basin with the aid of geophysical methods and deep drillhole data; and the foliated Riphean rocks are there reported to be cut by younger, Late Vendian, magmatic arc granitoids. Development of the PVB and contiguous Pechora-Ural region during the Mid to Late Riphean relates to crustal extension and progressive epicontinental rifting. On land in the TVB, basinal sequences are represented by thick, turbiditic assemblages, but the elongate basin evidently deepened northeastwards to oceanic status, beneath the taiga of Pechora.

Along the TVB, SW-directed compressional deformation and generally low-grade metamorphism produced meso- to megascopic, upright open folds with steeply NE-dipping slaty cleavages. Later strike-slip movements along inverted, major faults were also involved. Beneath the Pechora Basin, and in the northern and Polar Urals, amphibolite-facies conditions prevailed. Biostratigraphic and isotopic age data constrain this major tectonothermal event - the *Timanian orogeny* — to the Vendian period, c. 600-570 Ma. In the northern and Polar Urals, this was succeeded by latest Vendian molasse sedimentation. In a palaeotectonic scenario, the oceanic domain, with its early, subduction-related, magmatic arc complex and microcontinental blocks and slivers, was telescoped and accreted against the northeastern margin of Baltica during the Timanian orogeny. During this amalgamation, subduction polarity is deduced to have reversed, following inferred slab break-off, creating a new magmatic arc and converting this passive margin segment of Baltica into an active one.

The full cycle of Riphean-Vendian, craton margin to rift-basin deposition, oceanic and early primitive arc magmatism, and ultimate contractional orogenic deformation with the generation of a new magmatic arc has all the hallmarks of comparable tectonomagmatic cycles in the now dispersed, Avalonian-Cadomian, arc-related terranes of eastern North America and Southwest and Central Europe. Employing recent and refined palaeomagnetic data, involving the Baltican plate in an inverted position in Late Neoproterozoic time, it can be demonstrated that the TVB, Pechora-Polar Ural region and the Avalonian-Cadomian terranes show clear linkages and good alignment along the West African/Amazonian margin of Gondwana during this time interval. Interestingly, the Timanian contractional event is broadly coeval with extension and rifting along the adjacent, but orthogonal, Baltoscandian margin of Baltica and the very earliest stages of opening of the Iapetus Ocean.

RCM7 : WEpo06 : PO
Oblique Rifting and Basin Development: Eocene-Oligocene Svalbard

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Classic views of continental rupture emphasize orthogonal stretching during initial rifting. Yet many neotectonic and ancient rifts reflect oblique divergence. The Paleogene Forlandsundet basin of Svalbard, Norway, a basin exposed on the upturned shelf edge at the northwesternmost corner of Eurasia, offers a unique onshore exposure of a nascent transtensive rift margin that matured to an ocean basin. The region became the site of oblique deformation as the Mid-Atlantic Ridge propagated northward into the last vestiges of Laurasia to meet the Gakkel Ridge of the Eurasian basin.

The eastern margin of Forlandsundet basin records a two-phase history with Middle to Upper Eocene meandering fluvio-deltaic deposits exposed over broad basin areas. Deformation of these now-lithified first-phase strata occurred prior to lithification. During the second phase, a narrow earliest Oligocene rift graben filled with up to 1 km of undeformed, unlithified alluvial-fan/fan-deltaic strata was superimposed on the broader, older Forlandsundet basin. Although no basin data can constrain the initial generation of proper oceanic lithosphere offshore, the ages of the deformed and undeformed strata constrain the age of initial continental rupture. The onset of rifting likely occurred in latest Eocene to earliest Oligocene time within a maximum possible interval of 49-33 Ma, and initial stretching occurred at maximum temperatures 104ºC based on vitrinite-reflectance values.

Stretched conglomerate clasts in which fractures between clast segments were filled with lithic-arenite matrix indicate that deformation occurred prior to lithification of the first-phase strata. Orientations of fracture planes within clasts, clast elongation directions, stylolitic surfaces between clasts, and slip on striated conjugate faults share orientations suggesting a genetic relation under similar bulk strain consistent with stretching 10-20 degrees west of north and subhorizontal shortening close to E-W. Following this distributed deformation by granular flow of the sandy matrix and clast fracture, throughgoing faults developed across the basin when shear localization became possible. This protracted deformation is expressed as dominantly normal- and oblique slip with T axes indicating a mean extension direction at 308/9 (trend and plunge) oblique to the 340 degree-trending margin. Deformation accommodated combined extensional and wrench components as P axes are dominantly subvertical. In addition these T-axes orientations are similar to that of clast elongation, but with P axes more inclined suggesting deformation evolved from subhorizontal to inclined shortening, consistent with an increase in the extensional component of deformation. Gentle kilometer-scale folds throughout first-phase strata record a mean shortening direction of 046 degrees and represent folding under dextral transtension. On the basis of these basin-scale structures, initial rifting was transtensional with a NW extension driven by the incipient NE-striking Molloy spreading-ridge segment whose Oligocene position of lay immediately west of Forlandsundet basin.

RCM7 : WEpo07 : PO
Detecting Marginal Tectonic Events in a Cratonic Setting (Finland, Baltic Shield) Through Apatite Fission Track Thermochronology

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Presented here are further results from ongoing research involving the use of the Apatite Fission Track (AFT) analysis in the Finland part of the Baltic shield.

This part of the shield has largely been considered stable since the late Proterozoic. However the margins have experienced several significant tectonic events, including collisional (Caledonide Orogeny) and rifting (North Atlantic Margin formation) phases. The magnitude of these marginal events is such that their subtle far-field influences may have propagated into the cratonic interior. The unique nature of AFT, with respect to its low temperature sensitivity, means that it is the most appropriate tool for detecting and investigating the extent and nature of these far-field influences.

Earlier preliminary results have previously been published (Murrell and Andriessen, 2000). Initial T-t modeling of these data showed the presence of a significant cooling event at ~1050 Ma followed by re-heating during the early Phanerozoic. This was followed by slow cooling, which became more rapid in the Tertiary. The new results largely match the earlier ones but the employment of a new thermal model has allowed further refinement of the previous model derived interpretations. The new model results suggest that the initial cooling occurred slightly later at ~ 950 Ma and that Phanerozoic re-heating peaked in the Devonian then cooled slightly and remained stable for the rest of the Paleozoic and the Mesozoic before cooling rapidly in the Tertiary.

The initial (~950 Ma) cooling could be related to uplift arising during amalgamation of the Rodinia supercontinent. The Phanerozoic re-heating is most likely due to burial beneath sediments and the rapid cooling in the Tertiary due to removal of these sediments as a result of the formation of the North Atlantic Margin. These interpretations are being tested through the utilization of other geochronometers (such as U/Th-He, Zircon Fission Track, and $^{40}Ar/^{39}Ar$ on Feldspar) and a new fission track annealing model (Ketcham, 1999). We also discuss important implications for the results arising from the ~950 Ma cooling event and subsequent initial age of the samples. Samples with such large initial ages are extremely susceptible to subtle subsequent re-heating and small differences in maximum temperature can result in significantly different final ages. This implication is also true for very subtle heterogeneity in Apatite chemical composition with small differences in chemistry possibly resulting in large differences in final age. Other problems arising due to samples with large ages and which require consideration include the probable influence of low temperature (<60º) annealing and α-recoil induced crystal damage.

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RCM7 : WEpo08 : PO
Spitsbergen (Svalbard) as Northwestern Corner of the Eurasian Plate: Two Types of Continental Margin

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Spitsbergen is located in the northwestern corner of the Eurasian Plate in a key area for the reconstruction of geological history in the North Atlantic and Arctic regions. According to modern interpretations, Spitsbergen was assembled during Caledonian orogeny from four different terranes with their own pre-Caledonian history. They are separated by N-S faults and a Devonian graben, and overlain by Carboniferous to Tertiary platform sediments. A Tertiary fault belt results from the opening of the Atlantic and occurs around the western shore of the archipelago. The marine part of the area can be subdivided into three tectonic units - typical shelf in the southeast and two continental slopes in the north and in the west - the Arctic and North Atlantic basins, respectively. Geophysical results of seismic profiles and aeromagnetic observations carried out mainly by Norwegians and Russians, were used for reconstruction of the continental margins. In the west, the Tertiary fold-and-trust belt was formed in a dextral, transpressive regime along the intracontinental transform margin between the Barents and Greenland Shelves during the Paleogene opening of the North Atlantic. Conditions of compression alternated with extension. The N-S direction of the main Tertiary folds is parallel to the western continental margin. In general, the folds inherit the more ancient Caledonian structures. In the north of Spitsbergen, an extensional regime dominated during Mesozoic - Cenozoic tectonic events. Around 30 km wide, a NE trending aeromagnetic anomaly is observed to the SE of Spitsbergen. It is traced from Bjorn Island in the south, crossing the Kong Karl Islands, and to the continental margin far to the NE. The tectonic nature of the anomaly is confirmed by seismic profiling. This anomaly may reflect the easternmost extension of Spitsbergen Caledonian basement. It was later reactivated during the attempted opening of Atlantic Ocean during Mesozoic time. The remnants of this palaeorift are represented by the Orel (Northeastern) trough, filled by (Mesozoic?) Tertiary deposits.

RCM7 : WEpo09 : PO
Coast-Parallel Faulting of Tertiary Flood Basalts and Sediments at Kap Brewster, Scoresby Sund, East Greenland

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A thick Tertiary tholeiitic flood basalt lava pile with subordinate pyroclastic rock, terrestrial and/or marine sediment interlayers (Blosseville Group: Upper Paleocene-Lower Eocene), crops out in coastal area of East Greenland between Kangerdlugssuaq (Blosseville Kyst) and Kap Brewster (Scoresby Sund). Its further extension is in inner part of Scoresby Sund.

At Kap Brewster, eastern part of Savoia Halvoe, the basalts are directly succeeded by fossiliferous, mainly shallow-marine, deposits of the Kap Dalton Group subdivided into the Bopladsdalen Formation (Lower Eocene, upper part), and the Krabbedalen Formation (Lower Oligocene). These deposits fill a small graben located within a large coastal downthrown tectonic block bounded in the northwest by a major coast-parallel dip-slip fault - the Muslingehjoernet fault. A single occurrence of littoral Miocene deposits - the Kap Brewster Formation, is located along this fault.

(1) Older fault system. The Muslingehjoernet fault, together with some smaller-scale coast-parallel (NNE-trending) dip-slip faults, represent an older system, formed under extensional regime roughly at the Oligocene/Miocene transition. The main fault had been active during, and possibly also slightly after, deposition of basal unfossiliferous coarse-clastic beds (?Upper Oligocene or ?Miocene) of the Kap Brewster Formation. This is evidenced by tectonic brecciation, slickensides and calcitization of clasts in these beds.

The succeeding finer-clastic fossiliferous shallow marine to littoral beds of the Kap Brewster Formation (Miocene) are only slightly tectonically disturbed. Their contact with basalts at both sides of the Muslingehjoernet fault is sedimentary: along this contact, large ostreid shells are firmly attached to the basalt wall.

(2) Younger fault system. Several subordinate, NW-trending, dip-slip faults which delimit a graben filled with the Kap Dalton Group deposits, represent a younger extensional fault system of Miocene or post-Miocene age.

RCM7 : WEpo10 : PO
The Structure of the Disko-Nuussuaq Basin (W-Greenland): Time and Space Transition between a Sedimentary Basin to a Volcanic Passive Margin

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The Disko-Nuussuaq area, West Greenland, is a key-area to study the time and spatial relationships between a sedimentary basin and a rifted volcanic margin. The evolution of the Cretaceous to Late Palaeocene sedimentary basin is three-fold : (1) Late Albian-Early Cenomanian early rift stage in fluvio-deltaic environment, (2) Late-Cenomanian to Santonian thermal subsidence stage and, (3), late rift-stage of Campanian age associated with the deposition of the offshore-type Kangilia argilites. The basin is probably the southern continuation of the Melville Bay basin (Whittaker et al., 1997). It marks, at the latitude of the southern Baffin Bay, the plate separation rift-stage between Canada and Greenland. We outline the importance of tectonic heritage in the basin structure and discuss the significance of a major inherited structure, the Itilli Fault. The sedimentary basin is overlaid by discordant tuffs and hyaloclastites that mark the base of a thick volcanic pile of Palaeogene age. The earliest volcanics emplaced in a contrasted topography associated with a Late Cretaceous to probably Palaeocene uplift (Dam et al., 1998). It is significant that extension decreased and stopped at the location of the exposed sedimentary basin during the extrusion of the Palaeocene-Eocene volcanic pile. At the debatable exception of the Itilli fault, extension in the basin was shifted oceanward at the location of a major structure, the syn-magmatic W-Greenland coastal flexure (Geoffroy et al., 2001). We overall demonstrate the close analogy in structure and evolution between the W-Greenland Disko-Nuussuaq area with the North-Atlantic margins.

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Thursday PM Session

RCM7 : THpm22 : F3
Fresh View on the Seismic Structure of Lomonosov Ridge

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The Lomonosov Ridge is one of the most remarkable geological structures in the High Arctic. This more than 1800 km long continent sliver divides the Arctic basins into a Mesozoic and a Cenozoic part. In general, it is widely accepted that the ridge once was attached to the Barents and Siberian shelves. Some 60 Ma, when sea floor spreading started in the Eurasian Basin this continental sliver was continuously separated from the continent by the rift process. Details on its internal structure are very sparse. Only during the last decade geoscientific knowledge on some parts of the ridge grew very fast due to in total four international surface ship expeditions as well as submarine swath mapping. Seismic reflection data acquired between 88°N and 80°N in combination with the newly released bathymetric chart for the high Arctic give new insight into the structural elements of the ridge. Do seismic data indicate an almost flat ridge at 88°N mostly unaffected from the rift processes, the ridge looks totally different south of 85°N. Here, the Lomonosov Ridge is broken into large blocks with a deep valley in its central part. The sediments in the central trough are more than 1000 m thick, but show no or only little faulting. This suggests that the central trough has been formed mainly during the last rift event around 60 Ma. Furthermore the seismic data suggest that the ridge around 88°N was more heavily eroded than more to the Siberian Laptev Sea margin. Although, the seismic velocities derived from wide-angle recording clearly indicate the presence of an erosional unconformity along the whole ridge it is less pronounced close to the junction of the ridge with the Laptev Sea shelf. This may be due to higher sedimentation rates just after break-up or to different rift processes, which affected the ridge in Mesozoic and Cenozoic times.

RCM7 : THpm23 : F3
Crustal Structure and Evolution of the Laptev Sea Rift, N-E Siberia, Revealed by Seismic Data

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The eastern Arctic Ocean is unique among the world's oceans due to its wide continental shelves, and especially to its plate tectonic setting. Today, the total opening rate at the boundary between the North American and Eurasia plates varies between 1.3 cm/a and 0.7 cm/a over a distance of 300 km from seafloor spreading in the Eurasia Basin to extension of continental lithosphere on the shallow Laptev Shelf. The plate boundary is marked by earthquake epicenters which show a small scattering around the Arctic mid-oceanic ridge and continue on the shelf as an about 500 km wide zone (Franke et al. 2000). This interaction of the active Arctic mid-oceanic ridge with the north-eastern Siberian continent since the Late Cretaceous resulted in a complex horst and graben system on the Laptev Sea shelf.

In 1997 the Federal Institute for Geosciences and Natural Resources (BGR), Hanover, in cooperation with Sevmorneftegeofizika (SMNG), Murmansk, carried out their third geophysical research expedition on the shelves of the Laptev and East Siberian Seas. About 4000 km of seismic (MCS) data and additional refraction seismic data made a conclusive interpretation of the main structural elements possible.

The most prominent rift basin is the Ust' Lena rift with a minimum width of 300 km E-W at latitude 75 N. It is bounded to the Laptev horst in the east by a westerly dipping major listric fault. The 100 to 150 km wide Laptev horst is subdivided into three parts by minor rift basins. Another rift graben, the Anisin basin, is separated from the Kotel'nyi horst in the east by a deep fault.The rift basins, showing a Cenozoic sedimentary cover of up to 14 km presumably have formed as linked half-grabens, accompanied by the development of a major fault which is interpreted to represent a hinge zone. Though the rift formed in interaction with an active mid-oceanic ridge there are some indications that the Laptev Sea rift is a member of the 'passive rift' type.

Franke D, Krueger F & Klinge K, *Journal of Seismology*, **4**, 99-116, (2000).

RCM7 : THpm24 : F3
The Laptev Sea: A Natural Laboratory for Addressing the Processes of Rupture of Continental Lithosphere and their Impact on Natural Environment

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The shallow epicontinental Laptev Sea (LS) forms a southern rim of the Eurasia spreading oceanic basin in the Russian Arctic. Thus, this area is one of a few places in the world where a currently active mid-oceanic ridge (the Gakkel ridge) approaches a continental margin. The spreading began about 58 Ma ago and remained active throughout the whole Cenozoic. Because of its tectonic setting, the LS represents a unique natural laboratory for addressing the processes of initial breakup of continents and their impact on natural environment. Fundamental studies were undertaken during the last 15 years by several Russian and German institutions and the present-day data set consists of ca. 30,000 km of multichannel seismic reflection lines and a considerable amount of environmental data collected in frame of ongoing Russian-German program 'Laptev Sea System'. These data reveal a vast offshore rift system and specific seismic features of its sedimentary fill.

A difference in subbottom geology between its western and eastern parts is a principal feature of the LS. These two regions are constituted, accordingly, by a deep and highly stretched Ust' Lena rift basin, and a horst and graben province with a high-standing pre-rift basement. The seismic data suggest that the extension and sedimentation were initiated in the Ust' Lena Rift and then, in the Late Cenozoic as the Gakkel Ridge spreading axis migrated eastward of the continental edge with a half-spreading rate, mostly affected the eastern region.

The Gakkel Ridge is buried under a thick pile of Cenozoic sediments in vicinity of the LS continental margin. As evident from the gravity field, its rift valley is traced onto the continental slope up to the 2000 m isobath. The up-slope continuation of the rift valley is formed by two asymmetric grabens, in which a hydrothermal benthos community and a high heat flow were established.

In a modern tectonic setting the LS is an area of interaction of the North American and Eurasian lithospheric plates. The seismicity reveals active normal faulting suggesting that the near-bottom sediments are affected by extensional dislocations. These acoustic features are detected by the high resolution seismic data and PARASOUND echosounder records.

Young tectonic movements represent an important factor of development of the Laptev Sea environment. The fault-related dislocations affect the sea-bottom morphology that, in turn, causes a pattern of the near-bottom currents, distribution of water masses, sediment transport paths. The principal difference between western and eastern Laptev Sea, which is well-seen in subbottom geology, can be also recognized in some characteristics of the bottom sediments and water masses. This gives evidence that the active extension rupturing continental lithosphere of LS also influences the processes occurring in the modern marine environment.

RCM7
Tectonics and Sedimentation Associated with Arctic Margins

RCM7 : THpm26 : F3
Tectonic Structure and Evolution of Sedimentary Basins on the Continental Margin of Northern Eurasia

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The fundamental tectonic features of the Eurasian Arctic continental margin are discussed in terms of structure, geological history and hydrocarbon potential of the major shelf basins. The Barents-North Kara Basin occupies a typical passive margin that borders the Eurasian oceanic opening and displays a prolonged Paleozoic - Mesozoic depositional history resulting in a great thickness of sediments with positively proven oil & gas reserves. Giant gas condensate fields have also been discovered in the South Kara Basin, although accumulation of cover sequences did not begin here until about the Paleozoic/Mesozoic boundary and was probably more influenced by the West Siberian rather than the central Arctic scenario. The location of the Laptev Basin at a unique structural T-junction between continental margin and the Eurasian Basin spreading axis accounts for a specific geodynamic environment leading to post-breakup extension and associated formation of unusually stretched and thinned continental crust beneath a substantial thickness of predominantly Mesozoic and Cenozoic sediments. The East Siberian Basin and the Chukchi Basin are least explored, and until a better understanding of the relationship between their subsidence history and the formation of the Amerasian oceanic basin is achieved, it may appear premature to consider these basins as belonging to a typical passive margin.

The age and the geodynamic mechanism of basement formation in all basins are subject to debate. In the west the final cratonization of the basement is attributed to the latest recorded deformational event (Baikalian in the Barents-North Kara Basin, Hercynian in the South Kara Basin) succeeded by the beginning of accumulation of undeformed platform sequences. In the east the initial, latest Precambrian or early-middle Paleozoic folding only led to a temporary basement cratonization, and, after a lengthy period of cover sedimentation, the mid-Cretaceous reactivation caused superposed deformation of variable intensity in the basement complexes, as well as initial disturbance in the pre-late Mesosoic cover rocks. Deep basement depressions characterized by the apparent absence of the ‘granite’ crustal layer (the so called ‘basalt windows’) occur along the length of the Russian Arctic shelf and represent the main sources of controversial geodynamic interpretations. Extensional stretching and thinning of continental crust are proposed as the main processes responsible for formation of one of those ‘windows’ in the Laptev Sea. It is not clear, however, to what extent such model developed for a specific Cenozoic geodynamic environment can be applied to other locations, especially in the western seas where the formation of basement depressions occurred during a much earlier period of basin history.

RCM7 : THpm27 : F3
Features of Inheritance in the Tectonic Structure of the Arctic Continental Margin of North East Eurasia

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Novosibirsk and Vil’kitski rifts are positioned in front of the late Mesozoic fold belt where they parallel and / or overlap the suspect foredeep basins. The rifts were emplaced directly after or simultaneously to the final stage of the late Mesozoic orogeny. Middle Cretaceous molasses can be present at the base of the rift sedimentary fill.

The western boundary of the Laptev Sea rift system follows the border of domains with distinctly different pre late Mesozoic history. This boundary is an offshore northern continuation of the Udja rift system faults known to exist since the Proterozoic. The NW strike of some of the grabens on the Laptev Sea shelf is coincident with the middle Paleozoic facies zonation on the Kotel’nyi Island. It permits to hypothesize that those rifts inherit the basement structural grain. The continental slope in the east Laptev Sea and the De Long Island area is an offshore projection of the onshore late Paleozoic Enisey-Khatanga rift between Taimyr fold belt and the East Siberian Craton.

The topography and the geometry of the upper units of the sedimentary cover show that the present day and late Tertiary tectonic structure of the Laptev Sea shelf at the most general approach is a centrocline open oceanward. The East Siberian and Chukchi Seas shelf occupy a leveled structural terrace between the Amerasia Basin and a late Tertiary orogene onshore. The base of the Pliocene to Quaternary sequence shows gentle monoclines and gentle platform type synclinal basins with minor complications. Rift related features in both areas are restricted to the lower portion of the late Mesozoic to Cenozoic cover sequence. So the changes in the structural styles upsection show decrease in the tectonic activity.

Nevertheless there are local manifestations of the late Tertiary to Recent geodynamic activity. Those are topographic highs indicated by islands, earthquake zones, and volcanoes. Their relationships with the rifts at the base of the sedimentary cover and with the tectonic features in the adjacent deepwater basins are variable. The connection of the topographic highs bordering the Laptev Sea with the basement structure and the Eurasia Basin tectonic grain is obvious, whereas in other cases the links of late Tertiary to Recent high energy geodynamic manifestations with the earlier and neighboring tectonic settings are to be found.

RCM7 : THpm30 : F3
Early Triassic A-Granites of Taimyr: A Result of the Northern Asia Superplume

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Permian-Triassic magmatism widely present in northern Euroasia is considered to be the result of a superplume (Yarmolyuk, Kovalenko, 1996; Dobretsov, 1997). Flood basalts are widespread on the Siberian platform, in the West Siberian basin, in the southeastern part of the Kara sea, and on Taimyr. Alkaline granitoids related to this event are widespread in the Central Asian fold belt. Isotopic dates show that the greatest volume of trap and granitoid magmatism relates to the Early Triassic - 249-245 Ma (Campbell et al., 1992; Dalrymple, 1995; Basu et al., 1995; Yarmolyuk, Kovalenko, 1996). Our investigations show that not only Early Triassic flood basalts and dolerites, but also A-granites connected with this magmatism, are widespread in Taimyr. Small stocks, laccoliths, and dykes of subalkaline and alkaline granites, quartz monzonites and syenites are present in the western part of this region. They intrude Late Carboniferous - Permian terrigenous rocks, Permian - Early Triassic terrigenous-volcanogenic rocks and also flood basalts and dolerites. These granitoids have metaluminous compositions, high K_2O/Na_2O (1.5-2.1), K_2O (5-6 wt.%), $Ga/Al^{IV}x10^4$ (1.9-2.4), Rb and Nb values, allowing us to classify them as A-granites. Isotopic studies show that $^{143}Nd/^{144}Nd$ is between 0.51224 and 0.51273, $^{87}Sr/^{86}Sr_i$ is between 0.70472 and 0.70644, and εNd(Ò) changes from +3.5 up to -5.18, suggesting a hybrid mantle-crustal source. U-Pb (249-241 Ma) and Ar-Ar (245-232 Ma) ages of Taimyr A-granites agree with the time of trap magmatism on the Siberian platform. The formation of this magmatic complex also took place in a within-plate setting, because the collision of the Kara block with the Siberian continent was finished by the time of the Permo-Triassic boundary (Vernikovsky, 1995).

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Vernikovsky VA, *Petrologiya*, **1**, 63-81, (1995).

RCM7 : THpm31 : F3
Early Paleozoic Kinematic Model of Severnaya Zemlya (SZ) Terrain

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Taymyr-Severnaya-Zemlya folded area is the important unit in the structure of the Arctic sector. It is subdivided into three basic structural zones - South-, Central-, and North-Taymyr separated by large overthrusts. To reveal the history of the Northern block we studied Paleozoic sedimentary cover laying on the Precambrian basement on the island of October Revolution of SZ archipelago area. The paleomagnetic laboratory experiments carried out on standard techniques including thermal an AF stepwise magnetization. Nevertheless, using various techniques of paleomagnetic data interpretation (principal component analysis, remagnetization circles and combined analysis of remagnetisation circles and direct observations) it was possible to determine mean directions for three serial intervals of Paleozoic section. Positive fold test testifies that in all cases magnetization was acquired before deformation of investigated strata. The new paleomagnetic data suggest that SZ block over a period from Early Ordovician to Late Silurian was moving from the southern hemisphere to the northern, from area of moderate latitudes to equatorial ones with counter-clockwise rotation on about 65. It is generally agreed, that the structure of south-western frame of Siberian platform was formed in response to large-scale slip-strike motions, which are principally caused by rotation of Siberia and it is logical to assume the similar style of shear kinematics also for the North part of Siberia in limits of Taymyr-Severnaya-Zemlya folded area. Strike-slip faults resulted from rotation of Siberian and Kara plate are the most simple explanation of the kinematics of the motion of SZ terrane relative to Siberia and mechanism of collision of these blocks. If it is granted that simulated kinematic situation has been retained during all the Late Paleozoic, then the concurrence of APWP curves of Siberia and Kara continent will be achieved in an interval 340-300 Ma, that, probably, will correspond to the time of collision of Kara and Siberian continents. The collision age derived from this model is in a good agreement with available geological and geochronological indicators of this tectonic event.

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RCM7 : THpm32 : F3
Is Franz Josef Land Affected by Caledonian Deformation?

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From geochronological and geophysical data, Caledonian deformation is thought to extend into the Arctic region, either east or west of Franz Josef Land. We evaluate the detrital populations of zircon (ion-microprobe U-Pb ages) and muscovite (^{40}Ar-^{39}Ar ages, both individual grains by laser, as well as incremental heating of populations) of two sediment samples from the Nagurskaya drill core on northwest Alexandra Land island, Franz Josef Land. The results of these analyses are used to determine the age, provenance, and thermal history of the sediments and then to assess the extent to which Caledonian deformation affected Franz Josef Land.

Samples L1 and L2 were from depths of 3044 and 3092 meters, respectively. Maximum ages for the sediments from the detrital zircon populations are ca. 1 Ga for L1 (n=29) and ca. 1.35 Ga for L2 (n=19). Detrital muscovite total fusion (laser) $^{40}Ar/^{39}Ar$ ages range from ca. 360-665 Ma for L1. The incremental heating profile for a bulk muscovite sample defines a non-plateau maximum age of 644 Ma and indicates argon loss. In L2, detrital muscovite total fusion (laser) $^{40}Ar/^{39}Ar$ ages range from 750-1200 Ma. Duplicate incremental heatings of L2 yield similar results inasmuch as both sample aliquots indicate argon loss. One analysis of L2 defines a non-plateau maximum age of 700 Ma. The second analyses defines a non-plateau maximum age of 1.1 Ga.

These results suggest a Meso- to Neoproterozoic age for the sediments. The sediments suffered partial argon loss, either due to natural diffusion or during a relatively young thermal event. The results of diffusion modelling will be presented in order to constrain whether or not argon loss was due to reheating. The most likely thermal events include overprinting by Caledonian deformation and/or overprinting due to Siberian trap magmatism. We will then speculate on the location of the inferred Caledonian deformation front.

RCM7 : THpm33 : F3

The Structure of the Northern Svalbard Continental Margin

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The evolution of the northern continental margin started with the opening of the Eurasian Basin and the Greenland Sea some 55-60 Ma. Because of the heavy ice conditions there is little knowledge about the structure and distribution of sediments. In summer 1999 the first systematic seismic profiles were acquired east of 15° E. Over 1470 km of multichannel seismic reflection data were collected up to 82° N, while 21 sonobouys were launched.

The P-wave velocity in the uppermost sediments across the inner shelf of northern Spitsbergen are surprisingly high (above 2 km/s). This indicates compaction of this sediments due to a former ice shield. At the mouth of Hinlopen Street the shelf is heavily eroded and forms an embayment. This structure evolved due to extensive slumping. We find indications of very coarse material in the uppermost layers in the adjacent Sofia Trough/ Nansen Basin. In this trough a weak reflection dipping to 8 s TWT is identified in the seismic data, resulting in a sediment thickness of at least 8 to 9 km.

The inner shelf east of Hinlopen Street shows little sedimentation since the last glacial period. In the seismic data we see only a thin veneer of overcompacted sediments above the acoustic basement. Beneath the outer shelf up to 3 km of sediments rest on a down-faulted acoustic basement. The shelf slope is heavily eroded due to bottom water activity.

At about 30 degree East the morphology of the shelf slope is influenced by glacial sedimentation. The existence of a glacial trough mouth fan indicates a massive sediment transport by ice streams during former glacial periods.

The sediment thickness in the adjacent Nansen Basin is 4 km at maximum.

RCM7 : THpm34 : F3

Northwestern Svalbard and its Adjacent Oceanic Province- New Seismic Refraction Lines for a Better Understanding of the Crustal Nature

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In the last few years seismic refraction experiments in the western/northwestern part of the Svalbard continental fragment, its margin and the adjacent oceanic province were carried out within an international cooperation. The direct vicinity of the slow spreading Fram-Strait-MOR-System, as well as shear tectonics and the existence of a potential mantle plume during separation from Northeast Greenland were supposed to affect the COT of northwestern Svalbard. The acquired data provide high resolved P-wave velocity models for interpretation of the crustal structure.

The crust in the vicinity of Molloy/Knipovich Ridge is of oceanic origin, but the detailed structure varies spatially. We observed partly no true oceanic layer 3, while otherwise oceanic layer 2 is underlain by a primitiv layer which may reflect layer 3. P-wave velocities of 7.4 to 7.9 km/s are detected underneath these crustal parts and can be interpreted as upper mantle peridotites.

The COT eastward of this province of thinned oceanic crust shows only few features of a volcanic rifted margin. Across the western Svalbard continental margin north of Van Mijenfjord (77ºN-78ºN) no essential igneous crust can be mapped. Only at the direct transition a small lense (<20 km width, max. 5 km thickness) of higher velocities is observed. The deepest parts of steep and narrow high velocity zones may reflect local melt intrusions off Van Mijenfjord. These zones are probably old shear zones which were reactivated throughout the breakup. Moho depths on the continental side vary between 32 and 36 km.

Additional seismic data were collected towards the Yermak Plateau. The crustal thickness is about 20 to 28 km, but the continental character remains more or less unchanged up to 81ºN. Crustal thinning took place underneath Danskoya Basin (DB). It is possible to divide the southern Yermak Plateau into two crustal blocks due to a change in crustal P-wave velocity. Slighty decreased upper crustal velocities underneath DB may point to a stretched or rifted zone directly north of the NW-Tip of Svalbard. No clear influence and deep seismic evidence of a possible Hot Spot on the southern Yermak Plateau is observed.