ICAM8 Abstracts

Marine geology & geophysics

Exploring wonderments about the ~synchronous Early Eocene (50-55 Ma) creation and reconfiguring of plate boundaries in the Arctic Basin, along the rim of the north Pacific, and at north Pacific spreading centers

David W. Scholl

dscholl1934@gmail.com

INTRODUCTION: In the early-Eocene Arctic (chrons 25-24, 53-56 Ma), a new North American(NA)-Eurasian(EU) plate-boundary was created at the nascent Gakkel Ridge spreading center. Spreading, initiated by rifting along Eurasia's Barents-Leptev continental margin, opened the Eurasian Basin. Opening progressively separated the rifted crustal ribbon of the Lomonosov Ridge from its birth place along the Eurasian margin. In the Paleocene north Pacific, the only subduction zone (SZ) bordering the Arctic Basin was the Alaska SZ where Pacific crust had been underthrusting Alaskan continental crust since at least the Permo-Triassic. However, In the early Eocene (50-55 Ma), the Alaska SZ extended offshore and westward to the Kamchatka SZ as the Aleutian SZ. The Aleutian SZ and it's overlying arc massif cordoned off the NW corner of the Pacific Basin to form the backarc Aleutian Basin and, to the north, to tectonically shutdown the former oblique convergent plate boundary connecting Alaska and Siberia via the Beringian continental margin. To the south in the north Pacific Basin, birthing of the Aleutian SZ was ~synchronous with a CW (~20 degs) rotation of the Pacific-Farallon spreading ridge and a CCW (~37 degs) reorienting of the Pacific-Kula spreading ridge.

WONDERMENTS: These observations prompt the wonderment if, in the early Eocene, a Northern Hemisphere plate-driving mechanism was causatively involved in plate boundary creation and reconfiguring. Neither the NA or EU plates are structurally connected to a lengthy sector of plate-driving subducting slab. But, at ~50-60 Ma, the NW motion of the NA plate turned to the SW, a change ascribed to a convecting mantle's drag on NA's cratonic root. The turn would have worked to pulled open the Eurasian Basin and compressively force the Alaska SZ to extend westward as the intra-oceanic Aleutian SZ.

Paleo-Current Activity in the Eastern Arctic Ocean - Evidence from Seismic

Estella Weigelt & Wilfried Jokat

estella.weigelt@awi.de

Four stages of deposition regime have been detected on high-resolution seismic reflection profiles. First, in strata of Paleocene-Eocene age small vertical faults indicate differential compaction of probably anoxic sediments deposited in the still isolated Eurasian Basin.

Than, a high-amplitude-reflector sequence indicates a time of widespread changes in deposition realm associated with the gradual opening of the Fram Strait and ongoing subsidence of the Lomonosov Ridge (LR) in Eocene and Oligocene. Episodical incursions of water masses from the North Atlantic were the consequences and led to the deposition of sediments of strongly different lithology.

The third stage marks widespread and pelagic sedimentation since earliest Miocene. Sediment waves are evidence for paleo-bottom current activity and the onset of an ocean circulation system. The slope of the LR is structured into terraces, indicating fault-controlled sediment drifts arisen due to the onset and intensification of current circulation. Advanced deepening of the Fram Strait likely enabled an effective exchange of water masses between the North Atlantic and Arctic Ocean. Continuous sagging of the LR, reactivation of former faults and bottom currents passing along the ridge may shape the steep sediment free flanks of the terraces in addition.

Depositional Evolution of the Western Amundsen Basin, Arctic Ocean

Carlos F. Castro, Paul C. Knutz, John R. Hopper, & Thomas Funck

cfc@geus.dk

Seismic reflection data collected in the western Amundsen Basin as part of the Law of the Sea program for the Kingdom of Denmark show a uniform and continuous cover of sediments over oceanic basement. An interpretation of seismic facies units shows that the depositional history of the basin reflects changing tectonic, climatic, and oceanographic conditions throughout the Cenozoic.

A new stratigraphic model of the Amundsen Basin is presented that includes four distinct phases of basin development. From the onset of seafloor spreading up to the mid-Eocene, the Amundsen Basin formed a small, isolated lake system with high sedimentation rates linked to terrestrial input and high pelagic productivity. During the late Eocene–early Oligocene, sediment wedging and mass transport into marginal depocentres reflect a phase of tectonic instability linked to the high Arctic Eurekan Orogeny. In the early to mid-Miocene, mounded, asymmetric sedimentary features interpreted as contourites, indicate a distinct change in sedimentation style. This was probably associated with a establishment of a counterclockwise geostrophic current system in response to the onset of a deep oceanic connection through the Fram Strait. In contrast, the Plio–Pleistocene stage is characterized by erosional features such as scarps, channels, and levees, indicative of a change to a high-energy environment of suspension currents. These deposits may be associated with discharges from northern Greenland but also brine formation originating below thick multi-year sea-ice over the northern Greenland continental shelf.

Natural prolongation of the East Siberian continental margin in the Amerasia basin based on the complex of geological and geophysical data

Smirnov, O., Poselov, V., Kireev, A., Butsenko, V., Savin, V., Zholondz, S.

oleganus@mail.ru

In the last decade, a number of high-latitude expeditions were organized by various organizations within the continental margins of the Laptev, the East Siberian and Chukchi seas. Obtained multichannel seismic (MCS) reflection data, in combination with the results of deep seismic sounding (DSS) and density modeling, reveal the structure of the sedimentary cover, acoustic basement and consolidated layers of the crust within the Eurasian shelf and deepwater structures of the Amerasia basin.

As a result of the analysis of MCS materials, the continuous tracing of the main sedimentary complexes of the Mesozoic-Cenozoic age from the shelf of the Eastern Arctic seas to the deep-water region was revealed. Within the margin, a thick sedimentary basin stretches along the entire shelf boundary. The age of the oldest sedimentary complexes within the basin varies significantly. The internal structure of the acoustic basement (metasedimentary complex?) within this sedimentary basin and on the shelf of the East Siberian Sea is characterized by similar seismic parameters.

The DSS results along profiles crossing the continental margin, as well as the results of 2D density modeling, indicate continuous prolongation of the layers of the consolidated continental crust from the shelf to the deep-water area. Thus, a natural geological prolongation of the shelf structures of Eurasia in the Amerasia basin is justified on the basis of various geological and geophysical data, while there is no evidence of regional transform faults within the shallow - deep-water transition zone.

The Earth crust structure of the East Siberian continental margin by the results of integrated modelling of seismic, gravity and magnetic data

Savin V.A., Piskarev A.L., Butsenko V.V., & Poselov V.A.

savinvasily@rambler.ru

The problem of the Earth crust structure of the East Siberian continental margin is relevant in connection with the reconstruction of the Arctic evolution and the delimitation of the outer continental shelf limits. Weak and uneven study leads to ambiguity and controversy of the proposed structure models of the region. Further progress to solve this problem is possible through a joint interpretation of all factual data.

In the present research, the Earth crust structure has been studied by numerical modelling on the basis of solving forward and inverse problems of gravity and magnetometry in 2D and 3D formulation. The modelling technique allowed limiting geometry of boundaries and properties of crustal layers based on the MCS and DSS data, as well as taking into account multi-parameter petrophysical information about rheological, density and magnetic properties of the crust.

The diagnostic features of the main Earth crust structural elements have been identified on the basis of an integrated analysis of heterogeneous geophysical data. The 2D crustal models of the region were constructed for three possible types of passive continental margins: magma-rich, magma-poor and mantle exhumation. The model testing demonstrates that the factual data best correspond to the model of the hyperextended passive continental margin of the magmatic-rich type for the most part of the studied region.

The crustal structure of Lomonosov Ridge, Marvin Spur and Alpha Ridge

Thomas Funck & John Shimeld

tf@geus.dk

The 2016 Canada-Sweden Polar Expedition acquired seismic reflection and refraction data to increase the understanding of the tectonic evolution of the Arctic Ocean. The expedition was part of the Canadian UNCLOS program and utilized two icebreakers: the Swedish Oden and the Canadian Coast Guard Ship Louis S. St-Laurent. For the refraction work, sonobuoys and on-ice seismometer stations were used. Results from five lines are presented here: two transects across Lomonosov Ridge, two lines on the northern flank of Alpha Ridge and one profile on the crest of Marvin Spur. Velocity models for the crust were developed by forward modelling of travel times, supplemented by gravity modelling to provide better control on deeper structures, in particular the Moho depth. The two lines on Alpha Ridge reveal a velocity structure that is compatible with other refraction data from the ridge. The crust is up to 18-km-thick with velocities >6.8 km/s in the lower crust. On Marvin Spur, a double reflection supports the presence of a high-velocity lower crust with a Moho depth of 23 km. Lower crustal velocities are 6.3 km/s in support for a continental affinity of the spur. The models for Lomonosov Ridge show a magmatic intrusion into the continental crust on one line, in support for a local HALIP-related overprint of the ridge. In the continent-ocean transition towards Amundsen Basin, a zone with rather smooth basement and velocities of 5.2 km/s is interpreted as highly serpentinized and exhumed mantle, questioning interpretations that seafloor spreading started at Chron C25.

Continental Affinities of the Alpha Mendeleev Ridge

Ruth Jackson, Deping Chain, & John shimeld

ruth.jackson@canada.ca

The origin of Alpha-Mendeleev Ridge has been an enigma. Many theories on the Ridge's tectonic evolution have been postulated since 1935 with insufficient information to test them. In the last decade significant new data sets have been acquired including geophysical data, geological samples and improved onshore/offshore geologic mapping that aid in clarifying the Ridge's origin. The velocities and thickness of crust from refraction data and large amplitude magnetic anomalies indicate the Ridge is a large igneous province that can have either a continental or an oceanic origin. Comparisons based on topography, magnetics and pseudo-gravity indicate it is most similar to the Kerguelen Plateau. This plateau is part of a large igneous province known to include continental crust. A seismic refraction profile across the Chukchi Borderland, a continental fragment, and the less understood Mendeleev Ridge recorded shear waves on ocean bottom seismometers. Poisson's ratios indicative of both an upper and lower continental crust were determined. On the Nautilus Spur of the Alpha Ridge expendable sonobuoys recorded clear converted shear waves also consistent with continental crust. The circum-Arctic geology of the small polar ocean provides compelling evidence of a long-lived continental landmass north of the Sverdrup Basin in the Canadian Arctic Islands and north of the Barents Sea continental margin. The geophysical data, onshore geologic constraints and sparse geological samples are consistent with a large igneous province enveloping continental crust.

Heat flow measurements from central Arctic Ocean – considering the seafloor to the mantle

Grace E. Shephard, Steffen Wiers, Evgenia Bazhenova, Lara F. Pérez, Luz María Mejía, Carina Johansson, Martin Jakobsson, Matt O'Regan

grace.shephard@geo.uio.no

Constraints on the tectono-thermal evolution of the Arctic Ocean are hampered by notably sparse heat flow measurements. Previous results from the submerged continental fragment of the Lomonosov Ridge, and the adjacent oceanic seafloor of the Amundsen Basin, reveal variable magnitudes, including those higher than expected considering plate cooling or simple uniform stretching models. New heat flow results gathered from 17 sediment cores acquired during the "Arctic Ocean 2016" and "SWERUS-C3" expeditions are presented. Three sites located in the Amundsen Basin reveal heat flow of 71-95 mW/m2, in line-with or slightly higher (1-21 mW/m2) than expected from oceanic heat flow curves. These values are substantially lower those of another study that found 104-127 mW/m2 on similarly aged oceanic crust in the Amundsen Basin. A slow upper mantle seismic anomaly in the vicinity of the North Pole might explain some of this discrepancy. Sites from the Lomonosov Ridge and Marvin Spur recovered heat flow in the order of 53-76 and 51-69 mW/m2, respectively. When considering the potential enhanced surface heat flux from radiogenic heat production in the crust, these variable measurements are broadly in line with predictions from uniform extension models for continental crust. The regional complexity highlights the difficultly in disentangling temporally and spatially evolving crustal, lithospheric and mantle processes to present-day surface heat flow measurements.

Improving the Arctic Gravity Project grid and making a gravity anomaly map for the State of Alaska

Bernard Coakley, James Beale, Rose Gabbert & Monica Youngman

bjcoakley@alaska.edu

Incremental improvements to the Arctic Gravity Project (AGP) grid have accumulated through the steady acquisition of marine gravity anomaly data in the Arctic Ocean and, largely, due to the addition of airborne surveys over land. The explosion of data collected to establish the Extended Continental Shelves of the Arctic coastal states has quite substantially increased the available data in and around the Arctic Ocean.

A consistent issue with the AGP grid has been a very irregular distribution of gravity anomaly data in Alaska. While parts of the state have been well-surveyed (e.g. the North Slope) much of this remote region has not. Access is difficult. Control points for gravity ties are non-existent. As a result, the anomalous field for Alaska has not been well determined.

This may be changing due to the extensive airborne survey conducted by the US National Geodetic Survey as a part of their effort to redetermine the geoid for all US Territory. Nearly all of Alaska has been flown at ~6 km elevation with a 10 km line spacing as a part of the GRAV-D project. These data have been collected by a single group, using consistent procedures and the same equipment. As a result, these data form the basis for a new gravity anomaly map for the State of Alaska.

Using the new data, both at sea and collected through the GRAV-D project will substantially improve knowledge of the gravity field. All of the new data will be included in the updated AGP grid, which should be available in a year, updating the last release from 2008.

Mapping the entire Arctic Ocean by 2030: Is it possible?

Martin Jakobsson, Larry A. Mayer, Caroline Bringensparr, Rezwan Mohammad, & Paul Johnson

martin.jakobsson@geo.su.se

The General Bathymetric Chart of the Oceans (GEBCO) and the Nippon Foundation have jointly established the Nippon Foundation - GEBCO Seabed 2030 Project, with the goal of facilitating the complete mapping of the World Ocean floor by 2030. The project is based on globally distributed Regional Data Assembly and Coordination Centers (RDACCs), each assigned the responsibility for a region of the World Ocean. The Arctic and North Pacific Oceans fall under an RDACC established as a shared center between Stockholm University and the University of New Hampshire; the work of the International Bathymetric Chart of the Arctic Ocean (IBCAO) will now be part of Seabed 2030. The most recently released IBCAO Ver. 3.0 is a gridded digital depth model with a cell-size of 500 x 500 m. Estimates of how much of the Arctic Ocean has been mapped are based on counting the grid cells that contain bathymetric data. In Ver. 3.0 approximately 11 % of the cells contain multibeam bathymetry. Seabed 2030 has adopted a depth-dependent target resolution scheme (depth range/target grid-cell size): 0-1500 m/100 m; 1500-3000 m/200 m; 3000-5750 m/400 m; 5750-11000 m/ 800 m. This implies a higher gridding resolution for most of the Arctic Ocean than in the previously released IBCAO versions. In this presentation, the Seabed 2030 project will be outlined with a specific focus on the North Pacific-Arctic Ocean. The current status of data coverage at the higher Seabed 2030 target resolutions will be shown.

POSTERS

Surficial geology of the Amerasian Basin from sub-bottom profiler data

Kai Boggild, David Cole Mosher, Catalina Gebhardt, Martin Jakobsson, Larry Mayer, Matt O'Regan, Kelly Hogan, & Dayton Dove

martin.jakobsson@geo.su.se

International research efforts of the past decade have led to a multi-fold increase in the quantity of marine geophysical and geological data holdings in the high Arctic. There is now sufficient subbottom profiler, multibeam and seafloor sample data in many regions to map the surficial geology and provide it as a layer to compliment the International Bathymetric Chart of the Arctic Ocean (Jakobsson et al. 2012). Such additional information provides a resource for collective analysis of the morphology and geology of the Arctic seafloor, and has a variety of applications including environmental assessment, habitat mapping, geohazard identification and oceanographic and geologic process studies. Acoustic facies derived from subbottom profiler data form the foundation of this surficial geology map. More than 140,000 km of subbottom profiler data are now interpreted and mapped in the Amerasian Basin. Additionally, gridded single beam and multibeam echosounder data help define geologic boundaries. Mapped acoustic facies reveal the distribution of sediment types and associated processes in the region, such as extensively ice-scoured shelves; debris flows and fan deposits along continental margins; and drifts, bedforms, and deep-sea channel systems in the Canada abyssal plain. Here we present the acoustic facies used for classification and the current extent of mapped surficial units in the Amerasian Basin

The sedimentary cover structure of the East Siberian Shelf by the results of 3D gravity modelling

Savin V.A. and Piskarev A.L.

savinvasily@rambler.ru

The two 3D models of the Earth crust have been constructed covering the Laptev Sea and the eastern part of the East Siberian Sea. Factual data included the MCS data collected by expeditions BGR, MAGE, SMNG, DMNG and etc. in 1986-2016 (more than 150 lines). This made it possible to study in detail the structure of the sedimentary cover.

Based on modelling results the thickness map of the sedimentary cover has been detailed, the geometry of sedimentary sequences has been studied, the boundaries of sedimentary basins have been clarified and a scheme of the sedimentary cover has been drawn. A system of Late Mesozoic – Cenozoic continental rift, post-rift basins and individual Late Mesozoic synorogenic basins have been noted within the East Siberian Shelf.

Several stages of Late Mesozoic – Cenozoic rifting have been indicated in the sedimentary cover structure of the region. The following stages of sedimentation within the Laptev Sea are distinguished: Early – Late Cretaceous, Paleocene – Eocene, Oligocene – Early Miocene and Late Miocene – Quaternary. The Early Mesozoic (?), Early – Late Cretaceous, Paleocene – Eocene and Oligocene – Quaternary stages have been distinguished within the East Siberian Sea.

The stages of sedimentation correspond to the phases of formation the deep-water basins of the Arctic Ocean. Comparison of the phasing and zonality of rifting processes on the East Siberian Shelf indicates their close spatiotemporal connection with the processes taking place in the deep-water part of the Arctic Ocean..

Testing Contrasting Hypotheses for the Early Eocene Origin of North America's Pacific subarctic Margin—the Aleutian Subduction Zone and its backarc Aleutian Basin

David W. Scholl, R. J. Stern, G.A. Barth, D. Scheirer, M. Malkowski, & J.A. John

dscholl1934@gmail.com

INTRODUCTION: In the E. Eocene (50-55 Ma) major plate boundary reconfigurations occurred in the Arctic Basin and also in the subarctic north Pacific, e.g., the seaward shift of the convergent North American-Kula plate boundary from the Beringian continental margin (BCM) to the offshore Aleutian Subduction Zone (ASZ), arc (AA), and backarc Aleutian Basin (BAB). Two hypotheses have been proposed to explain this new plate-boundary arrangement:

1) A large sector ~0.5 x10^6 km^{2}) of Mesozoic oceanic plate accreted to the North American plate forcing the offshore creation of the ASZ, AA, and BAB.
2) The BAB formed in-place by backarc spreading behind a seaward migrating ASZ away from the BCM.

CONSTRAINING OBSERVATIONS:

1) The Eoc AIA is a westward extension of the Alaska Peninsula constructed of Permo-Triassic arc basement.
2) Paleomagnetic data attest that wrt Alaska the AA formed in place.
3) The ASZ is a western continuation of the Permo-Triassic Alaska SZ.
4) The BAB exhibits a prominent pattern of ~N-S-striking magnetic anomalies of unknown age trending ~normal to that of the ASZ.

HYPOTHESIS TESTING: IODP drilling has been proposed to test both premises by sampling ABB basement at the summits of sediment-buried seamounts. Basement and deepest sediment samples will determine edifice age, paleolatitude of formation, and formative setting. This information will determine if BAB basement is (1) an accreted sector of Mesozoic Pacific crust, or (2) Eocene crust formed by backarc spreading. These results will identify the tectonic setting that birthed the Aleutian SZ.

Seismostratigraphy and tectonics of Podvodnikov Basin and shelf of the East Siberian Sea

N. N. Zhukov, A. M. Nikishin, and E.I. Petrov

n.zhukov@ginras.com

New results of detailed study of deep-seated structure are presented for the Podvodnikov Basin. Interpretation of seismic lines in network over the East Siberian Sea is accepted to be a work basis. Two main stages of seismic complex formation—synrifting and postrifting—are distinguished in section of sedimentary cover. One phase of synrifting, whose boundary is traced at Aptian–Albian, has been established. The unconformity dated at Cretaceous–Paleogene in the East Siberian Basin is caused by two factors: completion of synrifting and superposition of deformations related to strike-slip shearing and compression.

The Podvodnikov Basin was formed in Aptian–Albian, being related to coeval onset of rifting, which is dated close to age of basalts from De Long plateau. An age of rifting–post-rifting is dated conditionally, as a boundary between Early and Late Cretaceous. Since the Late Cretaceous, the Podvodnikov Basin has gradually undergone a thermal post-rifting submergence. Clinoforms have been identified in postrifting sedimentary cover. The history of their formation may be preliminarily divided into three stages: (i) Paleocene–Eocene, whose sole serves as boundaries of (ii) Cretaceous–Paleogene unconformity; (iii) Eocene–Pliocene or Pliocene–Quaternary.

A strongly extended and flattened continental crust is suggested for the Podvodnikov Basin. This is followed from typical rift structures at the base of section. Rifts with such geometry and synrift sediments are typical for continental rifting.