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Abstracts

Abashev, Victor

Paleomagnetism and Geochronology of Flood Basalts from the Franz Josef Land Archipelago

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At present, views on the evolution of magmatism in the Franz Josef Land (FJL) archipelago are reduced to two points of view – either the short-term one-stage formation of a large igneous province at the beginning of the Cretaceous, or the effect of a long-lived hot spot from the Early Jurassic to and including the Early Cretaceous with several brief pulses of magmatic activation. Our paleomagnetic studies indicate a total prevalence of products of an exclusively Early Cretaceous episode of magmatism. The calculated virtual geomagnetic poles form a single "cloudy" distribution with its center shifted towards the Early Cretaceous paleomagnetic poles of Siberia. Analysis shows that the main reason for the significant variation of the poles is the high latitude position of the FJL and the secular variations of the geomagnetic field, and not the difference in the age of magmatism. The coincidence of the mean paleomagnetic pole of the FJL traps with the Early Cretaceous (145–125 Ma) apparent polar wander path interval of Siberia, rather than Eastern Europe, confirms the hypothesis of Mesozoic strike-slip activity inside the Eurasian continent. Isotopic-geochemical studies of FJL basalts, which are presumably different in age, indicate a single intraplate source of melts during the formation of the FJL traps. Our new $^{40}Ar/^{39}Ar$ data support one Early Cretaceous episode of magmatic activation. The exceptional predominance of normal polarity indicates that the peak of magmatism occurred at the end of the Barremian (chron M1) – Aptian, i.e. corresponds to the beginning of the Cretaceous superchron (C34n) about 125 Ma. The obtained estimates of the geological age and paleolatitudinal position (N 63°) of the FJL traps allow us to consider this area of plume magmatism as part of the High Arctic Large Igneous Province and to link its formation with the evolution of the modern Icelandic hot spot.

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Akinin, Vyacheslav

Magmatism in North Eastern Russia: An Update and Overview

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Precise U-Pb, $^{40}Ar/^{39}Ar$ and K-Ar ages and geochemistry now provide a robust basis for an accurate description of magmatism across NE and Arctic Russia. GIS and GEOCHRON 2.0 (690 records) help define its space-time variation. Pre Mesozoic magmatism mapped and dated mostly in Omolon and Omulevka-Prikolyma terrains. The most voluminous magmatism occurred in the late Mesozoic concurrent with subduction of Pacific plate(s) and rifting in the Arctic. The Late Jurassic (~153-147 Ma) Main Kolyma Belt batholithic magmas of the Verkhoyansk fold-belt are calc-alkaline Andean-style granitoids. A new interpretation suggests they originated in a back arc setting with respect to the Uyandino-Yasachnaya arc. Northern Belt granitic plutons are younger (135-120 Ma). The E-W part of the "Kolyma loop" they define might be due to right-lateral transform motion that displaced Chukotka and Arctic Alaska east with respect to the Verkhoyansk fold-belt. The Late Jurassic Uda-Murgal arc reflects the beginning of active Pacific arc development and onset of construction of the North-Eastern Asia margin. Voluminous magmatism

occurred across Chukotka and Alaska in the Cretaceous (125-100 Ma) when syn-extensional calc-alkaline granitoids intruded. These are distinct from coeval subduction-related magmatism located further south in Russia along the Pacific margin. Syn-extentional plutons may be linked to the plate tectonic events that reconfigured the Arctic. Along the Taigonos and Okhotsk part of margin (south), periods of shortening and magmatism are related to subduction beneath the continent. The position of these belts shifted little through time compared to the magmatic belts of Verkhoyansk-Chukotka-Alaska. Voluminous calc-alkaline magmas of the Okhotsk-Chukotka volcanic belt (OCVB) erupted in a neutral to slightly extensional tectonic regime at ~106 to 76 Ma. Northern circum-Pacific magmatism stepped south between 80-60 Ma to the Bering Shelf margin and then to the Aleutians before ~46 Ma trapping the Aleutian Basin and to Kamchatka (pre-55 Ma) opening the Sea of Okhotsk. Comparison of Cretaceous magmatism in NE Russia and Alaska with the Cordillera shows pronounced differences in tectonic setting. For example, from 125 to 60 Ma the Cordillera experienced Andean-style orogenesis.

Alvarez, Román

Subduction of the Rivera Plate Under North America Induces Rifting at the NW and SE Boundaries of the Jalisco Block

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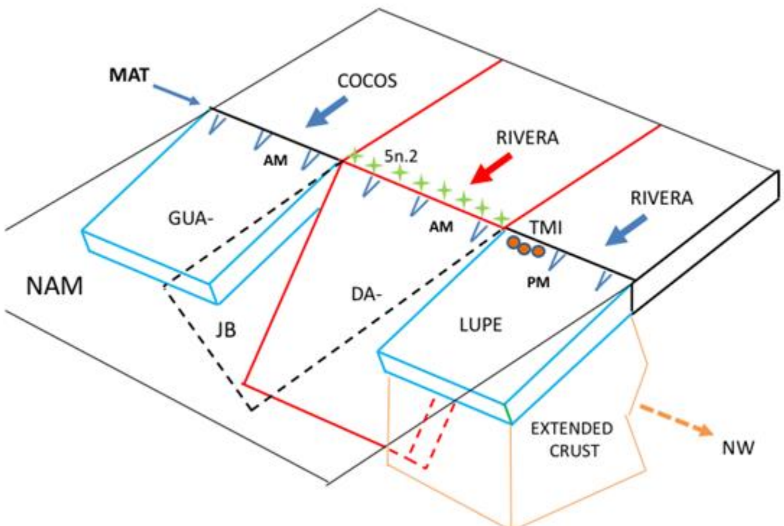
Previous seismological studies established that at the boundary between the Rivera and Cocos plates subduction angle changes from ~32º (Cocos) to ~55º (Rivera). Seismology does not provide reliable information in the NW sector of the Rivera plate owing to a strong decrement in seismicity. However, magneto-telluric and seismic tomographic determinations indicate that, in the NW sector, the plate continues to subduct at steep angles (50-60º), even registering a full roll-back (~85°) of the plate in the Bahía de Banderas region. Continuing to the NW in the San Blas basin, there is a wide-angle reflection survey that indicates the Rivera plate subducts at an angle ~30°. Therefore, the section of the Rivera plate corresponding to the Jalisco block appears to have rolled-back from an original subduction angle of 30º to the present 55° angle. The figure shows the area of the Jalisco block (JB), and the corresponding section of the subducted plate under North America (NAM), subducting at a greater angle than the neighboring sections. This suggests that the plate preceding the Rivera plate (Guadalupe plate) subducted uniformly at an angle of 30°, until the section corresponding to the JB started to roll-back. The plate roll-back in the Jalisco block region is supported by the SW migration of the volcanic front, parallel to the Middle America Trench (MAT), constituting the Central Jalisco Volcanic Lineament. Rifting at the SE and NE boundaries of the Jalisco block is manifested as a series of graben and half-graben structures; the existence of the NW limit however, has been debated for some time. Recent magneto-telluric, gravity, and vertical gravity gradient determinations allow to clearly defining this boundary that includes the Bahía de Banderas region, up to a newly proposed Compostela Triple Point. TMI, Tres Marías Islands. AM, Active margin. PM, Passive margin. Green stars: present location of Chron 5n.2 (9.9 Ma); this appears to be the trench-parallel boundary between the Rivera and Guadalupe plates.



Anfinson, Owen

Provenance analysis of the Devonian Andrée Land Basin, Svalbard

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The paleogeographic location of Svalbard in the Devonian represents an important component in understanding the tectonic and magmatic evolution of the Late Paleozoic Arctic more broadly. Here we present new provenance data, including detrital zircon U-Pb ages, collected from the stratigraphically well-constrained Mimerdalen section of Spitsbergen. Recent research has established the structural and depositional context of the Old Red Sandstone (ORS) within the south-easternmost part of the Andrée Land Basin and provides a unique opportunity to assess the

provenance of these sedimentary deposits. Detrital zircon U-Pb age results from the Pragian Wood Bay Formation through to the Famennian Plantekeløfta Formation help constrain the relative paleogeographic position of Svalbard during the Devonian. In addition, detrital zircon U-Pb age data previously collected from the North American and Russian Arctic from Late Paleozoic strata provide a framework to compare results from the ORS to better understand the overall tectonic and magmatic evolution of Svalbard. At the timing of abstract submission, the U-Pb ages have not yet been acquired, but these ages will be obtained prior to presentation.

Bar Rasmussen, Maja

Tilting of a bimodal Icelandic mantle plume as revealed by olivine trace element chemistry

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Ocean Island Basalts sample a chemically heterogenous mantle. However, the characteristics and cause of the heterogeneity remains unsure. Olivine with high Fo content (high Mg to Fe ratio) is an ideal proxy for characterising the compositions of primary melts and their mantle sources. Indeed, many studies have used olivine for evaluating chemical mantle heterogeneity (e.g., Sobolev *et al.*, 2007; Howarth & Harris, 2017; Søager *et al.*, 2015). However, such studies often lack regional coverage in Iceland which limits the spatial resolution. We present a study on 52 set of high-forsteritic olivine from the neovolcanic rift and flank zones, as well as Tertiary crust in Iceland using *in-situ* measurements of minor and trace element compositions. The olivine range in Fo content from $Fo_{79.9}$-$Fo_{91.8}$ and are spatially clustered following regional and rift versus off-rift variations. Trace element ratios suggests a peridotitic source lithology dominating rift-related volcanic regions, Öræfajökull and Snæfellsness, while a stronger pyroxenitic (a result from the incorporation of a subducted oceanic crust at depth) signal is captured in olivine from the propagating rift zone in South Iceland. By combining the trace element result in Icelandic olivine and previously analysed $^{3}He/^{4}He$ of the same samples (up to 47.8 R_A, Harðardóttir *et al.*, 2018), we see that olivine with low Mn/Zn and high Ga/Sc values, indicative of a dominating pyroxenitic source, have high $^{3}He/^{4}He$. This suggests, that the pyroxenite is entrained in a primordial component, which is a good candidate for the Icelandic plume. However, high $^{3}He/^{4}He$ values are also present in olivine with chemistry indicative of a peridotitic lithology, suggesting a bimodal nature of the plume. These results are best explained by a southward tilting plume with the head located beneath central Iceland. The high degrees of melting occurring at the head overprints deeply derived traces of the pyroxenite, while the low-degree melting occurring in a propagating rift, such as South Iceland could preserve pyroxenitic-inherited traces, possibly sampled deep in the plume stem. This model is supported by tomographic studies (Shen *et al*., 2002) and have also been proposed for the Hawaiian plume, suggesting that this could be a common reason for lithological variations beneath ocean islands.

Bedard, Jean

HIGH ARCTIC LARGE IGNEOUS PROVINCE MAGMATISM IN CANADA: GEOCHEMICAL AND PETROLOGIC CONSTRAINTS ON PETROGENESIS

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The Canadian HALIP is hosted by sedimentary rocks of the Sverdrup Basin. Existing age data show two main older HALIP tholeiitic pulses (128-120 Ma), with a younger tholeiitic-alkaline pulse (103-78 Ma). Published data were combined with 315 new analyses in this synthesis. Evolved tholeiitic to transitional-alkaline basalt and basaltic andesite compose older volcanic pulses (extrusive Isachsen and younger, similar, Strand Fiord Fm.) and correlative intrusives, with variable but generally low L/HREE indicating melting of spinel lherzolite. Detailed sampling of the main Strand Fiord sequences shows no systematic stratigraphic variation. Similarly, dense sample traverses of correlative sill or dyke swarms show random scatter of geochemical indicators. Isotopic data (Nd, Sr) suggest many HALIP magmas experienced low degrees of crustal contamination. Sulphur isotope data also commonly show crustal signatures, but detailed study of the Hare sill (confirmed by petrological experiments) implies gas transfer from contact-metamorphosed mudrocks and siltstones enriched in organic carbon and sulfur was an important S-contamination mechanism. Petrographic data on typical sills and dykes show the near-ubiquitous presence of complex antecrysts, some recording evolution of more primitive roots to the magmatic stem. Mineral data imply that the overall geochemical evolution is not due to simple closed system fractionation processes acting on a primitive parent, but reflect multiple mixing and recharge events in lower crustal reservoirs prior to final ascent. Younger alkaline lavas (Hassel and Hansen Point Fms), dykes and sills show marked concentrations at the northern rim of the basin and in a belt trending across central Ellesmere and southern Axel Heiberg Islands. The presence of the southern belt is consistent with proposals for an inherited rift. Alkaline magmas show HREE-depletion indicating melting in the garnet field, possibly of more enriched lithospheric sources. All of the alkaline series include high- and low-P_2O_5 members (HP vs LP). HP magmas tend to have higher Eu and Ba contents and to be more alkaline than LP magmas. Correlations of P_2O_5 with Zr, TiO_2 and K_2O are typically poor, however, suggesting a heterogeneous distribution of trace mineral phases during low-degree melting of a veined source.

Beier, Christoph

Geochemical Constraints on Plume-Ridge Interaction along the Southern Kolbeinsey Ridge

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Geochemically enriched intraplate mantle sources situated close to the depleted mantle upwelling underneath mid-ocean ridges emplace unique tracers with which the sources and their melting processes in these two juxtaposed geodynamic environments can be traced. The Arctic Kolbeinsey Ridge, extending north of Iceland, is one of the classic regions of such plume-ridge interactions. Here, we present new major element, trace element and Sr-Nd-Pb isotope data of glasses from the 290 km long southernmost Kolbeinsey Ridge segment and its southern boundary to Iceland, the Tjörnes Fracture Zone, along with published data from the northernmost Iceland volcanoes. Along the southern Kolbeinsey Ridge, trace element (e.g., $(La/Sm)_N$, Nb/Zr, K/Ti) and Sr-Nd isotope signatures generally decrease from enriched intraplate signatures in northern Iceland to mid-ocean ridge like signatures at the northern segment end. On a smaller spatial scale, we can show that the incompatible element and isotope variability along the southernmost 25 km of the Ridge is similar to that at the Tjörnes Fracture Zone and Theistareykir volcanoes. Much of the variability of the southernmost Kolbeinsey Ridge segment cannot be explained by simple mixing of melts and the peculiar enrichment and variability of trace element compositions can also not be explained by simple changes in the degree (e.g., $(Ce/Yb)_N$) or depth ($(Dy/Yb)_N$) of partial melting. Estimating the variability of degrees of partial melting

using fractionation-corrected major elements (Ca_8, Na_8, Al_8) shows that the degrees of partial melting generally exceed 10-15%, too large to sufficiently fractionate the incompatible element ratios. Instead, we propose a model in which the geochemical mantle heterogeneity between the plume and Kolbeinsey MORB asthenosphere is preserved in melts rising along the Tjörnes Fracture Zone and the slower spreading sections of the southernmost Kolbeinsey Ridge segment. We conclude that even in plume-ridge environments in which a relatively strong mantle plume interacts with a slow spreading center (<20 mm/a), structural crustal features may provide sufficient pathways to preserve much of the original signature of mantle heterogeneity whereas melts may more efficiently homogenized along the central parts of the spreading axis.

Berglar, Kai

Structure of the NE Greenland sheared margin

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In the course of BGR's GREENMATE project the northern and north-eastern shelf of Greenland was surveyed in August/September 2018 using R/V Polarstern. We collected reflection seismic data north of 84°N at the southern tip of Morris Jesup Rise and on the northeastern Greenland shelf area between 76°N and 82.5°N using a 3-km-long streamer.

In Paleocene to Eocene time seafloor-spreading occurred in Labrador Sea and Baffin Bay and in addition seafloor-spreading in the North-Atlantic occurred from chron C24 onward (Jackson and Gunnarson, 1990; Tessensohn and Piepjohn 2000). A relative northward movement of Greenland with respect to Eurasia took place in the Palaeogene resulting in compression/transpression affecting the region of northern Greenland and Svalbard. Later in the Oligocene, seafloor spreading in the Eurasia basin separated the Yermak Plateau and Moris Jesup Rise. Our working hypothesis is that the volcanism, which is manifested in Yermak Plateau and Morris Jesup Rise is related to the strike-slip movements during Paleocene break-up phase. The question arise how far the transpression/compression that originated by the northward movement of Greenland extended to the North.

A first interpretation of preliminary multi-channel seismic data indicates a segmented oceanic domain with transtensional terrace-like features along the sheared margin between 76°N and 82.5°N. The outer shelf shows a zone of compression/transpression possibly defining the position of the major strike-slip fault dividing Greenland and the Barents shelf prior to the opening of the Fram Strait. Further to the north, at the southern tip of Morris Jesup Rise, the basement is slightly inclined landward and shows no major fault zones compared to the southern profiles, which coincides with results from the Yermak Plateau (Berglar et al., 2016).

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Biasi, Joseph

Rapid and Frequent Flood Basalt Eruptions: Evidence from the North Atlantic Igneous Province and the Columbia River Basalts

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While significant progress has been made in recent years to understand the timing of flood basalt generation, it remains extremely difficult to constrain how long individual flood basalt eruptions last. Eruption duration has major implications for the geochronology, melt transport, melt generation, and climatic consequences of flood basalt events. Here we present results from Columbia River Basalts (CRB) and North Atlantic Igneous Province (NAIP) lavas from Baffin Island. To constrain the timescales of flood basalt eruptions, we used magneto-thermometry on six CRB dikes. This technique exploits the magnetic properties of wall rock to constrain the maximum temperatures that are reached when heated by a dike or other intrusion. We then combine these results with a 1D thermal conduction model to estimate a ‘lifetime’ of the dike. This method can be used for igneous dikes of any width, and in any host rock. This method can also distinguish individual thermal pulses from composite dikes. Our results suggest that shallow CRB dikes feeding eruptions of 500-1000 km^3 have a lifetime of less than two years. We also present paleomagnetic results from the NAIP. We found that all of the NAIP flood basalts on Baffin Island have a normal polarity, and show minimal secular variation. They were likely emplaced during the C27n chron, and likely correlate with the Anaanaa Member in West Greenland. These results suggest that the basalts were emplaced in much less than 300 kyr. Rapid and frequent eruptions of flood basalt would emit volatiles into the atmosphere at a rate that would overwhelm typical carbon/sulfur sinks. This provides a highly plausible explanation for major climate disturbances that coincide with the emplacement of flood basalts, such as the K/Pg and P/T boundaries.

Blischke, Anett

Tectono-magmatic evolution of the Jan Mayen microcontinent and Iceland plateau

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We revisit the tectonostratigraphic history and igneous provinces related to the development of the Jan Mayen microcontinent (JMMC) and the Iceland plateau rift (IPR) within the central NE Atlantic. Vintage and newer geological and geophysical data (1960–2017) were analysed, specifically seismic reflection and refraction line data, jointly interpreted with gravity, magnetic, multibeam, and igneous rock sample data. The JMMC–IPR portray the complexity of long-lived, active volcanic margins within an unstable rift-transfer setting, exhibiting both lateral and vertical crustal accretion. Overlapping ridge segments developed within an oblique rifting system during Eocene to Early Miocene. Eleven Cenozoic seismic-stratigraphic units, separated by ten locally varying unconformities and disconformities were identified. Six of them represent regional unconformities tied to distinct tectono-magmatic phases interlinked to

igneous centres either side along the JMMC that affected the central NE Atlantic prior to formation of Iceland: (1) Initial breakup phase, anomalous magmatic activity, rupturing overlying lithosphere along SW-NE striking, pre-existing fracture zones (~63-56 Ma); (2) Syn-breakup, formation of seaward dipping reflectors along the JMMC eastern margin from north to south during Early Eocene, a pre-curser to the Ægir ridge (55-52 Ma); (3) SE to NW rift propagation from the Greenland-Iceland-Faroe ridge complex into the JMMC domain within IPR-I and IPR-II segments, creating an overlapping spreading system with the southern Ægir ridge (49-40 Ma); (4) Formation of IPR-III segment and the Jan Mayen southern ridge complex. Extension within the Jan Mayen trough and separation from the main Jan Mayen ridge (35-25 Ma); (5) Final breakup and proto-Kolbeinsey ridge formation, western igneous margin of the JMMC and western Jan Mayen fracture zone (25-21 Ma); (6) Full separation along the JMMC western margin and the Kolbeinsey ridge (since 21 Ma). Tephra within Neogene deep marine sediments are likely sourced from both active volcanic systems, Iceland and the Jan Mayen Island igneous complex. The region represents a unique area of tectono-magmatic interactions, reactivation of pre-existing structural complexes, influenced by mantle anomalies and rift relocations and overlapping systems.

Boyes, Xenia

Characterising a new suite of Baffin Island lavas

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The Paleocene-aged sequence of basalts that outcrop along the southeastern coast of Baffin Island are geologically famous for having the highest measured 3He/4He ratios of any terrestrial rocks, up to 50 Ra (where Ra is the atmospheric 3He/4He), much higher than the canonical 8 Ra of mid-ocean ridge basalts (presumed to sample the upper mantle). This He is probably derived from a mantle reservoir with more primordial 3He—because it is less degassed—than the convecting upper mantle. Understanding the source of this signature is paramount in understanding both planetary evolution and the efficiency and pattern of current mantle convection.

A new suite of in-situ basaltic samples traversing the submarine-to-subaerial transition in Baffin Island lavas were collected in the summer of 2018; we are carrying out He and heavy noble gas isotope-ratio measurements on these samples. To support the He data and to better ascertain the mantle origin of these basalts and any crustal-level fractionation, assimilation, or alteration processes they may have experienced, a full characterisation of this new suite of samples is being performed. This includes whole-rock major and trace element analysis (XRF and solution ICP-MS), phase analysis (EPMA), and determination of the oxidation state of both submarine pillow-rim glass and glassy olivine-hosted melt inclusions through the measurement of $Fe^{3+}/\Sigma Fe$ (XANES). The results of these analyses are interpreted using petrologic tools such as PRIMELT3 and MELTS to compute the primary liquid composition and liquidus temperature, to estimate the potential temperature of the source, and to bracket the pressure range of melting and melt extraction. Preliminary bulk rock analysis run through PRIMELT3 to obtain primary melt estimates give an average MgO content of 18 wt. %, mean potential temperature of 1511 °C, liquidus olivine Fo91.7, and 27.1% melting of a fertile peridotite source with residues of mostly harzburgite.

Brandsdóttir, Bryndís

Asymmetric plume-ridge interaction around Iceland: Results from the Kolbeinsey Ridge Iceland Seismic Experiment

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The opening of the N-Atlantic at 54 Ma was accompanied by excess magmatism marked by thickened igneous crust and extensive subaerial volcanism. Variations in lower crustal structure along the 700-km-long KRISE7 refraction/reflection and gravity profile, straddling 66.5N across the Iceland Shelf, Iceland Plateau (IP), and western Norway Basin (NB), confirm that extinct spreading centers coexisted with the now abandoned Ægir Ridge (ÆR) prior to the initiation of the Kolbeinsey Ridge (KR). The western 300 km of the profile formed by rifting at the KR, whereas the eastern 400 km formed at the ÆR and IP, possibly containing slivers of older oceanic or continental crust rifted off the central E-Greenland margin. Crustal thickness increases gradually across the Iceland shelf, from 12 to 13 km near the KR to 24–28 km near the eastern shelf edge, decreasing abruptly across the shelf edge, to 12–13 km. The IP crustal thickness ranges from 12 to 15 km decreasing to 5–8 km across the western NB and 4–5 km at the ÆR. Thickened crust along the IP indicates that the rift propagated along the continent-ocean transition of the former central E-Greenland margin under the influence of the proto-Iceland plume, simultaneously with the abandonment of spreading at the ÆR. The 225-km KRISE1 profile along the southern segment of the KR quantifies the present influence of the Iceland hot spot on seafloor spreading; crustal thickness decreases from 12–13 km to 9–10 km away from Iceland. At similar distances from the center of the Iceland plume, crustal thickness along the KR is 2–2.5 km less than at the Reykjanes Ridge (RR), consistent with the asymmetry in plume-ridge interaction inferred from the axial depth and geochemistry of these ridges. Topography and crustal thickness patterns at the spreading centers are consistent with isostatic support for normal crustal and mantle densities. However, we infer that the lower crust beneath central Iceland is considerably denser than that beneath the adjacent ridges. Crustal thickness and geochemical patterns suggest that deep melting is spatially limited and asymmetric about Iceland while shallow melting is enhanced over a broad region. This asymmetry may be due to a mantle plume that is tilted from south to north in the upper mantle and preferentially melts deeper enriched material beneath the RR.

Breivik, Asbjorn

Dynamic topography development north of Iceland from subaerial exposure and erosion of the igneous Logi Ridge

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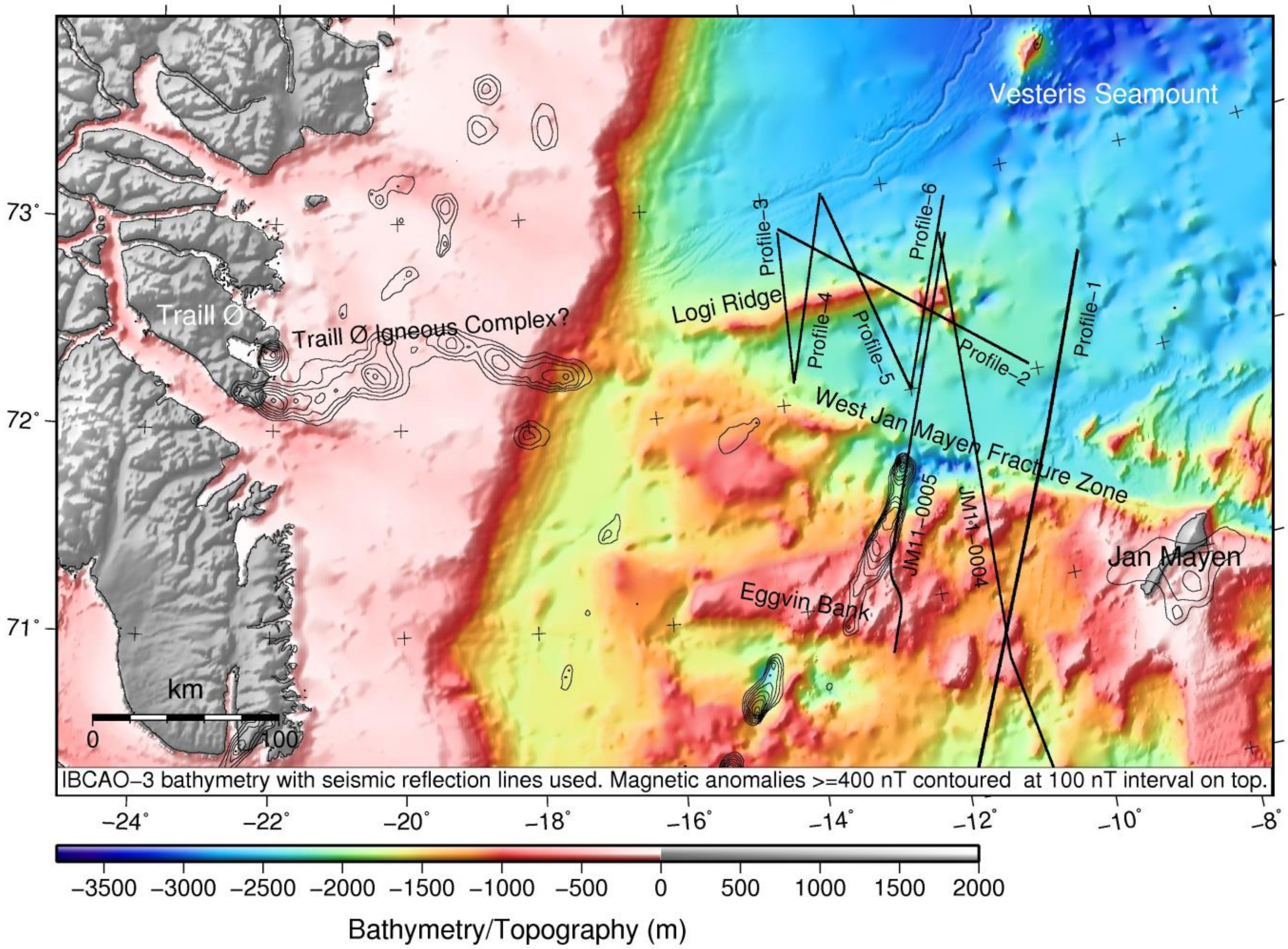
The Logi Ridge, located north of the West Jan Mayen Fracture Zone, is E-W oriented and 140-150 km long, terminating in an isolated seamount in the east. The seafloor surrounding the Logi Ridge is ~0.65 km shallower than conjugate seafloor east of the Mohn's Ridge, which has been attributed to dynamic uplift due to asthenospheric flow. Eight reflection seismic lines across the Logi Ridge constrain its development. Both the western and eastern parts have flat tops, indicating erosion at sea-level. Three different basement types surrounding the Logi Ridge are observed: rough basement represents abyssal hills; smooth basement caused by basalt flows overprinting early sediments; and irregular basement formed by basalt flows and intrusions. The surrounding sediments have two distinct units, where the age of the unit boundary is Middle Miocene (~12 Ma). Lava flows and erosion products from the Logi Ridge appears episodically in the lower unit throughout Late Oligocene to Middle Miocene. Ridge development may have started just after the Traill Ø intrusions were emplaced onshore Greenland. No erosion products are seen in the upper unit, proving Middle Miocene submergence. The end of erosion age can also be

estimated from seamount height, or present top seamount depth, using the age-dependent oceanic floor subsidence. The two methods have different sensitivity to parameters, which constrains uncertainty when compared. In the west there is good agreement with the age constrained by the sedimentation, proving little dynamic topography change. In the east, discrepancies between the methods are best explained by 0.15-0.3 km increase of dynamic uplift after submergence. Hence, most of the regional dynamic uplift occurred before the end of the Logi Ridge development in the Middle Miocene, suggesting a causative relationship. Minor recent magmatic growth and seafloor uplift over a ~100 km zone southeast of the Logi Ridge may be tied to the younger dynamic uplift in the east.



Brown, Eric

Constraining Mantle Source Conditions Beneath Iceland Using Markov Chain Monte Carlo Inversion

Eric L Brown[1], Kenni Dinesen Petersen[1] and Charles E Lesher[2], (1)Aarhus University, Department of Geoscience, Aarhus, Denmark, (2)University of California Davis, Department of Earth & Planetary Sciences, Davis, CA, United States

Basalts are generated by adiabatic decompression melting of the upper mantle, and thus provide spatial and temporal records of the thermal, compositional, and dynamical conditions of their source regions. Uniquely constraining these factors through the lens of melting is challenging, however, given that primary basalts are variable mixtures of melts derived from compositionally heterogeneous mantle sources consisting of a range of lithologies with different melting behaviors (e.g. peridotite vs. pyroxenite). To overcome these challenges, we have combined the Metropolis-Hastings Markov chain Monte Carlo sampling method with the forward melting model REEBOX PRO [1], which simulates adiabatic decompression melting of lithologically heterogeneous sources containing peridotite and pyroxenite. This coupling allows us to invert for mantle potential temperature (T_P), lithologic abundances and their initial trace element and isotopic compositions (and these parameters uncertainties), by identifying optimal models that produce the best fits to the observations. We have applied this combined methodology to magmatism along Reykjanes Peninsula in Iceland [2], exploring melting of depleted peridotite and an enriched peridotite/pyroxenite lithology (either KG1 pyroxenite, MIX1G pyroxenite, or G2 pyroxenite). Best-fit model sources have >90% depleted peridotite and <10% pyroxenite with T_P ~125-150 °C above ambient mantle. The enriched lithology has an EMORB-like trace element composition and the depleted peridotite lithology is similar to DMM [2] in terms of its trace element and Pb and Nd isotopic compositions. We now extend this modeling to magmatism in the Northern Volcanic zone at Iceland and relate variations in source composition and T_P to regional variations in lava composition.

[1] Brown & Lesher (2016); G^3, v. 17, p. 3929-2968

[2] Brown et al. (in review); EPSL

Capaldi, Tomas

Cordilleran magmatism and tectonic evolution of the western South American plate margin

Tomas N Capaldi[1], Brian K Horton[2], Ryan McKenzie[3], Chelsea Mackaman-Lofland[4] and Daniel F Stockli[1], (1)University of Texas at Austin, Department of Geological Sciences, Austin, TX, United States, (2)Univ of Texas at Austin, Austin, TX, United States, (3)University of Hong Kong, Hong Kong, Hong Kong, (4)University of Texas at Austin, Austin, TX, United States

Phanerozoic subduction along the western South American margin provides valuable insights into the temporal and spatial distribution of magmatism and associated isotopic patterns during major shifts in Cordilleran plate dynamics. Detrital zircon U-Th-Pb and Hf isotopic results throughout the continental arc systems of Chile-Argentina (28-33°S) are integrated with bedrock geochronology to define distinct spatial and isotopic trends synchronous with changes in continental margin configuration during (1) Cambrian to Ordovician terrane accretion, (2) mid-Paleozoic arc-cessation, (3) Carboniferous-Permian subduction initiation, (4) Permian-Jurassic continental back-arc rifting, (5) Cretaceous-Paleogene Andean retro-arc shortening, and (6) Neogene flat-slab subduction. The 550 Myr record of arc magmatism provides new constraints on radiogenic isotopic trends, patterns in arc tempo, and role of subduction angle on over-ridding plate processes. Magmatism east of -69 longitude exhibit radiogenic isotopic signatures indicative of reworked continental lithosphere with evolved (negative) εHf values, low (< 0.65) zircon Th/U ratios during phases of contraction. In contrast, magmatism west of -69 long displays juvenile (positive) εHf values and high (>0.7) zircon Th/U values recording increased asthenospheric contribution during extension. Progressive continental arc broadening and subduction angle shallowing initiated by the Late Cretaceous, and corresponds with an increase in arc magmatism tempo from Paleozoic-Mesozoic 45-60 Myr phases of high arc activity and 25 Myr lulls, to Cenozoic 25 Myr magmatic flare ups and negligible magmatic lulls (<5 Myr). New temporal, spatial, and isotopic constraints on Phanerozoic subduction indicate a complex geodynamic evolution that includes (1) accelerated relative convergence following the Jurassic to Cretaceous opening of the South Atlantic; (2) far field effects from the subduction of positively buoyant oceanic lithosphere; with (3) implications for Cordilleran cyclicity and prolonged (>200 Myr) slab anchoring into the lower mantle. New constraints from detrital zircon radiometric isotopes from the

Andean subduction margin can provide tools to test proposed tectonic models of ancient subduction settings across the Arctic region

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Chernykh, Andrey

The Arctida breakup and the HALIP formation – what is the linkage?

Andrey A. Chernykh, FSBI VNIIOkeangeologia, Saint-Petersburg, Russia

Currently a complexity of the tectonic structure of the Amerasia Basin of the Arctic Ocean and the fact of the High Arctic Large Igneous Province (HALIP) formation in Cretaceous time are widely accepted. However, a huge number of mismatched factual observations and conclusions have not yet developed into a single consistent model of the tectonic structure and evolution of this basin. More recently the tectonic models involving significant horizontal movements of continental crustal blocks during the formation of the Amerasia Basin were developed (Chernykh, 2014, 2015, 2018). These tectonic models are based on the results of interpretation of bathymetry, potential fields and seismic data. Significant horizontal movements of these blocks - the Alpha and Mendeleev ridges and the Chukchi Borderland - could take place only in a certain period constrained by geophysical data from the basin and geological data from continental surroundings. The role of HALIP in the processes of the Amerasia Basin formation seems to be substantial. At least, this magmatic event has led to a significant alteration of the crust of mentioned blocks, as well as the continental crustal blocks surrounding the Amerasia Basin in the Cretaceous time. Perhaps, the HALIP formation was the major cause of the Arctida craton breakup. The affirmative answer to the last question is currently not obvious due to the lack of sufficient number of age constraints for tectonic and magmatic events in the region, including uncertainty of dating of the HALIP (130-80 Ma) and its possible polyphase (e.g. Buchan, Ernst, 2019). These questions are supposed to debate in the presentation.

Coakley, Bernard

The Tectonics of Ultra-slow Seafloor Spreading as a Constraint on the Formation of the Canada Basin

Bernard Coakley, Univ Alaska, Fairbanks, AK, United States

All tectonic models for the Amerasia Basin make predictions about the relationship between the continental Chukchi Borderland and the structures beneath the Canada Basin. The tectonic setting of the extinct mid-ocean ridge (MOR) that bisects the Canada Basin argues that it was formed by ultra-slow seafloor spreading. Using the Gakkel Ridge as an analog for the extinct spreading center, in conjunction with other observations of the basin history, offers some constraints on the history of the region.

The Canada Basin is composed of continental-ocean transitional (COT) and oceanic (mid-ocean ridge; MOR) crust. A relict MOR is recognized from a linear gravity low and associated bilaterally-symmetric magnetic anomalies in the central basin. Approximately 300 km separates the outermost magnetic anomalies, which appear to define the limits of oceanic crust.

Two oriented well cores from the Early Cretaceous Kuparuk Formation on the North Slope of Alaska document consistent paleomagnetic pole orientations distinct from contemporaneous poles for the North American craton. The two poles can be brought into alignment by 65–70 degrees of counter-clockwise rotation of the "Arctic Alaska–Chukotka microplate" with respect to the North American craton. This rotation accounts for the complete opening of

the Canada Basin. As a result, the entire opening of the Canada basin by extension must postdate Kuparuk deposition.

Some age constraint on the MOR comes from the magnetic anomalies of the Canada Basin. The apparent absence of the Early–Late Cretaceous "long normal" chronozone C34N in this basin has been interpreted as an indication that seafloor spreading must have taken place prior to the "long normal" anomaly. This requires that spreading rate for the formation of the MOR is approximately 7.5 cm/year (300 km in 4 Ma). In contrast, spreading rates on Gakkel ridge range from 1.25 cm/yr near Fram Strait to 0.5 cm/yr full rate, where the ridge disappears below the Laptev Shelf as it approaches its pole of opening on mainland Eurasia. Taking the highest spreading rate observed on the Gakkel Ridge (1.25 cm/year), the 300 km wide zone of oceanic crust would have taken 24 Ma to form. This may require that the Canada Basin is younger than currently believed.

Dumais, Marie-Andrée

Magnetization Process of the Knipovich Ridge – New Data and Preliminary Results

Marie-Andrée Dumais[1,2], Laurent Gernigon[1], Odleiv Olesen[1] and Marco Broenner[1,2], (1)Geological Survey of Norway, Trondheim, Norway, (2)Norwegian University of Science and Technology, Trondheim, Norway

The Knipovich Ridge is a key to understand the tectonic evolution of the Fram Strait in the context of potential ferromanganese exploration. Remotely located between Greenland and Svalbard, and exposed to moderate to high diurnal magnetic activity, the Fram Strait region has long remained under-explored. As a result, the settings, magnetization and development of the Knipovich Ridge since the rupture of the lithosphere is still poorly understood. Recent increased interests for seafloor massive sulfides in the North Atlantic-Arctic Regions, supports the need for further magnetic investigations to study the axial volcanic ridge development and to aid mapping relevant fault and fracture complexes, local magmatic activity and potential prospects.

Here, we present a 3D model interpretation of the magnetization transiting from the Mohn’s Ridge to the southern tip of the Knipovich Ridge. The model rely on new high-resolution aeromagnetic data acquired and processed by the Geological Survey of Norway along the Knipovich Ridge during summer 2018 as part of the EPOS-N (European Plate Observing System - Norway) project.

Noteworthy, the magnetic signature of the ridge system is atypical when compared to conventional spreading systems, often resulting in clear linear anomalies. Locally thick sediment cover hinders the magnetic signal. A drastic change of magnetic signature is also observed between the Mohn’s Ridge and the Knipovich Ridge suggesting a change in the magnetization processes. From the model, we extract magnetization properties of the spreading ridge to characterize the nature of the magmatism process feeding the ridge system. Understanding the properties of the ridge links to the exploration potential of seafloor massive sulfides and to the ridge spreading history.

Einarsson, Pall

Magmatic rifting episode at Krafla 1975-1984, a model for rifting in Iceland

Pall Einarsson and Bryndís Brandsdóttir, Science Institute, University of Iceland, Nordic Volcanological Center, Institute of Earth Sciences, Reykjavik, Iceland

In 1975-1984, a sequence of rifting events occurred within the Krafla volcanic system, one of several systems constituting the boundary between the European and North American lithosphere plates in North Iceland. The Krafla rifting episode was accompanied by one of the largest earthquake sequences so far recorded along the divergent plate boundaries of the Atlantic. Each volcanic system (spreading segment) consists of a central volcano with associated fissure swarms that extend along the plate boundary perpendicular or oblique to the plate separation vector. Each fissure swarm is made up of spatially clustered set of subparallel fissures and normal faults. A total of about 20 discrete rifting events were identified, each one affecting only a portion of the Krafla fissure system. A localized magma chamber has been identified within the caldera of the Krafla volcano, both by seismic methods and geodetic location of a source of variable pressure. During most of the episode, magma apparently ascended from depth and accumulated in the magma chamber at about 3 km depth. The inflation periods were punctuated by sudden deflation events lasting from several hours to 3 months when the walls of the chamber were breached and magma was injected laterally into the adjacent fissure swarm where subsequently large scale rifting took place. During each event the flanks of a segment of the fissure swarm moved away from each other. For an idealized spreading segment the tectonic stress field evolves to produce a sequence of dikes propagating in one direction followed by a sequence of dikes propagating in the opposite direction. The first dike in each sequence is usually the longest, and is followed by successively shorter dikes. When extensional tectonic stresses close to a magma chamber have been largely relieved, then extrusion of magma may start. The model pattern of dike propagation and extrusion is consistent with data from the Krafla episode. With some variation this pattern is also consistent with earlier rifting episodes within the North Iceland Volcanic Zone in the 18th and 19th century, as well as the 2014-2015 rifting event in the Bárðarbunga volcanic system.

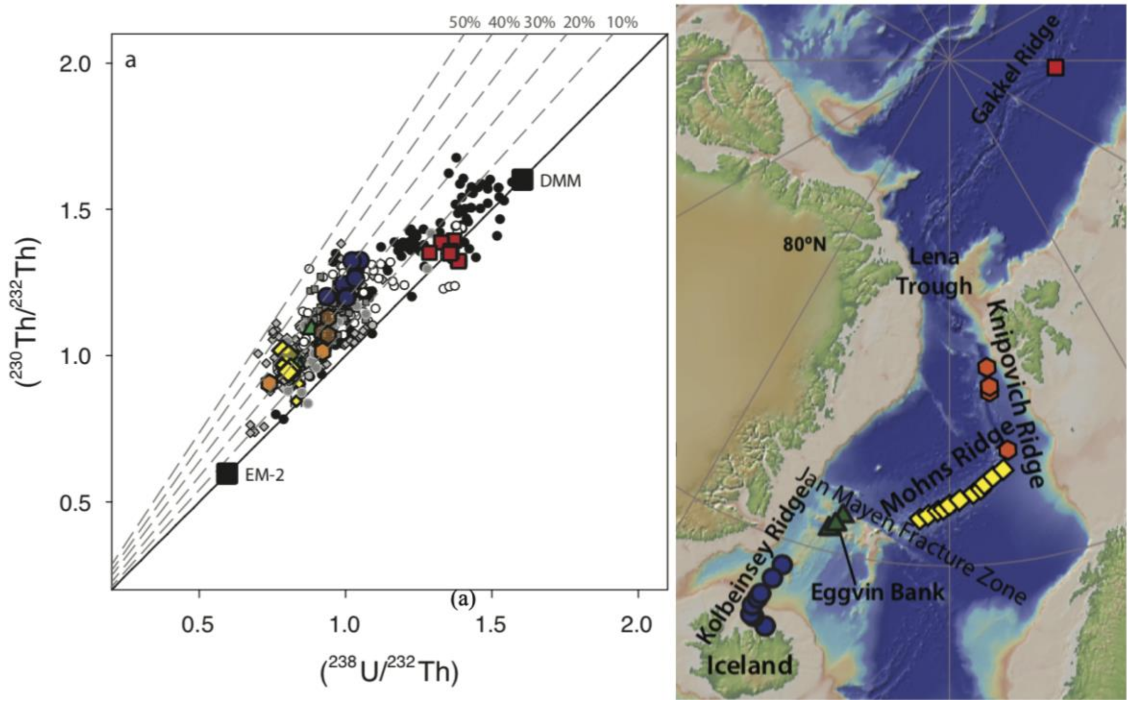
Elkins, Lynne

A review of magma generation beneath North Atlantic mid-ocean ridges

Lynne J Elkins, University of Nebraska-Lincoln, Lincoln, NE, United States and Kenneth W W Sims, University of Wyoming, Laramie, WY, United States

The North Atlantic mid-ocean ridge system has been an ideal laboratory for examining competing factors in mantle melting, from mantle temperature and upwelling rates to compositional heterogeneities. Studies of basalts from the ridge system and adjacent hotspots have illustrated that all of these factors may be involved in generating variable magma flux, crustal thickness, seafloor morphology, and basalt compositions. Mantle plumes beneath Iceland and Jan Mayen Island are associated with enhanced upwelling, elevated temperatures, and compositional heterogeneities, all of which affect magma generation, transport, and eventual crustal emplacement. Other areas like the Mohns and Knipovich Ridges record the effects of heterogeneous sources and very slow spreading, without accelerated upwelling or elevated temperatures. Ridges with ultraslow spreading rates also overlie cold melting regimes truncated by deep lithosphere.

The models of Klein and Langmuir [1987] and Bourdon et al. [1996] are borne out by elevated ($^{230}Th/^{238}U$) and ($^{231}Pa/^{235}U$) in young, depleted basalts from the Kolbeinsey Ridge, requiring a deep melting onset in the garnet peridotite stability field due to elevated temperatures, but relatively slow upwelling rates and little or no pyroxenite. Northern Kolbeinsey, Jan Mayen Island, and Mohns and Knipovich Ridge basalts, on the other hand, exhibit low age-constrained ($^{231}Pa/^{235}U$) and ($^{226}Ra/^{230}Th$) due to elevated melting rates. Modeling demonstrates that these ratios are poorly explained by enhanced upwelling, but can be explained by contributed partial melts of more fusible, recycled pyroxenite rocks [Elkins et al., 2011, 2014, 2016b]. While the Jan Mayen Island hotspot may locally contribute to the presence of pyroxenite-rich mantle, the Mohns and Knipovich Ridges are largely unaffected by the hotspot and may simply overlie mantle containing more mafic rocks, perhaps remnant veins of delaminated Greenland continental lithosphere. The ultraslow-spreading eastern Gakkel Ridge is likewise unaffected by plumes, but has among the lowest ($^{230}Th/^{238}U$) and highest ($^{226}Ra/^{230}Th$) measured in axial MORB, suggesting a low-temperature regime without residual garnet, possibly accompanied by melt-rock interactions in the lithosphere during melt transport.



Ershova, Victoria

The link between Paleozoic magmatism and tectonics of the western Russian Arctic

Victoria Ershova[1], Andrey V. Prokopiev[2], Andrei K Khudoley[3], Daniel F Stockli[4], Carmen Gaina[5], Mikhail Yu Kurapov[6], Nikolay N. Sobolev[7] and Evgeny Petrov[7], (1)Saint Petersburg State University, Saint Petersburg, Russia, (2)Diamond and Precious Metal Geology Institute SB RAS, Yakutsk, Russia, (3)St Petersburg State University, St Petersburg, Russia, (4)University of Texas, Austin, TX, United States, (5)University of Oslo, Centre for Earth Evolution and Dynamics (CEED), Oslo, Norway, (6)Saint Petersburg State University, Regional geology, Saint Petersburg, Russia, (7)A.P. Karpinsky Russian Geological Research Institute (VSEGEI), St. Petersburg, Russia

The western Russian Arctic comprises Barents Sea region (including Novaya Zemlya and Franz Josef Land Archipelagos) and Kara Sea (Kara terrane) regions (including Severnaya Zemlya Archipelago and Northern Taimyr). The studied region mainly represents by shallow seas, where the Paleozoic rocks are buried below relatively thick succession of younger deposits. Thus, the Paleozoic history could be mainly deciphered by studying rocks croup out on archipelagoes and Taimyr Peninsula.

Late Devonian to earliest Carboniferous basalts are known from Novaya Zemlya Archipelago and attributed to Middle Paleozoic rifting which is widespread across the region. Based on the pebbles from Jurassic conglomerates of FJL we assume that the Early Carboniferous felsic magmatism possibly spread over the north-eastern part of Barents Sea.

The Severnaya Zemlya Archipelago is characterized by Ordovician intrusive and effusive magmatism and it possibly is an evidence of development of active margin of Yapetus Ocean. The next prominent tectonic event revealed from the U-Th-He dating of zircons from the Middle-Upper Devonian strata of Severnaya Zemlya Archipelago is the latest Middle Devonian-Late Devonian uplift in the provenance area and could be correlated with either the Ellesmerian Orogeny or the terminal Solundian/Svalbardian stages of the Caledonian Orogeny. The Early-Middle Carboniferous felsic magmatism is widespread across the northern Taimyr and southern part of Severnaya Zemlya Archipelago and is an evidence of Carboniferous collision between this region and Siberia. Furthermore, the significant Early Carboniferous uplift constrains well based on U-Th-He dating of zircons from the Carboniferous rocks of Severnaya Zemlya Archipelago.

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Faleide, Jan

Quantification and Restoration of Pre-drift Extension across NE Atlantic Conjugate Margins

Jan Inge Faleide[1], Mohamed Mansour Abdelmalak[1], Grace E Shephard[1], Trond Helge Torsvik[1], Carmen Gaina[1], Sebastien Gac[1], Filippos Tsikalas[2], Olav Antonio Blaich[3], Sverre Planke[4], Dmitrii Zastrozhnov[4], Laurent Gernigon[5] and Reidun Myklebust[6], (1)University of Oslo, Centre for Earth Evolution and Dynamics (CEED), Oslo, Norway, (2)Vår Energi, Stavanger, Norway, (3)Aker BP, Oslo, Norway, (4)Volcanic Basin Petroleum Research, Oslo, Norway, (5)Geological Survey of Norway, Trondheim, Norway, (6)TGS, Asker, Norway

The sedimentary basins at the NE Atlantic conjugate margins formed in response to multiple phases of post-Caledonian rifting from Late Paleozoic time to final crustal breakup at the Paleocene-Eocene transition. The >200 million years of repeated extension caused comprehensive crustal thinning and formation of deep sedimentary basins. The main rift phases span the following time intervals: Late Permian, late Middle Jurassic-earliest Cretaceous, Early-mid Cretaceous and Late Cretaceous-Paleocene. To reconstruct the basin evolution and construct well-constrained paleogeographic/-tectonic maps we have to quantify the pre-drift extension through time and space. This is done using various techniques: The observed geometry of crustal thinning is compared to a reference thickness of the crystalline crust close to onshore areas which have experienced limited or no crustal extension since Permian time. The corresponding thinning factors are compared to stretching factors derived from both backstripping and time-forward modelling. To fit the observed thickness of the crystalline crust and the subsidence history, depth-dependent thinning has to be considered. For this purpose, we have constructed a set of conjugate crustal transects based on an integrated analysis of all relevant geophysical and geological data. In these transects the Cenozoic oceanic crust has been removed based on conventional plate reconstructions. In some of the conjugate transects there are still uncertainties with respect to the exact location of the continent-ocean boundary and the contribution from breakup-related igneous intrusions to the observed crustal thicknesses. We also present improved constraints on the deep basin configuration and depth to top crystalline basement at the outer mid-Norwegian margin. The total (cumulative) pre-drift extension since the Permian amounts to in the order of 300-400 km which correlates well with estimates from plate reconstructions based on paleomagnetic data. Paleogeographic maps will be presented and the implications for the regional basin evolution and provenance (source-to-sink) discussed, including the role of structural inheritance, varying regional stress fields and Arctic-North Atlantic large igneous provinces (LIPs).

Franke, Dieter

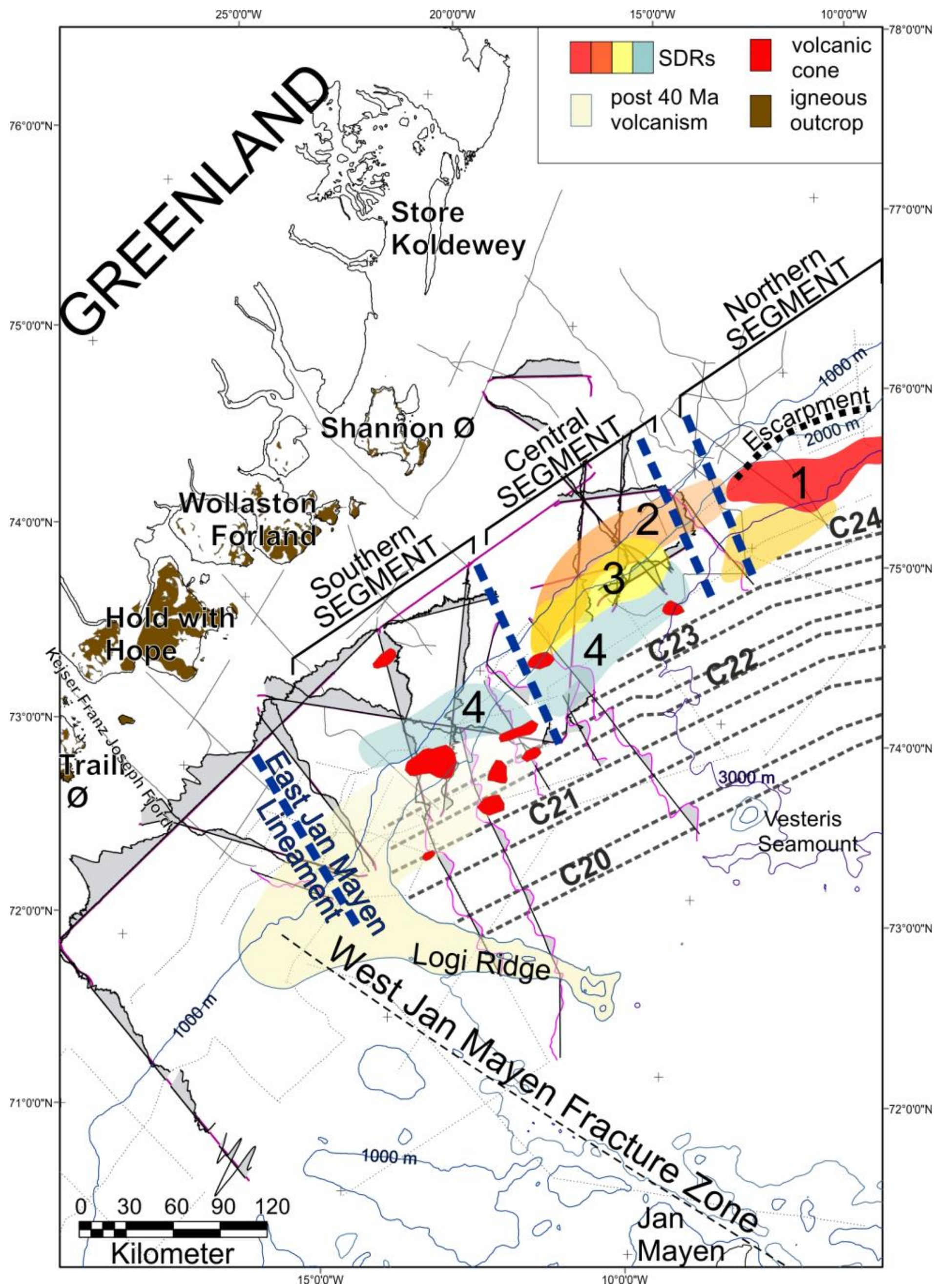
Polyphase magmatism during breakup of the NE Greenland margin

Dieter Franke[1], Volkmar Damm[2], Udo Barckhausen[3], Kai Berglar[1], Anke Dannowski[4], Axel Ehrhardt[1], Martin Engels[5], Thomas Funck[6], Peter Klitzke[7], Michael Schnabel[8] and Martin Thorwart[9], (1)BGR Federal Institute for Geosciences and Natural Resources, Hannover, Germany, (2)BGR Hannover, Hannover, Germany, (3)Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany, (4)GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany, (5)Federal Inst for Geosciences, Hannover, Germany, (6)GEUS, Copenhagen K, Denmark, (7)Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany, (8)BGR, Hannover, Germany, (9)Christian-Albrechts-Universität zu Kiel, Kiel, Germany

New marine geophysical data acquired across the partly ice-covered northern East Greenland continental margin highlight a complex interaction between tectonic and magmatic events. Breakup-related lava flows are imaged in reflection seismic data as seaward dipping reflectors (SDRs).

The new data indicate that the NE Greenland margin is broadly segmented into three segments and these have distinct tectono-magmatic styles. This implies a polyphase rift evolution with consecutive magmatic events. Phases of high magma supply and the formation of SDRs alternate with phases of tectonic deformation. SDRs in the central margin segment were the first to be emplaced before volcanic rifting took place in the northern margin segment. Finally, the SDRs in the southern segment were emplaced. The break-up of the Greenland Sea started at several isolated seafloor spreading cells whose location was controlled by rift structures and led to the present-day segmentation of the margin. The original rift basins were subsequently connected by steady-state seafloor spreading that propagated southwards, from the Greenland Fracture Zone to the Jan Mayen Fracture Zone. Overall, the volumes of SDRs decrease to north and to the south.

The new data indicate a major post-Middle Eocene magmatic phase around the landward termination of the West Jan Mayen Fracture Zone. This post-40 Ma volcanism likely was associated with the progressive separation of the Jan Mayen microcontinent from East Greenland.



Funck, Thomas

Seismic Imaging of Alpha Ridge and the Magmatic Overprinting of the Adjacent Lomonosov Ridge and Marvin Spur

Thomas Funck, GEUS, Copenhagen K, Denmark and John Shimeld, Geological Survey of Canada (Atlantic), Natural Resources Canada, Dartmouth, NS, Canada

In 2016, coincident seismic reflection and refraction data were acquired over the northern flank of Alpha Ridge and the adjacent areas of Lomonosov Ridge. The experiment was part of the Canada-Sweden Polar Expedition which employed the Canadian icebreaker Louis S. St-Laurent and the Swedish icebreaker Oden. Wide-angle reflections and refractions were recorded using sonobuoys and on-ice seismometer stations. A 100-m-long hydrophone streamer was utilized to record the coincident seismic reflection data. The source array consisted of up to four G-guns with a maximum volume of 2000 in^3. Results will be presented from two transects across the Lomonosov Ridge, one of which continues onto the Alpha Ridge, and a third transect along the 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. In addition, the coincident seismic reflection data were used to extract information on the geometry of layer boundaries in the upper part of the models.

The models for the northern flank of Alpha Ridge show up to 2 km of sediments overlying a three-layer crust consisting of: a 2-km-thick top layer with velocities between 4.4 and 4.8 km/s; a 3-km-thick layer of 5.6 km/s; and, a lower crustal layer of 6.8 km/s. The Moho depth is determined by gravity modelling and lies around 17 km but deepens to 22 km beneath the Fedotov Seamount. The velocity structure is similar to other models from the Alpha Ridge and Mendeleev Rise, indicating that the High-Arctic Large Igneous Province (HALIP) volcanism has created a highly homogeneous crust. The crust on Marvin Spur at the Amerasian flank of Lomonosov Ridge differs from igneous crust on Alpha Ridge. Lower crustal velocities are 6.3 km/s and are consistent with interpretations that the spur is a continental sliver. However, like Alpha Ridge, the Marvin Spur is overlain by volcanics, and a high-amplitude wide-angle reflection multiple is modelled as a 6-km-thick high-velocity lower crust, indicating significant HALIP-related magmatic overprinting of the spur. This overprint extends to the southern flank of Lomonosov Ridge where there is a volcanic edifice and also a 60-km-wide zone of elevated lower crustal velocities interpreted as magmatic intrusion.

Gaina, Carmen

The Crust and Upper Mantle of the Eurasia Basin Revealed by Geophysical Data and Mantle Tomography Models

Carmen Gaina[1], Andrew J Schaeffer[2], Anatoly Mikhaylovich Nikishin[3], Sergei Lebedev[4] and Alexander Minakov[1], (1)University of Oslo, Centre for Earth Evolution and Dynamics (CEED), Oslo, Norway, (2)Geological Survey of Canada, Pacific Division, Sidney, BC, Canada, (3)Moscow University, Moscow, Russia, (4)Dublin Institute for Advanced Studies, Dublin, Ireland

The present day plate boundary between the Eurasia and North America plates, the Gakkel Ridge, runs through the Eurasia Basin in the High Arctic, and is considered the slowest mid-ocean ridge on Earth (c. 6-13 mm/yr). The Eurasia Basin is floored by oceanic crust c. 57-0 Ma old, which formed under intermediate-slow seafloor spreading regime in the first 10 myrs, and slowed down since the Eocene until the present day. Here we present new results regarding the crustal accretion asymmetry inferred from magnetic data and new seismic reflection data, a model for the crustal thickness derived from gravity inversion and an analysis of available upper mantle tomographic models. Asymmetry in oceanic crust accretion occurred both at old and younger seafloor spreading stages in the conjugate Nansen and Amundsen sub-basins, with a general trend of higher spreading rate in the Nansen Basin. Since the Miocene, a dramatic decrease in spreading rate led to the formation of high mid-ocean ridge flank topography and thicker crust.

Upper mantle tomographic models consistently image low velocities at both ends of the Gakkel ridge in the upper 50 km and relatively higher velocity under the central Gakkel Ridge which roughly corresponds with thin crust and sparsely magmatic spreading processes. The AMISvArc tomographic model presents an image of the inflow of hot

North Atlantic asthenosphere into the Eurasia Basin suggesting a major effect of mantle heterogeneities for the character of the seafloor spreading.

Galloway, Jennifer

Environmental effects of the High Arctic Large Igneous Province: Land and Marine Impacts

Jennifer M Galloway, Geological Survey of Canada, Paleontology and Collections Section, Calgary, AB, Canada; Aarhus University, Aarhus Institute of Advanced Studies, Aarhus C, Denmark

Large Igneous Provinces (LIPs) may affect global climate and environments through interaction with volatile-rich host rocks encountered during emplacement through release of substantial quantities of CO_2, SO_2, CH_4, Hg, and trace metals. LIP volcanism is implicated in almost every mass extinction during Earth's history, often with contemporaneous rapid climatic change. The High Arctic Large Igneous Province (HALIP) is probably the least studied LIP in the world. It was widespread with exposed igneous components on Svalbard, Franz Josef Island, New Siberian Islands, and Axel, Ellesmere, and Ellef Ringnes islands in the Sverdrup Basin of Arctic Canada. However, the volume of material is poorly constrained and thought to be about ¼ the volume of the much larger Paraná-Etendeka LIP that is implicated in global carbon cycle perturbations and climate change during the Early Cretaceous. However, the size of a LIP does not appear to be as important as the composition of the host-rocks it encounters in causing environmental crises.

In the Sverdrup Basin of Canada, four main cycles of the HALIP are recognized: Valanginian-early Barremian; Barremian/late Hauterivian–Aptian basalts of the Paterson Island and Walker Island members of the Isachsen Formation; late Aptian-Cenomanian continental flood basalts of the Strand Fiord Formation; and, late Cenomanian-Maastrichtian Hansen Point volcanics. Cycles 1-3 comprise the main tholeiitic phase of magmatism between ca. 130-90 Ma. From the Late Jurassic to Late Cretaceous, multiple climatic and environmental events are documented in the Sverdrup Basin. These include 1) an interval of carbon perturbation in the Volgian (late Tithonian) that precedes the oldest known age of the HALIP in Canada; 2) a relatively cool and moist late Valanginian climate episode contemporaneous with a positive carbon isotope excursion in marine rocks; 3) an interval of warming in the Hauterivian; 4) multiple cold snaps in the late Aptian and Albian; and, 5) intervals of ocean anoxia.

This talk will explore the putative role of the HALIP in affecting climate and environmental change through various processes that may have included regional uplift, ocean nutrification, volcanic outgassing, coal combustion, and/or wildfires during its episodic emplacement in polar regions.

Gong, Wei

Subduction dynamics of the New-Guinea-Solomon arc system: Constraints from the subduction initiation of the plate

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A complicated subduction system, namely, the New-Guinea-Solomon arc (PN-SL), exists in the convergent boundary between the Indo-Australian and Pacific plates and the eastern end of the Neo-Tethyan tectonic domain. Since the late Cretaceous, the PN-SL system has gradually become into a complex trench-arc-basin-oceanic plateau subduction system with various stages of subduction development. Indicated by the earthquake distribution, the deep structure of the PN-SL subduction system is characterized by significant spatial variations. Among the subduction zones within the PN-SL subduction system, the extension depth of the subducting plate changes from over 500 km to nearly 100 km and the dip angle of the plate decreases from over 70º to 30º. Because of the large crustal bulge and the low-density structure, the Ontong Java Plateau, which is the largest oceanic plateau in the world, reconstructs the tectonic framework of the PN-SL subduction system. Driven by the subduction of the oceanic plateau, the Solomon Sea back-arc basin has subducted beneath the Pacific ocean and is even characterized by a multi-directional subduction process since Miocene, differing from the classical model of the subduction polarity reversal and transference or trench jump induced by the subduction of the buoyant lithosphere. This indicates that the convergent deformation process between the Ontong Java Plateau and the PN-SL system cannot just depend on the change of the plate density. The other structural elements need to be considered in the studies on the convergent deformation of the oceanic plateau. As an important influence factor of the strength of the lithosphere, the fluid activity of the subduction system induces the strength weakening and decrease of the melting point of the lithosphere. Moreover, the fluid is transported into the deep part of the Earth and makes contributions to the dehydration of the plate and the hydro-metasomatism within the mantle wedge, which changes the composition and rheological properties of the crust and mantle and induces partial melting of the mantle wedge and arc magmatism. It can be concluded that the fluid plays an important role in the subduction initiation and evolution and is the key entry point for understanding the subduction tectonic dynamics of the plate.

Grundvåg, Sten-Andreas

Late Jurassic to Early Cretaceous sedimentary response to opening of the Amerasian Basin and HALIP activity in Svalbard

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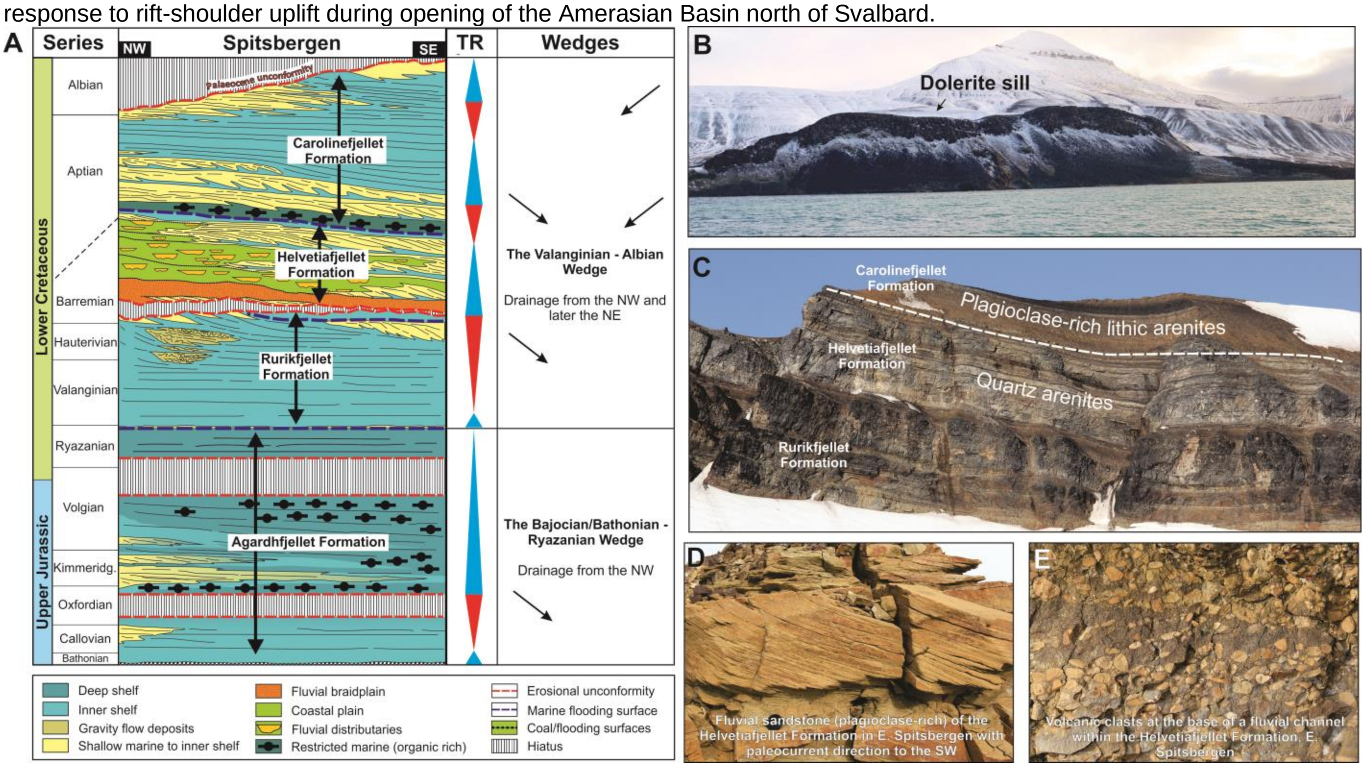
The Upper Jurassic to Lower Cretaceous succession in Svalbard consists of two prominent clastic wedges that prograded in a general southeastward (and later also southwestward) direction in response to recurrent uplift of northern Svalbard and adjacent terranes from the Late Jurassic onwards (Fig. 1A). A strong HALIP signal is well known from the Lower Cretaceous part of the succession. Numerous dolerite intrusions of Early Cretaceous age (Fig. 1B) are present across the entire outcrop belt (with sills predominantly penetrating Permian to Triassic strata) and in nearby offshore areas as revealed by reflection seismic data east and south of Svalbard. Bentonites occur locally as documented in onshore research boreholes. Previously published absolute datings of several intrusions and one bentonite bed yields ages in the range of 123.3–124.7 Ma, pointing to peak HALIP activity in the earliest Aptian. In addition, a regional provenance switch from quartz arenites to plagioclase-rich lithic arenites and volcanic clasts is evident in the Barremian–Aptian part of the succession (Fig. 1C, D, E). In eastern Spitsbergen, paleo-current directions also indicate an emerging provenance area to the NE. Further east at Kong Karls Land, basaltic lava flows occur interbedded with paralic deposits of late Barremian to Aptian age. Collectively, this indicate significant HALIP influence on the sedimentary system in Svalbard during the Early Cretaceous. Less known is the tectono-sedimentary response directly related to the opening of the Amerasian Basin, which pre-dates the short-lived HALIP activity. Several regional unconformities occur in the Upper Jurassic–lowermost Cretaceous succession, including the Oxfordian, the Volgian to lowermost Ryazanian, and the lower Barremian unconformities (Fig. 1A). Although the development and exact timing of the two former unconformities is yet to be investigated, the latter is commonly attributed to regional upwarping and southeastward tilting prior to the main HALIP pulse. Shallow marine and shelf sandstone units in the Upper Jurassic–lowermost Cretaceous succession typically pinch out to the SE, thus indicating a clear northwestern provenance area. We suggest that these sandstone units may record the initial sedimentary response to rift-shoulder uplift during opening of the Amerasian Basin north of Svalbard.



Heimdal, Thea

Thermogenic gas release from CAMP as a trigger for the end-Triassic crisis

Thea Hatlen Heimdal[1], Henrik Hovland Svensen[1], Morgan T. Jones[1], Sara Callegaro[1] and Egberto Pereira[2], (1)Centre for Earth Evolution and Dynamics (CEED), Department of Geosciences, University of Oslo, Oslo, Norway, (2)Universidade do Estado do Rio de Janeiro, DEPA, Rio de Janeiro, Brazil

Sills of the Central Atlantic Magmatic Province (CAMP) within the Amazonas and Solimões basins (Brazil) are temporally linked to the end-Triassic extinction (ETE), around the Triassic-Jurassic (T-J) boundary (201 Ma). The ETE is associated with major carbon cycle perturbations, including several negative carbon isotope excursions (CIEs), attesting to the input of isotopically light carbon. The sill intrusions are widespread in volatile-rich sedimentary deposits, such as carbonate, evaporite and organic-rich shale.

The majority of sills are evolved tholeiitic basalts/basaltic andesites defined as low-Ti (< 2.0 wt.% TiO_2), and are widespread in upper Paleozoic evaporite and carbonate, while low- and high-Ti (> 2.0 wt.% TiO_2) varieties are locally present in lower Paleozoic organic-rich shales (up to 8.0 wt.% total organic carbon). High-presicion U-Pb geochronology demonstrates at least two pulses of magmatism, starting with simultaneous low- and high-Ti activity, followed by a later pulse of predominantly high-Ti magmatism.

Thermal modeling and geochemical investigations based on sill samples and detailed logs from several boreholes drilled in the two basins suggest that contact metamorphism and interactions between the intruding magma and sedimentary rock likely generated sediment-derived volatiles such as CO_2, CH_4, SO_2 and Cl-compounds. The release of such a mix of volatiles could explain the severity of the biotic loss, while thermogenic carbon represents a credible source for the negative CIEs.

Carbon cycle modeling demonstrates, by testing detailed emission scenarios grounded by numerous complementary boundary conditions, that the carbon cycle perturbations associed with the ETE can be accounted for by CAMP-derived carbon release. While mantle-derived carbon alone cannot account for the negative CIEs, an extremely isotopically depleted carbon source (such as methane clathrates) is not required. In contrast, the release of mixed mantle- and sediment-derived carbon can explain the negative CIEs and increased atmospheric CO_2 concentration observed around the T-J boundary.

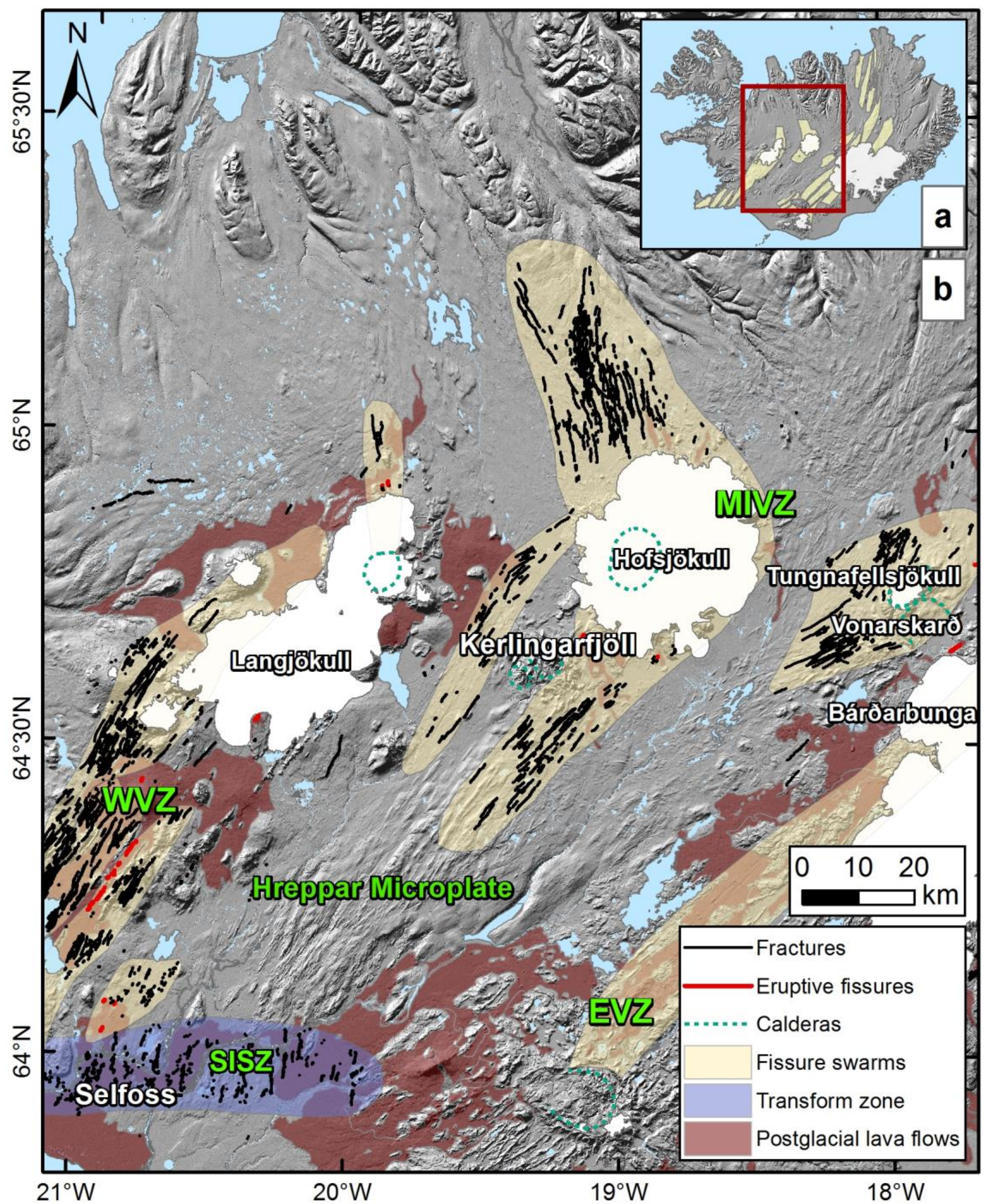
Hjartardottir, Asta Rut

The Mid-Iceland Volcanic Zone – A Sign of a Rift Relocation in Action?

Asta Rut Hjartardottir, University of Iceland, Reykjavik, Iceland and Pall Einarsson, Science Institute, University of Iceland, Nordic Volcanological Center, Institute of Earth Sciences, Reykjavik, Iceland

The Mid-Iceland Volcanic Zone (MIVZ) consists of the Hofsjökull and the Tungnafellsjökull central volcanoes with their fissure swarms, as well as the Kerlingafjöll and Vonarskarð central volcanoes. It marks the northern boundary of the Hreppar Microplate, which is also bounded by the Western and Eastern Volcanic Zones (WVZ, EVZ), as well as the transform South Iceland Seismic Zone (SISZ) (Fig. 1). Several fissure swarms branch from the Hofsjökull central volcano; the Northern Hofsjökull fissure swarm, the Western Hofsjökull fissure swarm, and two fissure swarms which extend south from the Hofsjökull, one located to the west of the Kerlingafjöll central volcano and another one to the east of Kerlingafjöll. The northern Hofsjökull fissure swarm is in many aspects unusual, compared with other Holocene fissure swarms in Iceland. It, along with the majority of fractures and faults in it, has a northwesterly orientation and is therefore far from being perpendicular to the plate spreading vector in north Iceland. Fracture orientations in the northern Hofsjökull fissure swarm are also more variable than at most other fissure swarms in Iceland, likely indicating changes in the stress field with time. The branching of the southern fissure swarms to either site of the rhyolitic Kerlingafjöll central volcano may indicate that dikes do not extend to shallow levels in the crust below the rhyolitic massif, due to density effects. The presently low spreading rate of the WVZ suggests eastward migration of the locus of spreading towards the EVZ. The MIVZ may represent an intermediate state in this process of a rift relocation to the EVZ and the transform motion along the SISZ.

Fig. 1. (a) The location of The Mid-Iceland Volcanic Zone (MIVZ) and its surroundings. (b) Fractures (or faults) and eruptive fissures within and near the MIVZ. WVZ=Western Volcanic Zone, EVZ=Eastern Volcanic Zone, SISZ=South Iceland Seismic Zone.



Hopper, John

Sediment thickness, crustal thickness, and residual topography of the North Atlantic: estimating dynamic topography around Iceland

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Residual oceanic bathymetry is a common method for estimating dynamic topography in response to underlying mantle convection. Residual bathymetry is defined as the difference between the observed depth and the predicted depth of oceanic crust based on plate spreading models. Two important corrections must be made to the observed seafloor depth to calculate the residual topography. First sediments must be unloaded and second, a correction for crustal thickness variations must be made. As part of the NAG-TEC Atlas project, a new total sediment thickness map and new crustal thickness maps were produced over the North Atlantic region. Combined with a regional kinematic model to estimate age of oceanic crust, these allow for a new residual bathymetry map of the North Atlantic to be produced, giving insight into the dynamic topography of the region associated with Iceland mantle plume. The results show that the residual bathymetry is regionally elevated, with only a few restricted areas around the Fram Strait and northern Knipovich Ridge showing negative residuals. The regional background residual is between 500-1000 m, increasing up to 1500 m along the actively spreading Reykjanes and Kolbeinsey ridges. These values are generally consistent with estimates of the amount of dynamic topography predicted by global mantle convection models. The strongest anomalies, over 3000 m, are located over Jan Mayen Island and Iceland, indicating the presence of significant thermal anomalies within the mantle associated with these two areas.

Hutchinson, Deborah

USGS T-3 Ice Island Marine Heat Flow Data for the Amerasian Basin of the Arctic Ocean

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Between 1963 and 1973, A. Lachenbruch, B.V. Marshall, and U.S. Geological Survey (USGS) colleagues collected 356 marine heat flow measurements from T-3 (Fletcher's) Ice Island as it drifted over Canada Basin and Nautilus Basin, across Mendeleev and Alpha Ridges, and reached the Canada/Greenland margin. Most of this dataset has not been previously analyzed and until 2019 was available only in unpublished USGS reports. We have digitized, verified, and updated the data and combined them with the T-3 navigational track (provided by John K. Hall), the lengths of cores recovered at each heat flow site, and databases for physiographic province designation and surface sediment type. Average heat flow for the dataset is ~54.7±11.3 mW m^{-2}, and Nautilus Basin/Mendeleev Plain (n=49) is the only well-sampled province with statistically higher heat flow (63.8±6.1 mW m^{-2}). Alpha Ridge (n=209) and Mendeleev Ridge (n=60) have average heat flow of 53.3±12.2 mW m^{-2} and 50.0±6.8 mW m^{-2}, respectively. Thermal gradients are mostly linear, implying that conductive heat flow dominates and that sediments are in equilibrium with the overlying bottom water. Thermal conductivity of the near-seafloor sediments are within the normal range, but lower for Nautilus Basin than for Mendeleev and Alpha Ridges. We use modern (2005 to 2016) seismic imagery collected coincident with the T-3 data to interpret heat flow variations. Although heat flow does not correlate with sediment thickness or bathymetry at a large scale, heat flow tracks with seafloor relief at some local scales (especially on Alpha Ridge), implying a complex pattern of seawater recharge and discharge. Even before the acquisition of modern datasets, Lachenbruch and Marshall (1969) interpreted the juxtaposition of higher heat flow in Nautilus Basin and normal heat flow at Alpha Ridge as an edge effect associated with lower thermal conductivity volcanic rocks beneath Alpha Ridge. We built a simple model for heat flow across the Canada Basin-Alpha Ridge transition and adopted thermal conductivities consistent with the interpretations of Oakey and Saltus (2016) for the mid- and deep-crustal

rocks. The thermal model predicts lower than observed heat flow on Alpha Ridge, which implies that fluid circulation through HALIP volcanics enhances heat flow. We will also present additional evidence for fluid circulation through Alpha Ridge volcanics.

Jackson, H Ruth

Paleogeographic Consequences of Plate Reconstructions in the Arctic Region

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Developed with GPlates, Arctic reconstructions were done based on the available constraints. Our preferred model for the opening of the Amerasia Basin has two phases of opening. An initial phase of strike-slip motion parallel to the edge of the Northwind Ridge and a number of trends seen in the potential field and seismic data. The second phase is a rotation of Alaska away from the Canadian polar margin. Paleographic overlays are developed superimposed on the reconstructions for critical periods in the opening of the Amerasia Basin starting at 160 Ma. In the preferred model the Alpha Mendeleev Ridge is considered to have a continental core based on geochemistry of dredge samples, Poisson's ratios, and sedimentary source arguments. The core was engulfed by volcanism. The purpose of the paleogeographic models is to test the validity of the reconstructions through time with geological data.
The Sverdrup Basin, situated along the polar margin of Canada, received sediments from the North episodically from the Carboniferous to the mid Jurassic. A low-lying continental land mass referred to as Crockerland shed material into the Sverdrup Basin over a distance of 800 km parallel to the margin and up to 350 km into the North American continent. In early Cretaceous a circum-Arctic unconformity was followed by arrival of a plume with wide spread volcanism forming the High Arctic Large Igneous Province. In the Barents Sea and on Svalbard from the Barremian to Aptian continental sediments were derived from the present day position of the Alpha Ridge indicating there was no ocean basin between the Alpha Ridge and the Barents Shelf. From 110-90 Ma limited dredge samples recovered from the Alpha Mendeleev Ridge indicate the HALIP was active across its range. By 85 Ma the drifting and rifting in the Canada Basin was completed. At 53 Ma the seafloor spreading was initiated in the Eurasia Basin along the Gakkel Ridge based on clear magnetic lineations.

Jackson, Matthew

The Iceland Hotspot: a Long-Lived, Hot Plume Sampling Early Hadean Material from the Deep Mantle

Matthew G Jackson, University of California Santa Barbara, Earth Science, Santa Barbara, CA, United States

Large volumes of melt were erupted throughout the North Atlantic Igneous Province (NAIP) in the early Cenozoic (62 to 58 Ma), including the Baffin Island and West Greenland flood basalt province, the eastern margin of Greenland, and Scotland. A salient feature of NAIP lavas is that they sample the highest terrestrial mantle-derived $^3He/^4He$ ratios globally (up to 49.8 Ra in Baffin Island-West Greenland), where elevated $^3He/^4He$ reflects ancient domains preserved in the Earth's interior. The Iceland hotspot has continued to erupt lavas with elevated $^3He/^4He$, including mid-Miocene northwest Iceland lavas (up to 40.2 Ra, or 47.5 Ra), and Pleistocene neovolcanic zone lavas (34.3 Ra). Each of these temporally- and geographically-separated high $^3He/^4He$ provinces of the Iceland hotspot are characterized by different mantle-derived radiogenic Sr-Nd-Pb-Hf isotopic compositions, and there is no evidence for convergence on a common Sr-Nd-Pb-Hf composition at higher $^3He/^4He$. In addition to being heterogeneous, the high $^3He/^4He$ Iceland

components are sampled by a hot plume: calculated primary magmas for the Baffin Island-West Greenland picrites yield higher mantle potential temperatures (1510-1628 °C) than high-MgO (>10 wt.%) global MORB located far (>500 km) from hotspots (1315-1482 °C). This is consistent with the global trend between $^{3}He/^{4}He$ and buoyancy flux formed by global hotspots, which is interpreted to reflect hotter, more buoyant plumes sampling a high $^{3}He/^{4}He$ domain. Consistent with this interpretation, seismic shear-wave velocity anomalies are lowest (reflecting higher mantle temperatures) in the shallow mantle beneath the highest $^{3}He/^{4}He$ hotspots (including Iceland), while lower $^{3}He/^{4}He$ hotspots have higher velocity anomalies (cooler temperatures). A high $^{3}He/^{4}He$ mantle domain that is deep and dense would help explain these geophysical relationships with $^{3}He/^{4}He$, as entrainment of such a domain would be favored by only the hottest, most buoyant plumes. A deep, dense domain is also favorable to preservation of early-formed isotopic anomalies--including ^{182}W and ^{129}Xe--both of which have been observed in Iceland hotspot lavas. It will be important to target hotspots with high buoyancy flux, including flood basalt provinces, for short-lived isotopic systems sensitive to early-Hadean processes.

Jian, Hanchao

Magmatic crustal accretion at the ultraslow spreading Southwest Indian Ridge segment at 50º28’E

Hanchao Jian, Woods Hole Oceanographic Institution, Geology & Geophysics, Woods Hole, MA, United States; Dalhousie University, Halifax, Canada

The oceanic crust is formed by a combination of magmatic and tectonic processes at mid-ocean ridges. Under ultraslow spreading environment, vast observations of thin crust and mantle rocks indicating the dominance of tectonic processes with little magmatism. However, the strong along-axis variations of gravity and bathymetry indicate that melt focusing should exist to form large volcanic centers. In order to understand the role of magmatism in ultraslow spreading, we study a magmatically robust segment of the Southwest Indian Ridge at 50º28’E (segment 27) with ocean bottom seismometer data.

Three-dimensional tomographic result at the center of segment 27 shows a 9.5km-thick crust, containing a round-shaped lower-crustal low velocity anomaly (LVA). A full waveform inversion over the LVA reveals a strong velocity contrast at its top boundary, suggesting the correspondence to an axial magma chamber (AMC) with a melt accumulation at the roof. However, this extreme magmatism quickly diminishes along the ridge axis. The along-axis variation of crustal structure is very significant, where the crustal thickness decreases to less than 4 km beneath the neighboring non-transform discontinuity (NTD) on the western side, within a 30-50 km distance, requiring a highly focused melt delivery from the mantle. Unlike the volcanic center, the NTD exhibits a typical structure composed of a thin, intensely fractured volcanic upper crust overlying a partially serpentinized mantle, without lower crust. The thin upper crust may have been fed by the AMC through shallow processes, such as lateral dyke propagation, of which the evidence is found as a small mid-crustal LVA on the west side of the AMC.

We conclude that the extremely magmatism is due to a focused melt flow towards the large volcanic center, enhanced by the large-scale along-axis variation in the lithospheric thickness. The focused melt forms the localized AMC and thick lower crust at the volcanic center, whereas the lateral redistribution of melt from the crustal AMC through shallow processes forms a relatively uniform upper crust along a long stretch. However, due to the wide spacing of volcanic centers and oblique spreading at NTDs impeding dyke propagations, amagamtic extensions with little magma emplacements at any depth are also observed. The wide spectrum of melt supply leads to a complex interaction between magma emplacement, tectonic and hydrothermal processes, which creates a diversity of seafloor

morphology and extremely heterogeneous crust at ultraslow spreading ridges.

Johansen, Sondre Krogh

Late Mesozoic magmatism in the northern Barents Sea

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The Norwegian part of the northern Barents Sea (North of 74°30'N) is not opened for petroleum exploration, but as a part of the resource assessments of the Norwegian Continental Shelf, the Norwegian Petroleum Directorate (NPD) is performing regional studies of this area covering about 170.000 km^2.

The Late Mesozoic magmatism in the northern Barents Sea is generally thought to be related to the formation of a High Arctic Large Igneous Province (HALIP) during the Early Cretaceous. Igneous sills and dykes are on seismic data offshore mapped to be penetrating the strata at multiple stratigraphic levels (Triassic and Jurassic) and the same can be observed onshore on Svalbard and Franz Josef Land.

We present new interpretations from the Norwegian part of the northern Barents Sea, and based on a relatively dense grid of 2D regional seismic data acquired between 2012 to 2017. These offshore observations are combined with onshore geological fieldwork on Svalbard conducted during the same period. The main observations of intrusions from the seismic interpretations are that they commonly found in synclines of Jurassic synclines and on the slopes of Triassic clinoform sequences.

Igneous intrusions may impact the petroleum system in both positive and negative ways and understanding the distribution of these features are considered important in petroleum system assessments.

Jones, Morgan

Ashlantic: A multi-proxy approach to unravelling the relationship between the North Atlantic Igneous Province and the Paleocene-Eocene Thermal Maximum

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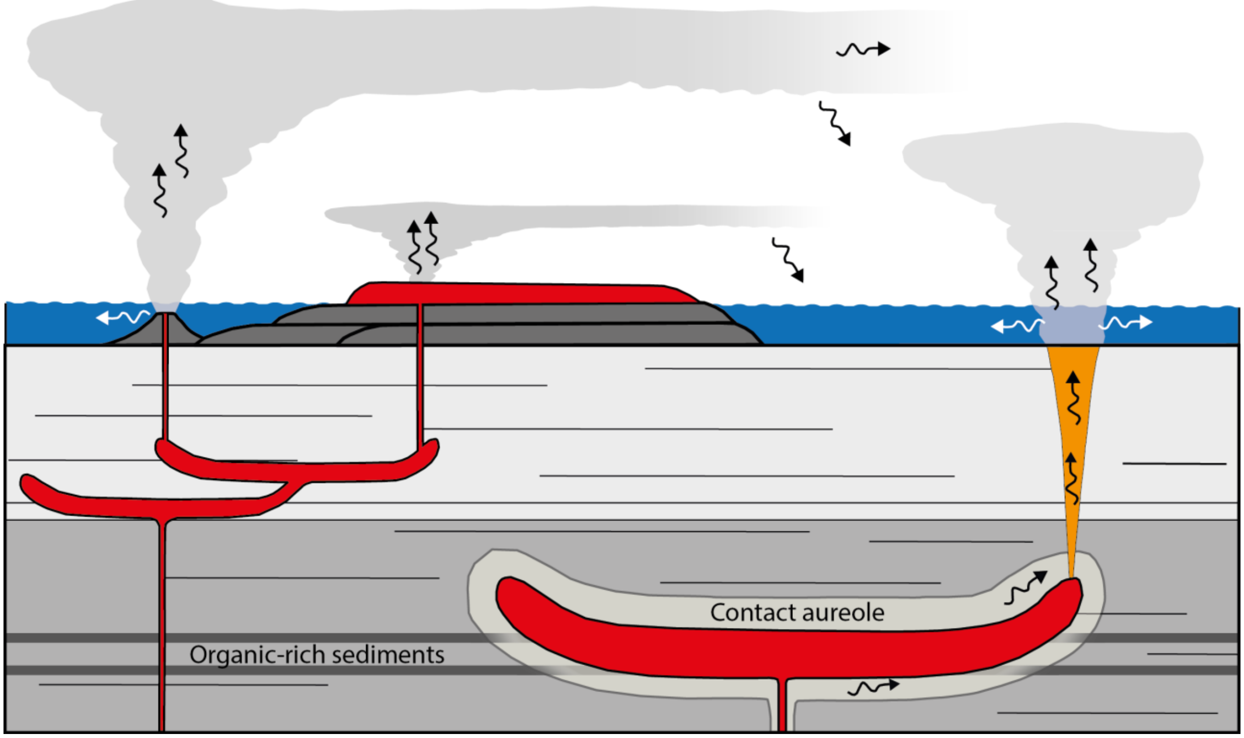
There is a striking temporal correlation between the emplacement of large igneous provinces (LIPs) and extreme climate change events in the sedimentary record. One such example is the Paleocene-Eocene Thermal Maximum (PETM), an extreme (5-6 °C) and rapid (<20 kyr) global warming event at ~56 Ma that persisted for at least 100 kyr. The PETM coincided with a major pulse of magmatism from the North Atlantic Igneous Province (NAIP), suggesting a possible causal relationship. The island of Fur, located within Limfjorden in northwest Denmark, is an excellently preserved epicontinental shallow marine sequence from latest Paleocene to mid Eocene times. The PETM interval is an expanded sequence with high sedimentation rates, allowing the identification of changes on a fine temporal scale.

The sequence also contains over 180 distinct volcanic ash layers that originated from NAIP volcanic centers in east Greenland and northwest British Isles.

Here we present the preliminary findings from Fur, spanning approximately 300 kyr from the initiation of the PETM to post-PETM strata. High precision U-Pb dating of magmatic zircons helps to constrain the timing and duration of the PETM, as well as local sedimentation rates. Detailed chemostratigraphic logs, such as total organic carbon (TOC) $\delta^{13}C$ analyses, are used to define the onset and duration of the PETM, providing a geochronological framework for numerous environmental and volcanic proxies. Inorganic proxies, organic biomarkers, and the organic paleothermometer TEX_{86} suggest a significant increase in sea surface temperatures and ocean anoxia during the onset of the PETM. Weathering proxies such as clay fractions and lithium isotopes indicate a rapid increase in silicate weathering rates concurrent with this temperature rise. Volcanic proxies such as mercury anomalies and visible tephra layers show that explosive volcanism was active at the onset of the PETM, suggesting that the NAIP may indeed have played a primary role in the instigation of this extreme climate warming event.



Khudoley, Andrei

Late Devonian Magmatism in the North-East Siberia: Northern Continuation of the Yakutsk-Vilyui LIP

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Basalt flows with Frasnian limestone interbeds have been studied in the lower course of the Lena River where they form the northernmost outcrops of the Upper Devonian volcanic unit, widely distributed throughout the east margin of the Siberian Craton. Total thickness of the volcanic unit reaches 400 m. SiO_2 concentrations vary from 45% to 50%, and TiO_2 concentrations vary from 1.8% to 2.9% averaging at 2.4%. Significant variation in alkali elements concentrations is likely controlled by post-magmatic hydrothermal processes, rather than the initial composition of the magmas. The multi-element primitive-mantle normalized diagram does not show negative Ta-Nb or Ti anomalies implying low influence of crustal contamination. The gentle slopes on REE chondrite-normalized diagram equate to relatively low (La/Sm)n and (La/Lu)n ratios, with averages of 1.5 and 5.6, respectively. Eu anomaly ranges from 0.52 to 0.97. Epsilon Nd(t) values in all samples are close to +4.3.

On the almost all diagrams studied samples occupy the field of within-plate basalts. On the (Nb/Yb)pm vs. (Th/Yb)pm diagram all samples are located within the field of mantle-derived melts, and low (Tb/Yb)pm values (<1.7) are indicative of melting of spinel peridotite mantle material at depths less than 90 km.

Chemical and Nd isotope compositions of the studied basalt flows are close to those from the Late Devonian dykes and basalts related to Yakutsk-Vilyui LIP. Formation of the Late Devonian LIP associated with rifting best expressed in the Vilyui and Sette-Daban regions. Although no Devonian grabens were documented in the lower course of the Lena River, wide distribution of basalts with rift affinity implies progradation of rifts at least to the northern margin of the Siberian Craton.

The study was partly supported by the RSF grant 17-17-01171

Klitzke, Peter

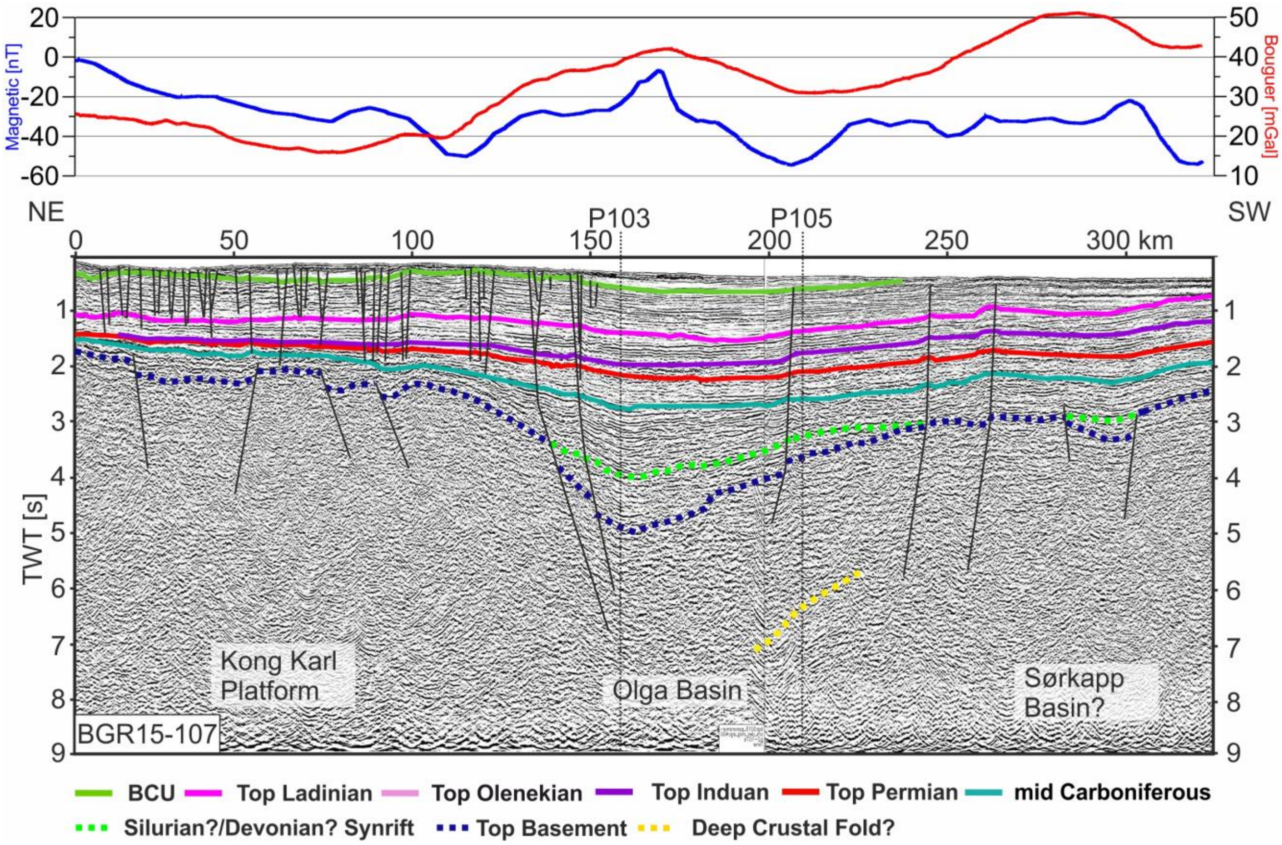
The Olga Basin in the northern Norwegian Barents Sea (Arctic) – a Caledonian or Timanian affinity?

Peter Klitzke, Dieter Franke, Axel Ehrhardt, Rüdiger Lutz and Lutz Reinhardt, BGR Federal Institute for Geosciences and Natural Resources, Hannover, Germany

The epicontinental Barents Sea experienced multiple stress regime changes including Silurian-Devonian continental collision, multi-stage late Paleozoic to Mesozoic rifting and late Cenozoic uplift and erosion. Generally, a Caledonian basement grain is assumed for the Norwegian Barents Sea. Seismic reflection and refraction lines and magnetic data reveal a NNW-SSE trend in the NW Barents Sea which appear to line up with N-S striking Caledonian structures on Svalbard. A second Caledonian arm is proposed to branch off northeastwards but crosscuts important structural elements such as the Olga Basin almost perpendicularly.

We acquired ~1750 km of 2D multi-channel seismic lines, ~350 km of wide angle seismic lines by means of sonobuoys, and potential field data in the wider area of the Olga Basin southeast of Svalbard in 2015 in order to reconstruct the basin evolution with regard to inherited structures.

The absence of major compressional structures in the newly acquired seismic lines strongly imply a post-Caledonian initial subsidence phase (Fig). The Olga Basin evolved as W-E striking halfgraben along a major normal fault in the north. Interestingly, the Olga Basin is characterized by unusual positive magnetic and positive gravity anomalies which coincide with the earliest subsidence phase and imply the involvement of magmatism during the early basin evolution. The basin axis neither fits the assumed Caledonian trends nor to the striking of Carboniferous rifting for that region. We discuss whether the Olga Basin evolved entirely independent from proposed Caledonian structures and a Timanian affinity. The correlation of the earliest subsidence phase with the preservation of Cretaceous sediments indicates that deep magmatic structures again influenced the Cenozoic basin inversion.



Koglin, Nikola

Zircon Grains from Serpentinite of the Voykar Massif, Polar Urals: Trace Elements, U-Pb and Lu-Hf Isotopic Data

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The Voykar Massif consists of an ultramafic complex in the NW, followed by a mafic complex and an evolved island arc to the SE. Previous radiometric dating has yielded a late Neoproterozoic age (585±6 Ma; Savelieva et al. 2007) for the ultramafic complex, a range of late Cambrian to Silurian ages (428±7 to 490±7 Ma; Khain et al. 2008, Remizov et al. 2010, Estrada et al. 2012) for the mafic complex, and Early Devonian ages (c. 390–400 Ma; Estrada et al. 2012) for the evolved island arc. The mafic complex is dominated by gabbro, dolerite, and basalt with minor andesite and plagiogranite formed in a supra-subduction zone environment. By the river Lagortayu, the mafic complex also contains serpentinite fragments with zircon grains that are visible in thin section.

LA-ICP-MS U-Pb dating of the zircon grains yield an upper intercept age of 548±5 Ma with an age range of 527–549 Ma. Additionally, few older grains up to 3277 Ma were found. Trace element patterns of the zircon grains show fractionation from high HREE to low LREE with pronounced positive Ce and negative Eu anomalies. Discordant grains and those with with younger ages (<548 Ma) are enriched in LREE without Ce anomaly. Hafnium isotopic data of the main age group show $^{176}Hf/^{177}Hf_{(t)}$ from 0.28242 to 028249 and $\varepsilon Hf_{(t)}$ ranging from 1.9 to -1.0. Two grains show lower $^{176}Hf/^{177}Hf_{(t)}$ and $\varepsilon Hf_{(t)}$ (0.28228 and 0.28229; -5.6 and -6.5, respectively). The older grains mostly exceed the ratios for the depleted mantle.

The previously obtained age for the ultramafic complex and our new age on mantle-derived serpentinite indicate zircon formation in the mantle during the Timanian Orogeny. Although a primitive island arc signature was found for the mafic complex, the evolved Hf isotope data point to an involvement of a crustal component in the underlying mantle to different extents, which is expressed by two Hf isotope groups.

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Kurapov, Mikhail

New data on the Triassic Granitic Magmatism of Northern Taimyr

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Granite intrusions of different ages are widely known throughout the Taimyr Peninsula and play significant role in its geological evolution. Triassic intrusions are less prevalent and mostly reported from the northwestern part of north-west Taimyr. The studied intrusions are located on the northwestern coast of Taimyr Peninsula and on several islands in Kara Sea.

Intrusions cut the Early Paleozoic metasedimentary rocks and can be divided into two groups. The first group are coarse- to medium-grained quartz-syenites and alkali-feldspar-granites. U-Pb dating of these granites yelled age of 253 Ma. Ar-Ar micas ages varies from 236 to 251 Ma. The granitoids are high- to medium acidic, high alkaline (alkali-calcic to alkalic), ferroan and magnesian, mainly peraluminous. The second group is represented by coarse-grained granodiorites and granites. U-Pb zircon ages of these granites range from 228 to 238 Ma. Ar-Ar micas and amphibole ages varies from 226 to 235 Ma. They are acidic to low acidic, moderately alkaline (alkali-calcic, calc-alkalic), magnesian, peraluminous and metaluminous. First group is also characterized by relatively low initial $^{87}Sr/^{86}Sr$ ratios (0.7037-0.7046) and negative to slightly positive εNd(t) values (-1.0 4 to 1.03). For the second group initial $^{87}Sr/^{86}Sr$ ratio is 0.7056 and εNd(t) value is -4.0.

Early Triassic high alkalic predominantly ferroan granites are most likely to be the A-type granites. Middle- Late Triassic moderate alkalic magnesian granites have transitional I/S-type character. Thus Early and Middle- Late Triassic granites of Northern Taimyr were probably formed from different source.

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Langmuir, Charles

Ocean Ridge Perspectives on and from the Arctic

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The Arctic is traversed by slow and ultra-slow spreading ridges that reveal the temperature and composition of the underlying mantle. Iceland and associated ridges are the shallowest spreading centers of the ridge system, while the Gakkel includes some of the deepest ridges. Many Arctic ridges violate the classic plate tectonic ridge-transform paradigm, showing a diversity of spreading architecture that is found nowhere else. Temperatures beneath Iceland and associated ridges are the hottest globally. While the Gakkel is deep, its temperature is not extremely low, and extents of melting are influenced by thick lithosphere that also leads to discrete and widely separated volcanic centers. The large temperature gradients in the Arctic need to be considered for other tectonic and geological interpretations of this region. The Kolbeinsey and Reykjanes ridges are anomalous in a global context, because they have low Sm/Yb ratios and Na_2O contents. These effects have been noted in the Indian Ocean (Yang et al 2017) and can be seen adjacent to near-ridge hotspots worldwide. They likely reflect lateral flow from a plume, where mantle beneath the ridge has been pre-depleted by deep melting in the garnet stability field beneath the hot spot, and subsequently refertilized by low degree melts from deeper enriched mantle. This effect is seen on a smaller scale for individual volcanic centers of the Gakkel eastern volcanic zone. Once these effects are taken into account, global trace element data acquire cleaner correlations, showing the ubiquitous role of low-degree melts in influencing upper mantle heterogeneity. Arctic ridges are adjacent to subcontinental mantle, and a subcontinental mantle isotopic signature is apparent in locations such as the Gakkel western volcanic zone (Goldstein et al. 2007). This is consistent with an origin for the "EM1" isotopic flavor as subcontinental mantle. Examination of MORB globally shows that the EM1 signature is present where ridges are near continents, and is absent for Pacific ridges, which are surrounded by dipping subduction zones that provide a barrier to subcontinental mantle. This provides a coherent framework for understanding isotopic variations worldwide.

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Larsen, Lotte

Petrology of Paleocene Basalts in the Davis Strait: Voluminous, High-Temperature Melt Generation at a Transform Margin

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Volcanic rocks recovered from drilling and dredging in the Davis Strait are an integral part of the rifting history along the conjugate margins of Canada and Greenland. The *c*. 1000 km long transform part of the margin contains thick successions of volcanic rocks recovered in four wells: Hekja O-71, Gjoa G-37, Nukik-2 and Hellefisk-1, and dredged on the northern Davis Strait High (DSH). Biostratigraphic and radiometric ages indicate Paleocene volcanism and range from Danian to Thanetian (biozones P2 to P5, *c*. 62.5–56 Ma). Volcanic rocks are predominantly basaltic lavas, however, both picrites and basalts are found on the DSH. Most of the samples are geochemically depleted in highly incompatible trace elements. Calculated potential temperatures and melt fractions for the DSH are high (1500°C , ~20 vol %), suggesting that the volume of magma emplaced in the crust was large. These results are consistent with geophysical evidence for magmatic underplating in this region. At all sites, the rare earth element (REE) patterns display near-horizontal heavy-REE limbs (Tb–Lu), indicating residual lithologies of spinel peridotite, i.e. lithospheric thicknesses of <80 km. On the Greenland margin, samples from the Gjoa well suggest a lithospheric thickness similar to that interpreted for the Baffin Island volcanics (~60 km) whereas samples from the Hellefisk and Nukik-2 wells suggest a lithosphere somewhat thinner than this. Samples from the Hekja well and DSH have unique, strongly depleted compositions corresponding to very thin lithosphere, perhaps oceanic around 40 km. This result is consistent with their structural position within the transform fault zone but could also be explained by melting of an ultra-depleted mantle source. We consider the melting took place beneath a thin strip of crust of oceanic character that runs along the transform fault zone and is associated with a thick magmatic underplate. The transtension necessary to induce melting along the transform was limited to the Paleocene Epoch and took place throughout this time. When the spreading direction changed in the early Eocene from WSW–ENE to approximately S–N, the associated shift to a transpressive regime along the transform caused magmatism to cease in the Davis Strait, whereas Eocene volcanism continued to the South and North.

Lease, Richard

Distal Tephra in Arctic Alaska Throughout 117 to 68 Ma: Zircon U-Pb Geochronology, Abundance, and Inferred Source

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Felsic tephra interbedded with strata of the Colville Basin of Arctic Alaska record continuous volcanism throughout the middle to Late Cretaceous. We have analyzed zircon U-Pb ages from over 100 tephra samples that span 800 km of depositional dip to illuminate influences on basin evolution. The tephra are preserved as bentonite or silicified tuff and generally display intra-sample, local, and regional age consistency: Most samples display unimodal grain age distributions that suggest little reworking, tephra mean ages young upsection, and marker horizons from sections separated by >100 km have similar ages.

On the eastern North Slope, the ca. 117 to 68 Ma marine Hue Shale Formation contains thousands of tephra spanning 250 m of section. Tephra up to 10 cm thick are relatively sparse in the ca. 117 to 98 Ma Gamma Ray Zone (GRZ), which accumulated at a rate of 1-2 m/Myr. An overlying ca. 98 to 95 Ma regional inoceramid bivalve horizon marks a major sea level lowstand in the Colville basin and elsewhere in the circum-Arctic. Tephra abundance and sedimentation rates (6-8 m/Myr) increased after ca. 95 Ma. An initial increase in tephra abundance occurred ca. 95 to 88 Ma, and individual beds are up to 20 cm thick. Tephra abundance peaked ca. 88 to 82 Ma wherein tephra make up more than half of the 60 m total unit thickness and individual beds exceed 1 m thickness. Finally, tephra decreased in abundance and bed thickness (max: 10 cm) ca. 82 to 68 Ma, after which shale deposition was terminated by clastic input to the Canning Fm.

On the central North Slope up-dip from the Hue Shale, local tephra and syn-depositional detrital zircon grains occur throughout ca. 115-70 Ma continental shelf clastic successions. On the western North Slope and Chukchi shelf, tephra are abundant in shallow marine to nonmarine deposits, and several dated samples span ca. 104 to 89 Ma.

Possible sources for Cretaceous tephra in the Colville Basin include the Okhotsk-Chukotka Volcanic Belt (OCVB) and High Arctic Large Igneous Province (HALIP), both >1000 km away. The Colville tephra have previously been interpreted as distal pyroclastic fall deposits from Plinian-style caldera eruptions. The ca. 88-82 Ma peak in Colville tephra abundance is coeval with the most voluminous stage of felsic ignimbrite volcanism in the central OCVB, suggesting that this region was the likely source.

Lesher, Charles

The East Greenland flood basalts: The importance of melt mixing for the compositional variability during the rift-to-drift transition in the North Atlantic Large Igneous Province

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The east Greenland flood basalts provide a window into source composition and melting dynamics in the ancestral Iceland plume during continental breakup in the Northeast Atlantic. Approximately 6000 m of lava preserved along the Blosseville Kyst include >350 flow units erupted in 2-3 myrs with no significant hiatus in volcanism. Previous work has shown marked variations in rare earth element chemistry through the stratigraphy attributed to secular cooling of the mantle and variable efficiencies in melt pooling with time (1). Radiogenic isotope compositions of subsets of lavas taken from relatively restricted portions of the stratigraphy exhibit uniformity, but differ from each other, suggesting a temporal evolution in the mantle source (2). To distinguish the relative importance of source and process in the generation of the east Greenland flood basalts, we have measured major and trace elements, and Sr-Nd-Hf isotope compositions on a nearly flow-by-flow basis through the entire stratigraphy. When combined with published data, this high-resolution geochemical record of magmatism shows that the vast majority of the lavas are evolved (MgO ~7 wt. %) with a range in incompatible trace element ratios (i.e., Nb/Zr) and isotopic compositions similar, but larger than found for present-day Iceland. We propose that the variation in lava compositions comprising this temporal record is governed to a first order by the delivery of enriched and depleted melts from the mantle that are variably mixed en route to the surface, as proposed for Iceland (3). This effect dampens the signals of secular changes in mantle temperature and composition. Recognizing the role of such melt mixing is essential to place robust constraints on the thermal and compositional state of the mantle during flood basalt volcanism.

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Lu, Yu

Crustal magmatism and lithospheric geothermal state of Arctic region

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Arctic Ocean includes two deep-water basins with oceanic crust. The Eurasia Basin is now spreading along the Gakkel Ridge, which is an extension of the northeastern segment of the Atlantic mid-ocean ridge. The Gakkel Ridge has the slowest spreading rates in the world. The Amerasia Basin is now inactive in seafloor spreading. An oceanic plateau lying in the north of the Amerasia Basin, the Alpha-Mendeleev Ridge (AMR) is interpreted as part of a high Arctic large igneous province (HALIP). HALIP is one of the largest magmatic complexes on the earth, and its offshore part distributes on the north of the Amerasia Basin. Some onshore parts of HALIP are located on the Canada and Europe continental margin. The origins of the HALIP and AMR remain debated. The thermal structures of Arctic region can be helpful to understand the magmatic activity of the HALIP. The Curie-point depths (Zb) inverted from magnetic anomalies are effective to reveal thermal structure independently. We show that Curie-point depths are between 5 and 50 km in the region. Oceanic lithosphere has small Zb, and the largest mean Zb is found at continental margin. Comparing the Zb and heat flow of oceanic crust with the theoretical half-space cooling model, we found that data for crustal age < ~70 Ma fit well with the theoretical model, but data from the Amerasia Basin between ~110 and ~160 Ma isochrons indicate higher lithospheric temperatures than theoretical predictions. We argue that the geothermal state of the Amerasia Basin is affected by late magmatism, such as HALIP. Post-spreading magmatism is absent in the Eurasia Basin. We found that the Zb from east Svalbard to Franz Josef Land are similar with those from AMR. This finding supports that HALIP is dominant by dykes of the giant radiating swarm and that the dykes also distribute discontinuously from Svalbard to Franz Josef Land. We suggest that the open of the Eurasia Basin occurred on the edge of HALIP, and some dykes of HALIP were separated with the spreading of the Gakkel Ridge. The minimum Zb area in HALIP might be the centre of HALIP radiating dykes.

Luchitskaya, Marina

Granitoids and dike complexes of Cape Svyatoi Nos, Verkhoyansk-Kolyma fold area, Laptev - East-Siberian seas region: U-Pb SIMS zircon data, geochemical affinity and geodynamic setting

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Cretaceous granitoids, Upper Jurassic-Lower Cretaceous volcanic-tuffaceous-terrigenous complexes are exposed within the Cape Svyatoi Nos. Ages and geodynamic setting of rock complexes remain controversial. Granitoids intrude volcanic and terrigenous rocks with contact aureoles. Detailed information on volcanic-sedimentary complexes is in A.V.Moiseev abstract. Dikes cut granitoids, rarely there are pre-granitic dikes. Field works in 2018 indicate that dikes have EW strike and dip to N, NE; thickness up to 5 m.

Granitoids range from quartz monzodiorites, granodiorites to granites, dikes are composed of quartz diorite porphyrites, granodiorite porphyres and dacites.

Zircons from granitoids and dike rocks have magmatic genesis: fine oscillatory zoning, no evidence of inherited cores, Th/U values 0.23 to 0.94. Concordant ages for granitoids are 114±1, 112±1, 114±2 Ma; for dike rocks are 113±1, 111±2, 119±1 Ma. We consider these dates as representing crystallization ages of granitoids and dike rocks, corresponding to Aptian-Albian boundary or Aptian.

In terms of TAS diagram granitoids are granodiorites and granites, and dike rocks are diorites, granodiorites and granites. They are assigned to calc-alkaline and high-K calc-alkaline series. Spidergrams of granitoids and dikes are typical for subduction-related igneous rocks. The Zr vs 10^4Ga/Al and Rb vs Y+Nb diagrams indicate that the granitoids and dike rocks are similar to highly fractionated I- and S-type granites and volcanic arc granites consequently.

Within the eastern sector of the Russian Arctic granitoids similar in age to those of Svyatoi Nos are included either in the N-S chain of tin-granites which trends southwards from Big Lyakhov Is. for about 1000 km (Layer et. al. 2001, Dorofeev et. al., 2001) or to the east in the Arctic margin of Chukotka. Aptian-Albian (117-105 Ma) granitoids of Chukotka are related to postcollisional ENE-WSW extension-related granite-metamorphic core complexes or basins superimposed on Mesozoides (Bondarenko, 2004; Katkov, 2010; Miller, Verzhbitsky, 2009; Sokolov et al., 2015; Miller et al., 2018). Preliminarily we suppose that formation of Svyatoi Nos granitoids and dikes are related to extension in the Arctic Chukotka at 119–111 Ma. Work was supported by RNF project № 18-77-10073.

Lutz, Rüdiger

Mantle exhumation in the Eurasia Basin since the early evolution of the slow spreading Gakkel Ridge

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We study the basement configuration in the slow-spreading Eurasia Basin, Arctic Ocean. Two multichannel seismic (MCS) profiles, which we acquired during ice-free conditions with a 3600 m long streamer, image the transition from the North Barents Sea Margin into the southern Eurasia Basin. The seismic lines resolve the up to 5000 m thick sedimentary section, as well as the crustal architecture of the southern Eurasia Basin along 120 km and 170 km, respectively. The seismic data show large faulted and rotated basement blocks. Gravity modeling indicates a thin basement with a thickness of 1–3 km and a density of $2.8*10^3$ kg/m^3 between the base of the sediments and the top of the mantle, which indicates exhumed and serpentinized mantle. The Gakkel spreading ridge, located in northern prolongation of the seismic lines is characterized by an amagmatic or sparsely magmatic segment. From the structural similarity between the basement close to the ultra-slow spreading ridge and our study area, we conclude that the basement in the Eurasia Basin is predominantly formed by exhumed and serpentinized mantle, with magmatic additions. An initial strike-slip movement of the Lomonosov Ridge along the North Barents Sea Margin and subsequent near-orthogonal opening of the Nansen Basin is supposed to have brought mantle material to the surface, which was serpentinized during this process. Continuous spreading thinned the serpentinized mantle and subsequent normal faulting produced distinct basement blocks. We propose that mantle exhumation has likely been active since the opening of the Eurasia Basin.

Malyshev, Sergey

Mesoproterozoic magmatism of the Udzha paleo-rift (Northern Siberian Craton) based on gechemical and paleomagnetic data.

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The Udzha structure is located between the Anabar shield and Olenek uplift un the northern part of the Siberian Craton and oriented along a north-south trending paleo-rift. Inside the Udzha paleo-rift, Mesoproterozoic volcano-sedimentary rocks are exposed, which are cross-cut by mafic intrusions. Precambrian successions are covered by Phanerozoic sediments along an unconformity. The pre-Late Neoproterozoic sequence is divided into two units: (i) Limey-shales with tuff interbeds of the Ulahan-Kurung and Ungoakhtah formation, (ii) carbonate-dominated Khapchanyr formation and terrigenous Udzha formation, which has an overall thickness of ~1500 m.

We provide new trace elements geochemistry, U-Pb dating and paleomagnetic data on mafic dykes on Udzha complex. The chemical composition of the Udzha dyke complex corresponds to moderately alkaline basalts (SiO_2 = 46–52%; K_2O + Na_2O = 1.7–4.4%). On the trace elements and paleomagnetic data, all intrusions are separated on two magmatic pulses. In general, there is a steady increase in the normalized ratios from the least to the most incompatible elements. PM-normalized trace elements patterns of the first pulse define a large compositional range, and in general pronounced enrichment in LREE, a wide range in Ta and Nb, and negative Ti. The second pulse demonstrates flat shape REE pattern, fewer variations of Ta and Nb depletion and weak Ti depletion. Both pulses pronounced enrichment of Pb and depletion of Sr. Nd (eNd values ~ 0) and Sr (eSr values from 10 to 60) isotopy signature shows from moderate to significant input of crust material in the source.

U-Pb dating was carried out on the regionally largest dike from the second pulse with a coarse grain texture, plagioclase (65 vol.%), clinopyroxene (20 vol. %), quartz (~ 10 vol. %) and hornblende (5 vol. %) mineral composition. Apatite was employed for U-Pb dating, which was performed at the University of Tasmania (Hobart, Australia) by laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) using an Agilent 7900 quadrupole mass-spectrometer connected to a 193 nm Coherent Ar-F excimer laser and Resonetics S155 ablation cell. Analyzed apatite grains form pronounced regression line on the Tera-Wasserburg diagram, which intersects the concordia at 1386+-30 Ma which is indistinguishable from the age of the Chieress dyke (Anabar Shield, 1384+-2 Ma).

The obtained age yields new constraints on the timing of sedimentation in the area. The magmatic event occurred in two phases, that supported by paleomagnetic data. The proposed geodynamic model for the based on Nd-Sr isotopy and trace elements is the mafic intrusions were caused by passive rifting extension in which MORB type melts became enriched by wet mantle plume with sub-continental geochemical signs.

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Massey, Erica

Geochemical-Textural Analysis of Palagonitized Basaltic Glass in a Lapilli Tuff Dredged From the Alpha Ridge, Arctic Ocean

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Palagonitized volcanic glass deposits, whether formed from basaltic submarine, glaciovolcanic, or lacustrine magma-water interaction, are paleoenvironment proxies of eruptive style, pressure depths of ice or water, and microbial ecosystems. In August 2016, the collaborative Canada-Sweden Polar Expedition under Canada's UNCLOS (United Nations Convention on Law of the Sea) Program dredged approximately 100 kg of volcanic rocks from the Alpha Ridge. The recovered samples consist of lapilli tuff with rounded glass-rich lapilli and angular basaltic clasts. The vitric fragments consist of fresh sideromelane glass of alkali basalt composition, and plagioclase microlites. Cognate, angular clasts incorporated in the juvenile magma during eruption are cogenetic. Together with the dominance of glassy vitric clasts in the tuff, this feature suggests a primary, phreatomagmatic eruption. Basaltic glass lapilli display a fresh glassy core surrounded by Fe- and Ti-rich zones and palagonite rims formed by rapidly cooled and quenched magma. Geochemical-textural relationships were investigated on glass, palagonite, and secondary phases by optical microscopy, electron microprobe (EMP) and mineral mapping techniques. Three distinct zones are evident: (1) fresh sideromelane; (2) an Fe-rich phase; and (3) Ti-rich inclusions mixed with clays. Commonly, a Si-Fe rich phase forms a film along the outer edge of zeolite growth and a Mn-phase with a filamentous morphology infills voids. In the palagonite rim, an inner zone is elevated in SiO_2 (51.2 wt%) relative to sideromelane and an outer zone increases in FeO, MnO, MgO, and H_2O. Water content in palagonite rims range from 7.5 wt% to 11.9 wt%, less than commonly reported for younger Pleistocene samples (15 wt% to 40 wt%). Among the materials discussed, the zeolite has the highest values of SiO_2 (59.4 wt%), Al_2O_3 (22.5 wt%), and Na_2O (4.8 wt%). The composition and geochemical-textural zoning observed in Alpha Ridge basaltic glass differs from other palagonitization studies. Further work may shed light on the climate that prevailed in the Late Cretaceous and on the timing for submergence of the Alpha Ridge.

Mayle, Micah

Using geodynamic models to constrain mantle sources for syn-extensional magmatism

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Isotropic and trace element analysis of syn-rift magmas often point to multiple melt sources and petrogenetic models for syn-rift magmas. Suggested magma sources include MORB-like asthenospheric mantle, melt metasomatized and/or hydrated asthenosphere or lithospheric mantle, active or fossil plume material, and entrained remnants of subducted slabs. Distinguishing between petrogenetic models based on geochemical and geothermobarometry data is difficult. Geodynamic modeling offers an alternative means of testing petrogenetic models by simulating P-T-t conditions in the extending lithosphere and rising mantle during rifting. We have adapted the finite-element modeling package ASPECT (Advanced Solver for Problems in Earth's ConvecTion) to include melting, melt transport, and melt freezing in models using complex multi-layer viscoplastic rheologies. The model parameterization allows for multiple Earth layers, each with its own creep properties and melting behavior. The new features in ASPECT will be used to evaluate potential magma sources in the West Antarctic Rift System (WARS), which lies on the over-riding plate of a previous subduction margin and straddles the boundary of East and West Antarctica. Isotopic and trace element analysis of the dominant alkaline magmas in the WARS suggests a primary OIB-like source, leading to interpretations of a mantle plume. However, more recent work has suggested the influence of metasomatic phases in the asthenosphere or lithosphere. Consequently, several magma source models have been proposed: i) an active or fossilized plume at the base of the lithosphere; ii) melting of a remnant subducted slab; and iii) melt of hydrous fluid metasomatized mantle (either lithosphere or asthenosphere) from previous subduction. We will test these various models by incorporating the appropriate fertile domains into our ASPECT finite-element model and comparing predicted melt positions, volumes, and timing with what is observed within the WARS system. A similar approach is

proposed to test petrogenetic models for Cretaceous-Paleocene Arctic magmatism.

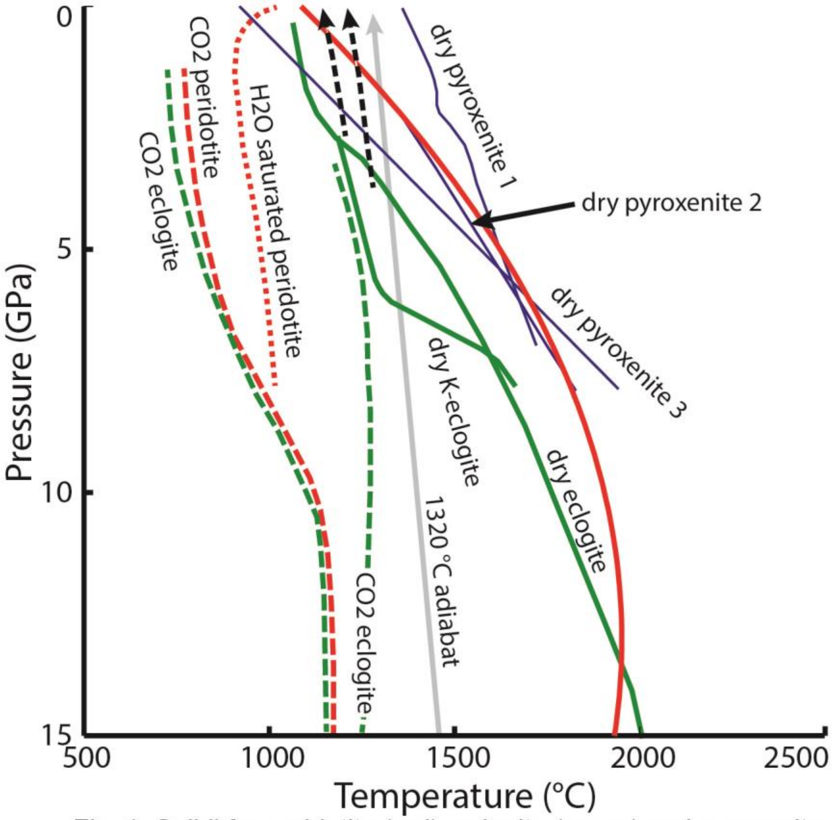

Fig. 1. Solidi for peridotite (red), eclogite (green) and pyroxenite (blue). Solid lines are dry solidi, dashed are CO2 and H2O saturated. Asthenosphere follows mantle adibat during rifting (gray line). Black dashed lines show hypothetical ascent paths for lithospheric mantle beginning at 80 km and 100 km depths. Fertile phases melt immediately upon decompression under a rift, but the melt production history differs depending on phase and pre-rift position of the source material. P-T-t fields from geodynamic models constrained to match the tectonic evolution of a rift can be used to test possible melt source models.

Meier, Michaela

Earthquake Distribution Along an Entire Ridge Segment of the Ultraslow Spreading Knipovich Ridge

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The Knipovich Ridge is part of the Arctic Ridge System comprising very slow spreading ridges. In the class of ultraslow spreading ridges, the Knipovich Ridge with its full spreading velocity of 14 – 17 mm/yr is one of the slowest and most obliquely spreading ridges. Magmatic centres along the Knipovich Ridge are mostly defined by seamounts. Amagmatic segments, where tectonism dominates the spreading, act as transfer regions between magmatic centres, since transform faults are absent.

The detailed spreading processes at ultraslow spreading ridges still remain unclear. We want to study tectonics and magmatism and their interplay along the Knipovich Ridge by the distribution of local seismicity at segment-scale. We further are interested in how ridge segmentation works in the absence of transform faults.

Knipovich Ridge was equipped with a maximum of 30 ocean bottom seismometers along a length of 160 km. The seismometers are positioned between 75.7 and 77.2°N to both sides of the rift valley. They recorded seismicity continuously for on average 11.5 months between summer 2016 and 2017. We used the detection algorithm Lassie and a Kurtosis-based picking algorithm followed by review of the picks by an analyst. The velocity model used for location is defined by well constrained events. We present here first results of this project.

We found that earthquakes are not equally distributed along the ridge axis. We observe regions of enhanced seismicity and regions with no or very little seismic activity. Focal depths undulate along the ridge axis up to depths of 20-25 km. We also found clusters of events, one in the north, close to volcanic features, and one close to station 19, south of the Logachev Seamount, a prominent volcanic edifice.

The depth distribution of earthquakes reflects the boundary between brittle and ductile deformation, depending on temperature and composition of rocks. This thermal boundary has a varying depth along the rift axis and allows the focussing of melts, e.g. towards Logachev Seamount, where deep seismicity is entirely absent. Seismically less active regions above the band of seismicity may be due to specific composition of rocks, e.g. serpentinised peridotite that leads to ductile reaction on applied stresses. Seismicity clusters may be related to magmatic activity or tectonism of transfer regions.

Metelkin, Dmitry

New Isotope-Geochemical, $^{40}Ar/^{39}Ar$ and Paleomagnetic Data for Basalts from the Franz Josef Land Archipelago: Comparison with HALIP and the Siberian LIP

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We present new results of isotope-geochemical, geochronological and paleomagnetic studies of basalts from the Franz Josef Land archipelago (FJL). The characteristics obtained are compared with data on the closest manifestations of the High Arctic Large Igneous Province (HALIP) and the Siberian LIP. The basalts of the FJL have a similar geochemical composition with basalts of the Siberian traps, Mendeleev Ridge, the De Long Islands and Iceland, which is a reflection of the similarity of their source and conditions of formation. On discriminatory diagrams, the composition points of the studied rocks fall into the regions of either continental basalts or intraplate magmatism. The elevated level of $^{143}Nd/^{144}Nd$ in the FJL basalts distinguishes them from the reference MORB. Nevertheless, these characteristics of the FJL basalts also differ somewhat from typical continental traps of the Siberian LIP. The geochemical characteristics, in general, better match the compositions of the De Long and Mendeleev Ridge basalts. The obtained set of $^{40}Ar/^{39}Ar$ and paleomagnetic data does not confirm the presence of a Jurassic magmatism episode for FJL and indicates magmatic activity in a narrow interval: 145–125 Ma. The coincidence of the isotope-geochemical characteristics and the age of magmatism at the FJL with basalts of Mendeleev Ridge and the De-Long Islands confirms the possibility of including them into the HALIP. The slight difference from Icelandic basalts can be interpreted as the result of a mixture of magmas with lower mantle isotopic characteristics of the Earth’s gross

composition, with upper mantle magmas of the Mid-Atlantic Ridge. Within the framework of the presented comparison and taking into account the paleomagnetic data on paleogeography obtained for the FJL, the indicated manifestations of basalt magmatism of Siberia, the Arctic and North Atlantic correspond to the existing ideas about their common origin and can be considered as a trace of the Icelandic hot spot over the past 250 Ma.
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Michael, Peter

High H2O and Large Ion Lithophile Elements in Basalts from the Western Volcanic Zone of Gakkel ridge: a subduction signature?

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A regional mantle geochemical anomaly extends northwards from Mohns and Knipovich ridges in the south through Lena Trough and the Western Volcanic Zone of Gakkel ridge [WVZ: 8° W – 3°E], ending in the Sparsely Magmatic Zone [SMZ: 3°E-29°E] of Gakkel ridge [1]. All MORB from the WVZ are enriched in large ion lithophile elements (LIL) and H_2O at a given level of mantle enrichment (i.e., constant La/Sm) compared to MORB globally and from Gakkel's Eastern Volcanic Zone [EVZ: 29°-85°E]. H_2O/Ce and Ba/Nb attain their highest average values around Lena Trough [2]. The order of enrichment for the anomaly is: Ba≥Rb>Cl=H_2O=Th>Pb=K>La>U>Nb. Although the high-H_2O and high-Ba anomalies coincide geographically, correlations between H_2O/Ce and LIL/HFS ratios are poor. WVZ lavas also have high Sr and low Nd isotope ratios, like Indian Ocean MORB, and carry a "DUPAL" signature [1]. Along the EVZ, basalts more closely resemble Pacific MORB in H_2O/Ce, Ba/Nb and Sr-Nd-Pb isotopes [1]. The transition for trace element and volatile ratios is not as sharp as it is for isotopic ratios: H_2O/Ce, Ba/La and Ba/Nb ratios remain elevated to 25°E along Gakkel Ridge. A few sporadic MORB with high H_2O/Ce from the EVZ do not have the distinctive LIL/HFS and isotopic ratios of the WVZ. The WVZ's distinctive composition may arise from incorporation during melting of subcontinental lithospheric mantle (SCLM) that was stranded during the recent continental breakup in this region [1]. Phlogopite and amphibole that were residual after lithospheric melting to make alkali basalts, as seen on Spitsbergen, could account for elevated Ba/Nb and H_2O/Ce [1]. Certain observations are problematic for this hypothesis, e.g., Ba/Rb should be much higher in MORB from WVZ, and the role of phlogopite for additional H_2O is strictly limited by K contents and stoichiometry. Also, Cl/K in MORB from WVZ is too high compared to the EVZ to be caused by amphibole or phlogopite. The high-H_2O, high-Ba characteristics might also be related to Paleozoic subduction in this region. The two hypotheses are not mutually exclusive. It is possible that the Paleozoic mantle wedge that evolved during the closure of Iapetus became SCLM that now surrounds the mid-ocean ridges.

[1] Goldstein, S.L. et al. (2008) doi:10.1038/nature06919 [2] Nauret, F. et al. (2011) doi: 10.1093/petrology/egr024

Miller, Elizabeth

Magmatism and Rifting in the Arctic: A Pacific Margin Perspective

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The Arctic experienced four major episodes of Phanerozoic rifting, the first two linked to plate tectonic re-configurations along the evolving proto Pacific margin and the second two to geodynamic interactions between North Atlantic rifting and Pacific margin subduction. Characteristic aspects of the rifting process include initial surface uplift related to mantle heating and magmatism, regional erosion, and deposition of large volumes of sediments. The sedimentary and magmatic expressions of these rift episodes establish critical links between Pacific subduction systems and Arctic events, aid in reconstructing dispersed fragments of Arctic geology, and demonstrate the lasting influence of subduction on the evolving geologic framework of the Arctic.

After Caledonian suturing of Baltica and Laurentia (post ~ 420 Ma) clastic wedges were shed during a widespread rift (and strike-slip) event associated with establishment of a subduction zone system connecting the Cordillera and Uralian margins with magmatism beginning as far back as 390 Ma. Fragments of this magmatic and rifting event are now dispersed to Alaska and Chukotka (A&C) and form parts of allochthonous terranes as far south as California.

After Siberia joined Baltica along the Uralian suture at the end of the Paleozoic, reconfiguration of Pacific margin subduction systems occurred during eruption of Siberian Traps and formation of West Siberia Basin. This rift system shed voluminous sediments across the Barents Shelf and into newly formed basins which occupied a back-arc position to a developing chain of Triassic offshore island arcs such as Talkeeta and Wrangellia.

In the mid-Cretaceous, clastic wedges were again shed across the Arctic, linked to rift-related uplift that formed the Amerasia Basin. Magmatism in the Chukotka plutonic belt (~120 to 100 Ma) was coeval with uplift and erosion of earlier deep marine deposits which provided time-stamped sediments into the Colville Basin of Alaska. It is hypothesized that rifting in the Amerasia Basin took place during southward step-out of subduction as suggested by the space-time evolution of 125 to 60 Ma subduction related magmatic belts across A&C.

The slow opening of the Eurasia Basin took place at a time when Pacific margin subduction zone(s) moved successively out to Kamchatka by rifting before 55 Ma and to the Aleutians before 46 Ma.

Minakov, Alexander

How Do Tectonic Stresses and Lithospheric Heterogeneity Control Large-Scale Volcanism in High Arctic?

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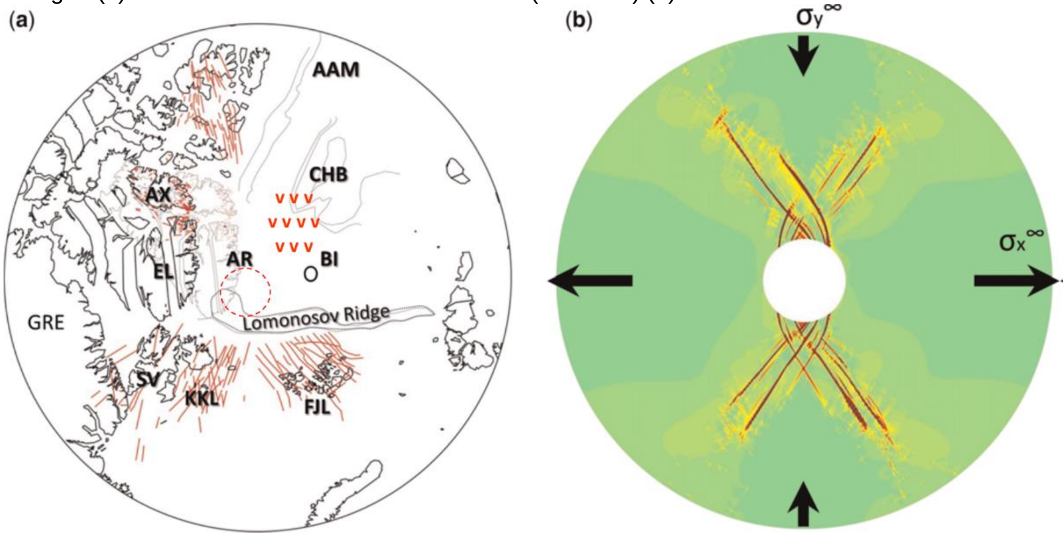
The lithospheric structure is an important factor controlling the distribution and chemical composition of the large-scale volcanism. The primary magmas related to the hotspot events are often emplaced into the crust in the form of dolerite dikes radiating from a volcanic center. Since the emplacement is geologically fast, the general pattern of the dike swarms may be used to obtain the orientation of horizontal tectonic stresses at the time of emplacement. However, the robustness of this approach needs more attention in the view of possible complex modes of magma emplacement and lithospheric heterogeneity.

We model the dike propagation using methods of continuum mechanics assuming that the dikes form as a result of shear or tensile fractures. Our finite element model consists of a laterally heterogeneous and radially anisotropic elastoplastic plate containing a circular hole and subjected to both pressure and pure shear load. The heterogeneities can activate certain dike propagation paths but do not affect the trajectory. The effect of intrinsic elastic anisotropy versus tectonic stress (stress anisotropy) cannot be separated from the geometry of dikes along and, thus, requires additional constraints (such as seismic anisotropy data). Geophysical observations from several areas exhibit useful insights how the emplacement depth, tectonic stress and crustal structure control different patterns of localized plastic deformation in shear and tensile modes around the magmatic center.

Firstly, we apply our model to simulate the propagation of a 48-km dike in Iceland emplaced during the Bárðarbunga rifting event in 2014-2015. The observed sub-parallel strike-slip mechanisms of volcano-tectonic earthquakes associated with the dike propagation is consistent with a dilatant shear failure within the crust assuming the plastic strain tensor as a primary source of acoustic energy.

Second, we model the quadruple distribution of large-scale volcanism (dikes, sills and lava flows) within the early Cretaceous High Arctic Large Igneous Province (in the Barents Sea, Canadian Arctic Islands, Deep Arctic Ocean and Russian Eastern Arctic shelf) and discuss its relation to the initial opening of the Arctic Amerasia Basin.

In Fig. 1 (a) Reconstruction of HALIP dike swarm (~130 Ma) (b) Results of numerical model.



Minakov, Alexander

Stress and deformation analysis in the Barents Sea in relation to Paleogene transpression along the Greenland-Eurasia plate boundary

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Cenozoic contractional structures are widespread in the Barents Sea. While the exact dating of the deformation is unclear, it can only be inferred that the contraction is younger than the early Cretaceous. One likely contractional mechanism is related to Greenland plate kinematics at Paleogene times. We use a thin plate finite element modelling approach to compute stresses and deformation within the Barents Sea in response to the Greenland-Eurasia relative motions at Paleogene times. The analytical solution for the 3-D folding of sediments above basement faults is used to assess possibilities for folding. Two existing Greenland plate kinematic models, differing slightly in the timing, magnitude and direction of motion, are tested. Results show that the Greenland plate's general northward motion promotes growing anticlines in the entire Barents shelf. Folding is more likely in the northern Barents Sea than in the south. Folding is correlated with the Greenland plate kinematics through time: model M1 predicts a main phase of contraction at earliest Eocene while model M2 predicts contraction later in the Eocene. Both models successfully explain folding above NW-SW Timanian trended faults in the southern Barents Sea. One model explains folding above SSW-NNE Caledonian-trended faults in the north. We conclude that Paleogene Greenland plate kinematics are a likely candidate to explain contractional structures in the Barents Sea.

Moiseev, Artem

Volcanogenic-sedimentary rocks of the Cape Svyatoi Nos, Verkhoyansk-Kolyma fold area, Laptev – East-Siberian seas region: geochemical affinity and geodynamic setting

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Granitoids, volcanogenic-sedimentary and terrigenous complexes are exposed within the Cape Svyatoi Nos. Age, geodynamic setting and relations of the rocks remain controversial. Volcanic-sedimentary rocks are usually treated as belonging to the upper Jurassic - lower Cretaceous Anyui–Svyatoi Nos active margin of the South Anyui Ocean and the Kolyma Superterrane (Natal'in, 1984; Parfenov, 1984; Zonenshain et al., 1990). However, there are still no reliable data on the age and composition of these volcanites. On small-scale geologic maps age (K-Ar method) of the volcanites identified as early Cretaceous (115-100 Ma) (Burguto et. al., 2016; Kos'ko et. al., 1985), or as the late Jurassic (145-160 mA) (Aulova, 1991).

Volcanic-sedimentary complexe represented by the horizons of amphibole andesites, andesites, tuffs, greywacke. Flows of andesites represented mostly massive, rarely amygdaloidal structure. The volcanic-sedimentary rocks dip inclined, to 40^0. There were no folds hinge. The visible thickness is up to 400 m. Volcanic-sedimentary complexe cut with granitoids and dike rocks Aptian-Albanian age (study of granitoids in this abstract book authors Luchitskaya and Moiseev).

In terms of TAS diagram the volcanic rocks are andesites and dacites. They are assigned to normal calc-alkaline series. Chondrite-normalized patterns show LREE enrichment (La/Yb=3-5.1). On the spidergrams, they are enriched in LILEs (Rb, Ba, Th), characterized by negative (Nb, Zr, Hf, Ti), similar to subduction-related igneous rocks.

The zircons were not separated from the volcanic rocks. Detrital zircons were separated from the layer of greywacke. One grain has 1900 Ma age. The sample dominated by Triassic-early Jurassic (ca. 175-220 Ma, 92 %) zircons forming peaks at 195 Ma. The robust late Jurassic peak has 7 grains (~8 % of the sample population), with the major peak at 157 Ma. MDA is defined as late Jurassic. The youngest allows to suggest the age of the Volcanic-sedimentary complexes as the late Jurassic-early Cretaceous.

The geochemical composition of volcanogenic-sedimentary rock of the Cape Svyatoi Nos suggests their formation in a suprasubduction environment. The age of the volcanic-sedimentary complex is estimated by the late Jurassic-early Cretaceous. Work was supported by RNF project № 18-77-10073.

Mukasa, Samuel

Integration of dredged submarine rock samples and seismic reflection profiles reveals mid-Cretaceous rifting, uplift, and two pulses of basaltic volcanism on Chukchi Borderland and Alpha Ridge, Amerasia Basin

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Integrating dredged rock sample data from the Chukchi Borderland and Alpha Ridge with seismic reflection profiles across or near dredge sites reveals mid-Cretaceous rifting and magmatic activity accompanied by regional uplift, extension, and subsidence. In 2008, as part of the joint U.S. and Canadian Extended Continental Shelf project, shallow water volcaniclastic rocks were dredged from Alpha Ridge and subaerially erupted alkali basal from Northwind Ridge. The alkali basalts give a 40Ar/39Ar age on plagioclase of ca. 112.0±1 Ma, and are interpreted to be products of melting of the subcontinental lithospheric mantle. From a normal fault salient called Healy Spur, samples were collected of two continental flood basalt (CFB) pulses displaying a progressive increase in asthenosphere signatures from low-Ti tholeiitic basalts erupted at ca. 100 Ma, to high-Ti alkaline basalts erupted at ca. 83 Ma. The eruption sequence and geochemical and isotopic characteristics of these lavas closely resemble those of CFB provinces associated with the pre-breakup stages of rifting continents.

Reflection seismic profiles show that northern Chukchi Borderland and Alpha Ridge contain rift basins of similar age and character, suggesting the region shares a common geologic history of continental rifting. Bright reflections at the base of rift basins that thicken against bounding normal faults are interpreted as syn-rift basalt flows locally flooring and filling grabens. Since both 112 Ma and 100 Ma basalts were dredged from exposed normal fault scarps, we interpret the rifting event as mid-Cretaceous in age. A later reactivation of normal faults appears to have led to the formation of transpressional pop-up blocks observed on Alpha–Mendeleev Ridge and constructional volcanic edifices that may represent a later stage of volcanism associated with the younger pulse of ca. 83 Ma basalts.

Murphy, Alain

Amerasia Basin: A mantle plume driven ocean basin.

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The Mesozoic to recent tectonic evolution of the Arctic region is one defined by the opening of two ocean basins – the Amerasia and Eurasia basins. The older system, the enigmatic Amerasia Basin, whose age is more poorly constrained, consists of a two-phase opening sequence: with an early initial stretching resulting in attenuated continental crust with no true oceanic crust; and a later period of seafloor spreading with possible additional rifting that resulted in limited oceanic crust within Canada Basin. The evolution of the Amerasia Basin is influenced, and may be driven, by a mantle plume that gave rise to the High Arctic Large Igneous Province (HALIP).

A circum-Arctic mid-Hauterivian stratigraphic unconformity pre-dates the significant Barremian-Aptian (~125 Ma) episode of dyke and sill emplacement within the Sverdup Basin, Svalbard, Franz Joseph Land, and the Barents Shelf. It is likely that the mantle plume which ultimately produced the HALIP magmatism caused significant regional thermal uplift causing the circum-Arctic unconformity and that the age for the “break-up” of the Canadian Archipelago margin corresponds with this uplift. This is broadly coincident with Phase 1 of the opening of Canada Basin.

The early phase resulted in attenuated continental crust throughout much of the Amerasia Basin, as revealed by velocity analyses, petrographic and potential field data. This attenuated continental crust has been modified by the emplacement of significant volumes of onshore and offshore HALIP-related magmatism. This magmatism was protracted, coeval with the oceanic opening of Canada Basin and gave rise to the Alpha Ridge and Mendeleev Rise.

The evolution of the Amerasia Basin illustrates the influence of mantle plume processes on the tectonic evolution of some ocean basins. It is proposed that the location of the Amerasia Basin and its evolution is largely controlled by mantle plume processes. Similar mantle plume controls on tectonic evolution have been recognised at Kerguelen - Broken Ridge, southern Africa – Indian Ocean and, within an oceanic setting, the Ontong Java Nui LIP.

Odlum, Margaret

Thermal record of deformation, exhumation, and fluid-rock interactions along the Billefjorden Fault Zone, Pyramiden, Svalbard

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The Billefjorden Fault Zone is a major north-south trending lineament in Svalbard that has been a locus of deformation during multiple tectonic phases in the Arctic (i.e., Caledonian, Ellesmerian/Svalbardian, Carboniferous extension, Eurekan) and has influenced the sedimentary and tectonic evolution of central Svalbard since at least the late Silurian (Scandian phase of the Caledonian Orogeny). Rock samples were collected within and adjacent to the Baliobreen Fault, a major fault within the Billefjorden Fault Zone, near Pyramiden to help constrain the timing of deformation and fluid-rock interactions recorded along the fault. Integrated medium to low temperature thermchronometers will provide important temporal constraints on the long-term thermal history along the fault through the multiple phases of deformation and tectonic inversion. Apatite U-Pb thermochronometry, microtextural analysis, and trace and rare earth element analysis will provide information on timing of deformation and fluid-rock interactions along the fault as well as geochemical information about the nature and sources of fluids within the fault zone. Together, the new thermochonometric and geochemical data will have important implications for the tectonic and deformation history of central Spitsbergen, as well as implications for understanding fault zone evolution along a major lithospheric scale fault that has undergone multiple phases of deformation and reactivation.

Pease, Victoria

Triassic-Jurassic Island Arc Magmatism: A pre-Canada Basin framework

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The latest Jurassic–Early Cretaceous Brooks Range orogen is flanked by the Colville foreland basin to the north and the Yukon-Koyukuk hinterland Basin (YKB) to the south. We present geochemical and geochronological data, and an isotopic pilot study, of igneous clasts from an Early Cretaceous conglomerate exposed along the Alatna River in the northeast YKB which add to the growing body of evidence documenting intra-oceanic subduction and an extensive Late Triassic – Early Jurassic island arc prior to the development of the Canada Basin.

Twenty-one clasts were analyzed for chemistry, eight for isotopes, and three yielded zircon for U-Pb (LA-ICP-MS) analyses. Depletion in high field strength elements (e.g. Nb, Ta) relative to LREE [$(Nb/La)_{NMORB}$ = 0.1-0.7], and enrichment in fluid mobile large ion lithophile elements (e.g. Sr, K, Rb and Ba; Rb_{NMORB}= 12-80), are consistent with subduction-related island arc chemistry for most samples. On the basis of REE-patterns and age data, the KKB clasts are divided into four compositional groups: ***Group 1*** is tholeiitic and its age is unknow; ***Group 2*** is calc-alkaline and a diorite from this group yields a concordia age of 213 ± 2 Ma (95% conf.)*;**Group 3*** is tholeiitic and a diorite from this group yields a concordia age of 195 ± 1 Ma (95% conf.); G***roup 4*** is calc-alkaline and a granodiorite from this group yields a concordia age of 194 ± 2 Ma (95% conf.). Limited Sm/Nd analyses indicate all groups have juvenile isotopic signatures similar to modern island arcs (εNd = +7.7 to +8.8). Preliminary Pb analyses indicate that tholeiitic Groups 1 and 3 have isotopic compositions similar to MORB.

The juvenile island arc chemistry and ages of the clasts from the northeastern YKB confirm that they represent erosional remnants of a late Triassic – early Jurassic island-arc. These ages (213 Ma) and Jurassic (195 Ma) ages are older than those previously reported for island arc rocks in the region, e.g.- the Koyukuk arc terrane or the Brooks Range ophiolite. Triassic-Jurassic arc magmatism may account for similar ages found in the modern Arctic detrital zircon record (c. 215-200 Ma, Sverdrup Basin; c. 190-215 Ma, Arctic Alaska; c. 205 Ma, Wrangel Island; c. 216 Ma, Chukotka; c. 210 Ma, Taimyr; c. 190-210 Ma, Barents Sea shelf) and suggests a relatively widespread active margin at this time.

Petrov, Evgeny

Large Arctic mafic provinces and MZ_2 –KZ post-orogenic basite magmatism evolution of Barents-Kara region

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At least four tectonic-magmatic stages of mafic magmatism had been in the Mesozoic-Cenozoic history of the Arctic: 1) **Early Triassic**, short-lived, but quite large in volume (Siberian Platform, Taimyr-Severnaya Zemlya, South Kara regions, Polar Urals, arch. Novosibirsk Islands, etc.); 2) **Late MZ** mostly Cretaceous (FJL, Svalbard, N-Greenland, Canadian Arctic Islands, De Long Isl.), extended over time with two main peaks, less extensive than Early Triassic, but significant in wide area; 3) **Early-post-KZ** (British-Arctic province of traps, including both coasts of Greenland, early volcanism of Iceland, north of Britain and west Spitsbergen); 4) **Late KZ** not big in volume, but spread over large area - Spitsbergen, Novaya Zemlya on the west: De Long Isl., north of Yakutia, Chukotka, Magadan on the east. The range of post-Miocene volcanic rocks of the Chukotka continues through St. Lawrence isl. to Alaska, forming a belt of dispersed fields of young (6 million years) volcanoes to the west - north-west of the Aleutian island.

The main conclusions from the different stages products of the Eurasian Arctic and North Atlantic continental mafic rocks are next:

1) Mz_2-magmatites differ from the later igneous rocks by their widespread and relative petrochemical (oxides) constancy. Low potassium tholeites & normal-alkaline basalts with quartz & hypersthene. 2) Magmatites KZ_1 and

Miocene are less common, alkaline rocks with normal nepheline are dominated. 3) Post-Miocene, Late Miocene (younger than 5-9 Ma) volcanoes are characterized by local distribution. Beside to alkaline basalts, alkaline-ultramafic lava is common. 4) The Mz_2-KZ rocks of continental mainly mafic magmatism is the presence of isotope-geochemical marks (OIB type) of plume character 5) Oceanic and continental magmatites (Norwegian-Greenland Basin) differ in their petrogeochemical features due to the different depth of melt formation and the composition of the mantle substrate. Continental magma is enriched with incompatible rare elements compared to oceanic lava. 6) Mz_2-stage of continental magmatism is characterized by spreading area with cover effusions of platobasalts and isometric volcanic-tectonic structures (Franz Josef Land or De Long Isl.). The KZ-stages of magmatic activity characterized by linearly structures presented by extended dikes (volcanic ridges and sliding zones) controlled by systems parallel faults, which corresponds to volcanoes of central type. 7) Mostly toleitic Mz_2-magmatism, less alkaline mafic type, marked the stage of a great restructuring of the modern Arctic geodynamic system. Massive effusions of basalts let down the central part of the Arctic. Following this, as a result of spreading (rifting) and the opening of the Eurasian basin with the penetration of the Atlantic Ocean into high latitudes zone, formed the structure of modern surface of the Arctic.

Petrov, Oleg

New Tectonic Map of the Arctic

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In 2019, the compilation of the new Tectonic Map of the Arctic (Tectonic Map of the Arctic, 2019: eds. O. Petrov, M. Pubellier) was completed. The map was compiled under the international project Atlas of Geological Maps of the Circumpolar Arctic, 1:5M with the participation of representatives of all Arctic states under the auspices of the Commission for the Geological Map of the World at UNESCO.

The new 1:5M Tectonic map of the Arctic is a GIS project, which provides a transition to three-dimensional geological mapping. The project includes the crustal and sedimentary cover thickness maps, the crustal types map, the tectonic zonality map of the basement, schematic map of key igneous provinces of the Circum-Arctic region and the geological transect compiled taking into account the latest scientific geological and geophysical data accumulated in recent decades as a result of high-latitude expeditions and scientific programs to substantiate the extended continental shelf in the Arctic.

The new Tectonic map of the Arctic proved the continental nature of the Central Arctic Uplifts as a natural geological extension of Eurasia. Close structural relationships of deep-water parts of the Central Arctic and the shallow continental shelf of Northern Eurasia are substantiated by geological and geophysical characteristics of the consolidated crust, the upper mantle and sedimentary cover, as well as the common parameters of the magnetic and gravitational potential fields. These new data and bottom sampling results for steep seabed escarpments obtained in 2012, 2014 2016, using drilling and a submarine manipulator, suggest that the Central Arctic Uplifts area is part of the Eurasian lithospheric plate and confirm the notions that the boundary between the North American and Eurasian lithospheric plates originated in the Canada Basin in the first half of the Cretaceous. This stage of continental rifting in the Amerasian Basin ended in the formation of the high-latitude volcanic HALIP trap province, represented by tholeitic and alkaline magmatism shows in the Svalbard region, in Franz Josef Land, in Arctic Canada and in the Alpha-Mendeleev Rise. The formation of recent boundaries of lithospheric plates began much later, in the Paleogene, within the Gakkel Ridge, rift depressions of the East Siberian Sea and the Northeast of Russia.

Piepjohn, Karsten

The Eurekan deformation – a reconstruction of the Cenozoic deformation in the Arctic based on geological and structural field data and observations

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Geological and structural fieldwork during a number of CASE-expeditions (Circum-Arctic Structural Events) in different segments of the European and North American Arctic has shown that the Eurekan deformation is not a simple classical fold belt but a collage and combination of a number of different deformation zones, subordinate fold belts and large strike-slip fault zones. Besides the contractional kinematics within local Eurekan fold belts and thrust zones (West Spitsbergen Fold-and-Thrust Belt, Kap Cannon Thrust Zone, reverse faults on Ellesmere Island), the Eurekan deformation is dominated and controlled by strike-slip deformation parallel to the present continental margins of Barents Shelf, North Greenland, Northern Ellesmere Island and along the Wegener Fault and Vendom Fiord Fault Zone. It is characteristic for the Eurekan deformation, that different areas were affected by contractional and lateral movements at the same time: an early phase was characterized by contraction in the West Spitsbergen Fold-and-Thrust Belt and sinistral movements along the Wegener Fault, and a later stage by contraction across Nares Strait and dextral strike-slip movements along the Hornsund Fault Complex between NE-Greenland and Svalbard.

Here, we present an attempt for a reconstruction of the Eurekan deformation in the Cenozoic, which is based on geological field observations: Mapping of geological units and fault zones, structural cross sections, analyses of kinematics and timing of the single fault zones, comparison of the geology and structure of the involved continental plates and tectonic blocks – and the magnetic anomalies and tectonic evolution of the opening of the surrounding oceanic basins (Labrador Sea/Baffin Bay, Greenland and Norwegian seas, Eurasian Basin). In most existing reconstructions, a combination of contractional and extensional movements is assumed to explain the tectonic evolution and movements of the Eurekan deformation in the different involved areas. In our reconstruction, we also include the role and significance of lateral movements, the observed or estimated time of active phases of the local Eurekan fault zones and fold belts in Svalbard, North Greenland and on Ellesmere Island and their kinematics.

Planke, Sverre

HALIP Implications for Early Cretaceous Sedimentation in the Barents Sea

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The initial phase of the High Arctic Large Igneous Province (HALIP) occurred during the early Cretaceous, in the Barremian-Aptian times. We have mapped the distribution of major sill complexes and associated less-extensive extrusive deposits in the northern and eastern Barents Sea based on integrated seismic, gravity, and magnetic interpretation, and on-shore fieldwork. The mapping reveals abundant igneous rocks in the northern and eastern Barents Sea covering an area of ~900,000 km2 with a conservative volume estimate of 100,000 to 200,000 km3 of intrusions. The igneous province is dominated by sheet intrusions injected into Triassic and Permian sedimentary sequences and is referred to as the Barents Sea Sill Complex (BSSC). Extrusives are less abundant, but present on Franz Josef Land and eastern Svalbard. Hydrothermal vent complexes are rare, with only two candidates identified on seismic data in the eastern Barents Sea. The magmatism is temporally constrained by U/Pb TIMS ages of sampled intrusive rocks and tuffs at c. 122-125 Ma. Extensive mapping of high-resolution 3D and 2D P-Cable and conventional seismic reflection data reveal an extensive Barremian to Aptian age sediment package of marine strata in the west-central Barents Sea. This offshore prograding unit are the distal extension of the fluvial Helvetiafjellet Formation on Spitsbergen, sourced from a hinterland to the north and northwest of Svalbard. We propose that the early Cretaceous uplift and erosional events were the results of doming caused by a mantle plume triggering the HALIP. Younger, Late Cretaceous igneous events usually incorporated in the HALIP had similar implications for the regional geological evolution with renewed uplift of the Barents Shelf, including Svalbard and adjacent areas in the Arctic.

Ploetz, Aline

Local Seismicity in the SW Laptev Sea Rift

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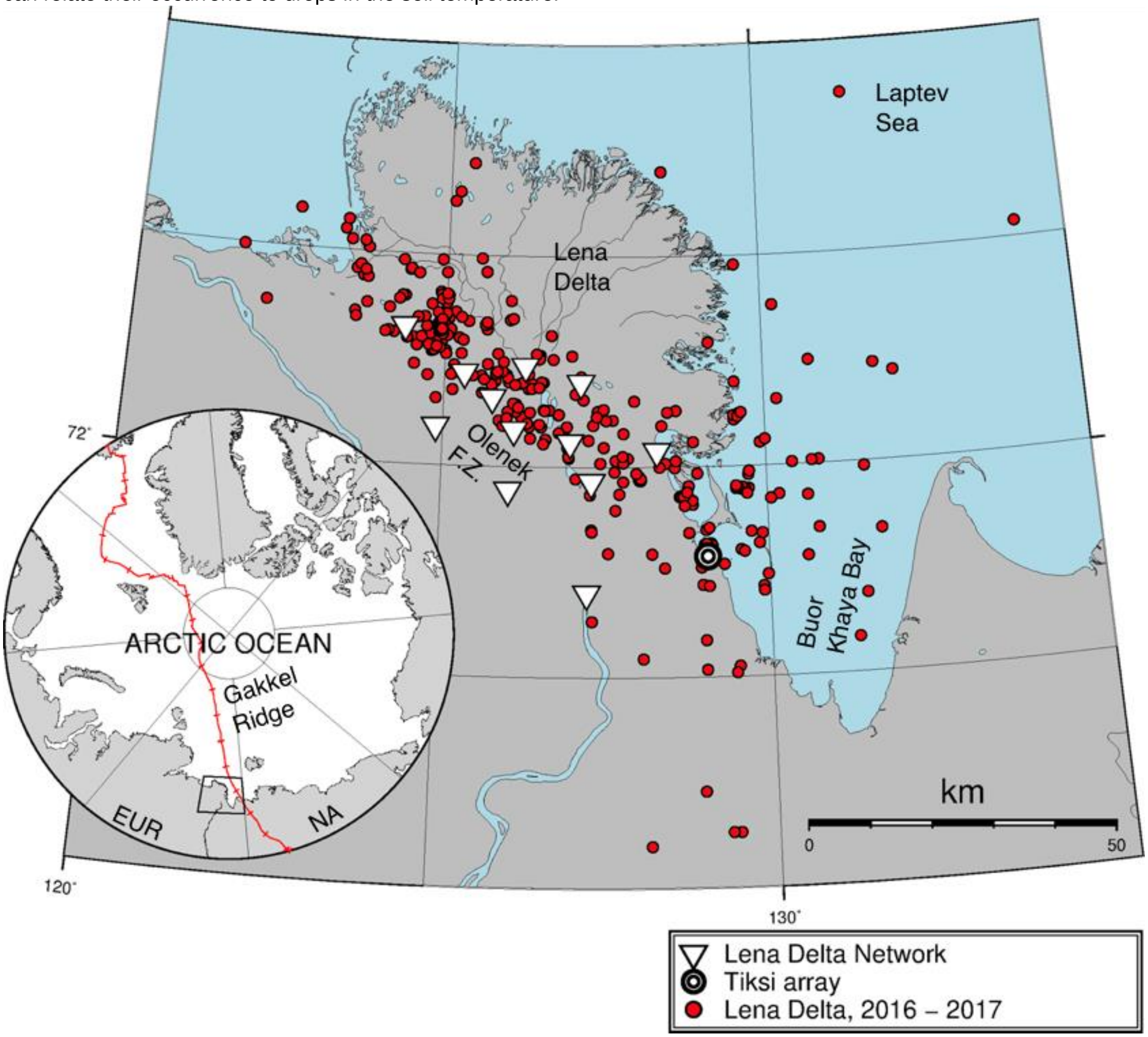
From the Arctic Ocean the ultra-slow spreading Gakkel ridge is propagating into a continental rift system – the Laptev Sea Rift. This rift system provides a rare opportunity to investigate mechanisms of recent continental breakup. In general, divergent plate boundaries are accompanied by magmatic and earthquake activities. The earthquake activity at the Gakkel Ridge is confined to the rift valley. Though, the Laptev Sea Rift indicates less and more diffuse seismicity and an absence of magmatic activity. Up to now, the complex geodynamic setting of this region is not fully understood, e.g. if the continental rift is still in an extensional mode, or either if an assumed separate microplate exists. In our ongoing study we investigate the geodynamic processes of the continental rift system of the Laptev Sea, their major tectonic zones and the amagmatic rifting in an Arctic and global context.

We present location results from nine months of data (08/2016 to 04/2017) recorded at 25 seismological stations, temporary installed as a network in the Lena Delta and as a seismological array, with 2 km aperture, in the vicinity of Tiksi. Results show high seismicity along the southern rift grabens in the Buor-Khaya Bay and along the Olenek fault zone (NW-SE) in the southern Lena Delta. Whereas, we noticed less earthquake activity north of the Lena Delta. With a minimum 1D local velocity model, we located several hundreds of earthquakes with local magnitudes mL <4. Focal depths are mainly <25 km. In the Buor-Khaya Bay local earthquakes are concentrated along the western graben shoulder. It is however unclear if this seismicity marks a continuation of the Olenek fault in East-West direction or if it is caused by another fault in North-South direction.

Furthermore, we observed several thousands of very small and local events especially during the winter months and can relate their occurrence to drops in the soil temperature.



Pointon, Michael

They came from near and far: altered volcanic ash layers within the Late Cretaceous Kanguk Formation, Sverdrup Basin

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The mudstone-dominated Late Cretaceous Kanguk Formation of the Sverdrup Basin, Canadian Arctic, contains numerous diagenetically altered volcanic ash layers (bentonites) that provide a record of Late Cretaceous volcanism within the High Arctic. Eleven bentonites were sampled from an outcrop section in the Sawtooth Range, Ellesmere Island. Five of the sampled bentonites were analysed for combined zircon U-Pb age and Hf isotopes. All of the bentonite samples collected were analysed for whole-rock geochemistry.

Two distinct types of bentonite are identified from the whole-rock trace element geochemistry and zircon Hf isotope data. (1) Nine decimetre-thick peralkaline rhyolitic to trachytic bentonites occur distributed through the late Turonian to early Campanian (*c*. 92–82 Ma) outcrop section. These bentonites originated from mildly alkaline magmas with limited crustal contamination that were likely erupted in an intra-plate tectonic setting. The considerable thickness of many of these bentonites suggests that the volcanic centres were proximal to the Sverdrup Basin. Local volcanism associated with the High Arctic Large Igneous Province (HALIP) is the inferred source of these bentonites. (2) Two thinner, centimetre-thick, sub-alkaline, dacitic to rhyolitic bentonites of late Turonian to early Coniacian age (*c*. 90–88 Ma) were also identified. The geochemistry and isotope data from these bentonites support a parent magma with a greater degree of crustal contamination that was erupted from volcanoes within an active continental margin tectonic setting. The lack of nearby potential sources of sub-alkaline magmatism, together with the thinner bed thickness of the sub-alkaline bentonites and small size of euhedral zircons, are consistent with a more distal source area. The age and geochemistry of these two sub-alkaline bentonites correlate with an interval of intense volcanism in the Okhotsk-Chukotka Volcanic Belt (OCVB), Russia. Consequently, during late Turonian to early Coniacian times intense volcanism within the OCVB may have resulted in widespread volcanic ash dispersal across Arctic Alaska and Canada, reaching as far east as the Sverdrup Basin.

Prokopiev, Andrey

The middle Palaeozoic stage of mafic magmatism and evolution Vilyui paleorift basin (eastern Siberian platform)

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The middle Palaeozoic Vilyui paleorift basin (eastern Siberian platform) and conjugate the Yakutsk–Vilyui large igneous province (volume of basic igneous rocks is c. 200 000 km3), covering its entire territory, are one of the large-scale examples of the joint manifestation of rifting and magmatic activity. As shown by authors, opening of the Palaeozoic rift basins in Siberia due to tectonic processes was accompanied by crustal extension followed by dyke intrusion. Temporal correlation between dyke intrusion and stages of extension and rapid basement subsidence in different troughs of the sedimentary basin was carried out. Possible mechanisms of rifting (extensional *vs.* plum-related) and the thermal regime of the lithosphere beneath the rift zone of the Vilyui sedimentary basin are considered based on the available isotopic ages of dike swarms (Vilyui–Markha, Kontai–Dzherba, and Chara–Sinsk), rates of sedimentation (by means of backstripping analysis), and results of numerical thermomechanical modeling. The results prove the contribution of both plate-tectonic and magmatic factors to the formation of the Vilyui rift and show a relationship between the rapid extension of the lithosphere and the formation of mafic dike swarms in the Yakutsk–Vilyui Large Igneous Province of the Siberian Platform at the Frasnian–Famennian boundary, with a peak at ~374 Ma, and at the end of the Late Devonian, with a peak at ~363 Ma. There were two pulses of dike formation

during rapid subsidence of the basin basement in the period 380–360 Ma, with a sedimentation rate of 100–130 m/Myr, at a background rate of 10–20 m/Myr. Results of thermomechanical modelling revealed that the best-fit model is that combining the mechanisms of intraplate extension (passive rifting) and the ascent of a mantle plume (active rifting). A conclusion about the nature of the heat source of mafic magmatism has been drawn: The plume-driven regime of the lithosphere can better explain the dynamics of extension during rifting than the decompression melting mechanism. The best-fit model predicts the formation of the Vilyui basin under extensional conditions with a depth-integrated horizontal driving force of 2.0×10^{13} N/m, which corresponds to a pressure of 0.73*lithostatic.

Prokopiev, Andrey

New data on geochemistry, age and geodynamic settings of felsic and mafic magmatism of the northeastern part of October Revolution Island (Severnaya Zemlya Archipelago)

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In the northeastern part of October Revolution Island there is an exposed 1000 m thick volcaniclastic rocks, including variegated tuff-siltstones, tuff-mudstones, tuff-sandstones, and rhyolite lavas. The rocks have sublatitudinal strike and are deformed by early WE-trending sinistral strike slips and thrusts and by late mainly submeridional strike-slip faults. This volcaniclastic complex is overlain by flat-lying thin Carboniferous-Permian continental terrigenous rocks. Volcanic rocks yielded age at 463±3 Ma (Middle Ordovician, zircons, SHRIMP). Subvolcanic granite porphyry dated at 461–472 Ma (12 samples, Middle Ordovician, zircons, SHRIMP) while basalts, basaltic lava breccias and dolerite sills yielded ages at 467±16 and 435±15Ma (baddeleyite, SHRIMP).

Granite porphyry and rhyolites have similar geochemical features. The rocks are subalkaline and peraluminous. Chondrite-normalized REE patterns show a moderate negative Eu anomaly reflecting fractionation of the plagioclase phase. But, on discrimination diagrams, figurative points of granite porphyry lie mainly in the field of within plate granites, and rhyolite values are localized in the field of volcanic arc granite. REE patterns of basalts and dolerites are similar to those of E-MORB. Chemical composition of mafic rocks reveals their arc basalts and volcanic arc basalts signature. Obtained data suggest that, the studied rocks could be formed on the active continental margin of the Ordovician-Silurian in age.

To the east the volcaniclastic rocks are separated by a submeridional dextral strike-slip fault from Cambrian sedimentary rocks. The rocks underwent two deformation stages. Early east-verging tight to isoclinal folds of the first generation deformed by dextral strike-slip faults are observed. Rare folds with subvertical axes are associated with second strike-slip stage. Deformed rocks are intruded by Late Silurian to Early Devonian tholeiitic gabbro-diorite and dolerite dikes (407±1, 416±1.5 Ma, baddeleyite, SHRIMP).

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Ranta, Eemu

Volatile characteristics of an EM-type mantle component in Iceland

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Trace element, as well as radiogenic (He-Sr-Nd-Hf-Pb) and oxygen isotope variability in primitive Icelandic lavas exceeds that of surrounding MORBs and define an Icelandic mantle that is laterally hetereogeneous. This diversity likely reflects mixing of ambient depleted MORB mantle (DMM) with plume-derived recycled and primordial components, and a distinct enriched mantle (EM) component sampled by the Öræfajökull volcano [1]. Volatiles such as H2O, B and Cl [2] may hold unique, time-independent constraints about the origins of different mantle domains as their stable isotope signatures can remain unchanged over their residence time in the mantle. In this respect, the Kverkfjöll volcanic system, located in the Northern Rift Zone, emerges as an interesting study area, as it is known to host some of the most volatile-rich tholeiitic basalts in Iceland [3].

We report new major and trace element, volatile abundance (H2O, B, Cl, S) as well as Pb and stable (δ11B, δ18O, δ37Cl) isotope data from subglacial pillow rim glasses from Kverkfjöll. The glasses are exclusively basaltic (MgO = 4-8 wt.%), moderately enriched in incompatible trace elements and have notably high concentrations of B = 1.0-3.5 ppm, Cl = 200-480 ppm, H2O = 0.6-1.1 wt.% compared to other Icelandic rift tholeiites. The Pb isotopic signature is off-set from the main Icelandic array towards the EM-type signature of the Öræfajökull volcano. The δ18O is low at +3.9±0.1‰ (2SE) and independent of melt evolution.

The Cl/K (0.07), B/Pr (0.4) and H2O/Ce (270) ratios are moderate and do not vary with melt evolution, suggesting that volatile addition by assimilation of brines or hydrothermally altered crust is limited during crustal residence times of the magmas. The volatile enrichment of the Kverkfjöll glasses, heavy δ11B = -3.1±0.8‰ (2SE) and δ37Cl values of 0.0±0.2‰ (2SE), together with 3He/4He = 8.5 R/RA [4] resemble a DMM source modified by subduction fluids [5]. The enriched Pb isotopic signature could imply that these volatile charasteristics are linked to old recycled material in the Kverkfjöll mantle source.

Richter, Marianne

Evidence for a paleo-subduction zone under the western Gakkel Ridge, Arctic Ocean

Marianne Richter[1], Oliver Nebel[1], Roland Maas[2], Ben Mather[3], Nebel-Jacobsen Yona[1], Henry J Dick[4], Fabio A Capitanio[1] and Peter A. Cawood[1], (1)Monash University, School of Earth, Atmosphere and Environment, Melbourne, VIC, Australia, (2)University of Melbourne, School of Earth Sciences, Melbourne, Australia, (3)University of Sydney, School of Geosciences, Sydney, NSW, Australia, (4)Woods Hole Oceanographic Institution, Woods Hole, MA, United States

Chemical heterogeneity in Earth’s upper mantle is consequent to multiple cycles of melt extraction, fluid-borne metasomatism and relicts of recycled oceanic lithosphere and/or delaminated subcontinental lithosphere. The distinct elemental and isotope patterns of enriched and depleted mantle sections can be traced through the study of either abyssal peridotites or indirectly through their derived melts. Previous studies showed that mantle beneath the Gakkel Ridge in the Arctic Ocean is highly heterogeneous and isotopically distinct (Goldstein et al., 2008; Liu et al., 2008;

Stracke et al., 2011). This diversity has been explained by the integration of sub-continental lithospheric mantle and/or by re-enrichment and ancient depletion events. Nonetheless, no consensus has been reached to explain the extreme heterogeneity at the ridge. Here, we present new geochemical data of dredged seafloor basalts from the Gakkel Ridge and suggest that the chemical diversity is a remnant of a fossil subduction overprint stored in the upper mantle underlying the ridge. Paleogeographic reconstructions show that the western part of the Gakkel Ridge was subject to subduction activity between 145 and 130 Ma. Geochemically, this overprint is expressed in Gakkel Ridge basalts by elevated Pb and Sr isotope signatures, enrichment of Ba/Th, and depletion of Zr/Nb. These signatures are equivalent to present day island-arc and back-arc basalts from the Western Pacific. Thus, we propose that the distinct isotopic signature and heterogeneity of the mantle beneath the Gakkel Ridge results from a paleo-subduction zone and is key to resolving and redefining plate reconstructions in the High Arctic.

Goldstein, S.L. et al., 2008. Origin of a 'Southern Hemisphere' geochemical signature in the Arctic upper mantle. Nature, 453(7191): 89-93.

Liu, C.Z. et al., 2008. Ancient, highly heterogeneous mantle beneath Gakkel ridge, Arctic Ocean. Nature, 452(7185): 311-6.

Stracke, A. et al., 2011. Abyssal peridotite Hf isotopes identify extreme mantle depletion. Earth and Planetary Science Letters, 308(3-4): 359-368.

Ruppel, Antonia

Combined aeromagnetic and structural studies along the continental margin of NE Greenland

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Complex fold belts and strike-slip zones resulting from Eurekan deformation characterize the continental margins of northern North America and Svalbard. One of these major deformation zones is the Wandel Hav Mobile Strike-Slip Belt in NE Greenland, which was subject of our multi-disciplinary geoscientific investigations in 2018. Until now, the timing of deformation is controversially discussed being either Cretaceous or Paleogene in age.

Structural field work during the expedition CASE 20 (BGR's Arctic research program **C**ircum-**A**rctic **S**tructural **E**vents) were combined with the acquisition of new aeromagnetic data, which were gathered with a line spacing of 2 km. The new aeromagnetic data cover the area between Kronprins Christian Land and Independence Fjord and comprise about 6300 km new line data. They will allow to trace exposed and mapped geological units and structures into adjacent areas, which are covered by sea water, ice or by glaciers that represent roughly 75 % of the surveyed area.

Preliminary results of the aeromagnetic data support the occurrence of NW-SE trending structures parallel to the continental margin of NE Greenland. Combined aeromagnetic, geological, and tectonic field data show that the Wandel Hav Mobile Strike-Slip Belt consists of several blocks separated by major NW-SE trending faults. Further, structural observations demonstrate that the Wandel Hav Mobile Strike-Slip Belt is not the result of a classical fold belt deformation but rather affected by a single deformation regime, which is characterized by N-S contraction combined with NW-SE dextral strike-slip tectonics. So far, deformation of Paleogene deposits has not been reported for NE Greenland. However, during investigations on the island of Thyra Ø (Wandel Hav, NE Greenland), consolidated Palaeocene sediments that have been affected by folding and small scale thrust faulting were discovered. Therefore, a post Palaeocene tectonic event is required, which can be related to Eurekan deformation in the Arctic. The results of CASE 20 will be combined with already existing aeromagnetic data North of Greenland and across Lincoln Sea for a better understanding of the entire North and NE Greenland continental margin.

Ruppel, Antonia

Integrated geophysical and structural geological studies along the Vendom Fiord Fault Zone, Ellesmere Island, Nunavut, Canada

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Ellesmere Island plays an important role in terms of Paleogene deformation, which is fundamental for our understanding regarding the plate tectonic configuration when Greenland represented an independently moving plate. The aim of the expeditions CASE 8 and 12 (**C**ircum **A**rctic **S**tructural **E**vents)in 2004 and 2011, respectively, including structural field work and geophysical investigations, was to distinguish whether or not the ca. NNE−SSW trending Vendom Fiord Fault Zone (VFFZ) can be related to the Wegener Fault or if it represents an independent fault system.

For this purpose, high-resolution aeromagnetic data were acquired over the Vendom Fiord area on southern Ellesmere Island and combined with land-based susceptibility measurements and structural geology. The aeromagnetic survey covered an area of ca. 7000 km^2 and was performed with a 2 km line spacing.

Six magnetic domains, five magnetic boundaries and four structural trends of lineaments are classified for the survey area and correlated with field observations. One of these boundaries is well in line with the Front of the Eurekan Fold-and-Thrust Belt. Furthermore, a regional compilation of new and existing aeromagnetic data allows conclusions regarding the Eurekan Frontal Thrust and its prolongation. In general, structural trends were revealed from tilt derivative maps and are most likely related to early Eocene strike-slip deformation attributed to Eurekan stage 1.

Field investigations revealed that the VFFZ is characterized by a network of NNE−SSW and NW−SE striking fault lines related to a dextral strike-slip regime. One set of structural trends consist of NNE−SSW-directed positive tilt lines, which coincide with dextral strike-slip faults observed in the field along the VFFZ and can be traced onward underneath the Prince of Wales Icefield. Here, the assumed prolongation of these structures underneath the ice can be strengthened by the tilt lines and the observed magnetic anomaly data.

The aeromagnetic data indicate a change in strike direction of magnetic domains suggesting that the NNE-SSW striking fault zones in the Vendom Fiord area west of Inglefield Uplift turn into an E−W trend adjacent to Bache Peninsula. However, the new data revealed no evidence for a connection between the VFFZ and the Wegener Fault.

Saltanov, Vasily

Taimyr Hot Spot and Its Role in the Formation of Mantle-Crustal Ore-Bearing Strontium-Barium Carbonatite

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The largest Fad'yukuda-Kotui gravimagnetic ring structure and a belt of ore-bearing Sr-Ba carbonatite were identified when compiling the State Geological Map of Russia within the Early Cimmerides of the Taimyr Peninsula, northern part of the Siberian Platform, and the East Taimyr–Olenek folded branch of the Late Cimmerides. When considering first-order mantle convective cells and hot spots that existed before the break-up of Pangea, it was established that the ring structure occupied a definite place in the northern Eurasian plate, corresponding to the Taimyr hot spot of the Triassic lower mantle plume.

In the southeastern part of the hot spot at the northern termination of the Siberian Platform, there is an outcrop of the unique Guli clinopyroxenite-dunite, picrite-melanephelinite and ijolite-carbonatite volcano-pluton. In the Byrranga mountains the ring structure is characterized by occurrence of Middle to Late Triassic differentiated platinum-bearing ultramafic-mafic intrusions with titanomagnetite and Co-Ni mineralization, volcanic rocks of the trachyandesite-trachytic formation, ring intrusions of ferrogabbro-monzonite-granosyenite, nepheline-syenite formations, diamond-bearing alneite and crustal carbonatite.

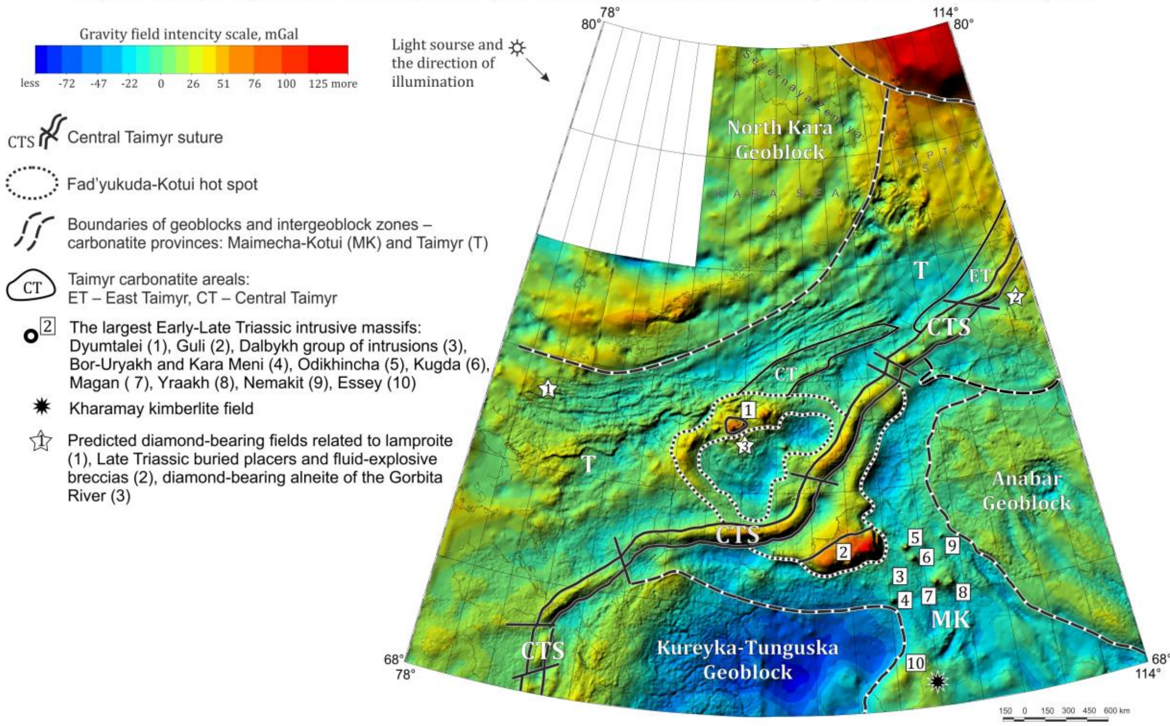
West Taimyr and East Taimyr areals of small intrusions, carbonatite, fluidolite correspond to offshoots from the hot spot. West Taimyr magmatism culminates in the formation of dike fields of potentially diamond-bearing lamproites and alkaline syenite diatremes, and in the East, in carbonatite with gold-bearing polymetallic and fluorite-barite mineralization.

Location patterns of the carbonatite relative to the Taimyr hot spot, its mineralogical, geochronological and isotopic-geochemical features make it possible to outline a model of the mantle-crustal origin of ore-bearing carbonatite.

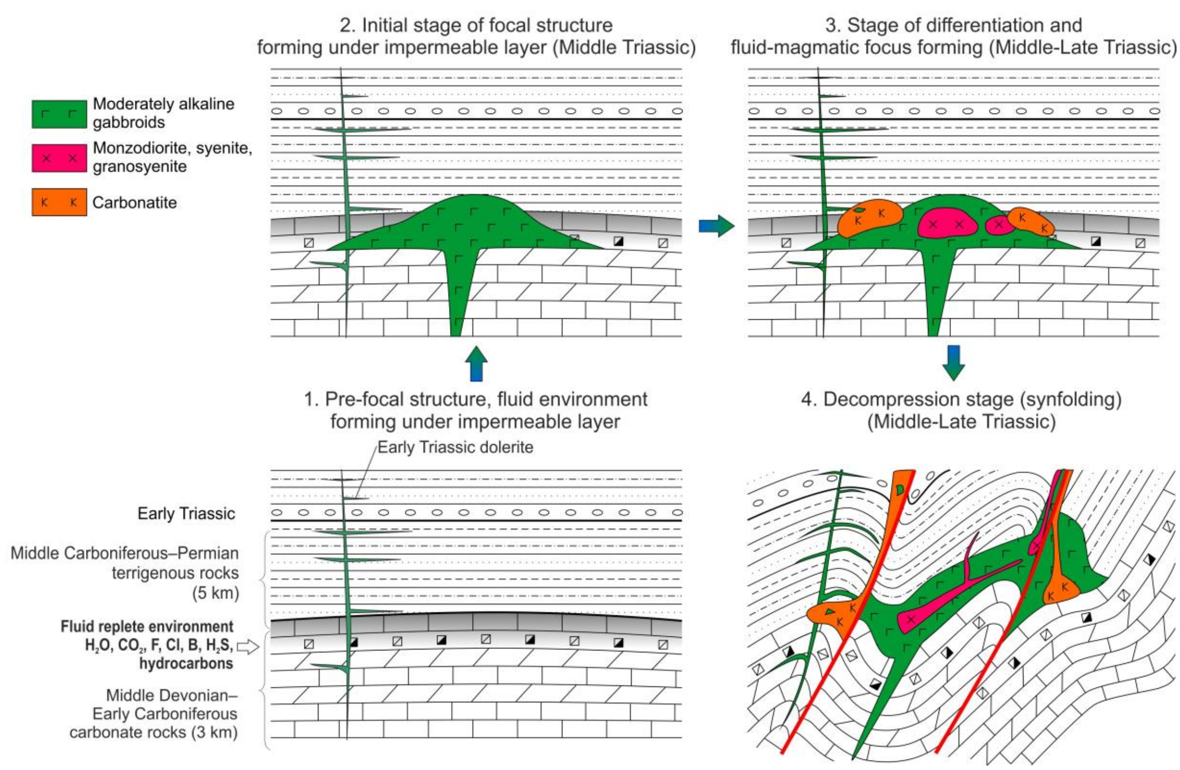
The available data indicate the mixing of juvenile and near-surface fluids as a result of the interaction of ultramafic-mafic magmas in intermediate upper-crust foci under the clay-terrigenous caprock of Upper Paleozoic. Evolution of the focal structure consisted in the magmatogenic-fluidogenic differentiation at high temperature and pressure, partial melting of the host sedimentary carbonate rock to form fluid explosive breccias and injective Sr-Ba carbonatite.

Location of Sr-Ba carbonatite areas in the Taimyr Peninsula and Maimecha-Kotui province intrusions relative to the Fad'yukuda-Kotui hot spot on the gravity map

Bouguer reduction, density of the intermediate layer is 2.67 g/m^3. Level is conditional (colour pseudorelief). Compiled in VIRG-Rudgeofizika, 2002



Model of the mantle-crustal origin of ore-bearing carbonatite of East Taimyr



Savelev, Aleksandr

The Early Cambrian magmatism of the north-east Siberian platform (Neleger River area).

Aleksandr Dmitrievich Savelev[1,2], Sergey V. Malyshev[1], Andrei K Khudoley[1,2] and Aleksandr Pasenko[3], (1)St Petersburg State University, St Petersburg, Russia, (2)Tomsk State University, Tomsk, Russia, (3)Institute of Physics of the Earth RAS, Moscow, Russia

The Early Cambrian mafic magmatism commonly known as the Kharaulakh event has been documented in the north-east of the Siberian platform in the Olenek uplift and in the frontal thrust sheets of the Verkhoyansk fold-and-thrust belt in the Kharaulakh Mountains. Intrusions of the Kharaulakh event are sills that typically cut Neoproterozoic succession. The uppermost magmatic body is located within the lowermost Cambrian sedimentary rocks and is interpreted to be a volcanic flow. U-Pb age of pebbles ranges from 545 to 525 Ma showing that duration of the Kharaulakh event-related magmatism was close to 20 My (Khudoley et al, 2013, Prokopiev et al, 2016).

New study of the sills of the Neleger River valley expands existing database on the chemical composition of the Kharaulakh event magmatic rocks. They are enriched in titanium with TiO_2 ranging from 3.7% to 6.2%. Studied magmatic rocks have very similar patterns when plotted on the mantle-normalized multy-element diagram and follow OIB trend. Some Neleger sills samples are characterized by positive Ti, P and Eu anomalies and negative Sr anomaly. Chondrite-normalized REE distribution shows LREE enrichment with (La/Lu)n and (La/Sm)n values averaging at 5,84 and 1,69 respectively and no or slightly positive Eu anomaly. Mafic sills from the westernmost exposures have higher concentrations of V as well as lower concentrations of SiO_2 and Al_2O_3 compared to the bodies of the western part of the study area.

Such chemical compositions of the basaltic magma are typical for the continental rifts, and Kharaulakh event correlates well with the latest Neoproterozoic – Early Cambrian rifting of the south-east margin of the Siberian platform. Gradual variation in chemical composition of the intrusions is typical for magma formed at the different stages of rift evolution, likely pointing that sills are getting younger westward.

The study was supported by the RSF grant 18-17-00240

Schaeffer, Andrew

Examining the crust and mantle structure surrounding the Beaufort Sea, western Canadian Arctic

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The formation and evolution of the western Canadian Arctic Archipelago represents a long-standing tectonic puzzle. The eastern Beaufort Sea juxtaposes young Arctic Ocean with Paleo-Proterozoic Canadian Shield. Controlled source off-shore seismic data suggest that Banks Island represents the western edge of the rifted margin established during the opening of the Arctic Ocean. In this scenario rifting caused Banks Island to subside and accumulate sediments rich in petroleum source material. Conversely, surface-wave based velocity models of North America indicate

velocities at 100-150 km depths similar to those beneath Canada's diamond mines in the central Slave craton. These results suggest Banks Island basement is part of the Canadian Shield and any kimberlites are promising diamond candidates. Furthermore, the southern Beaufort Sea Mackenzie Delta margin represents a well-developed fold and thrust belt <=65 Myrs old but has only been recently recognized as likely active. This belt accommodates either slow thrusting of continental crust over the oceanic crust, or insipient subduction of the oceanic crust beneath the margin.

We exploit data from new land seismic networks to investigate crustal structure and seismicity of the Beaufort Sea and surroundings. A key question is how mantle structure typical of the Canadian Shield is reconciled with crust of a rifted passive margin. Specifically, inference of thick cratonic-like lithosphere underlying Banks Island is incompatible with a tectonically disrupted and thinned margin of the Canada Basin. Preliminary results of crust and mantle structure from dispersion analysis, 1D inversion, and receiver function analyses, indicate a ~30 km deep Moho beneath the Beaufort Sea and Banks Island, with slight thinning northwards towards Prince Patrick and Melville Islands. Mantle velocities remain elevated, indicative of cooler lithosphere. Anisotropy orientations from SKS splitting indicate margin parallel fabrics, perpendicular to those expected for a tectonically extended margin; however, their source depths remain elusive.

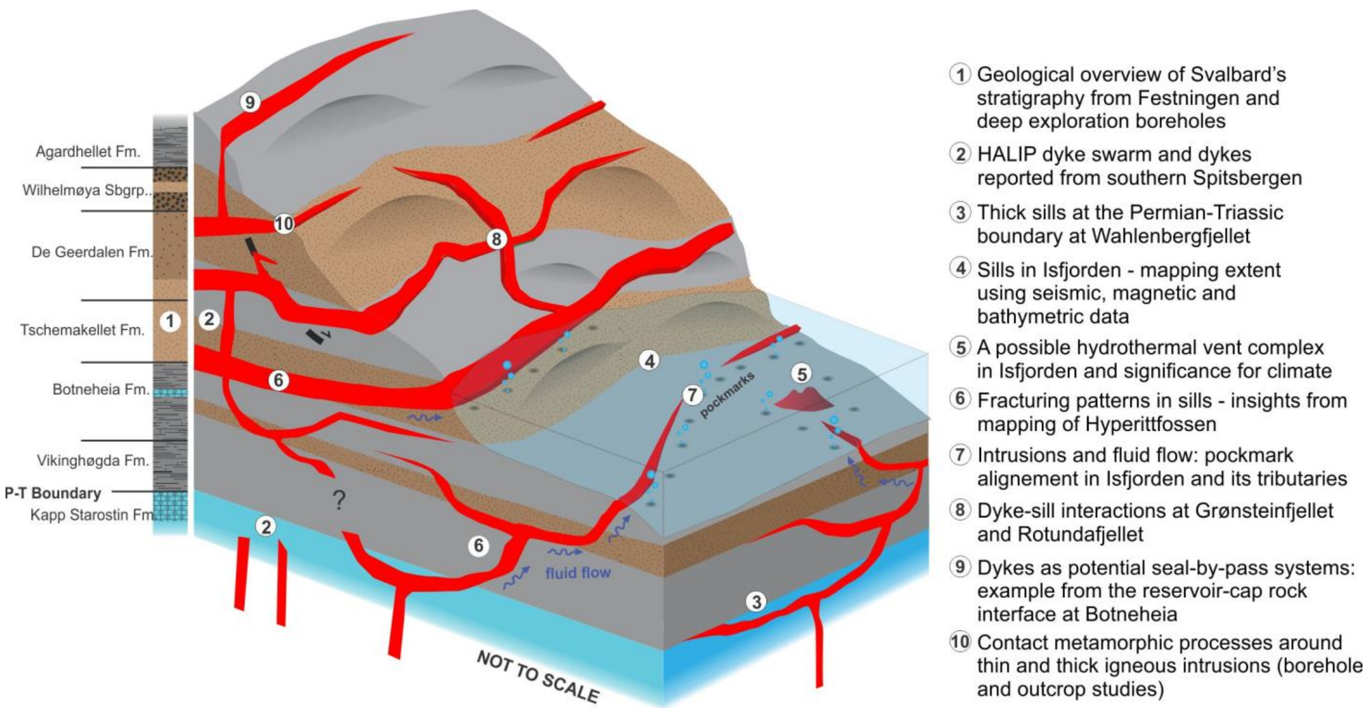
Senger, Kim

Early Cretaceous dolerites in Spitsbergen: a virtual field trip to the most accessible HALIP exposures

Kim Senger, University Center on Svalbard, Dept. of Arctic Geology, Longyearbyen, Norway

Early Cretaceous magmatism associated with the early phase of the High Arctic Large Igneous Province (HALIP) led to the emplacement of significant magmatic volumes across the circum-Arctic. In Svalbard, HALIP magmatism is manifested by predominantly basaltic intrusions and lava flows collectively classified as the Diabasodden Suite, named after the Diabasodden type locality in central Spitsbergen. Here the dolerites primarily occur as sills intruded in Permian-Jurassic siliciclastic host rocks, with dykes present locally. As in other volcanic basins worldwide, the Svalbard intrusions have had an impact on the various petroleum system elements and compartmentalize a siliciclastic reservoir-cap rock system locally targeted for CO_2 storage.

In this contribution, I present a virtual field trip to key localities of the Diabasodden Suite in Spitsbergen (Figure 1). The virtual field trip integrates numerous data types to introduce each stop, including regional geological and geophysical maps, stratigraphic columns, borehole data, publications, detailed terrain models draped with geological maps, geological profiles and seismic profiles. For most localities, these are complemented with high-resolution virtual outcrop models processed using photogrammetry, with photographs acquired from boats, drones or by walking. Such virtual outcrop models allow the detailed three-dimensional representations of the outcrops at cm-to-dm resolution (large, "seismic-scale", outcrops) or mm-to-cm resolution (details, such as contact metamorphic aureoles). Drone footage and detailed outcrop photographs are, where available, also included in each stops. The storyline (Figure 1) is designed to firstly introduce the regional stratigraphy before using localities as examples for specific topics, including contact metamorphism, intrusion geometry, fracture patterns or the effects of intrusions on fluid flow. As such, the virtual field trip introduces some key elements in an interactive 3D environment to bring the HALIP exposures in Svalbard to a broader audience. In addition, for those fortunate enough to visit these localities in person, the virtual field trip serves as a useful pre-field trip tool to introduce the different field sites.



Shephard, Grace

Updated tectonic reconstructions of the Cretaceous Arctic: Digital plate model and applications.

Grace E Shephard[1], H Ruth Jackson[2], Carmen Gaina[1], Karsten Piepjohn[3], Gordon N Oakey[4], Qingmou Li[5], John Shimeld[4], Ivar Midtkandal[6] and Kai Boggild[4], (1)University of Oslo, Centre for Earth Evolution and Dynamics (CEED), Oslo, Norway, (2)Geological Survey of Canada Atlantic, Dartmouth, NS, Canada, (3)BGR Federal Institute for Geosciences and Natural Resources, Hannover, Germany, (4)Geological Survey of Canada (Atlantic), Natural Resources Canada, Dartmouth, NS, Canada, (5)Bedfort Institute of Oceanography, Canada, Dartmouth, NS, Canada, (6)University of Oslo, Tectonostratigraphic Research Group, Dept. of Geosciences, Oslo, Norway

An updated digital plate reconstruction is now timely for the Arctic. Recent concentrated mapping efforts and data interpretations by the community at large have rendered new updates for Mesozoic and Cenozoic times, in particular. It is now understood that the timing and kinematics of the Amerasia Basin's opening must also be viewed in context of two other major contemporaneous Cretaceous events, namely the emplacement of the High Arctic Large Igneous Province (HALIP), and the closure of outboard oceanic basins (the South Anuyi and Angayucham oceans) and associated terrane accretion. In addition to legacy data, we utilize the most recent mapping of structural lineaments and kinematic indicators (e.g. Chian et al., 2016; O'Brien et al., 2016; Hutchinson et al., 2017 and more), magnetic and gravity anomalies (e.g. Saltus et al., 2011; Gaina et al., 2011; Døssing et al., in submission), crustal thickness and crustal types (e.g. Lebedeva-Ivanova et al., 2019; Skolotnev et al., 2018).

The result is a revised two-phase (I: rifting, II: seafloor spreading and extension) model for the Amerasia Basin, as built in GPlates. The model, complete with plate boundaries and terrane boundaries, serves as an update to Shephard et al. (2013). We present 3 end member models with different timings to encompass the range of opening constraints and HALIP timings; an early/extended model (I:160-145 Ma, II:145-85 Ma), and middle model (I:145-125, II:125-120 Ma), and a temporally restricted model (I:130-126.57 Ma II:126-120 Ma). We compare outputs of the

models including extensional rates and stretching factors, as well as the predicted distribution of stretched continental crust for the Alpha-Mendeleev Ridge. Using this latter point as an example of the palaeogeographic implications, we show a volumetric comparison between the Early Cretaceous Boreal Basin deposits of the Barents Shelf and the proposed “Crokerland” can be iteratively reconciled. We also propose that the incipient arrival of the HALIP mantle plume would have enhanced uplift and erosion rates immediately prior and during eruption in these regions. Additional updates for the Paleogene Eurekan Orogeny (e.g. Piepjohn et al., 2016) will also be shown.

Shimeld, John

Tectono-magmatic elements of the Alpha Ridge and possible associations with the High Arctic Large Igneous Province

John Shimeld[1], Thomas Funck[2], Qingmou Li[3], Gordon N Oakey[1], Kai Boggild[1] and Ruth Jackson[1], (1)Geological Survey of Canada (Atlantic), Natural Resources Canada, Dartmouth, NS, Canada, (2)GEUS, Copenhagen K, Denmark, (3)Canadian Hazard Information Service, Natural Resources Canada, Ottawa, ON, Canada

Published seismic interpretations suggest that the Alpha Ridge consists of voluminous tuff deposits and possible intercalated sediments, overlain by an upper carapace of basalt flows and sills emplaced no later than the Campanian, possibly during the youngest magmatic phase of the High Arctic Large Igneous Province (HALIP). The Alpha Ridge is widely posited to be an offshore component of HALIP, yet the constructional history of the ridge remains largely unknown.

Coincident seismic reflection and refraction data collected during the 2016 Canada-Sweden Polar Expedition across the northern and southern flanks of the Alpha Ridge reveal a range of igneous phenomena, and allow preliminary identification of important tectono-magmatic elements. Depth conversion of the seismic reflection profiles enhances details of the igneous crust and its internal reflection geometries. Positive bathymetric features on the ridge, such as the Fedotov Seamount, exhibit acoustic facies interpreted as stacked effusive volcanic sequences emanating from discrete volcanic centres. Along the southern ridge periphery, at the Nautilus Spur, wedge-shaped sequences with dipping internal reflections manifest outbuilding of the ridge during early constructional phases. There is no clear evidence for significant amounts of either syn- or post-magmatic tectonic faulting, but igneous intrusions on the northern periphery of the ridge are broadly parallel to both the Marvin Spur and the CESAR valley, suggesting that a tectonic fabric in this orientation affected the conduits for magma delivery. A second fabric, at a high angle to the first, is especially evident along the southern ridge periphery where volcanic edifices are elongated in a broadly NE trend. Principal constructional phases of the ridge appear to have ended in the Late Cretaceous, but regionally significant magmatism persisted well into the Cenozoic, as demonstrated by igneous intrusion and disturbance of sediments overlying the ridge. Surprisingly recent activity may be indicated by a possible igneous diapir and disturbed sedimentary unit on top of the Fedotov Seamount, although these interpretations require confirmation through geological sampling.

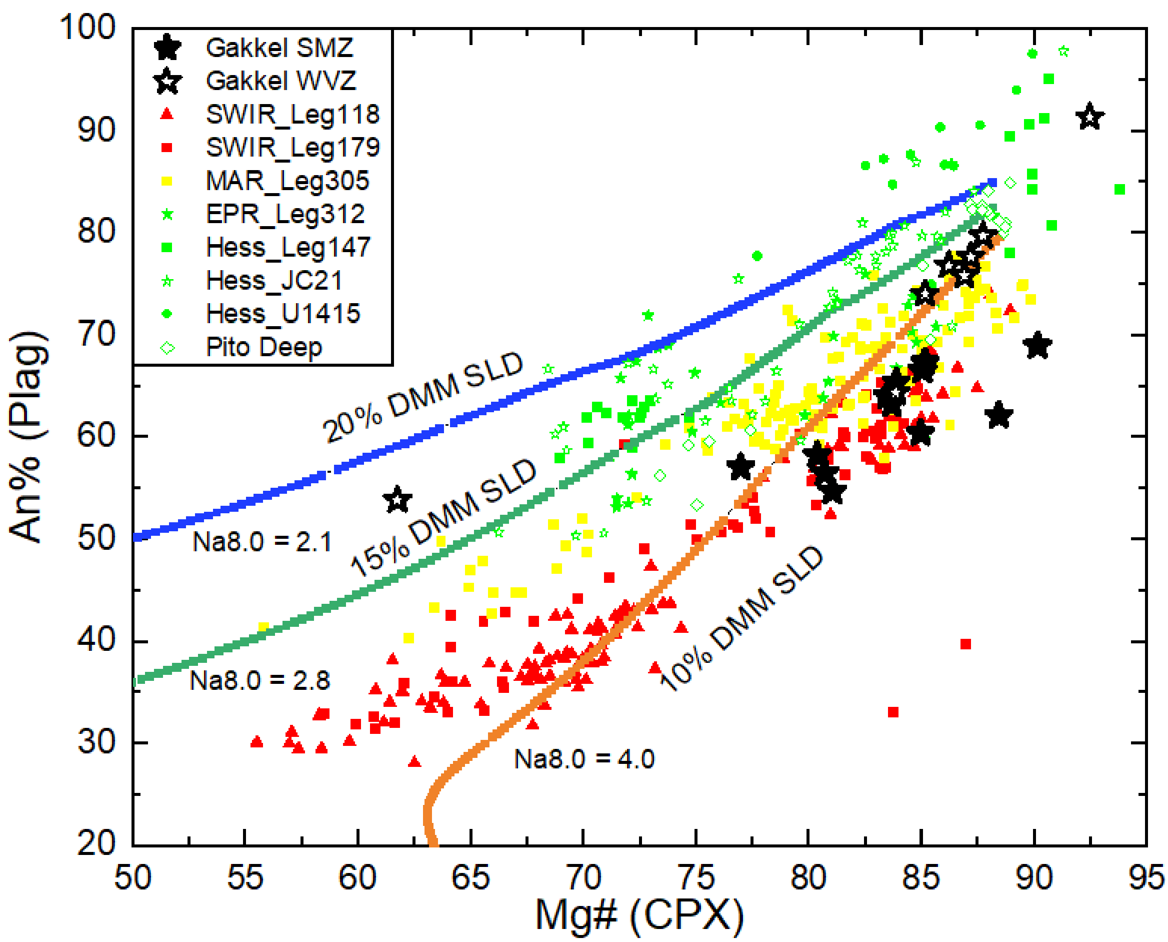
Snow, Jonathan

Gakkel Ridge Gabbros Reflect Distinct WVZ-SMZ Melting Regimes

Jonathan E Snow[1], Yongjun Gao[1] and Yungping Lee[2], (1)University of Houston, Houston, TX, United States, (2)University of Houston, Earth and Atmospheric Sciences, Houston, TX, United States

The Western Volcanic Zone (WVZ) of Gakkel Ridge is characterized by a distinctive more effusive seafloor morphology and magnetic signature compared to the Sparsely Magmatic Zone (SVZ; Michael et al., 2003; Jokat et al., 2003). Gabbros from Gakkel Ridge were recovered from 6 dredge hauls in essentially three areas of the SMZ (3 stations) and the WVZ (2 stations; Michael et al., 2003). Compared to the recovery of peridotite and basalt, the very limited recovery of gabbro is a reflection of the thinness of seismic layer three generally on Gakkel Ridge. We measured major and trace element compositions of mineral phases from 30 Gakkel Ridge gabbros. The results show a systematic difference between the SMZ and WVZ stations. Both sets of gabbros show correlations in An# and Mg# consistent with fractional crystallization of distinct sets of parent magmas (Figure 1). These consistent "solid lines of descent" for each region are most simply explained by a higher regional degree of partial melting in the WVZ compared to the SMZ, assuming a common upwelling mantle source composition. The primitive magma compositions agree with those that would crystallize average basalt major element compositions from the WVZ and SMZ respectively. The gabbro observations agree with the inference that the WVZ has a thicker crust derived from a higher degree of mantle partial melting than the SMZ. This appears to be a temporally persistent mantle melting anomaly in the off axis of Gakkel Ridge and the Morris Jessup plateau as well.

Figure 1: Major element composiitons of coexisting mineral phases from Gakkel Ridge Gabbros. WVZ (open Symbols) and SMZ (closed symbols). Corresponding mineral data from different spreading rates and three "Solid Line of Descent" crystallization paths for three melting models are also shown.



Sobolev, Ivan

Carboniferous magmatism of the Polar Urals (the first results of the ^{40}Ar / ^{39}Ar dating of dikes and sills of the Musyur complex)

Ivan Sobolev[1], Ilya Vikentyev[1] and Alexey Travin[2], (1)Institute of Ore Geology, Petrography, Mineralogy, and Geochemistry RAS, Moscow, Russia, (2)V.S. Sobolev Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia

In the Polar Urals there are numerous dikes and sills composed by dolerites, lamprophyres, monzonites, and essexites which cut Ordovician to Middle Devonian oceanic and island-arc formation and complexes. These intrusive bodies are usually referred to as Musyur hypabyssal complex. There are several ideas about the age, geodynamic environment of the formation, and metallogeny of this complex. Based on geological data, K-Ar dating of plagioclase and unrepresentative U-Pb dating of single zircon grains the age of Musyur complex varies in the wide range from the end of the Late Devonian to Triassic. We have carried out the first $^{40}Ar/^{39}Ar$ ages of the intrusive bodies of Musyur complex – 349±3, 347±9, 339±4, 334±3, and 313±10 Ma which do not contradict the geological data. These ages correspond to the time of collision of the Polar Ural island-arc with the paleocontinent Arct-Laurussia (Arctida+Baltica+Laurentia) resulted in the formation of the Early Ural Orogen (Kuznetsov, Romanyuk, 2014) (Fig.). Intrusion of dikes and sills could occur in places of local stretching during collision (349–334 Ma) and late collision (313 Ma) stages. Geochemical features of basic rocks such as LILE enrichment, Ta-Nb minimum, Pb and Th-U maximum, and high water saturation (4.5–4.7 wt.%) of the magmatic melt from which they crystallized confirm the connection of these dikes and sills with the collision processes.

The studies were carried out with the financial support of RFBR grants No. 18-05-70041 (“Arctic Resources”) and within the framework of the state assignment of the IGM SB RAS (project No. 0330-2016-0013).

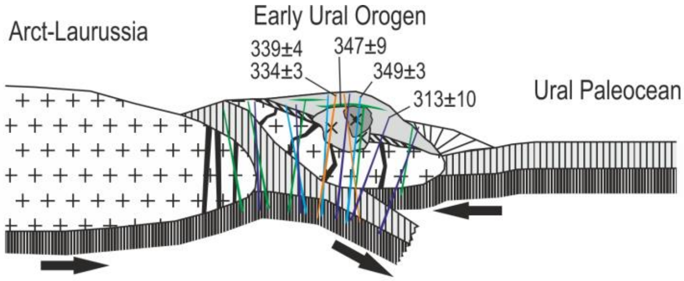


Figure. Paleotectonic reconstruction of the collision of the Polar Urals island-arc with Arct-Laurussia according to (Kuznetsov, Romanyuk, 2014) with significant changes and additions

– predominantly Precambrian crust;

– Late Cambrian – Early Ordovician rift magmatic formations;

– oceanic crust;

– lithospheric mantle;

Volcanic and sedimentary island-arc formations:

– Middle Ordovician – Lower Silurian;

– Silurian – Middle Devonian;

– accretionary prism formations;

Island-arc (Devonian) and rift-related (Carboniferous) plutonic complexes:

– Early-Middle Devonian gabbroids and plagiogranitoids of the Sob' complex;

– Early-Middle Devonian gabbroids, diorites and monzonitoids of the Kongor complex;

– Carboniferous dikes and sills of the Musyur complex: a – gabbro-dolerites (347±9 Ma), b – lamprophyres (349±3 Ma), c – monzodiorite-porphyres (339±4 Ma) and leucocratic (334±3 Ma) lamprophyres, d – essexite-dolerites (313±10 Ma)

Straume, Eivind

Cenozoic paleobathymetry of the Atlantic-Arctic oceanic gateways: Iceland plume pulsations and implications on paleo-ocean circulation

Eivind Olavson Straume, Centre for Earth Evolution and Dynamics (CEED), Department of geosciences , University of Oslo, Oslo, Norway, Carmen Gaina, University of Oslo, Centre for Earth Evolution and Dynamics (CEED), Oslo, Norway and Sergei Medvedev, University of Oslo, Centre for Earth Evolution and Dynamics, Oslo, Norway

We present a new continuous paleobathymetry model for the Atlantic – Arctic oceanic gateways (i.e. Greenland-Scotland Ridge and the Fram Strait) from the time of continental breakup between Greenland and Eurasia (~ 55 Ma) to the present. The model incorporates changes in dynamic support from the Iceland Plume including long-term variations (~ 10 Myr), and short-term pulsations (1 – 5 Myr) in plume activity recorded by the v-shaped ridges straddling the Reykjanes Ridge South of Iceland. The evolution of the Atlantic – Arctic oceanic gateways may have

played an important role in regional and global changes in ocean circulation and climate. Large – scale volcanism and dynamic support associated with the Iceland Plume shapes the morphology of the NE Atlantic Ocean making it much shallower than predicted from normal thermal subsidence of oceanic lithosphere. This influences ocean circulation in the Nordic Seas and the Arctic Ocean, which are important locations for deep water formation, and therefore important for the Atlantic Meridional Overturning Circulation (AMOC). However, detailed reconstructions of the Atlantic-Arctic ocean gateways are often undervalued in global paleobathymetric reconstructions. Our model includes a new model for dynamic support by the Iceland mantle plume through time. The reconstructions are based on an updated plate tectonic kinematic model and we have included new constraints on sediment thickness, crustal thickness, and a paleo-topographic model of the circum-Arctic region (including Greenland and Scandinavia). We show detailed reconstructions of selected time steps, when changes in paleobathymetry may have triggered changes in ocean circulation, and we show results from numerical ocean circulation experiments using our paleobathymetry as input. Our results may shed more light on how high northern plate tectonics, volcanism, and mantle processes have influenced ocean circulation and climate in the Cenozoic time.

Strauss, Justin

On the pre-Carboniferous evolution of the North Slope of Arctic Alaska with implications for circum-Arctic paleogeographic reconstructions

Justin Vincent Strauss, Dartmouth College, Department of Earth Sciences, Hanover, NH, United States

Despite its pivotal role in the opening of the Amerasian basin, the pre-Mesozoic assembly and displacement history of the composite Arctic Alaska–Chukotka terrane (or microplate) remains controversial. Here, I summarize sedimentological observations, stratigraphic subdivisions, detrital zircon U-Pb geochronology and Lu-Hf isotope geochemistry, detrital muscovite $^{40}Ar/^{39}Ar$ geochronology, and carbon and strontium isotope geochemistry from pre-Carboniferous sedimentary and volcanic successions of the North Slope subterrane of Alaska and Yukon to revise previous tectono-stratigraphic models for this part of Arctic Alaska. More specifically, I place these new data in the context of distinct platformal, basinal, and arc-related successions exposed in the northeast Brooks Range, which locally record Late Ordovician(?)–Early Devonian synorogenic sedimentation and Middle to Late Devonian contraction and felsic plutonism. These relationships highlight critical correlations with age-equivalent strata in the Franklinian basin of northeastern Laurentia (i.e., Canadian Arctic Islands and North Greenland), which, together with recent datasets from the central and western Brooks Range of Alaska, demonstrate that the Arctic Alaska–Chukotka terrane is composed of multiple unique crustal fragments whose amalgamation can be linked to Caledonian–Ellesmerian terrane juxtaposition along the northeastern Laurentian margin. Placement of the North Slope subterrane in a position adjacent to the Franklinian basin in the mid-Paleozoic requires significant strike-slip displacement along the northern Laurentian margin sometime prior to or during the Mesozoic opening of the Amerasian basin.

Tarduno, John

The High Arctic Large Igneous Province and the Deep Mantle

John Anthony Tarduno, University of Rochester, Earth and Environmental Sciences, Rochester, NY, United States

The High Arctic Large Igneous Province (HALIP) introduced at the International Conference on Arctic Margins (Tarduno, 1998) followed closely the original definition of a large igneous province: a large mafic outpouring that could not be explained by normal plate tectonic processes. It focused on the flood basalts of the High Canadian Arctic

(Figure 1) and Alpha-Mendeleev Ridge of the Arctic Ocean. Although age data were sparse, the qualitative similarities of HALIP with other large igneous provinces, including the giant Ontong Java and Kerguelen Plateaus of the Pacific and Indian Oceans, respectively, were apparent. The possibility that HALIP contributed to an ultra-hot Late Cretaceous climate was also emerging from spectacular vertebrate fossil discoveries, including turtles and champsosaurs, recovered from the High Arctic.

However, within the then-popular paradigm of fixed hotspots, an association of HALIP with Iceland, the nominal modern hotspot location, was problematic. Some paleolatitude data from HALIP basalts yielded values far too northerly. Plume volume flux as recorded by global hotspots also appeared incongruent with this linkage, as were further proposed ties to the much older Siberian Traps.

Here, I will review what we know about HALIP from new radiometric age and paleomagnetic data, and put this in a global context based on our new understanding of deep mantle structure and plume mobility. Numerical models and observations indicate that plumes can be deflected at mid-mantle depths by surface upwelling. On a larger scale, core-mantle boundary structure is dominated by the African and Pacific large low shear velocity provinces (LLSVPs). While their very base may be chemically distinct, seismic data are consistent with LLSVPs having a dominantly thermal signal. Geodynamic flow models predict that upwellings associated with LLSVPs will induce horizontal deep mantle flow that can cause plume migration. The balance of these near surface and deep mantle processes must be considered when evaluating hotspot-HALIP connections.

Tarduno, J.A., The High Arctic Large Igneous Province. Third International Conference on Arctic Margins, Celle, Germany, Abstract, 184, 1998.

Figure 1: Strand Fiord volcanics of HALIP, Expedition Fiord, Axel Helberg Island (photo: J. Tarduno)

Tegner, Christian

Mantle and crust dynamics of the High Arctic Large Igneous Province

Christian Tegner[1], Eric Brown[2], Nikolay Stolbov Sr[3], Kelley J Brumley[4], Gry Hoffmann Barfod[1], Rasmus Andreasen[1], Tiera Naber[5], Stephen Edward Grasby[6], Karsten Piepjohn[7], Victoria Pease[8] and Sverre Planke[9], (1)Aarhus University, Centre of Earth System Petrology, Department of Geoscience, Aarhus, Denmark, (2)Aarhus University, Centre of Earth System Petrology, Department of Geoscience, Aarhus C, Denmark, (3)VNIIOkeangeologia, Saint-Petersburg, Russia, (4)Stanford University, Stanford, CA, United States, (5)University of British Columbia, Earth, Ocean and Atmospheric Sciences, Vancouver, Canada, (6)Natural Resources Canada - Canadian Research Service, Calgary, AB, Canada, (7)BGR Federal Institute for Geosciences and Natural Resources, Hannover, Germany, (8)Stockholm University, Stockholm, Sweden, (9)Volcanic Basin Petroleum Rsch, Oslo, Norway

Recent geological and geophysical mapping, and geochronology, show that a major pan-High Arctic and mainly tholeiitic large igneous province (HALIP) formed at ca. 124-120 Ma including: (*i*) a >2000 km long and possibly radiating dyke complex cutting basement and Mesozoic basins from the Canadian Arctic to the Barents Sea; (*ii*) sill complexes in the Barents Sea and Sverdrup basins, and (*iii*) flood basalts in the Sverdrup Basin, in Franz Josef Land and in Kong Karls Land. The HALIP, as perceived today, also encompasses: (*iv*) ca. 114-112 Ma alkaline and tholeiitic flood basalts of Bennett Island and Chukchi Borderland; (*v*) ca. 100-80 Ma alkaline and tholeiitic basaltic

(with silicic components) magmatism known in the Canadian Arctic, Chukchi Borderland and from the Alpha Ridge; and (*vi*) ca. 71-61 Ma bimodal alkali basaltic and silicic volcanism in N Greenland and Nares Strait of Ellesmere Island.

Here we present new: (*a*) Sr-Nd-Hf isotope data for HALIP in Franz Josef Land, Kong Karls Land, Svalbard and Bennett Island (n = 44); (*b*) elemental data (also including the Canadian Arctic and Chukchi Borderland, n = 165); and (*c*) geochemical modelling. While Sr isotopes may be altered, initial e_{Nd} and e_{Hf} values are interpreted as magmatic compositions ranging from asthenospheric mantle values (+8 and +14, respectively) towards crustal values (-7 and +1, respectively). Fractional crystallisation models of mantle melts assimilating upper crustal material (<16% for basalt and <50% for basaltic andesite) can explain these systematics. In contrast, assimilation of sub-continental lithospheric mantle or lower crustal granulite (both known from Svalbard) do not provide reasonable fits to the data. The mantle-derived magmas vary from OIB-like (Bennett Island) to N-MORB-like compositions (also Bennett Island), with compositions in the other locations intermediate to these endmembers. Modelling of REE's shows that HALIP magmas *i-iv* are best explained by melting asthenospheric mantle (depleted to enriched lithologies) at variable, but always elevated mantle potential temperatures (up to 200°C above ambient mantle).

These results are best explained by melting a heterogenous and long-lived mantle plume to form HALIP magmas*i-iv,* and perhaps also *v*, and that upper crustal processes were important in modifying the mantle-derived melts.

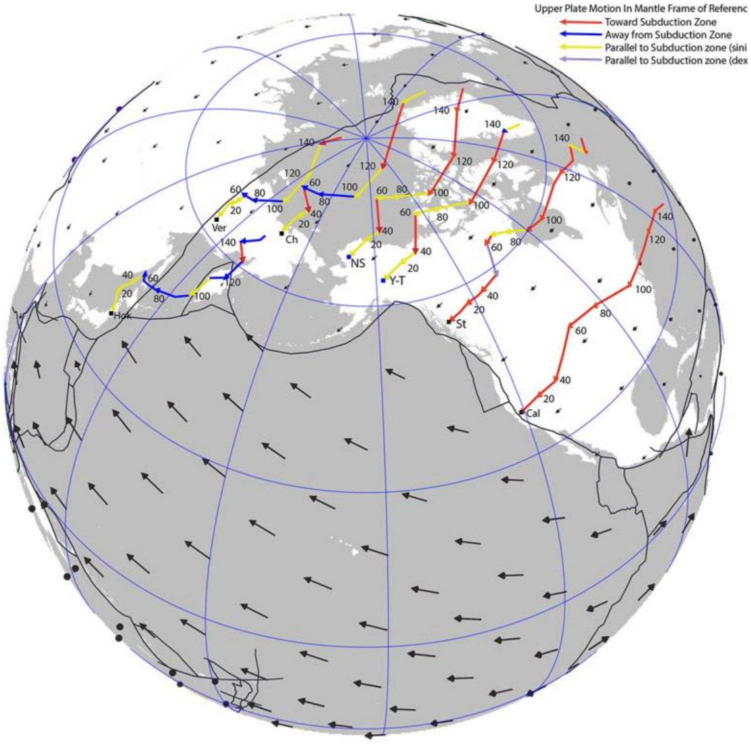
Toro, Jaime

Plate tectonic interactions along the northern Pacific-Arctic margin and their implications for magmatism and deformation

Jaime Toro, West Virginia Univ, Geology and Geography, Morgantown, WV, United States, Elizabeth L Miller, Stanford University, Stanford, CA, United States and Vyacheslav V Akinin, North-East Interdisciplinary Scientific Research Institute, Russian Academy of Science, Magadan, Russia

The Mesozoic and Cenozoic tectonic evolution of the North Asian and North American portions of the northern circum-Pacific were broadly similar. Both started as cratonal continental margins which later became active and received the accretion of a complex array of terranes of diverse origin, with the establishment of subduction zone(s) outboard of the accreted terranes. The long history of subduction of paleo-Pacific plates was the driving mechanism for accretion, deformation and magmatism along the entire length of the northern circum-Pacific margin. In spite of these similarities, there are important differences that require explanation: 1) an array of back-arc basins evolved along only the Beringian and Asian part of the margin, which persists to the present; 2) The northern Cordillera part of the margin experienced mainly compressional or transpressional tectonics while in the mid-Cretaceous, extensional deformation began in Alaska, Chukotka, and the Arctic in spite of similar rapid subduction rates. The exact relative plate motions along the northern paleo-Pacific margin cannot be determined with confidence back into the Cretaceous because the position of oceanic spreading ridges has been lost to subduction. We can, however, track the motions of the upper plates since those are constrained by a continuous record of Atlantic seafloor spreading. Engebretson et al. (1992) observed that the rate of subduction is not a good predictor of the character of orogenesis, while the degree to which a continental plate overrides its subduction zone, or retreats from it in a mantle frame of reference, is. We use a Gplates model, built on the work of Shephard et al. (2013), to show that in an “absolute” reference frame, the northern Cordilleran margin overrode its subduction zone almost continuously since the Late Jurassic while Alaska moved parallel to its subduction zone from ~100 to 60 Ma and again from ~40 to 0 Ma. Motion

of the Russian portion of the margin was away from its subduction zone from 100 to 60 Ma and parallel to it afterwards. This helps to explain the occurrence of mid Cretaceous extensional deformation Chukotka, the Bering region and parts of northern Alaska. It also explains the preservation and lack of deformation during the timespan the subduction-related Okhotsk-Chukotka Volcanic Belt developed (106-76 Ma).



Vatrushkina, Elena

Late Jurassic-Early Cretaceous suprasubduction volcanism on the south of the Chukotka margin

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The Late Jurassic-Early Cretaceous stage of evolution of the Chukotka region is characterized by the convergence of the Chukotka microplate with the Siberia. The last phases of spreading in the South Anyui Ocean, which separated two continental blocks, dated by age of the youngest cherts associated with oceanic basalts as oxfordian-kimmeridgian. At the south of the paleo-ocean due to subduction of the oceanic crust under the Siberia active margin, the Oloy volcanic belt is formed. Regarding the geodynamic setting on the North part of the South Anyui Ocean, there are different points of view. Most researchers suggest that on Chukotka margin was the Nutesyn continental arc. Currently, a number of researchers consider the volcanic complex as Kulpolney oceanic arc.

Detailed lithological studies of the Upper Jurassic-Lower Cretaceous rocks of Western Chukotka made it possible to detect the products of synchronous volcanism, to determine the age and geodynamic position of the volcanic source. The accumulation of the Oxford-Kimmeridgian deposits occurred on the Chukotka continental margin at a distance from the source of volcanic material. This source could be existing at this time at the north of the South Anyui ocean (Kulpolney island arc). The Oxford-Kimmeridgian sandstones contain small amount of admixed pyroclastic material and single detrital zircons with ages 156-159 Ma.

Tithonian-Valanginian deposits accumulated in a back-arc basin at the south edge of the Chukotka microplate. Tithonian-berriasian sandstones are characterized by a high proportion of ash in the matrix and the predominance of lithoclasts and monomineral grains of volcanic origin. Geochemical studies of volcanic pebbles indicate the presence in the volcanic source of the differentiated series from basaltic andesites to rhyolites. Its suprasubduction origin is revealed. Valanginian sandstones contain a small number of volcanic rock fragments. The absence of synchronous pyroclastic material in their composition indicates the cessation of volcanic activity. U-Pb zircon dating from the Tithonian-Valanginian sandstones and andesite pebbles of the Tithonian conglomerates allowed to determine the lifetime of suprasubduction volcanism on the Chukotka margin as 150-140 Ma. Work was supported by RSF Project №18-77-10073.

Vernikovskaya, Antonina

The Oldest Island Arcs in the Arctic: Neoproterozoic Subduction Related Volcanism in Taimyr

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Research of volcanogenic formations in the Taimyr fold belt showed that paleo-island arc fragments are widespread, ranging in age from the early to the late Neoproterozoic. Mainly these rocks are present in the Central Taimyr accretionary belt: in the vicinity of Three Sisters Lake (967–961 Ma), on Chelyuskin Peninsula and in Faddey bay (755–730 Ma) and also in tectonic windows among flyschoid deposits of Northern Taimyr on Gusinaya River and in the Nizhnyaya Taimyra (Lower Taimyr) River mouth (684–655 Ma). Particularities of the tectonic structure and geochemistry of the rocks from the other four regions of this fold belt indicate that they formed in island arc conditions. These igneous rocks originated from a mantle source with the Sm-Nd model age estimates: Nizhnyaya Taimyra R. plagiogranites – $\varepsilon Nd_{(655)}$= 6.1; T_{Nd}(DM) = 817 Ma, Maude bay plagiogranites – 1.7 < $\varepsilon Nd_{(755\text{-}740)}$ < 7.9; 785 Ma < T_{Nd}(DM) < 1297 Ma. Thus, this data can indicate a lengthier (~100 m.y.) formation and a more extensive system of island arcs along the northwestern margin (geographic coordinates) of the Siberian craton. According to isotope data (Sm-Nd, Ar-Ar, Rb-Sr) the accretion of island arc complexes to the Siberian margin took place during the Ediacaran: 606–573 Ma. The identification of Precambrian island arc complexes in the Taimyr fold belt is very important for the creation of paleogeodynamic reconstructions, including those concerning the beginning of the Arctida paleocontinent breakup and the accretion of its continental blocks to the Arctic margin of Siberia along with island arc terranes. This work was supported by the Russian Science Foundation (Projects No. 14-37-00030, 19-17-00091), RFBR (Project No. 18-05-00854).

Vernikovsky, Valery

Interaction of Collisional Magmatism and Siberian Plume in the Arctic at the Paleozoic -Mesozoic Boundary

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Detailed (U-Pb and Ar-Ar) dating of igneous rocks of the Taimyr fold belt shows that its vast granite magmatism, caused by the collision of the Kara microcontinent with the Siberian craton at the Permian – Triassic boundary, smoothly transitions into the flood basalts magmatism, associated with the Siberian plume and the formation of the large igneous province. The collision event led to the thickening of the continental crust, melting and formation of large volumes of syncollisional granites in the period of 315-304 Ma. Then the collision slowed down, stopped and the orogen collapsed, which led to postcollisional granitoid magmatism in the range of 264-252 Ma. The final period of development of the Taimyr folded area starts at 252-249 Ma and coincides in time with the manifestation of the Siberian plume, namely the outpouring of the trap basalts and the formation of intrusions from undifferentiated dolerites to layered intrusives with compositions ranging from peridotites to gabbroids and diorites, syenites and granites aged 251-249 Ma. The introduction of huge volumes of traps into the collision-heated continental crust has led not only to the differentiation of intrusive rocks to an acidic composition, but also to the introduction of separate syenite-granite intrusions of the same age.

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Williamson, Marie-Claude

Comparative Geochemistry of Volcanic Rocks Dredged from the Alpha Ridge and HALIP Volcanic-Intrusive Complexes, Northern Ellesmere Island, Canadian Arctic

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The Canadian portion of the High Arctic Large Igneous Province (HALIP) ranges in age from ~ 125 to 80 Ma. On Axel Heiberg Island and northern Ellesmere Island, the HALIP was emplaced episodically at several volcanic-intrusive complexes (VIC). Each VIC is characterized by a distinct eruptive style, narrow range of crystallization ages and geochemical signature. On Axel Heiberg Island (Type 1 VIC; ~120-95 Ma), tholeiitic lava flows and associated gabbroic sills and dykes of subalkaline affinity predominate. Type 1 VICs include the Surprise Fiord and Lightfoot River dyke swarms; Buchanan Lake sill complex; South Fiord and Middle Fiord complexes; and lava flows in the Isachsen Formation and Strand Fiord Formation. On northern Ellesmere Island (Type 2 VIC; ~92-90 Ma) igneous rocks consist of olivine normative, mildly alkaline (transitional) ferrobasaltic lavas and gabbros (Tanquary Fiord and Ekblaw Lake sills; Piper Pass intrusive complex; Wooton Igneous Complex; and lava flows in the Hassel Formation). The Hansen Point Rift Volcanics (HPRV; Type 3 VIC; ~80 Ma) consist of alkali olivine basalt, trachybasalt and rhyolite erupted from volcanic centres and lava domes. The classification of HALIP rocks into VICs enables a comparison with volcanic rocks dredged from the Alpha Ridge (AR) under Canada's United Nations Convention on Law of the Sea (UNCLOS) Program. The samples consist of lapilli tuff with vitric and lithic fragments. The juvenile

clasts consist of mildly alkaline (transitional) basalt glass with abundant plagioclase microlites. The plagioclase microlites yielded a 90 Ma $^{40}Ar/^{39}Ar$ age. Cognate basalt clasts are comagmatic volcanic rocks that were explosively broken and mixed with juvenile magma during eruption. A large basalt clast extracted from the AR lapilli tuff yielded $^{87}Sr/^{86}Sr$ of 0.703148 and εNd of +7.24. The AR sample plots in the mantle array and shows a close geochemical affinity with ferrogabbros of the Piper Pass intrusive complex and some Mg-rich basaltic lavas in the HPRV. This isotopic similarity suggests that the AR lapilli tuff is contemporaneous with VICs exposed on northern Ellesmere Island. The Alpha Ridge and Type 2 VIC characteristically display high magnetic anomalies that could result from the emplacement of predominantly ferrobasaltic magmas in the interval 95-90 Ma.

Xing, Junhui

Observation and Data Analysis of Submarine OBS Natural Seismic Events in Arctic Channel Area

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Members of our research group from College of Marine Geosciences, Ocean University of China took the "Xue long" research vessel from the Bering Strait to the Arctic Ocean to carry out China's ninth Arctic scientific expedition from July to September 2018. In this scientific research, we used the I-4C four-component seafloor seismograph developed by China to carry out the acquisition test of natural seismic events in the Arctic Channel area, which is the first time in China. The broadband OBS instrument made in China is independently developed by the Chinese Academy of Sciences. Three-component seismometer and a hydrophone are integrated in the cabin. A total of four components are recorded, and the frequency band is about 60 s - 100 Hz. Three OBSs were placed at the edge of the continental shelf in the northeast of the East Siberian Sea, with a water depth of about 200 to 300 meters. Two different sampling frequencies were used. The data collecting time is from 03.08.2018 to 04.09.2018. The submarine seismic signals with a length of about one month were recorded and all three OBSs were successfully recovered. In the records of nearly a month, several waveform signals of natural seismic events have been successfully received. In the presentation, we will show the data quality analyzed results of the collected submarine seismic records from various angles. Seismic waveform analysis shows that some of the recovered OBS records are of good quality, and the main phases of some seismic events are clearly identifiable. In addition, the characteristics of seafloor background noise in this area are also analyzed. There are differences in data quality between horizontal and vertical components, which reflects the poor coupling between OBS and seafloor. In view of some of the poor quality and abnormal data in this experiment, we analyze the causes and put forward some improvement schemes and suggestions for the next Arctic OBS scientific expedition.

Yang, Alexandra

Mid-ocean ridge basalts with subduction-related signatures from the Gakkel Ridge

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Subduction of oceanic lithosphere produces chemical heterogeneity in the mantle. While its signal is often called upon for OIB, it is rarely seen in MORB. Here we report MORB with geochemical signatures of arc basalts from the Gakkel Ridge and reveal their role in global MORB compositions. Two dredges collected from the eastern volcanic zone (EVZ) of the Gakkel Ridge during the AMORE cruise have subduction signatures. The most extreme have low Nb/U (7-10), Ce/Pb (7-8), and Ba/Rb (5-6) ratios, much lower than the canonical values for MORB. They also have higher $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios relative to the north hemisphere reference line, with higher $^{87}Sr/^{86}Sr$ (up to 0.7037) and low $^{143}Nd/^{144}Nd$ ratios (~0.5128) (Cai et al, this meeting), indicating the involvement of continental-derived sediments in their source. Both chemical and isotopic compositions can be explained by melting a depleted MORB mantle with addition of global subducting sediment (GLOSS) melt. Although similar arc-like MORB has been identified in the Chile Ridge where a slab window opens to deliver subducted slab materials into the MOR magmatism (Klein and Karsten, 1995), no proximal subduction zone is available to provide such a component beneath the Gakkel Ridge. Alternatively, the Arctic has been under continuous subduction during the past 200 Ma (e.g., Shephard et al., 2013). The subducted slabs must have released sediment-derived melts to metasomatize the cratonic lithospheric mantle or asthenosphere mantle beneath the Arctic. After the spreading of the Gakkel ridge, such subduction-modified mantle components were brought up to contribute to the MOR magmatism to produce the arc-like MORB in the EVZ. We are also able to identify the role of subduction-modified source in some of the Indian and Atlantic MORB. Therefore, we conclude that subducted slabs during Earth's history plays an important but normally subdued role in the MORB source.

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