Geochemical evidence for subduction related origin of the Bowers and Shirshov Ridges (Bering Sea, NW Pacific)

Maren Wanke[1,2], Maxim Portnyagin[1], Reinhard Werner[1], Folkmar Hauff[1], Kaj Hoernle[1], Dieter Garbe-Schönberg[2]

[1] IFM-GEOMAR, Leibniz Institute of Marine Sciences, Wischhofstraße 1-3, 24148 Kiel, Germany
[2] Institute of Geosciences, Christian-Albrechts-University of Kiel, Ludewig-Meyn-Straße 10, 24118 Kiel, Germany

The Bowers and Shirshov Ridges (hereafter BR and SR, respectively) are two prominent submarine structures of unknown age and provenance in the Bering Sea (Fig. 1). So far only a few geochemical data exist on the composition of basement rocks from the SR (Silantyev et al. 1985) and none for the BR. Age and geochemical data are crucial to evaluate if the ridges represent remnant island arcs (Cooper et al. 1981, Scholl 2007), intra-oceanic rises, accreted onto the continental margin (Ben-Avraham & Cooper 1981), an ancient spreading center (SR: Kienle 1972) or parts of the Mesozoic Hawaiian hot-spot (Steinberger & Gaina 2007).

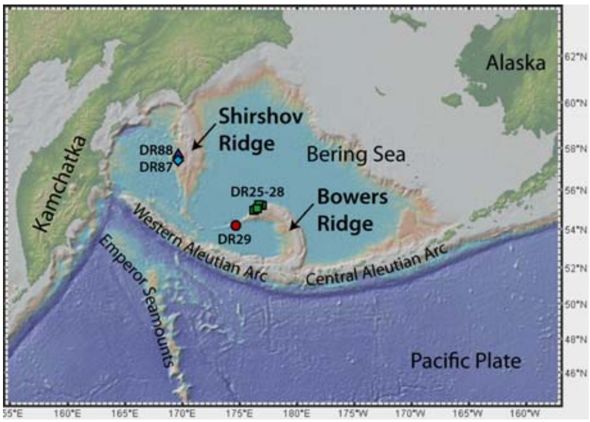

Fig. 1: Map of the study area. Each symbol indicates a dredge location (DR) on the BR (squares), the SR (triangle and diamond) or on a seamount next to the BR (circle).

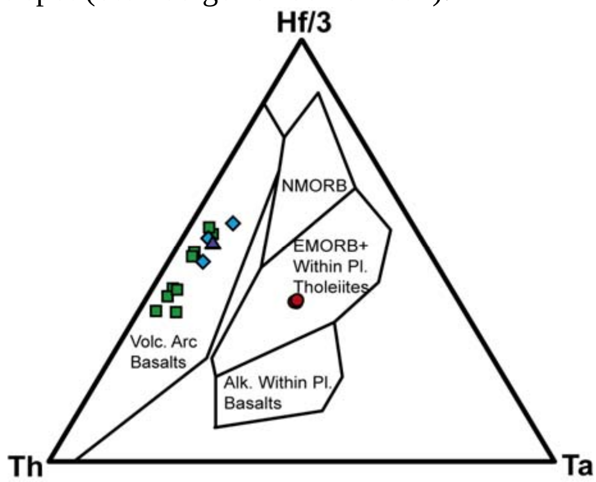

Fig. 2: Th-Hf-Ta diagram after Wood (1980) showing different tectonic settings for BR and SR and one seamount in between. Symbols refer to Fig. 1.

Here we report the first geochemical data on the composition of the basement rocks from the BR and SR, recovered during KALMAR R/V SONNE cruise 201 (Legs 1b and 2) in 2009. Fresh to moderately altered volcanic rocks were dredged from the northern slope of the BR, from seamounts on the western extension of the BR and from the western slope of the central part of the SR. We studied the petrography of the samples and carried out geochemical analyses of major and trace elements by XRF and ICPMS at ACME Lab (Vancouver, Canada) and CAU (Kiel). Sr-Nd-Pb(ds) isotopes were analyzed by TIMS at the IFM-GEOMAR (Kiel).

The rocks from the northwestern slope of the BR are clinopyroxene (cpx)-phyric basalts with minor amounts of olivine (ol) and plagioclase (plag) microphenocrysts, as well as hbl-plag-cpx-bearing basaltic andesites and trachyandesites. The rocks are strongly enriched in LREE (La_N/Yb_N = 3.2 – 8.5, N indicates normalization to primitive mantle), fluid-mobile elements (Pb, Ba, U, K) relative to NMORB and exhibit clear negative anomalies of HFSE (Nb, Ta and Ti) in primitive mantle-normalized incompatible element diagrams. The BR rocks also have a moderate adakitic signature, as indicated by elevated Sr_N/Y_N ratios (6.9 – 12.9). Hbl-cpx-plag trachybasalts from the SR have similar major and trace element compositions (La_N/Yb_N = 2.1 – 4.9) to the BR rocks. The other magmatic series from the SR comprises massive trachyandesites, trachytes and dacites with rare phenocrysts of plag and cpx. These rocks also have island-arc type incompatible element patterns and are distinct from other rock types from the BR and SR with less LREE enriched patterns (La_N/Yb_N ~ 1.8) and a strong negative Eu anomaly (Eu/Eu* = 0.74).

The rocks from BR have relatively unradiogenic Sr and Pb isotopes ($^{87}Sr/^{86}Sr$ = 0.70296 – 0.70311, $^{206}Pb/^{204}Pb$ = 18.22 – 18.30) and radiogenic Nd ($^{143}Nd/^{144}Nd$ = 0.51312 – 0.51314) compositions, which are well within the Aleutian Arc isotope array and intermediate between typical compositions of the Central and Western Aleutian rocks (Kelemen et al. 2003). The rocks from SR have slightly more radiogenic $^{87}Sr/^{86}Sr$ (0.70338 – 0.70414) and similar $^{143}Nd/^{144}Nd$ isotope compositions to the BR rocks. Silicic SR rocks have distinctively high $^{206}Pb/^{204}Pb$ (18.46 – 18.47) ratios compared to basalts from BR and SR.

Rocks dredged from a seamount on the western extension of the BR have very distinctive petrographic and geochemical characteristics. These are ol-phyric pillow basalts with minor (less than 5%) amounts of plag and cpx. The freshest whole rocks and pillow-rim glasses have relatively smooth patterns of incompatible trace elements, akin to intraplate oceanic basalts (Fig. 2). Trace element geochemical characteristics of the seamount basalts are similar to Hawaiian tholeiites. That might suggest the preservation of the older Hawaiian seamounts in the Bering Sea. Sr-Nd-Pb isotope data and our preliminary age determinations from the U-Pb-Th systematics of the rocks do not support this hypothesis. According to our current interpretation, the intraplate-type basalts west of the Bowers Ridge most likely originated by low-degree melting of the local mantle along a transform-like ridge connecting Bowers and Shirshov Ridges.

In summary, petrography and geochemical results indicate an island-arc origin (Fig. 2) for major parts of the BR and SR. Isotope data suggest that the BR and parts of the SR could have developed as parts of the former Aleutian Arc. Our further studies will be focused on obtaining absolute age data for the studied rocks, which will allow combining the petrologic data with tectonic and geodynamic models for the NW Pacific.

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