SO-249 Leg 2
BERING

7. Wochenbericht
(18.07. – 24.07.2016)

FS. SONNE
59°57´N / 170°56´E

The 6th week of R/V SONNE's cruise SO-249 was characterized by a transit from Petropavlovsk to the working areas where expedition mapping and sampling are planned near the Komandorsky Islands and at the Chukotka-Beringian continental margin at 60° - 62°N. Our first two dredges were carried out on a tectonic structure south of the Komadorsky bloc, a formation on which the western-most islands (Medny and Bering) of the Aleutian chain are located. Two previous dredges, made on this feature on the KALMAR expedition SO-201-2, yielded partly volcanogenic sedimentary rocks. Therefore we presumed at that time, that it represents a fragment of the Komandorsky forearc and not an accreted fragment of oceanic crust as originally postulated. This interpretation seems to have been confirmed by two SO249 dredges which also recovered exclusively sedimentary rocks.

By contrast to the schedule presented in the previous weekly report, we decided to sail after the Komandorsky dredges across the Aleutian Basin to the Chukotka-Beringian continental margin, where we arrived at 60°N and 179°E in the afternoon of June 21st. The nature of the northern section of the Chukotka-Beringian margin is completely unknown to date. It has been postulated that it represents a former subduction zone, which was active before inception of the Aleutian Arc. Our plan was to use multi-beam mapping and sampling in this area to deliver new insights about the formation of the northern margin of the Aleutian Basin and about the early history of the western Bering Sea. Mapping revealed that the slope of the northern Beringian margin is heavily fissured and cut by deep canyons. Its morphology indicates that at least the upper units of the margin are formed by sediment. Three dredges yielding solidificed sediment confirmed this observation. These samples were of limited interest to the geologists, who are mostly interested in volcanic rocks, but they are quite interesting from a biological standpoint as discussed below.

Following these dredges we mapped the slope at the junction of the Beringian and Chukotka margins. The satellite-derived (predicted) bathymetry shows seamounts and steep slopes in this area, which appear suitable for rock sampling by dredging. Unfortunately SO-249 multi-beam mapping revealed that the normally reliable predicted bathymetry failed in this case and that seamounts and steep slopes do not exist in the area. Therefore R/V SONNE headed to the southwest to the southern section of the Chukotka margin, where we discovered interesting structures. Here, the ocean floor is characterized by NW-SE striking faults which appear to be quite young. These faults offer not only good possibilities for rock sampling, but also provide important information on tectonic processes. Therefore we decided first to conduct comprehensive mapping in this area to be followed by sampling at the most appropriate sites. The first dredge from a steep fault scarp in this yielded a conglomerate containing lava clasts among dominantly siltstones and sandstones.

The biological specimens obtained during this week were mostly composed of relatively large benthic fauna. While the fauna in the deeper areas near the Komandorsky Islands was similar to material dregded along the northern Emperor Seamount chain during the first cruise leg, the species composition in the northern Bering Sea was entirely different. The northern part of the Bering Sea is a relatively nutrient-rich area and so we dredged a considerable number of large crabs (Crustacea), sponges (Porifera), as well as marine spiny-skinned animals (Echinodermata). Notable samples were several large spider crabs (see photo), a plethora of sponges in various sizes and shapes (see photos), and relatively large sea stars (see photo) as well as a large species of brittle star (Ophiuroidea) associated with deep sea corals (Octocorallia). Apart from these larger samples, we also obtained a considerable number of smaller epibenthic fauna, mostly lamp shells (Brachiopoda), bristle worms (Polychaeta), limpets (Patellidae), and clams (Bivalvia).

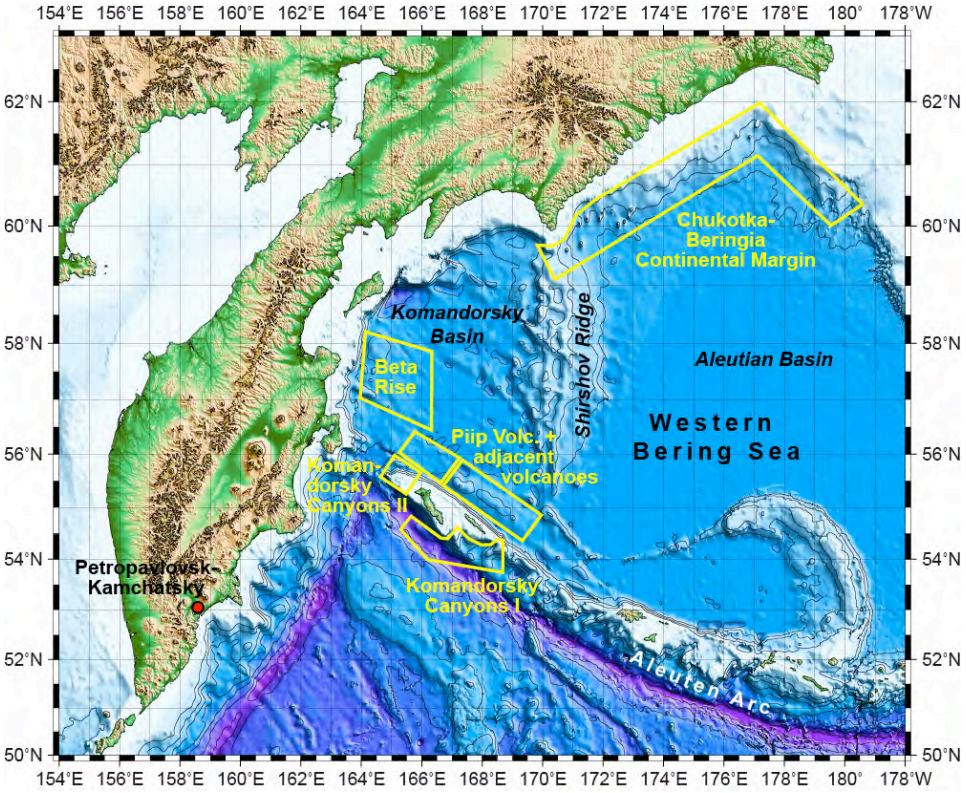
After completion of our studies at the Chukotka margin, we plan in the next week rock sampling at the western slope of the Shirshov Ridge, a large, N-S striking which divides the western Bering Sea into the Komandorsky and Aleutian Basins (see maps). Afterwards we

will sail into an area north of the Beta Rise, which is located in the western part of the Komandorsky Basin. This area is characterized by a remarkably high heat flow anomaly, which may indicate recent volcanic activity. We hope, that the relatively warm and sunny weather that we have experienced the past two days (>10°C!) will continue next week. All scientists are well and send their greetings to those at home.

Reinhard Werner (chief scientist SO249 Leg 2) and the cruise participants

Work around the clock: Scientists working in the night shift evaluate the content of a dredge which just arrived on deck. (Charlotte Rahmsdorf)

The mountains at the coast of Chukotka, located in Russias far east, in sighting range of R/V SONNE. (Roman Botcharnikov)



Map showing the main working areas (yellow marked) of R/V SONNE cruise So-249 Leg 2.

One of the many crabs that we caught during the last week. This animal was dredged up from about 2,100 m near the Beringia Margin. (Alexander Ziegler)

Almost all of this week's dredges contained large amounts of sponges. Although the delicate animals are often destroyed during dredging, their sometimes large size can be judged from this photograph taken on the deck - the pen measures about 15 cm in length. (Alexander Ziegler)

This tree-like, colorful sponge was found among the animals dregded up from about 2,000 m depth near the Beringia Margin. The sponge is associated with various smaller and larger bristle worms. (Alexander Ziegler)

After several weeks of dredging, we finally managed to catch the first large sea stars near the Chukotka Margin at about 2,100 m depth. (Alexander Ziegler)

SO-249 Leg 2
BERING

Weekly Report No. 8
(25.07. – 31.07.2016)

R/V SONNE
55°10´N / 168°00´E

At the beginning of the third week of the second leg of R/V SONNE cruise SO-249 we finished the investigations in our northernmost working area, the Chukotka-Beringia Margin. While multi-beam mapping revealed interesting fault systems, which may be related to right lateral strike-slip fault at the boundary of the Beringia and North American Plate, unfortunately, dredging of these structures did not yield magmatic rocks. En route to the Beta Rise in the western part of the Komandorsky Basin, we took four dredges on some dome-shaped features located at the western flank of Shirshov Ridge. Previous studies, among them those conducted on KALMAR expedition SO-201-2, indicated that an ophiolite complex may exist in this part of the ridge. SO-249 sampling in this area was very successful and recovered a variety of rocks types including harzburgites, dunites, orthopyroxenites, basalts, dolerites, and partially amphibolitized gabbros. This rock suite represents a cross section through the oceanic lithosphere and not only confirms the observations made on SO-201-2 but also makes it possible to gain new insights in the enigmatic nature and evolution of the Shirshov Ridge and so the geodynamic history of the Bering Sea.

On Tuesday, July 26th, R/V SONNE approached the area north of the Beta Rise, which is characterized by a distinct heat flow anomaly. Our studies in this area aimed to test the idea that this anomaly may be associated with recent volcanism. It appears, however, that this is not the case or that if there has been volcanism, its extent has been limited. Apart from the few already known bathymetric highs, we discovered three additional features, all relatively small, up to only 500 m high. It is unclear if these represent young volcanic edifices or tectonic structures. Our dredge recovered basalt fragments from one of these structures. Geochemical analyses of these rocks may help to clarify the origin of these features.

Subsequently, we sailed along the Alpha fracture zone to the Volcanologists Massif, on which Piip volcano, the westernmost active volcano of the Aleutian Arc, is located. This complex represents a key area for the reconstruction of temporal and geochemical variation of the magmatism along the Aleutian Arc and of magmatic processes in an area of highly oblique subduction. The Volcanologists Massif and Piip were studied during various Russian expeditions and on SO-201-2. However, major sections of this large complex have not yet been mapped at high resolution or sampled for geochemical studies. We decided to fill these gaps because of the importance of Volcanologists Massif and Piip for the understanding of magmatic processes in the western Aleutian Arc. Mapping and sampling focused on a tilted block northwest of the Volcanologists Massif, its largely unstudied eastern base and the upper portions of Piip, which appear to be three, coalesced cones. The combined bathymetric surveys of SO-201-2 and SO249 leg 2 have produced the first high-resolution map the Volcanologists Massif including Piip, which provides important information about the tectonic and volcanic structures of this complex. Dredges conducted on the upper slopes of Piip delivered mainly andesitic lava and large quantities of dacitic pumice. At the Volcanologists Massif we dredged a wide variety of rock types, dominated by olivine, clinopyroxene, and plagioclase phyric pillow lava. The lava fragments show frequently fresh glassy margins. Volcanic glass forms by rapid cooling of lava for example when hot lava comes in contact with water. Such glass is of particular interest to study the original composition of melts and their pre-eruptive volatile contents. Volcanic glass, however, is not stable and alters over the course of time; initially to palagonite and finally to clay. This process is accelerated when glass is exposed to seawater. Therefore it is a great achievement that we have sampled large amounts of fresh glass at several sites of the presumably oldest units of the Volcanologists Massif.

Due to the significant structural as well as bathymetric differences between the habitats sampled during this week, the diversity of the animals brought up in our dredges was relatively high. While primarily organisms inhabiting mud or loose sediments were found in the Alpha, Beta, and Gamma Fracture Zones, the rocky habitats surrounding Piip Volcano

were characterized by species adapted to this environment. A number of small and large animals were caught during the eighth week of our cruise. A selection of the most interesting is shown here. Some relatively large sea spiders (Pycnogonida), a group of chelicerates (Chelicerata), was caught completely intact near the Beta Fracture Zone (see photo). Near the Alpha Fracture Zone, we obtained eggs as well as juvenile and adult representatives of the Incirrata (see photo), a group of octopuses (Octobrachia). The striking structural diversity of sea cucumbers (Holothuroidea) is particularly well illustrated by two specimens dredged near the Alpha Fracture Zone and Piip Volcano, respectively (see photos). The animal taken from over 3,000 m depth is a representative of the group of sea cucumbers known as sea pigs, which typically inhabit muddy sea floors. In contrast to this rather delicate animal, the second specimen with its dorsal shields indicates adaptation to a rocky habitat.

After completion of the studies in the Piip area, R/V SONNE headed to a chain of small enigmatic structures that appear to emanate from the Volcanologists Massif in southeastern direction. Afterwards we will focus on the Komandorsky block in order to get insights into the inception and early history of the Aleutian Arc.

For the first time since sailing from Dutch Harbor on June 6th, we had a long period, while in the Bering Sea, of sunny weather, clear sky, and relatively warm air temperatures of up to 18°C. The crew and scientists enjoyed this very much after the interminable and dreary fog of the Aleutian Islands. All participants are well and send greetings from the southwestern Bering Sea to everyone at home.

Reinhard Werner (chief scientist SO249 Leg 2) and the cruise participants

A full dredge promises a lot of work but is also a big success in most cases.

Scientists collect samples from the dredge while they are observed by an interested audience.

R/V SONNE off the coast of Kamchatka. This week we experienced that the weather in the Bering Sea can also be very nice.

Photos taken by Stepan Krasheninnikov

This large sea spider - or pycnogonid - was collected intact from about 3,400 m depth near the Beta Fracture Zone. On one of its legs sits a small crustacean, an amphipod. (Alexander Ziegler)

One of the several, ghost-like octopuses collected in over 2,500 m depth near the Alpha Fracture Zone. (Alexander Ziegler)

This charismatic sea cucumber, a member of the Elpidiidae, is colloquially known as the sea pig - the animal was collected from about 3,100 m depth near the Alpha Fracture Zone. (Alexander Ziegler)

Although shaped quite different from the sea pig shown on the left, the animal pictured here is a sea cucumber as well. This specimen, a member of the Psolidae, was taken on Piip Volcano at about 700 m depth. (Alexander Ziegler)

SO-249 Leg 2
BERING

Weekly Report No. 9
(01.08. – 07.08.2016)

R/V SONNE
54°17´N / 162°04´E

During the fourth week of R/V SONNE cruise SO-249 Leg 2, our studies focused on the southwestern margin of the Bering Sea and there mainly on the Komandorsky Block. This more than 400 km long and up to 110 km wide structure forms the submarine base of the two Russian Aleutian Islands Bering and Medny. The grave of the discoverer Vitus Bering, the eponym of the Bering Sea and straits, is located on Bering Island who dies here at a hibernation in 1741 during his second Kamchatka expedition. The Komandorsky Block is the westernmost section of the Aleutian Island Arc. At its northwestern tip the junction of the Aleutian Trench and the Kurile-Kamchatka subduction zone is located. On the one hand SO-249 Leg 2 mapping and sampling aimed to get new insights in this geodynamically highly complex area. On the other hand we hoped to retrieve old rocks that can provide us with new data on the inception and early geological history of the Aleutian Arc - one of the major goals of the research project SO-249 BERING.

Before we started our investigations at the Komandorsky Block, we studied a chain of small enigmatic structures that emanate from the Volcanologists Massif in southeastern direction. Old maps based on single beam echo-sounding data show these features as nearly cone-like edifices. Therefore we hoped to discover a chain of young volcanic cones which may be the missing link between Piip Volcano and the further to the east located "Western Cones", which represent the westernmost recent volcanic structures in the US-part of the Aleutians. SO249 leg 2 multi-beam mapping, however, revealed that these structures are tiled blocs with a very smooth morphology. Nevertheless we made two dredge attempts at these features which returned besides a few lava fragments mainly semi-consolidated mud. Now it is almost sure that Piip is the only recent volcano in the Russian section of the Aleutian Arc since we also did not discover any young volcanic structures in the area to the west of Piip Volcano.

By contrast, our studies of the Komandorsky Block proceeded very successful. The dredge hauls at its southeastern flanks yielded a large amount of volcanic rocks besides sedimentary rocks which obviously form the lower portions of the slopes in this part of the block. Andesites dominate along the volcanics. At its northeastern flank we mainly dredged partly metamorphized and tectonized diorites and gabbros. At the northeastern tip of the Kommandorsky Block the dredges delivered a particular broad variety of volcanic rocks. These include aphyric, ol-plag-phyric, and cpx-ol-plag-phyric basalts and a broad spectrum of andesites including highly hornblende-phyric spessartites (see photo) and maybe also Adak-type high-Mg andesites (adakites). Furthermore the dredges contained metamorphically overprinted volcanics, iginmbritic rocks (see photo), tuffs and other volcaniclastic rocks. With that we have an excellent sample set available for further studies and analyses in the home labs.

The last week of active sampling was, like the previous eight weeks, characterized by a broad spectrum of marine animals. In addition to sediment samples from over a dozen stations, we obtained representatives from almost all major marine taxa, such as lamp shells (Brachiopoda), sponges (Porifera), cnidarians (Cnidaria), bristle worms (Polychaeta), spiny-skinned animals (Echinodermata), sea squirts (Tunicata), sipunculans (Sipuncula), moss animals (Bryozoa), arthropods (Arthropoda), leeches (Hirudinea), mollusks (Mollusca), and even a representative of the vertebrates (Vertebrata). Although a detailed analysis of the sediment samples will reveal an entire microcosm, it is usually the macroscopic specimens that attract attention on deck. Among the larger specimens dredged during this week were several different representatives of the Majidae, also called sea spiders (see photo). Apart from these, a rather unlikely catch was made this week using the chain bag dredge (SO249-DR155): an almost 1 m long grenadier fish (Macrouridae) was hauled on deck - these animals are also called rattails (see photo). The grenadiers are usually benthopelagic fishes that act as apex predators in deep sea habitats by feeding on other fishes, crustaceans, and cephalopods. All animals collected in the course of the scientific cruise SO-249 were fixed using specific chemicals (see photo) and have been placed in sampling vials according to their size for the transport to Berlin (see photo).

In the early morning of Sunday, August 7th, we finished the SO-249 Leg 2 station work and data recording as scheduled and R/V SONNE headed towards Petropavlovsk-Kamchatsky. On

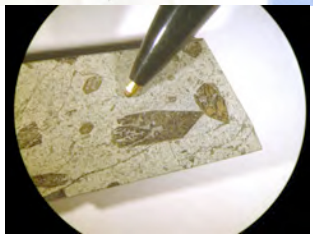
Monday morning, here we will say good be the most of our Russian colleagues. Afterwards we will sail to our final destination Tomakomai on Hokkaido (Japan). We will use this transit for demobilization, cleaning, maintenance and packing of our equipment and for a first evaluation of the data yielded on this journey.

Besides extensive multi-beam mapping and sediment echosounder profiling, a total of 52 dredge hauls in an average water depth of 2,900 m were carried out on SO-249 Leg 2. Of these, 36 delivered *in situ* samples of which 24 obtained volcanic rocks and/or intrusiva, 11 volcaniclastics, 5 metamorphic and 18 sedimentary rocks. No equipment was lost or seriously damaged.

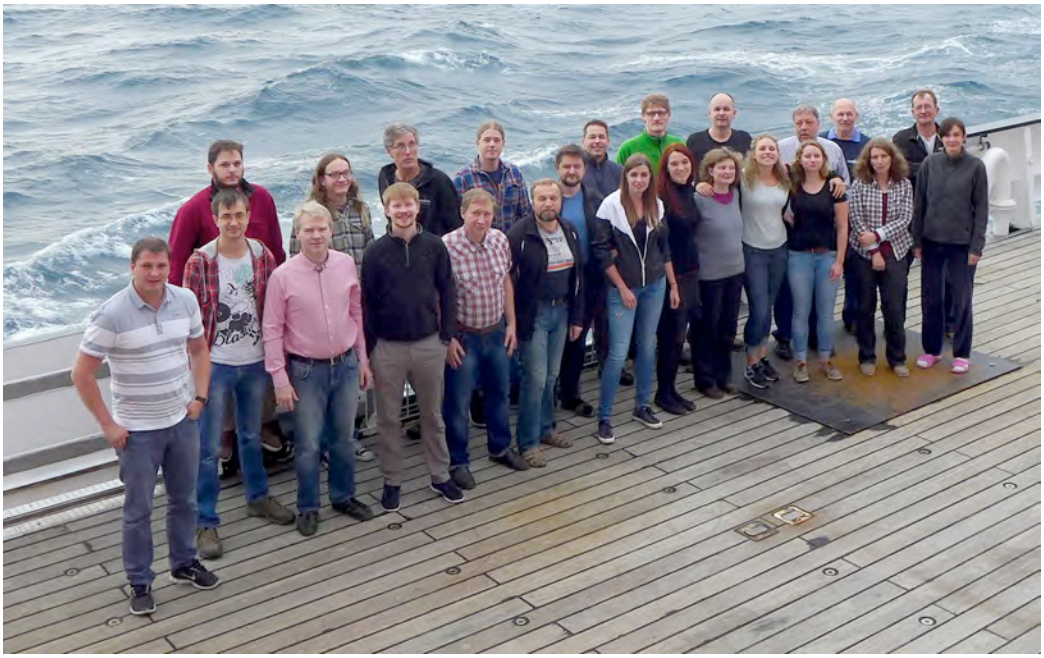
All participants send greetings from the Northwest Pacific to everyone at home.

Reinhard Werner (chief scientist SO-249 Leg 2) and the cruise participants

An ignimbritic rock dredged at the northern slope of the Komandorsky Block in ~3,400 m water depth. Ignimbrites are deposits of a highly fluid suspension of hot gas and ash particles formed during explosive volcanic eruptions or dome collapse. (photo GEOMAR)



A highly hornblende-phyric spessartite, a typical rock of the Komandorsky Block dredged in ~2,100 m water depth at its northern tip. The huge hornblende crystals are clearly visible under a mircoscope (small picture). (photos: GEOMAR)



The SO-249 leg 2 Scientific Party after most of the work is done. (Arnold Ernst)

This sea spider was caught at about 2,500 m depth on Piip volcano. Several leeches and skeleton shrimp were attached to this specimen. (Alexander Ziegler)

A member of the Macrouridae (grenadiers) was hauled on deck from about 2,600 m depth near the Komandorsky block. (Natalia Gorbach)

Common fixatives for zoological specimens include (from left to right) 4% solution of formaldehyde (or formalin), mixture of acetone and methanol (ACME), 4% solution of paraformaldehyde (PFA), RNALater, and 100% ethanol (EtOH). (Alexander Ziegler)

All specimens obtained during the scientific cruise SO-249 have been prepared for the long transport back home by placing them into plastic containers or watertight bags. (Alexander Ziegler)

SO-249 Leg 2
BERING

Weekly Report No. 10
(08.08. – 14.08.2016)

R/V SONNE
42°37´N / 141°37´E

The last week of R/V SONNE cruise SO-249 Leg 2 was characterized by the transit to our final destination Tomakomai on Hokkaido (Japan). En route we entered again the port of Petropavlovsk-Kamchatsky, where we said good by to most of our Russian colleagues. On August 9th, R/V SONNE headed towards Tomakomai. In order to avoid an upcoming typhoon, we had to cross the Kurile Island Arc and sailed into the Sea of Ochotsk. Among others, the transit was used for preliminary studies of the data and samples as well as for cleaning, maintenance, and packing of our equipment. In the evening of August 11th, we celebrated the end of a successful expedition. On Saturday, August 13th we finally reached the port of Tomakomai according to schedule at 08:00 am. Altogether 150 dredge hauls have been carried out on both legs of cruise SO-249, of which 75% were successful in delivering hard rocks. We are quite pleased with this, especially in view that several working areas were largely unknown to date and required extensive and time-consuming bathymetric surveys in order to identify appropriate sampling sites.

The scientists would especially like to thank Captain Mallon and the crew of R/V SONNE. Their hard work, high level of experience, great flexibility and willingness to help, as well as the pleasant working atmosphere on board, contributed directly to the success of the SO-249/2 expedition. We are also grateful to the German Federal Ministry of Education and Research for continuing support of marine research. Lastly I would like to thank “my” team, the SO-249/2 Scientific Party, not only for their excellent work on board but also that they crucially contributed to the good atmosphere on board throughout this expedition.

Reinhard Werner

The coast of the Russian peninsula Kamchatka. The large volcanoes as, for example, Mutnowski (in theory on the left hand side of the picture), are hidden by the clouds (Reinhard Werner).

View of Petropavlovsk-Kamchatsky with the 3,456 m high Koriaksky volcano in the background (Reinhard Werner).

The port of Tomakomai upon arrival of R/V SONNE at the end of SO-249/2 expedition (Reinhard Werner).