Japan-Russia Cooperation at the Knipovich Ridge in the Arctic Sea

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International Ridge-Crest Research: **Arctic Ridges:**

Japan-Russia Cooperation at the Knipovich Ridge in the Arctic Sea

K. Tamaki[1], G. Cherkashov[2], and Knipovich-2000 Scientific Party

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Introduction

The Knipovich-2000 Cruise was first planned through discussion between K. Tamaki, G. Cherkashov, and K. Crane at the InterRidge Arctic Ridge Workshop at Kiel, Germany in 1998. K. Tamaki submitted a proposal to the Ministry of Education, Science, Culture, and Sports of Japanese Government with a title of "InterRidge Arctic Ridge Research Program" to solicit funds to use the *R/V Professor Logachev* for a month-long research cruise. The proposal was accepted by the Ministry's Grant for the Aid of Scientific Research for the term of 1999 to 2001. A pre-cruise meeting was held at VNIIO, St. Petersburg in January 2000 and was attended by K. Tamaki, G. Cherkashov, K. Crane, H. Tokuyama, B. Baranov, M. Maslov, M. Sorokin (Polar Marine Geosurvey Expedition) and other Russian scientists. At the meeting K. Tamaki and G. Cherkashov were assigned as co-chief scientists of the cruise and the original science plan was devised to focus research at the Knipovich Ridge.

The research strategy consisted of an along-axis towing of ORE sidescan sonar with additional self recording instruments (LSS, CTD, magnetometer, and pH meter). Bottom rock sampling, CTD water sampling, bottom sediment sampling, heatflow measurements, and deployment of an OBS seismic network were planned to be carried out based on the obtained data. SEAMarc image data, bathymetry, and interpretations provided by Kathy Crane were invaluable for the planning of this scientific cruise. The second pre-cruise meeting was held at VNIIO, St. Petersburg and at the Institute of Microbiology, Moscow in June 2000 attended by K. Tamaki, G. Cherkashov, M. Sorokin, J. Campbell, and V. Gladysh (chief engineer of ORE system) to discuss the configuration of ORE towing system. Tamaki and Sorokin completed a contract document on the R/V Logachev research cruise during the meeting. The name of the research cruise was assigned as "Knipovich-2000". At the Moscow meeting, most of the Russian scientists who planned to join the cruise attended and discussed the science plans.

Operation of the cruise

The objectives of the Knipovich-2000 research cruise are summarized as follows.

1. Understanding the tectonics of ultraslow sea-floor spreading system at the Knipovich Ridge
2. Finding active hydrothermal vents along the Knipovich Ridge
3. Understanding the magmatism of the Knipovich Ridge.
4. Detecting microearthquake activity along the Knipovich Ridge

The instrumentation used in Knipovich-2000 cruise

1. ORE deeptow sidescan sonar (30 kHz, 2.4 km swath) that is installed

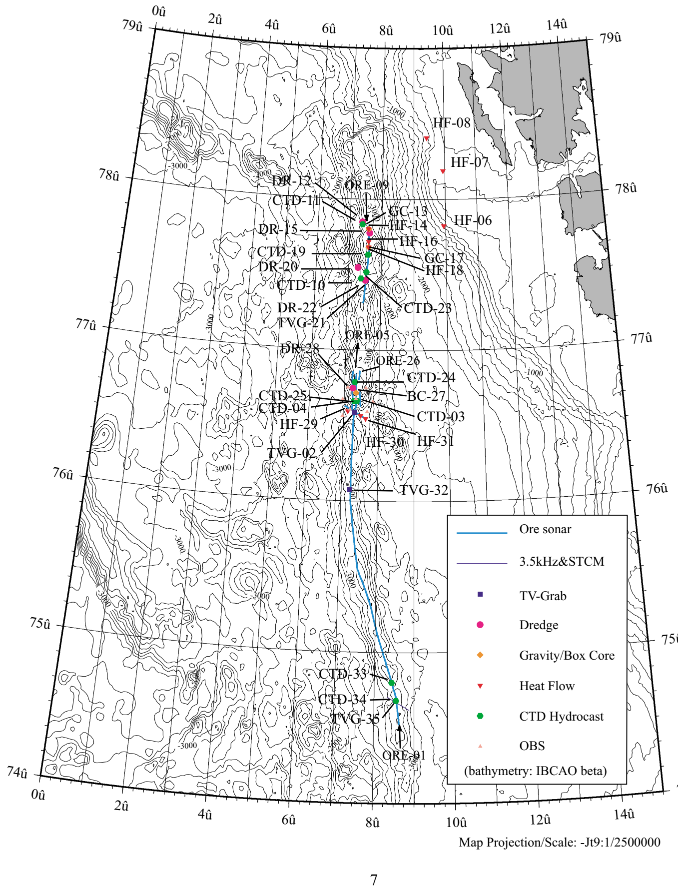

Figure 2. Ship's tracks and sampling sites of the Knipovich-2000 Cruise.

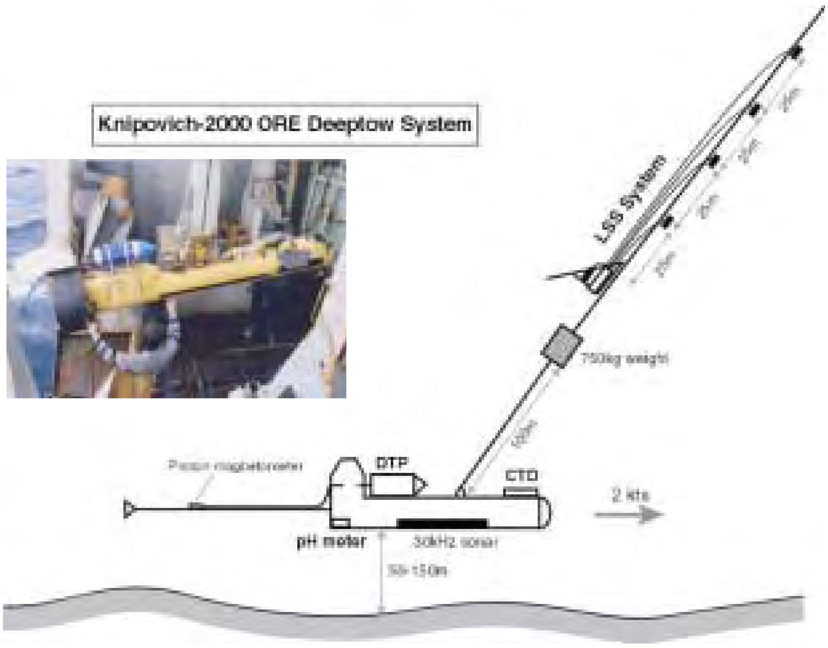

Figure 1. Schematic diagram showing the ORE system and attached self-recording devices. Insert - ORE deeptow sidescan sonar system

with the following four self-recording systems: A) LSS (Light Scattering System) provided by C. German and J. Campbell; B) CTD provided by K. Crane; C) Proton magnetometer provided by K. Tamaki and K. Okino; D) pH meter provided by Y. Koike (Fig. 1).

2. 3.5 kHz echo sounder
3. Shipboard Three Component Magnetomter provided by Y. Nogi
4. TV grab
5. CTD rosette waster sampler (12 x 5 L)
6. Gravity core (6 m)
7. Box core
8. Two heatflow meters

A) Norwegian system provided by K. Crane and A. Nilsen

B) Japanese system provided by M. Kinoshita and S. Goto

9. Dredge sampler
10. Ship positioning was done by DGPS system of Ashtech.

The Knipovich-2000 was divided into two Legs. Leg 1 is from August 30 (Bergen, Norway) to September 10 (Longyearbyen, Svalbard), 2000, and Leg 2 is from September 10 (Longyearbyen, Svalbard) to September 23 (Bergen, Norway). The ORE sidescan sonar system attached with the above multi-sensors along the axis of the Knipovich Ridge was towed from the southern end at 74° 30' toward the north with a swath width of 2.5 km and ship speed of 2 knots (Fig. 2). Mosaic mapping was done at the Logachev Area at 76°30'N (Fig. 3), the most intensive volcanic zone in the Knipovich Ridge. Most of operations of CTD, TV Grab, heatflow, OBS deployment, sediment sampling, and rock sampling were done based on the swath of sidescan sonar image (Fig. 4). In total 10 CTDs, 5 rock dredges, 3 sediments samplings, and 6 heatflow measurements were done. Eight OBSs were deployed at the Logachev area and seven were recovered by *R/V Haakon Mosby* after 25 days of recording the data at the sea bottom.

Results

The along axis ORE sonar images and a variety of stationary operations executed within the sonar swath pro-

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Figure 3. Mosaic image of the Logachev Area

vided a number of new findings on the Knipovich Ridge, a little known ultraslow-spreading system in the Arctic region. One of the most important achievements of the Knipovich-2000 cruise in terms of tectonics is identification of segmentation of the Knipovich Ridge. The ORE deeptow sonar images confirmed intensive volcanic activity at most of the topographic highs in the center of the rift. Specifically four large seamounts in the rift valley of the Knipovich Ridge all appeared as active volcanoes with abundant fresh lava flows and pillow mounds. They are identified as the centers of four fundamental segments of the Knipovich Ridge. The scale of each segment is about 100 km. We further identified smaller-order segmentation with a length of about 20 km. The correct identification of segmentation provided the basis to devise a sampling plan for the cruise. It will also contribute to any future research at the Knipovich Ridge.

The combination of ORE sonar images and TV grab operations turned out to be a strong tool for understanding the geology in the rift. The ORE sonar data were quickly processed into image mosaic maps on board and TV grab operations were planned using the images combined with SBL sonar navigation. TV grab operations provided bottom video images and at the same time returned invaluable rock samples for ground truthing and for sonar image interpretation.

The sonar images of the axial volcanoes made it possible to recover fresh basalt samples from the bottom. At four sites at the axial volcanoes fresh basaltic samples were obtained with abundant glass. Further laboratory analyses of major and trace elements and isotopes will elucidate the mantle geochemistry and dynamics of the Knipovich Ridge for the first time, as well as providing a powerful tool for understanding the magmatic processes in the rift in relation to tectonism.

The northernmost dredge samples from the rift wall contained unexpected hard sedimentary rocks. Although the reason for these outcrops of hard (= old?) sedimentary rocks in the rift wall is puzzling, the dredge results will constrain a unique tectonic history at the very northern end of the Knipovich Ridge. The age determinations of the sedimentary rocks by microfossil analyses are planned.

One of the heatflow data points in the northern Knipovich Ridge was very low with a value of 70 mW/m^2, despite the fact that it was obtained in the centre of the rift. The site appears to be located at the zone of non-transform offset. The reason for the anomalously low heat flow is difficult to understand but encourages further, more systematic heatflow measurements in this area for better understanding of the thermal structure of ultraslow-spreading systems. A heatflow transect at the Logachev rift mountain appears to fit with age-heatflow curve, but confirmation will need further systematic heatflow measurements in this area.

A focused survey was conducted at the Logachev rift mountain at 76°40', with additional mapping by ORE deeptow, a transect of heatflow measurements, deployment of OBS seismic network, TV grab observation and collection of fresh basalt samples. As the Logachev rift mountain is the largest volcano in the Knipovich Ridge, further composite analyses of all of the obtained data are expected to provide a fundamental contribution to the understanding of tectonics and magmatism of the Knipovich Ridge.

The temperature/salinity data for the water horizon 150 m above the bottom were obtained during towing the ORE system and five temperature/pressure anomalies were detected. The scale and origin of these anomalies require further studies and discussions. Anomalies with proposed hydrothermal origin will be compared with other data obtained during the cruise (light scattering, CTD from the hydrocasts, CH_4) and the results of post-cruise processing (TDM, He, trace elements).

Vertical CTD profiles (eight - in "CTD - LSS - pH" and two - in "CTD – pH" configurations) were carried out. As a result, the data on the distribution of temperature, salinity, light scattering, pH, ATP, as well as methane concentration in the water column above the different segments of the Knipovich Ridge have been collected. Anomalies in the distribution of all the studied parameters at different ridge segments were detected. The site in the southern part of the ridge that was visited twice (74°48'N 08°26.5'E) with anomalies of LS, CH_4, pH and ATP, seems the most promising for finding hydrothermal activity.

Relationship of detected anomalies (first of all, the CH_4, LS and pH) to hydrothermal activity will be studied in the laboratory after the analysis of other indicator components (*e.g.* TDM, helium and trace elements) in the water samples. It is important, that the selection of indicator elements depends on the type of hydrothermal activity (jet or diffuse flow) and geological setting (host rocks etc). Anomalies also need to be sorted out based on the variety of indicators, since the anomalies can be caused not only by the hydrothermal activity, but also by other non-hydrothermal factors, like tidal currents, underlying sediments, water flowing down along the continental slope, etc. We hope to determine the geological control of the distribution of hydrothermal zones and to compare their geological setting with that of the analogous zones at the Mid- Atlantic Ridge and the South-West Indian Ridge. Preliminarily, it can be suggested that hydrothermal sites related to basalt magmatism (as at TAG, Snake Pit, etc.) can be expected in the northern part of the ridge, where there is more volcanic activity, whereas in the southern part, the hydrothermal activity related to ultramafic rocks (as at Logachev and Rainbow sites) is more likely. Additionally, the sediment hosted hydrothermal mineralization at those parts of the rift valley which are covered with thick sediments can not be excluded.

A post cruise meeting for the Knipovich-2000 Cruise is planned to be held in early November, 2001 at St.-Petersburg. Further integration of analysed results will provide additional, novel information about the geology and geochemistry of the Knipovich Ridge. The home page of Knipovich-2000 is now at *http://www2.ori.u-tokyo.ac.jp/~asada/k2k/* with more updated information.

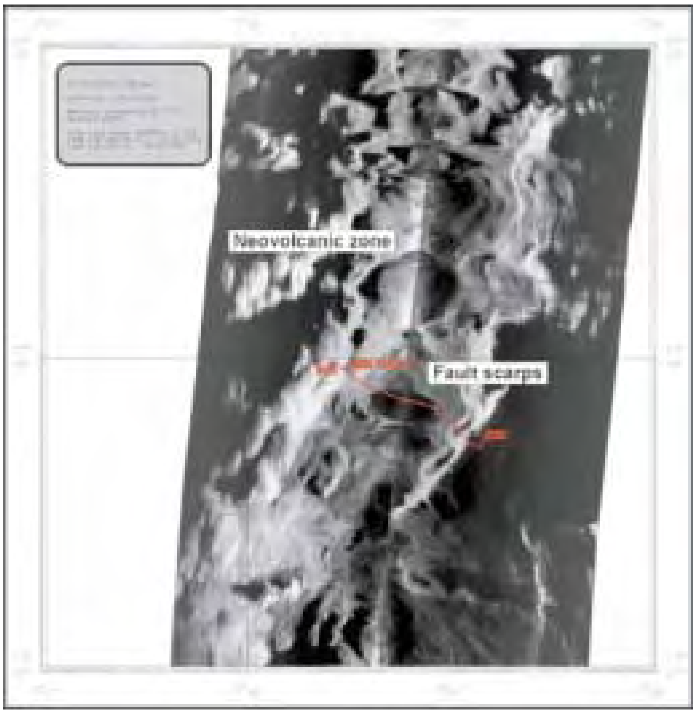

Figure 4. TV Grab towing track of ORE sonar image at the site TVG-21 at the northern part of the Knipovich Ridge