R/V PROFESSOR BOGOROV
CRUISE REPORT: CRUISE 37
POSETIV
PARAMUSHIR - OKHOTSK SEA EXPEDITION TO INVESTIGATE VENTING

Vladivostok - Vladivostok
September 23 - October 22, 1994

Edited by
Christoph Gaedicke, Boris Baranov and Evgeniy Lelikov
with contributions of expedition participants

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Content

1. Introduction

(B. Baranov, C. Gaedicke, E. Lelikov)

Since the discovery of fluid venting in the late seventies the processes involved in the marine geochemical cycle, especially those of fluid and gas flux through the sediment-water interface have become a new and exciting area of interest and research. Today numerous vent fields have been discovered and described. Special benthic communities which include molluscs with bacterial symbiotes and polychaete worms are related to fluid discharge onto the sea-floor. The main scientific objectives have been to qualify and quantify the amount of water and gas discharge at the sea-floor in order to estimate the role of these sources to the global biogeochemical cycle of elements. Thus the mapping of vent fields and the description of related geological structures such as the bottom-simulating reflector (BSR) were among the first steps of investigation. The BSR is a acoustically detectable horizon in the sedimentary column. Above this horizon gas hydrates of methane (and sometimes higher order hydrocarbons) and water occur in varying amounts in an ice like condition. The depth of the BSR below the sea-floor depends on physico-chemical parameters such as temperature and pressure, as well as the chemical composition of the fluids. The BSR occurs widely in the area of investigation. To evaluate fully the nature and origin of vent phenomena, thought to be related to tectonic processes in the forearc and backarc region of island arcs, multidisciplinary research is necessary.

From September 23 to October 22, 1994 a joint expedition with scientists from the Pacific Oceanological Institute (POI), Vladivostok/Russia, the Shirshov Institute of Oceanology, Moscow/ Russia, the Institute for Marine Geology and Geophysics (IMG&G), Yuzhno-Sakhalinsk/Russia, the Research Centre for Marine Geoscience (GEOMAR), Kiel/Germany and the Netherlands Institute for Marine Research (NIOZ), Texel/The Netherlands was carried out on board the Research Vessel *Professor Bogorov* during her 37th cruise. The Expedition was the principle part of the INTAS project 93-1881 - A Joint Russian-European Expedition to Paramushir Island: Reconnaissance Mapping of a Giant Deep Sea Vent in the Sea of Okhotsk - funded by the European Union. In order to evaluate the scale and nature of venting, a scientific party including geophysicists, sedimentologists, geochemists and micropalaeontologists worked closely together.

Areas of investigation

The main goal of the Expedition known as **POSETIV** (Paramushir - Okhotsk Sea Expedition To Investigate Venting) was the mapping of vent fields on the western slope off Paramushir Island, in the northern part of the Kuril Island arc system south of Kamchatka. The vent field, discovered by Russian scientists in the eighties (Avdeiko et al. 1984; Zonenshain et al. 1989), is one of the largest sources ever described. In this area an eruption flare of methane-rich fluids extending up to 500 m above the seafloor marks the site of active venting.

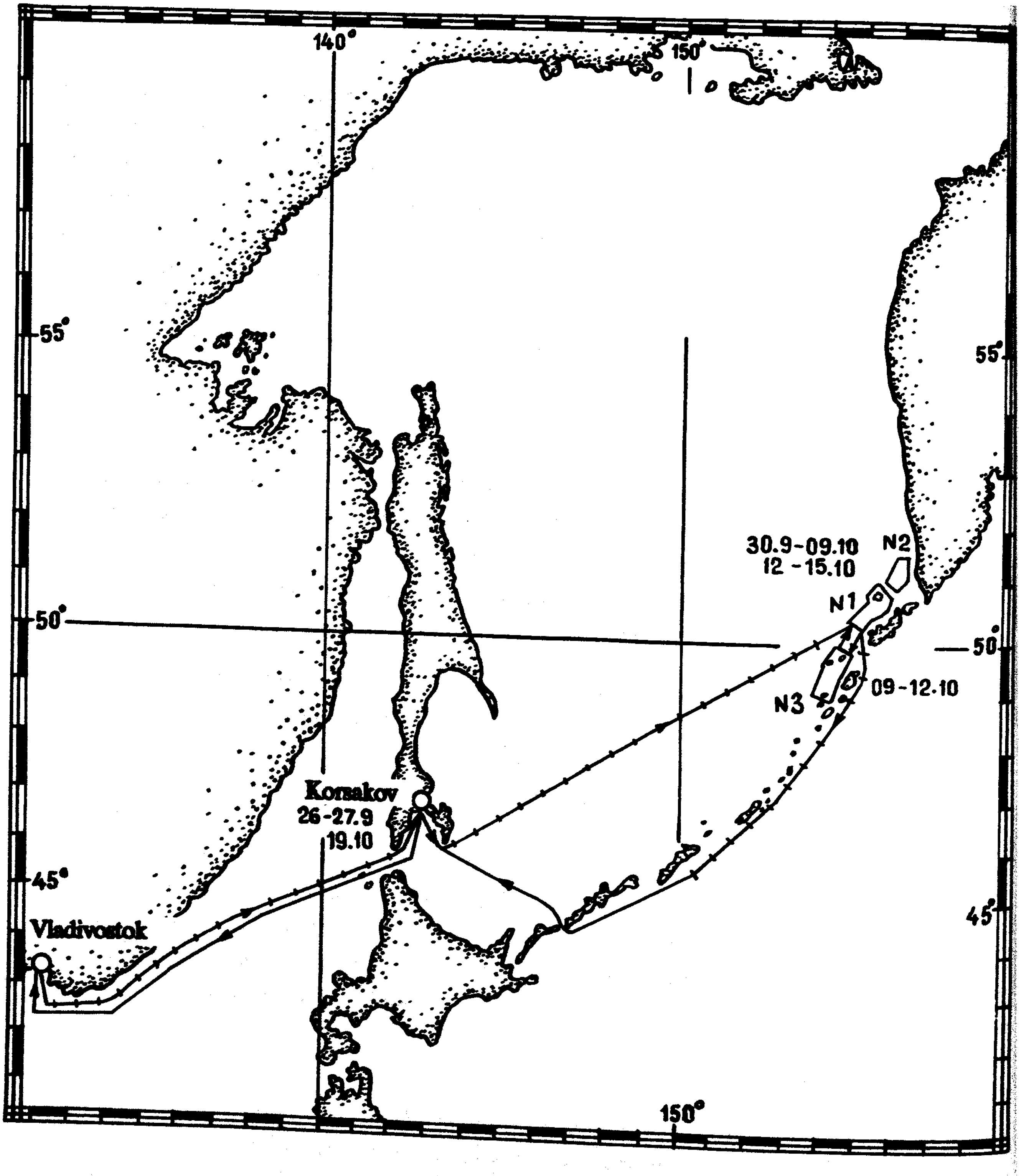


Fig. 1.1. Route of the 37th cruise of the R/V Professor Bogorov. Areas of investigations are shown.

Three areas were studied in detail by seismic mapping, geochemical and sedimentological sampling (Fig. 1.1).

The first and main area of investigation was the western slope off Paramushir and the area around Atlasova Island with the active volcano Alaid. Single-channel seimic profiles were run and sediment and water samples were taken. The area of venting was studied with a close spaced seismic grid and with numerous stations for sampling bottom water as well as sediment.

The western shelf and slope off the southern tip of Kamchatka was the second area of interest. Due to the seismic profiles which indicate a different structural and sedimentological origin, just one water sampling location was run in the area before moving back to the original area of investigation to complete seismic profiling as well as sediment and water sampling.

The possibility of finding similiar geological structures and thus discovering new vent fields in the area of Onekotan Island just south of Paramushir lead to the third area of investigation. A seismic survey was run in the backarc region off the island. According to this brief survey, no BSR was found and due to bad weather conditions the survey was aborted. After moving back again to Paramushir, waterchemistry and single-channel seismic profiles were run west of the Island close to the volcano Chikurachki.

During the expedition sampling at 65 stations using a grab sampler, gravity corer and bathometer - a specially designed water sampler to obtain bottom water samples took place. 75 single-channel seismic and side-scan sonar profiles with a total length of about 1700 km were run (Fig. 1.2). Most of these profiles were digitally as well as analogically recorded. The weather during the latter part of the expedition was increasingly stormy with waves of more than 3-4 m encountered.

Apart from four days lost through the storm, the travel to and from the work area took 11 days and 2 days were needed to pick up and drop off the seismic team from the port of Korsakov (Sakhalin island). Total working time on the polygons was 13 days.

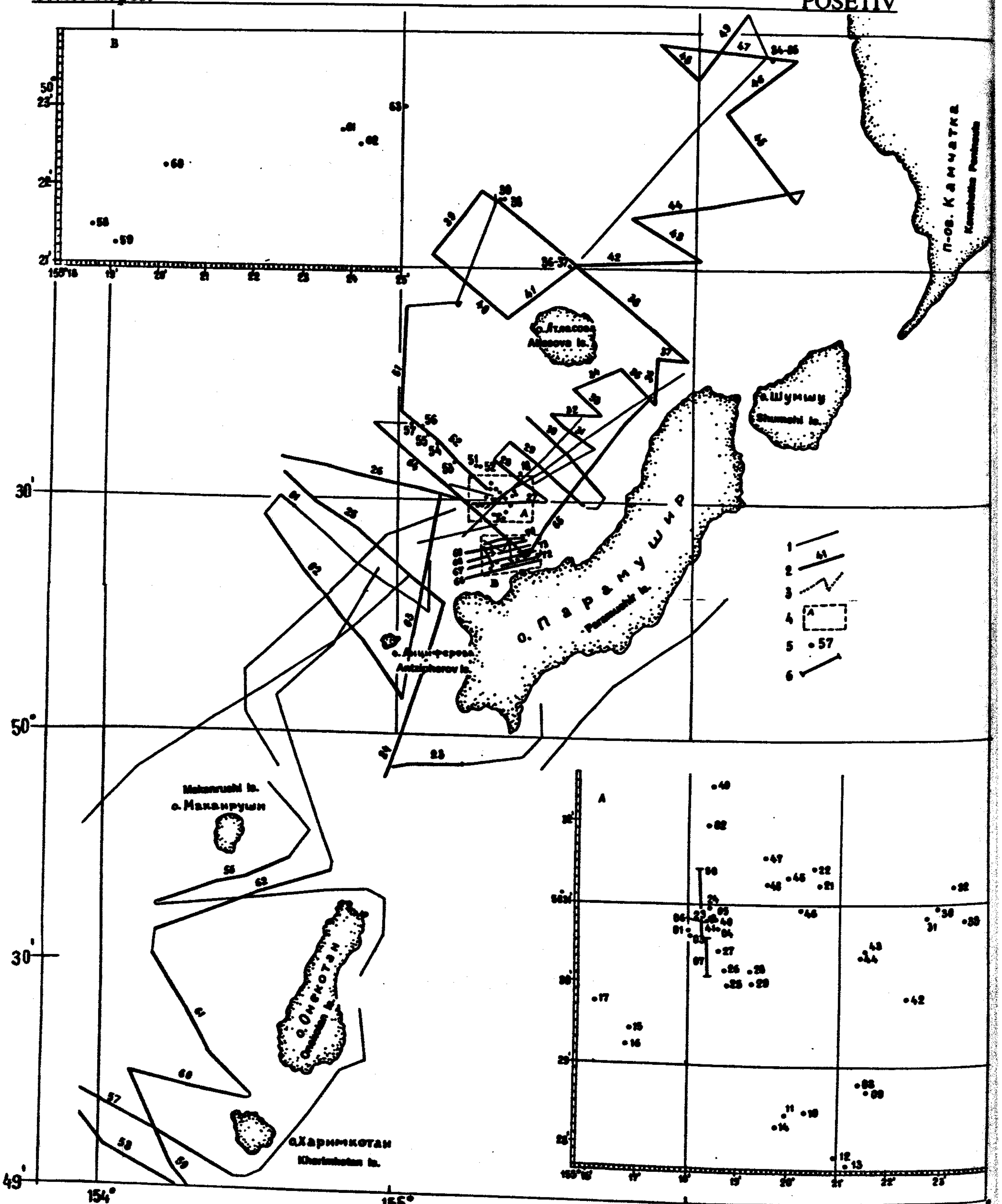


Fig. 1.2. Location of the sampling stations, bathymetric, single-channel and side-scan sonar profiles. Areas A and B are surveyed in detail (1-3 batymetric, seismic and side-scan sonar profiles; 4 areas of detailed investigations; 5 water and sediment sampling stations; 6 dredge stations).

2. Participants & Scientific Groups

1.	Evgeniy P. Lelikov	POI	co-chief scientist
2.	Christoph Gaedicke	GEOMAR	co-chief scientist
3.	Lev M. Gramm-Osipov	POI	deputy chief scientist
4.	Vladimir K. Annin	POI	first technical chief
5.	Anatoliy V. Mozherovskiy	POI	scientific secretary

Geomorphology Group

6.	Alexander S. Svarichevskiy	POI	head of group
7.	Ralf Freitag	GEOMAR	
8.	Valentina A. Kondratenko	POI	
9.	Yuriy I. Mel'nichenko	POI	
10.	Alexander I. Svininnikov	POI	

Gas-Geochemistry and Sedimentology Group

11.	Anatoliy I. Obzhirov	POI	head of group
12.	Evgeniy I. Basov	NIOZ	
13.	Alexander N. Derkachov	POI	
14.	Susan Kinsey	GEOMAR	
15.	Anna V. Sorochinskaya	POI	
16.	Ol'ga F. Verestschagina	POI	

Geoacoustic Group

17.	Victor A. Sychiov	IORAS	head of group
18.	Boris V. Baranov	IORAS	
19.	Victor A. Lezhnin	IORAS	
20.	Vladimir L. Nikulin	IORAS	
21.	Roman G. Pavlov	IORAS	
22.	Sergey A. Volynkin	IORAS	

Single-Channel Profiling Group

23.	Igor N. Belykh	IMG&G	head of group
24.	Vasiliy N.Bugankov	FEMEGE	
25.	Aleksey N. Ilyev	IMG&G	
26.	Evegeniy N. Shilov	FEMEGE	
27.	Oleg I. Shishov	FEMEGE	

Participating Institutes

POI	Pacific Oceanological Institute, Far East Branch of Russian Academy of Sciences, Vladivostok, Russia
IORAS	P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia
IMG&G	Institute of Marine Geology & Geophysics, Far East Branch of Russian Academy of Sciences, Yuzhno-Sakhalinsk, Russia
FEMEGE	Far East Marine Engineering and Geological Expedition, Yuzhno-Sakhalinsk, Russia
GEOMAR	Research Center for Marine Geoscience, Kiel, Germany
NIOZ	The Netherlands Institute for Marine Research, Texel, The Netherlands

3.1 Geomorphology

(A. Svarichevskiy, A. Svininnikov)

The main task of the group was to obtain accurate waterdepth information, in order to prepare detailed bathymetric maps of the relief of the seafloor. A further task was the observation of plumes in the watercolumn which are generated by methane rich fluids expelled at active vent sites west of Paramushir.

Equipment

Geomorphological observations and bathymetrical mapping were carried out on board the R/V Professor Bogorov using the hull mounted echosounding systems designed by the „Elac" corporation (Kiel, Germany): Schelfrand, Enif and Super-Lodar with main frequencies of 30, 12 and 20 kHz, respectively. Locations of the geomorphological structures were determinated using a GPS navigation system. The receiving set - 'NavTracXL designed by Trimble Navigation was used to determine the ships location using three satellites in one second. All navigation data were entered into a computer. where, taking the average of the three independent values, ignoring those differing by more than one minute, the error in determination of the ship location was less than 20 m (1/4 of the ship length).

Methods

Bathymetrical mapping was carried out by echosounding through the subparallel gals system, oriented northwest-southeast, in the Paramushir area. In the seeping area and in Krasheninnikov bay, echosounding was carried out together with high frequency seismic profiling using the more compacted gals system. Ten lines were run crossing the seeping area northwest to southeast, and three were run on a northeasterly heading. The main echosounding lines had a length of 3-5 miles and the distance between the lines was not more than 0.7 miles. The mapping area was 22 square miles in total. In the second area of investigation (Krashenimmikov bay) four main and three additional lines were run to the northeast following the shoreline trend. The length of the lines was 12 miles and the distance between the lines was 1 mile.

Observations of hydroacoustic anomalies related to the saturation of bottom water by gases, were carried out throughout the cruise using all hull mounted echosounding systems.

In total 1300 miles were run over the areas under consideration and 740 miles were covered during transitions. The bathymetrical maps were drawn by hand using mapped echosounding lines from the time scale. Hydrological corrections were not taken into consideration .

Results

Hydroacoustic anomalies were recorded on twelve tracks run over the seeping area, and were seen as distinct reflections above the seafloor. In four cases these were recorded on both the wide- and narrow-beam echosounding equipment. In three of these the anomalies took the form of a plume. In all other cases the anomalies were only seen on the wide-beam echosounder as a cloud situated in the watercolumn above the seafloor. Figure 3.1.1 shows the position of the above mentioned anomalies. The anomalies recorded by the narrow-beam equipment have a north-easterly trend. Those anomalies recorded by the wide-beam echosounder, in general have the same trend (Fig. 3.1.1) This line on the seafloor is related to an area of small rises located at the foot of a NE trending tectonic terrace.

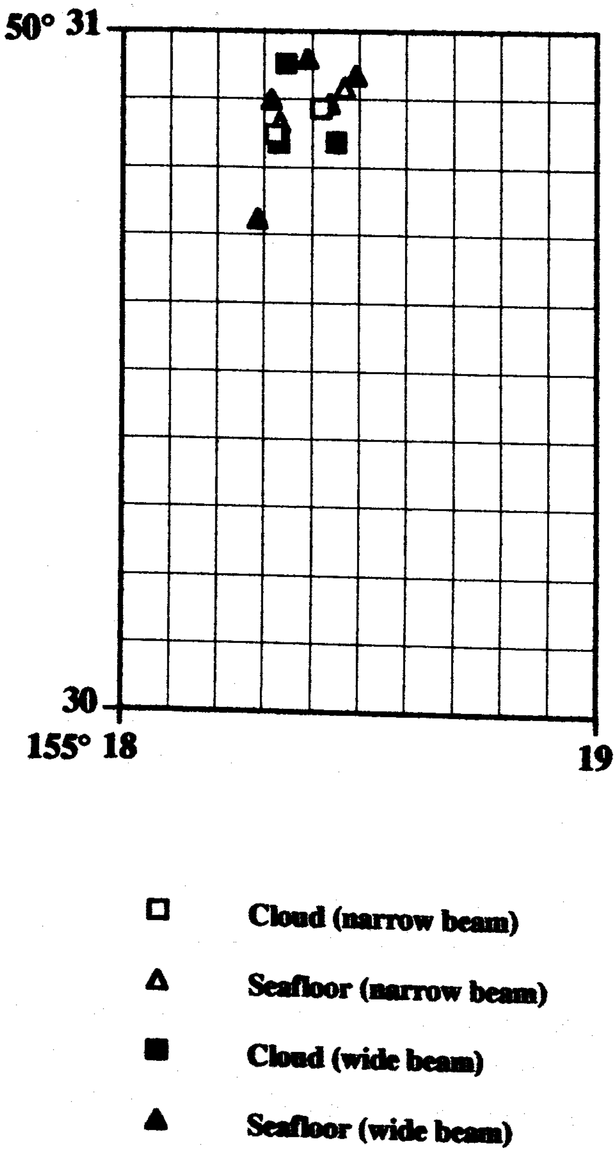


Fig. 3.1.1. Location of vent sites according to echosounder data.

As a result of the echosounding work, large scale (1:50000) maps were drawn by hand, of the seeping area and of Krasheninnikov bay, for seismic profiling (Figs. 3.1.2 and 3.1.3). These maps in addition to new data gathered during the cruise were used to plot a updated bathymetric map of the northern Kuril backarc area (Fig. 3.1.4).

The Golginskiy flexure extends to the west Kamchatka region. To the east it is bound by the Kuril island arc. The bottom and north-eastern slope of the depression were investigated during the transit from Paramushir to Onekotan island. In the Paramushir area an interesting pattern of a system of canyons or channels cutting into the sedimentary cover was seen. These channels start on the slope of the Kuril island arc system, where they are probably controlled by a NW running fault system. They then continue to the bottom of the depression and extend north eastwards. The origin of these structures is not yet clear, but due to their branching nature they do not seem to be the result of current activity. They are also unlikely to be the result of turbiditic flow since the inclination of the depression bottom is very slight.

The large number of volcanic structures and tectonic rises, sometimes forming plutonic `steps´, to be found in the area are not fully covered by sediment and form an extremely complex tectonic and volcanic landscape.

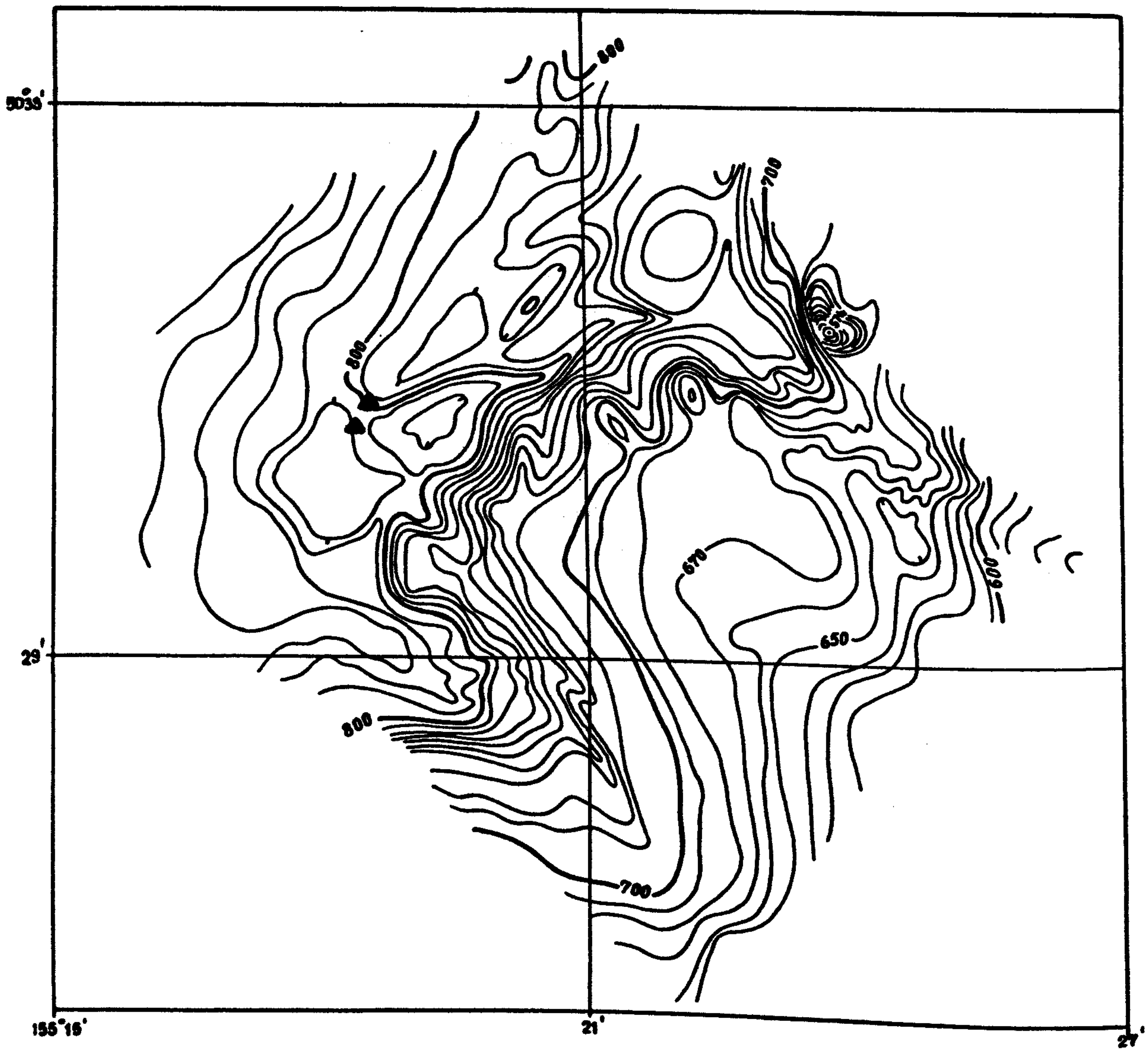


Fig. 3.1.2. Bathymetric map of the venting area. Contour intervals are 10 m, triangles indicate active vents.

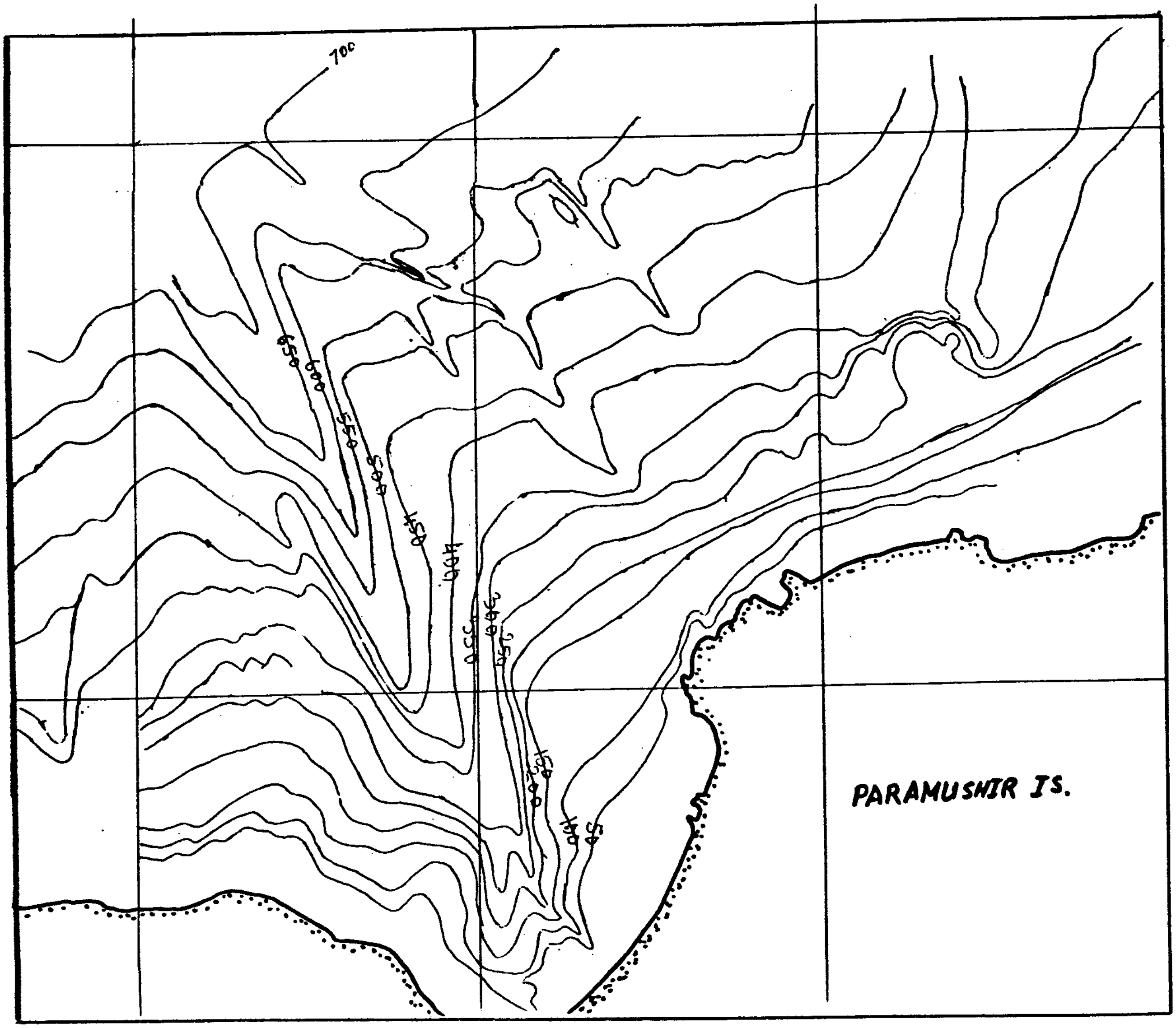


Fig. 3.1.3. Bathymetric map of the Krasheninnikova Bay. Contour intervals are 50 m.

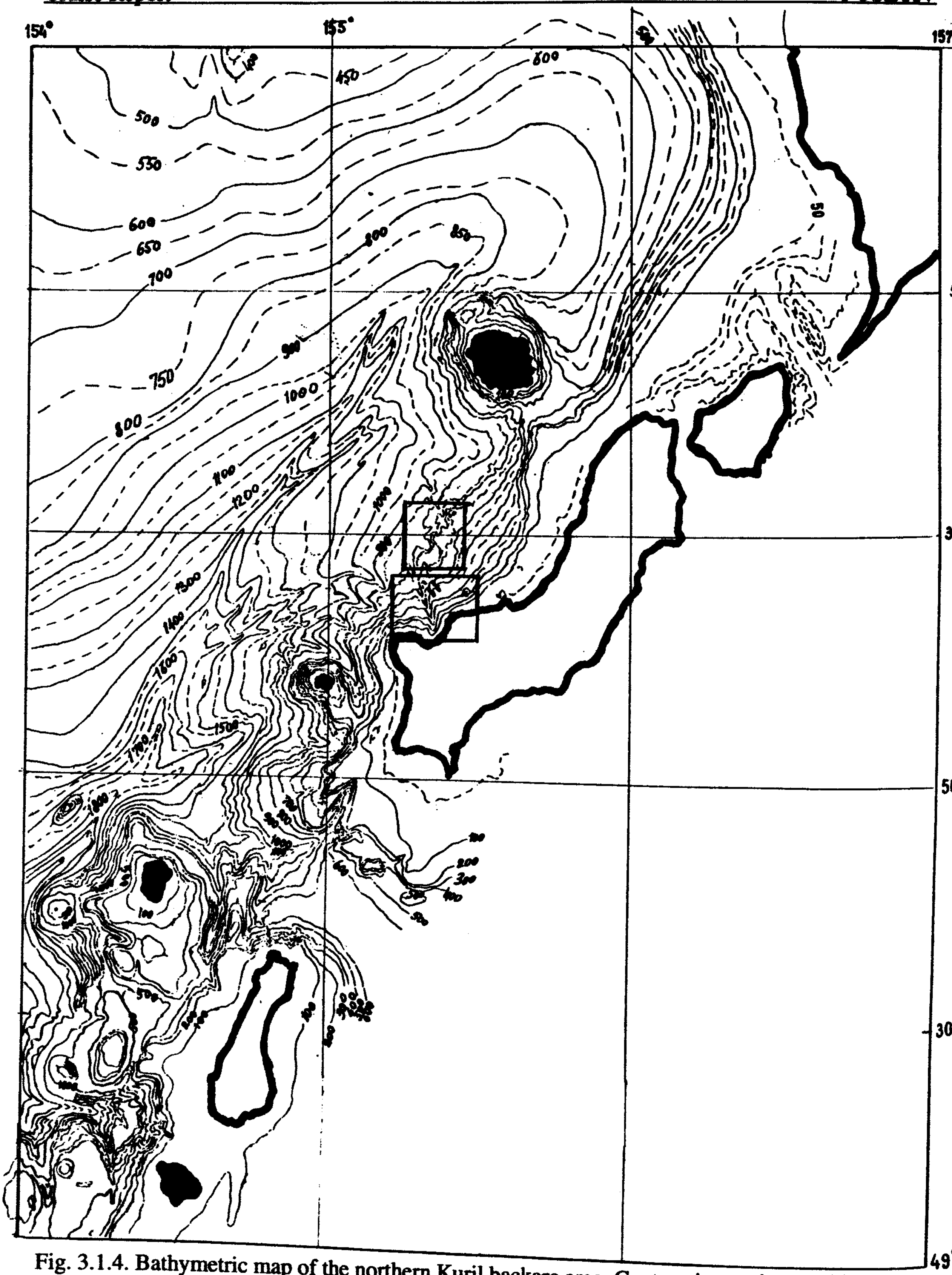


Fig. 3.1.4. Bathymetric map of the northern Kuril backarc area. Contour intervals are 100 m. Additional contour intervals are 50 m; rectangles indicate areas shown in Figs. 3.1.2 and 3.1.3.

3.2 Side-Scan Sonar Survey

(B. Baranov, V. Sychiov)

The tasks of the group were as follows:

1.To obtain the image of the already known vent off Paramushir island. From earlier dives of the PISCES submersible it is known that the diameter of the vent area is 50 meters. The area looks like an excavated surface, consisting of many holes with depths of up to 2-4 meters. These holes should give distinct pictures on sonographs.

2.To find other vents in the investigated area near Paramushir island.

3.To obtain some data on structural patterns according to the distribution of the minor forms of relief.

Equipment

During the investigation of the 37th cruise of R/V Professor Bogorov the deep towed complex MEZOSCAN was used. The aim of using MEZOSCAN was to carry out investigations of the sea floor surface by means of side scan sonar and seismic profiling.

The MEZOSCAN consists of a towed sonar body (TB), ship´s desk, RAST system and equipment for tugging the TB and launching and lifting the TB on or off board. The width of observation of the sea floor was determined to be 50-750 meters. The maximum depth for this modification is 2000 meters. The TB is towed behind the ship on an electric cable. Inside the TB there is special equipment connected to the RASTR system. The RASTR is a complex periphery using a PC AT 386 for reception of information.

Methods

It was suggested that side-scan sonar surveys would be the main part of this investigation. Accordingly it was proposed that sonar images from several polygons near Paramushir Island should be obtained. The dimension of each polygon was 30x10 km. To achieve an overlap of 30% the distance between tracks was 1km and the range of the fish to one side was 750 m.Ten tracks were run within each polygon.

Results

The results which were obtained using side-scan sonar are very limited. Sonographs of the earlier known vent were not obtained and new ones were not found. The reasons for this will be explained in the conclusions.

Secondly, almost all this area is covered by sediments with thicknesses of up to 5 km which give indistinct scattered patterns and some prominent forms of relief occur only rarely. Nevertheless, the sonographs obtained suggest that all minor forms of relief have a NW or NS strike. This strike corresponds well to the trend of such relief forms as small canyons and mounds (see Figs.3.1.2 and 3.1.3). According to sonar images it seems that the hummocky to chaotic seismic units (see part 3.3) have the same trend. This figure shows small mounds which are concentrated along lines in a NS direction.

Conclusions

As mentioned above the side-scan surveys were considered an important part of the work. However, the schedule of the cruise was very flexible and since the weather conditions were not good for these kinds of investigations, single channel seismic profiling was carried out. As a result good seismic images of the vent were obtained.This data suggests that the seismic method using a speed of 6 knots instead of 2 knots for side-scan sonar is more useful for recognition of the venting areas. Therefore, it may be better to use the side-scan sonar for investigations of a local area which have been outlined by seismic profiling. In this case the distance of the fish above the seafloor should be about 10 meters. Unfortunately, bad weather conditions and some problems connected with the winch meant that such work could not be carried out on this cruise.

3.3. Single-Channel Seismic Profiling

(B. Baranov, I. Belykh, C. Gaedicke)

During the POSETIV expedition, 71 continous single-channel seismic profiles with a total length of more than 900 nautical miles (more than 1600 km; see: Appendix I) were run. The main goals were to investigate the uppermost strata of the sedimentary column and the tectonic structure of venting areas and to map the bottom-simulating reflector (BSR). A sparker array provided the necessary sound source, and the receiving signal was recorderd both as an analog and a digital signal. (Tab. 3.3.1).

Table 3.3.1: Technical Specification of Single-Channel Seismic Profiling

Equipment	
Sound source	sparker array
Receiver	streamer containing 18 hydrophones grouped at 1 m interval
Filter	low pass 560 Hz, high pass 90 Hz
Analog registration	SAK-3, paper prints
Digital registration	IBM PC with two tape driver, 12 bits ADC
Acquisition	
Source offset	10 m
Source depth	1-2 m
Receiver depth	1.0-1.2 m
Ship´s velocity	5.5-6.0 knots
Shot point interval	2-3 sec
Length of recording	800 msec
Time delay range	0-1980 msec

Seismic profiling was supported by the shipboard navigation system GPS. Depending on the sedimentary cover the maximum penetration was up to 500 m with a vertical resolution of 4 m. Bad weather conditions caused high noise levels in some seismic lines. However, the quality of the whole data set is good, and digitally recorded seismic profiles will be processed onshore at the Institute of Marine Geology & Geophysics/Yuzhno-Sakhalin.

Three areas were investigated:

1. the area west of Paramushir and around Atlasova island in detail,
2. the area off the southwestern tip of Kamchatka, and
3. the backarc region of Onekotan island.

First interpretation of the seismic profiles provided necessary information about sedimentary patterns and possible gas discharge, and thus served as the basis for sediment and water sampling.

Preliminary results

1. Mapping of the bottom-simulating reflector (BSR)

The main objective of the single-channel seismic investigation during the expedition was the mapping of the bottom-simulating reflector (BSR) in order to investigate possible linkages between anomalies of the BSR track and its relationship to seeping phenomena on the seafloor. These are documented by near-bottom high methane concentrations. The BSR is thought to be the physico-chemical boundary of gas hydrates in the sedimentary column: below this boundary gases such as methane and higher hydrocarbons occur in free phase. Above this seismically detectable boundary gases are fixed as gas hydrates in an icelike condition. Regional or local changing pysico-chemical conditions such as anomalous high heatflow or unusual pressure conditions lead to the breakdown of gas hydrates and the following expulsion of the gases as cold seeps onto the seafloor, where the gas forms anomalous methane concentrations.

In the area of investigation the BSR appears as a prominent high amplitude seismic reflector which parallels the sea floor and can discordantly cross stratified sediment. Most of the energy is reflected by the BSR horizon resulting in a transparent sesmic facies of the underlying strata. The BSR was mapped in an area west of Paramushir and north of the Atlasova Islands (see also Fig. 4.1). In the northern area of investigation the boundary of the BSR is less clear than in the southern area.

Fig. 3.3.1 shows the BSR on single-channel seismic profile B37-52. Free gas in the sediment is responsible for the transparent, white shaded areas on profile B37-52 above the BSR horizon. On the profile the BSR emerges from depth in the direction of the seafloor. Near this location, bottom water sampling and analyses as well as hydroacoustic anomalies on echosounder profiles are documenting seeping activity in the area where the BSR horizon is closest to the seafloor position. Thus it is believed that an anomalous BSR trajectory is correlated to venting of methane rich fluids. In order to evaluate this question a close spaced grid of seismic profiles were run in combination with near bottom water sampling. The unusual BSR trajectory extends to the south and to the north of the already known venting area. In all cases a probably structurally controlled depression is associated with the unusual BSR patterns. Due to the appearance of structural features like faults and escarpments in the area it is believed that the methane rich fluids preferentially use these weak zones as pathways. In order to evaluate the tectonic activity in the venting area further deep penetrating multi-channel investigations are necessary.

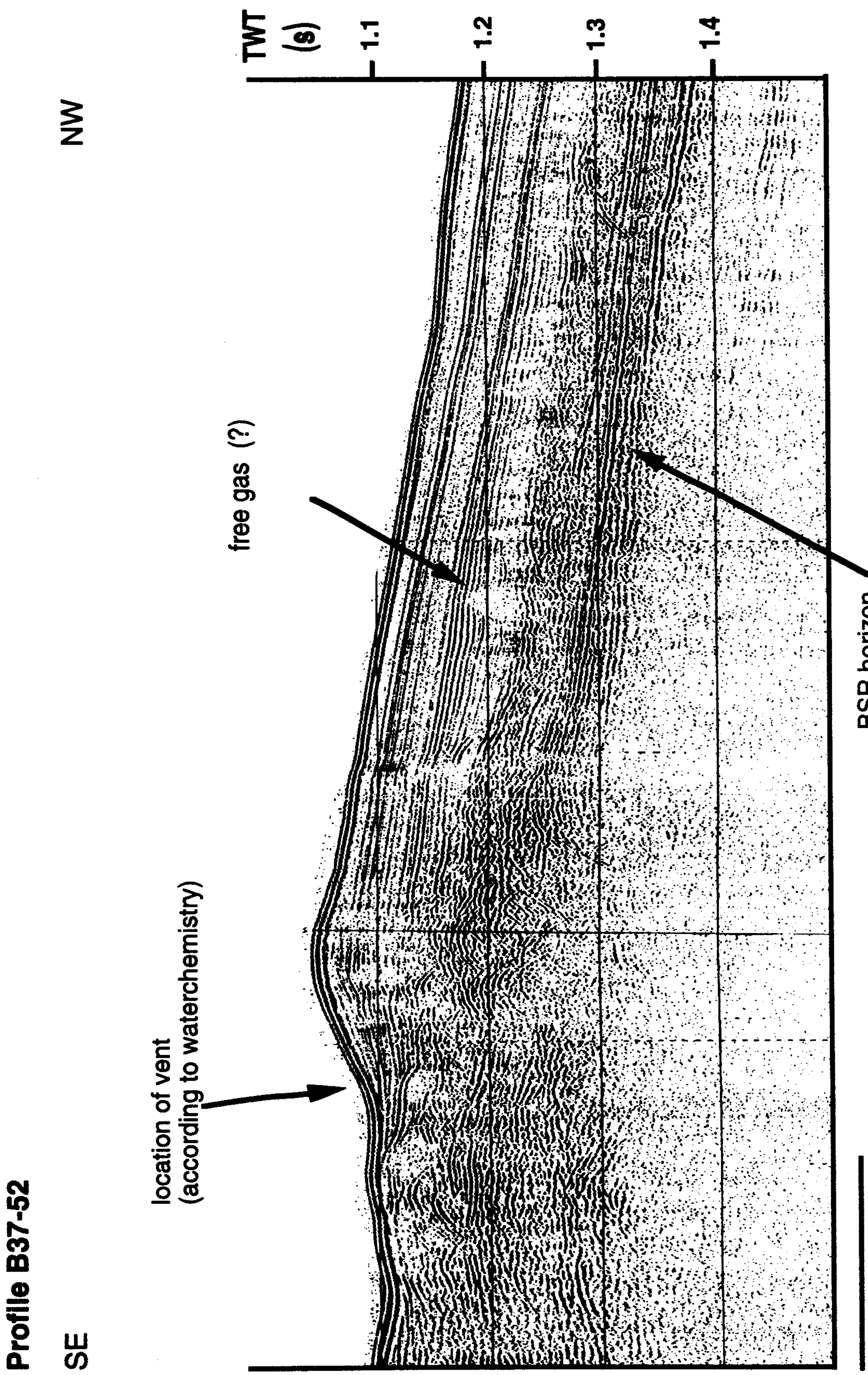


Fig. 3.3.1 Part of single-channel seismic profile B37-52.

In the northern area of investigation - the southwestern tip off Kamchatka - the BSR was mapped with single-channel profiles. Free gas is documented in the sediments as transparent, reflection free parts of the profiles. In contrast to the Paramushir area no venting of fluids was found, but water analysis show higher background concentrations of methane (see following part). The BSR trajectory is always parallel to the sea floor. In general the seismic facies pattern in this area is less complex: well stratified, undisturbed sediment dominates, there are no submarine volcanoes and no structural features that indicate recent tectonic activity. The acoustic basement was not reached using the sparker, confirming former russian investigations which showed sediment thicknesses of more than 5 km.

No BSR is occuring in the third area of investigation off Onekotan Island. The sediment thickness in this area is less than in the north. Volcanic activity with numerous submarine seamounts and probably related tectonic activity such as block tilting are important features in this area. The sea floor morphology reflects this complexity with steep slopes and escarpments. Due to the absence of the BSR there is no evidence for venting.

2. Truncation of layered strata west and south off Paramushir Island

Truncation of well layered sedimentary strata is documented in several profiles in the strait between Paramushir Island and Onekotan Island and on the shelf and slope area west of Paramushir.

After Kurashina (1967) the strait between Paramushir and Onekotan Islands (*Chetvertyy Kuirl´skiy Proliv*) is one of the main passages for North Pacific deep-water into the Sea of Ochotsk. In total 13.2sv (1sv = $1*10^6$ m^3 s^{-1}) of North Pacific deep-water enters the Sea of Okhotsk. This water is responsible for the strong currents between the Kuril Islands, resulting in erosion and truncation of the sediments (Fig. 3.3.2). Tectonic instability of the Kuril Island Arc and volcanism is leading to uplift and the exposure of older sediments to the deep ocean currents, while the sediment becomes redeposited `leeward´ in the Sea of Okhotsk. No equillibrium between erosion, sedimentation and tectonic activity has been established.

Tectonic instability and sea level fluctuations cause erosion and truncation on the shelf and slope west of Paramushir Island. In profile B37-36 (Fig. 3.3.3) at least three sea level rises are documented in ancient shelf surfaces which are now buried under the recent shelf. Instability of shelf deposits are indicated by slumping of sediment on the uppermost slope just below the shelfbreak. Channels are also a common faeture of this area. On profile B37-44 (Fi. 3.3.4) an active and a buried channel which parallel the shelfbreak can be seen. Multiple sea level changes are also documented in this area.

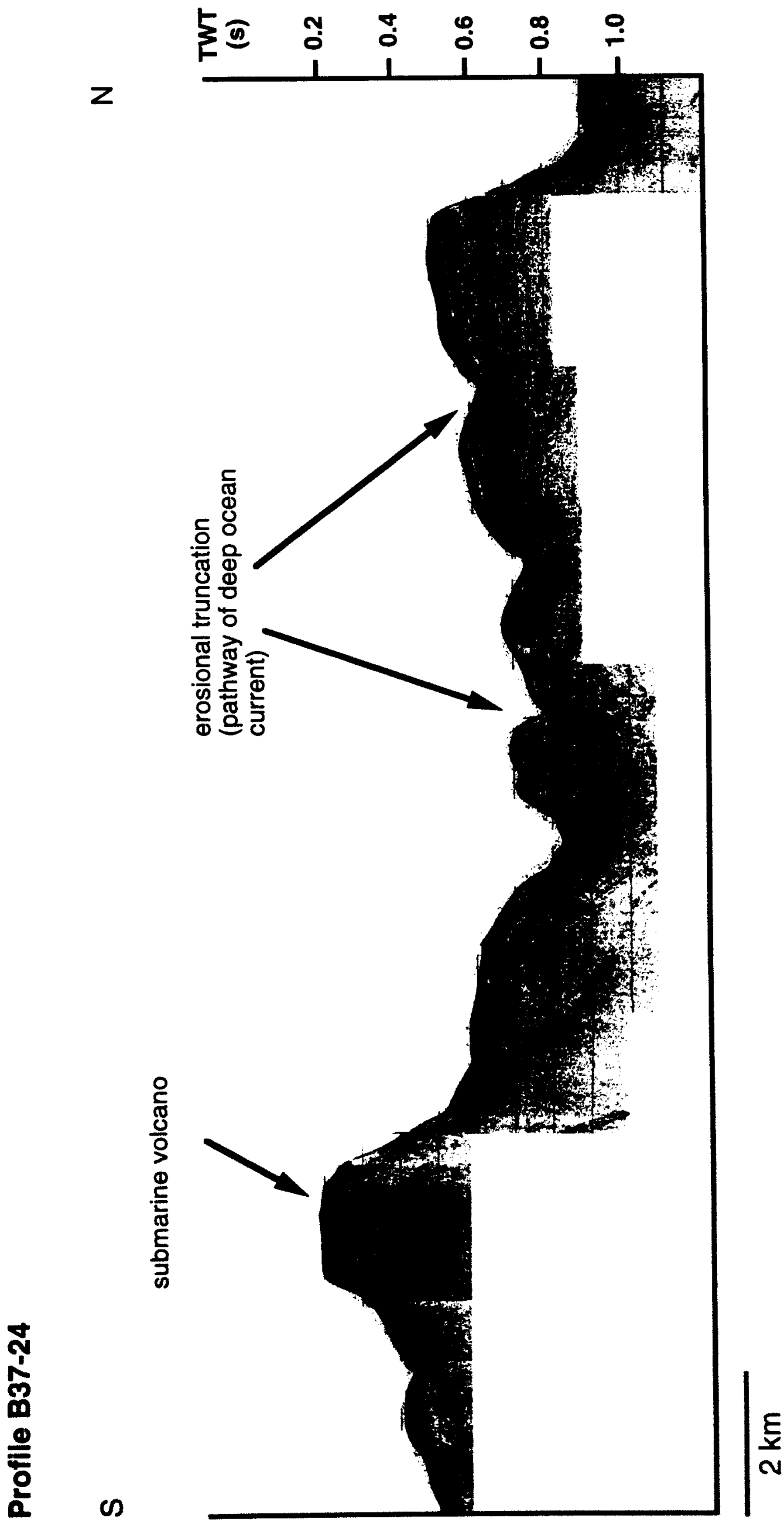


Fig. 3.3.2 Part of single-channel seismic profile B37-24.

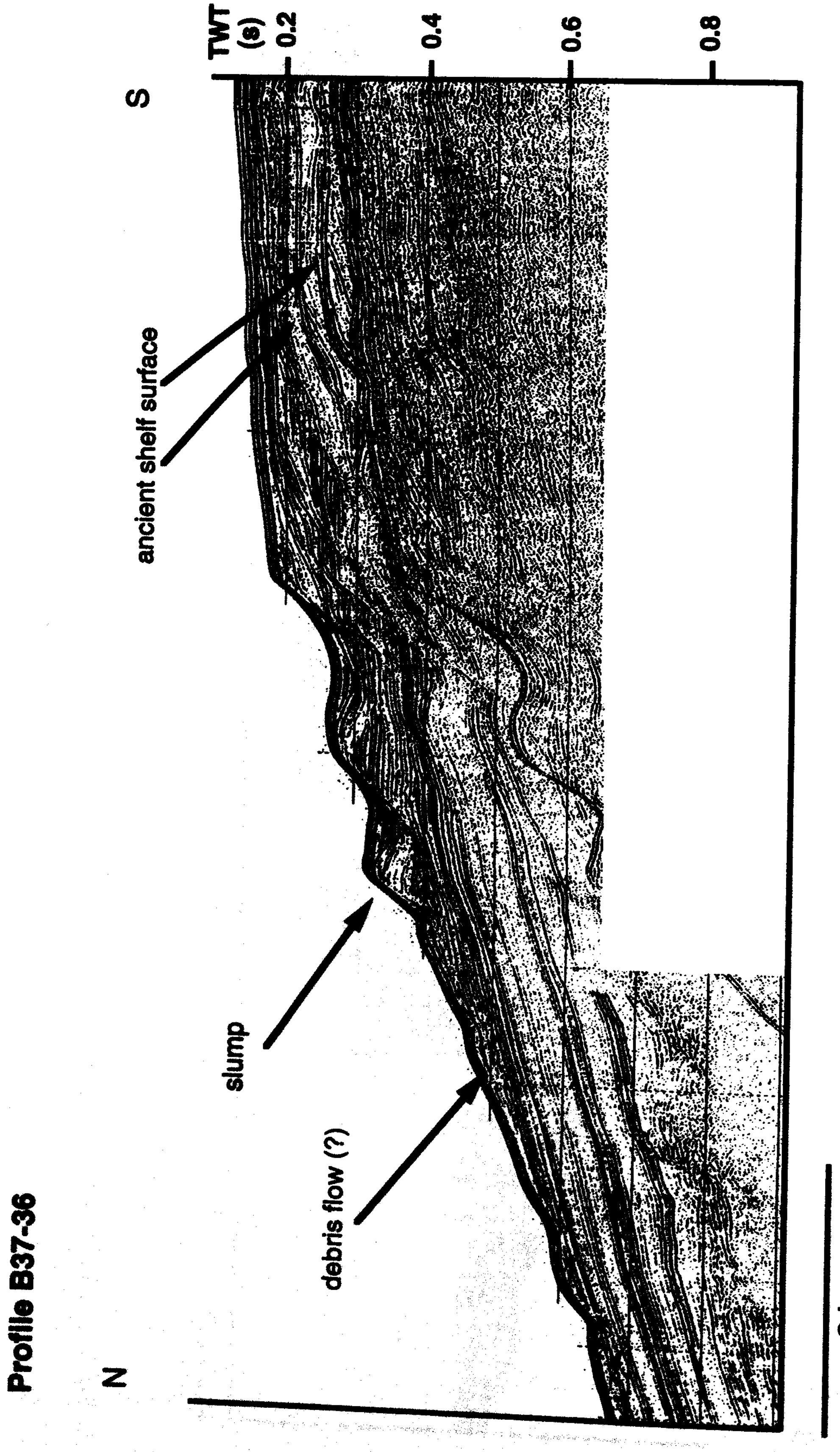


Fig. 3.3.3 Part of single-channel seismic profile B37-36.

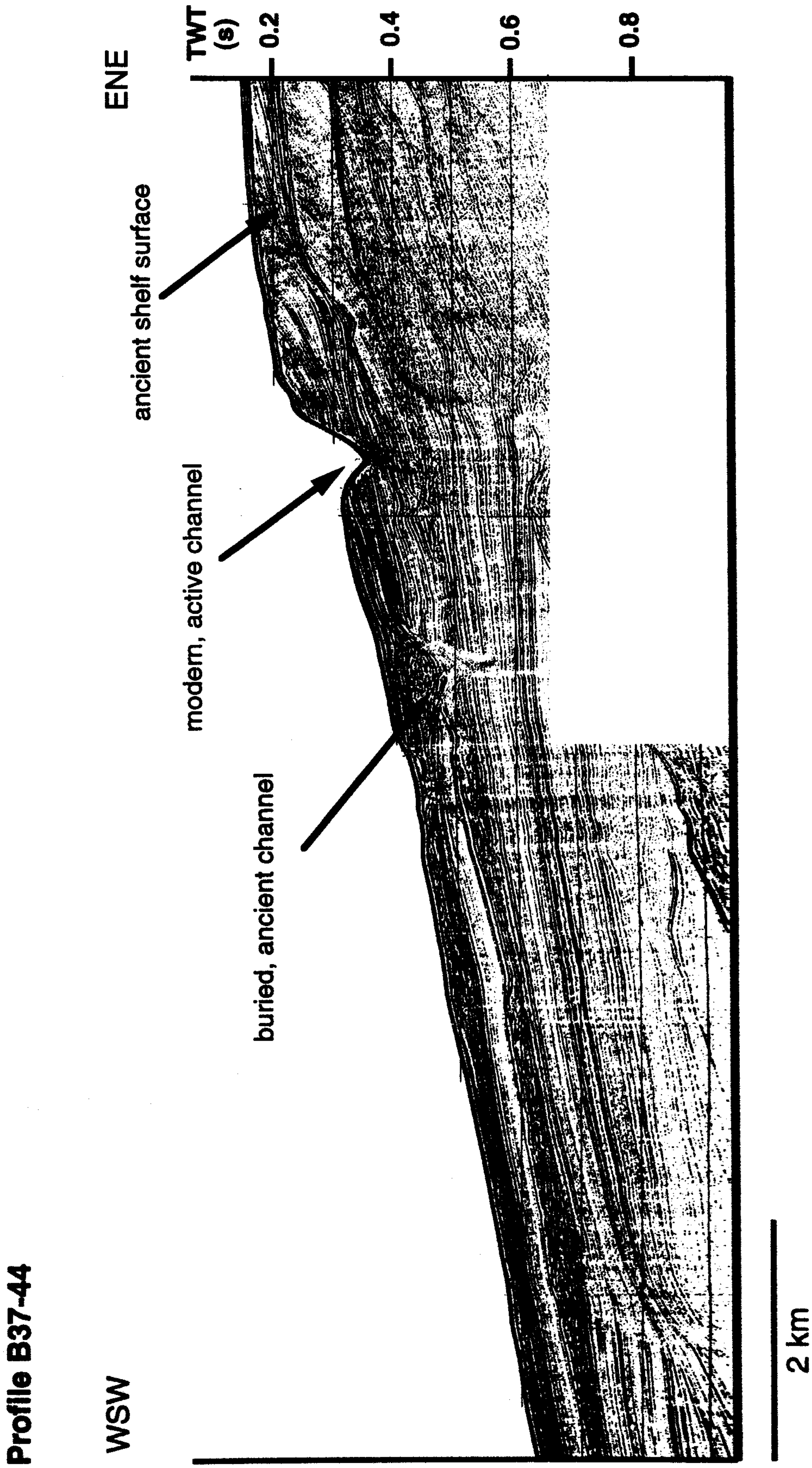


Fig. 3.3.4 Part of single-channel seismic profile B37-44.

3. Chaotic seismic facies near Atlasova Island and east of the seeping area

Around Atlasova Island a choatic seismic facies appears in seismic profiles forming an irregular circle (see also Fig. 4.1). The chaotic seismic facies is sometimes replaced by parallel reflectors belonging to normal hemipelagic sedimentation.The chaotic unit is believed to be of volcanoclastic origin and to be the expression of complex Alaid volcanism with lava flows and pyroclastic output. On profile B37-34 the chaotic unit outcrops onto the seafloor forming a hill some tens of meters in elevation. This outcrop pattern is very similar to a parasitic cone or small submarine volcano on the northern slope of Atlasova Island. No BSR is found within the circle.

A similar seismic facies pattern is found east of the venting area. These sediment may originate from the Paramushir volcanoes or from the submarine volcanoes off Paramushir. However, further investigations are necessary to verify the origin of the chaotic facies in this area. There is no evidence for venting within the area of the chaotic seismic unit, nevertheless the boundary between the well stratified sediments with the BSR horizon and the chaotic seismic unit is the main area of vents. The question now remaining is: Is there a relationship between both seismic units which causes venting?

4. Buried volcanic cones

Several submarine volcanoes were mapped by using single-channel seismic equipment. Volcanoes appear in seismic profiles with chaotic and structureless patterns. Fig. 3.3.4 shows a part of profile B37-65 close to the west coast of Paramushir Island. The volcano is now buried under sediment after an erosional truncation event.

Conclusion

The BSR was mapped using single-channel seismic tools. Thus in contrast to earlier investigations, the BSR pattern is more complex. The BSR occurs in the areas with highest sedimentary thicknesses. Venting of methane rich fluids is associateted with anomalous BSR trajectories which emerges onto the sea floor. This is one of the most important results of the POSETIV expedition.

The sea level history is well documented in the stratigraphic columns of the shelf areas. Several sea level rises as well as erosional events are preserved. Further investigations are necessary to evaluate their regional or global character. Profiles from the *Chetvertyy Kuirl'skiy Proliv* give evidence for the erosional strength of North Pacific deep-water currents entering the Sea of Okhotsk.

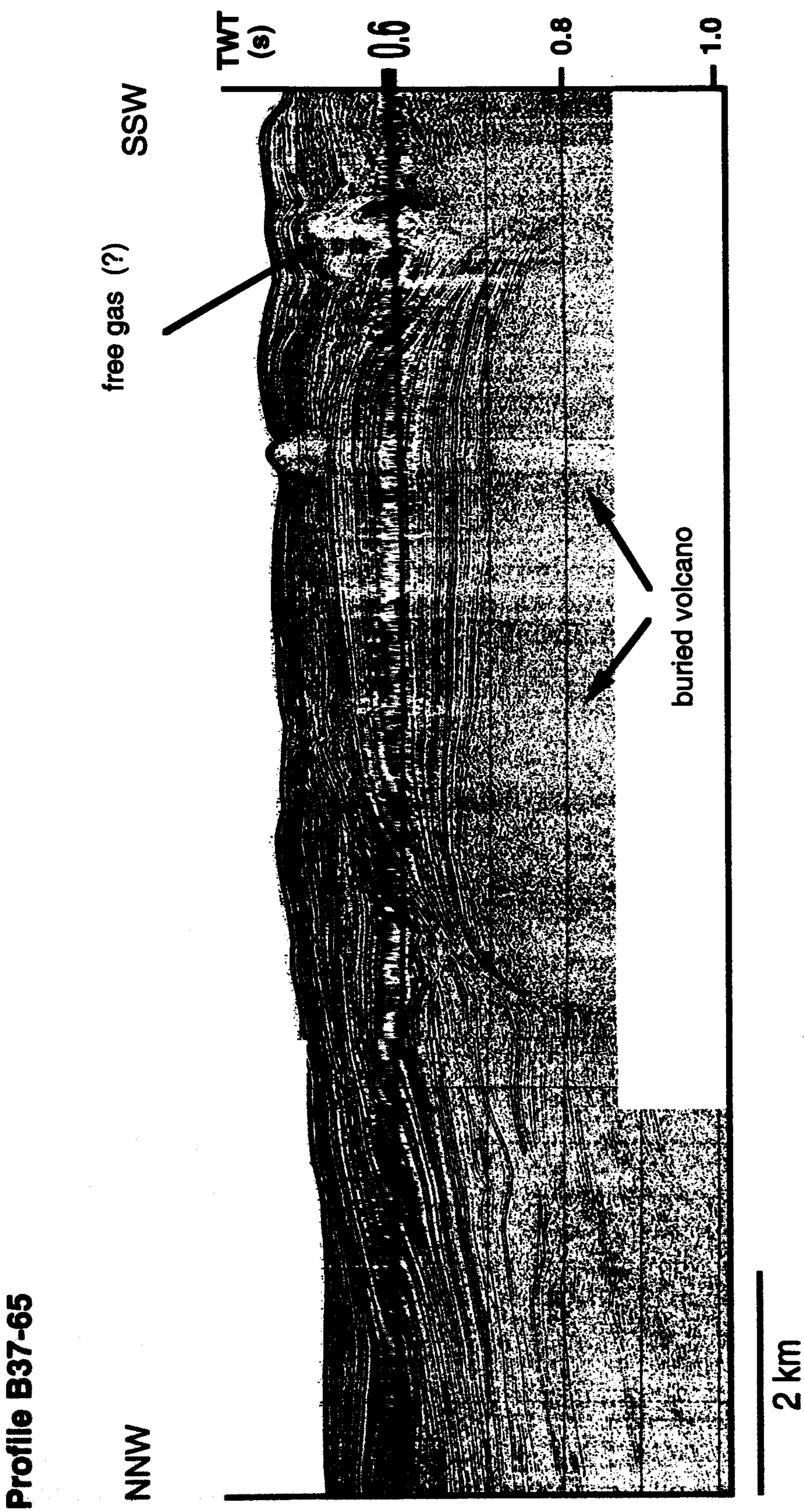


Fig. 3.3.5 Part of single-channel seismic profile B37-65.

3.4 Waterchemistry & Methane Analysis

(A. Obzhirov, A. Sorochinskaya, O. Verestschagina)

The main objective of the water- and geochemistry group during the POSETIV expedition, was the study of the vent fields off Paramushir island in order to explain their origin and to estimate their influence on the environment. To evaluate these targets co-operation with all scientific groups was necessary to achieve the following aims:

1. To determine dissolved gas composition and concentrations in venting areas and their surroundings, near bottom water samples were collected with a special bathometer water sampler designed by the Pacific Oceanological Institute.
2. Sediment samples were collected by gravity corer and grab sampler to obtain samples for analysis of interstitial water. Changes in lithology, mineralogy and microfauna related to venting activity were observed in collaboration with other scientific groups.
3. Single-channel seismic profiling assisted in locating seeping areas by carefully mapping anomalies of the BSR horizon. Equally the results of the water analyses helped to interpret the seismic profiles and to distinguish different and unclear seismic facies pattern.

Methods

Samples of seawater were obtained from depths of one metre above the seafloor by a bathometer with two bottles of special construction containing 1 litre of water each. The gas was extracted from the water by vacuuming (Obzhirov 1993). The composition and concentration of gas was determined on two gas chromatographs LHM-8MD (Russia). Methane, ethane, propane, butane, CO_2, O_2 and N_2 were detected. The sensitivity of determination of carbon-hydrogen gases is 0.00001% and 0.1% for other gases.

Results

39 bottom water stations were run. The results of the gas analyses are summarized in Tab. 3.4.1. One sample (station B37-40 and B37-41; two samples from the same location mixed together) was collected for onshore isotopic studies.

Near the venting area shown on the ELAC echo sounding records, four near bottom sea water samples were obtained (B37-05, B37-23, B37-40, B37-41; Fig. 3.4.1). The concentrations of methane changed from 1000 nl/l (st. B37-23 nearest to vent, waterdepth 793 m) to 180 nl/l (st. B37-01 located 0.3 miles west of the vent, waterdepth 800 m).

0.8 miles to the south of the vent field a similiar seismic facies pattern raised the possibility of discovering further active venting, which was confirmed by anomalous concentrations of methane with values of 598 nl/l and 510 nl/l (st. B37-25 and B37-29). Another active vent recognized due

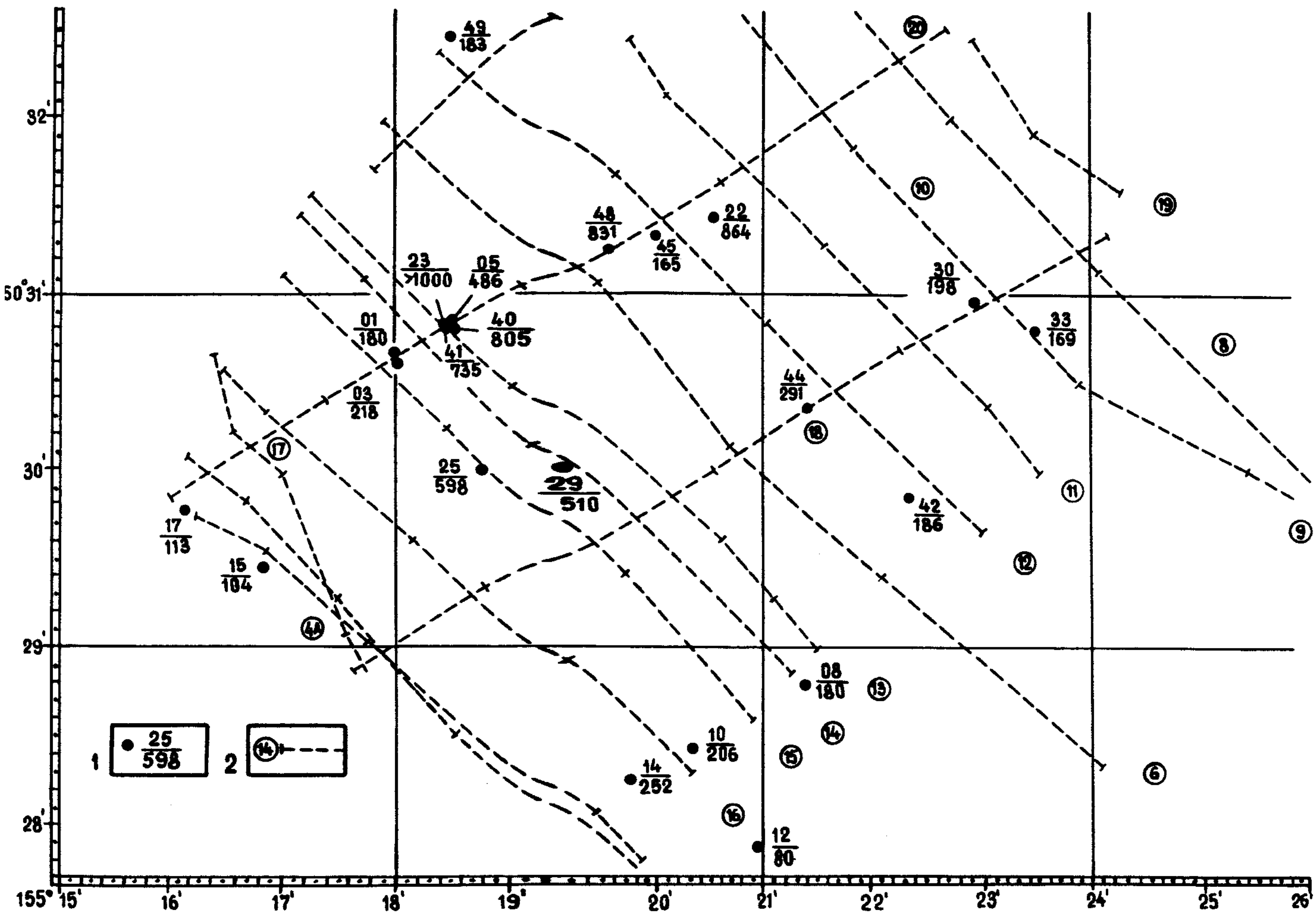


Fig. 3.4.1. Location of the water sampling stations in and around the venting area (1 = water sampling stations and their numbers, upper number indicates station number, lower number indicates methane concentration (nl/l); 2 = seismic profiles).

to seismic facies and methane concentrations was found 0.8-1.5 miles to the north-east of the main venting area, where concentrations of 831 nl/l at station B37-48 and 864 nl/l at station B37-22 were observed. Background levels of 80 nl/l methane were given by station B37-12 (waterdepth 710 m) 3.5 miles to the southeast of the location with the highest concentrations. These levels are two to three times higher than the `normal´ bottom water background of 30-40 nl/l methane. On the profile located to the northwest of the vent, at distances ranging from 5-14 miles, the concentrations of methane were 29-53 nl/l (st. B37-53, B37-54, B37-55, B37-56 and B37-57, Fig. 3.4.2). A relatively high (296 nl/l) concentration of methane was found on the profile at station B37-56. Low (40-97 nl/l) concentrations of methane were observed at the stations located 8 miles to the south of the vent (Fig. 3.4.3).

The amount of methane in sediments in the region of venting was equal to 18500 nl/l of wet sediment (st. B37-06, waterdepth 790 m). In the sediments at station B37-52 (waterdepth 915 m), however, the concentration of methane was 130880 nl/l of wet sediment.
Heavy hydrocarbon gases were almost absent in the near bottom water as well as in the sediment samples. The value of ethane was no more than 0.1 -0.5 nl/l.

Discussion

The new data set of methane analyses completes former sets, (Fig. 3.4.3) and is of high value for understanding the regional venting phenomena west of Paramushir island for the following reasons:

- samples were taken in very close grids, both in the seeping area and in the background area
- the choice of the bottom water sampling locations was controlled by high resolution single channel seismic profiles

As a result, high concentrations of methane, up to 1000 nl/ l in the centre of the venting area were found. This is about five times more than found in previous analyses. Moreover, a local area with anomalous methane concentrations ranging from 600 - 800 nl/l located about 0.8 - 1.5 miles away from the already known seeping area was found. An elongated arc-like, southwest-northeast trending area is now believed to seep methane in varying amounts. Comparison of these data with the single-channel profiles B37-13 and B37-20 which cross the sample locations show clear correlation between changes in the trail of the BSR which trends to the seafloor and the methane anomalies. The anomalies are thought to be the surface expression of the changes in the physico-chemical conditions which affect the BSR horizon by breaking down the stability of gas hydrates. Similiar seismic images were found on other seismic lines (B37-10, B37-12 to B37-15) and were carefully checked by water sampling. The relationship between the BSR anomalies and the high methane concentrations in the bottom water were confirmed. The background concentrations of methane in this area are 104 nl/l (st. B37-15) and 80 nl/l (st. B37-08), at these stations the BSR showed normal trailing.

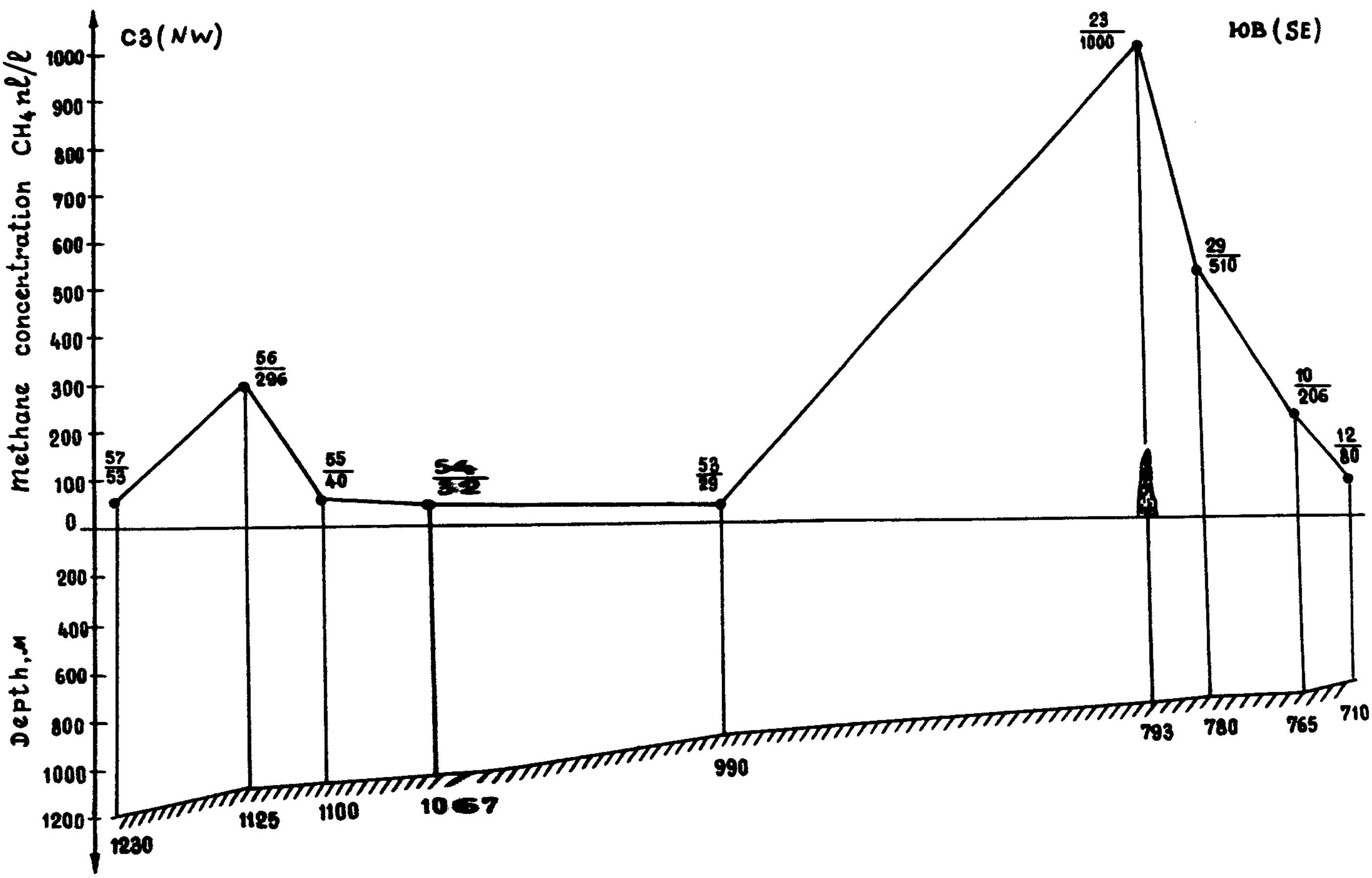


Fig. 3.4.2. Geochemical and bathymetric profiles from the basin to Paramushir island. Methane plume indicates the location of venting. Location of profile is shown in Fig. 3.4.3.

The level of methane concentration changes in areas located outside the venting area. The background methane content in the northwestern (St.B37-51 to B37-57) and southern areas (St.B37-58 to B37-65) are two to three times lower. However, the northwest boundary of the BSR, which is clearly mappable on seismic profiles B37-52 and B37-67, is correlated with an anomaly of 296 nl/l methane in the bottom water (st. B37-56). Due to the difference in BSR pattern in the venting area and at its northern boundary the anomaly is less distinct. Geodynamic activity, for example heatflow, would therefore seem to be greater in the venting area and decreases to the northwest. The absence of the BSR is responsible for the low methane concentration to the south.

The anomalously high methane content in bottom waters, which confirmed past analyses (Fig. 3.4.3), west off Kamtchatka (294 nl/l methane; st. 37-34) in the Golygin sedimentary basin, is of a different origin. The steady flux from sediments on the seafloor is distributed by microbiologically generated methane with a unknown thermogenic component. High methane content in sediments is shown by transparent cloud-like seismic facies pattern. The methane anomalies also serve as an indicator for oil and gas prospects in the area.

Conclusions

1. A large anomaly of methane (1000 nl/l) was found in bottom water in the central part of the vent field. The vent field has an arc-like trend which follows the trend of the BSR.

2. The background methane concentration in bottom water samples is 2-3 more in vent areas than in outside areas.

3. The changes in physico-chemical conditions which find their expression in BSR trailing are correlatable with anomaleous methane concentrations in bottom water samples.

4. The amount of methane flux depends on the regional and local geodynamic activity. It is related to heatflow, the presence of the BSR, and, less importantly, to structural geological features. It is now believed that the BSR horizon is heated due to unstable geodynamic conditions together with high heatflow caused by postsedimentary volcanic intrusions, this then leads to the breakdown of formerly stable gas hydrates. Weak zones in the sediments such as faults and fissures provide the pathways for the methane rich fluids.

The good correlation of the datasets obtained during this expedition with high resolution seismic profiles shows the importance of collaboration between different scientific groups in multi-disciplinary fieldwork.

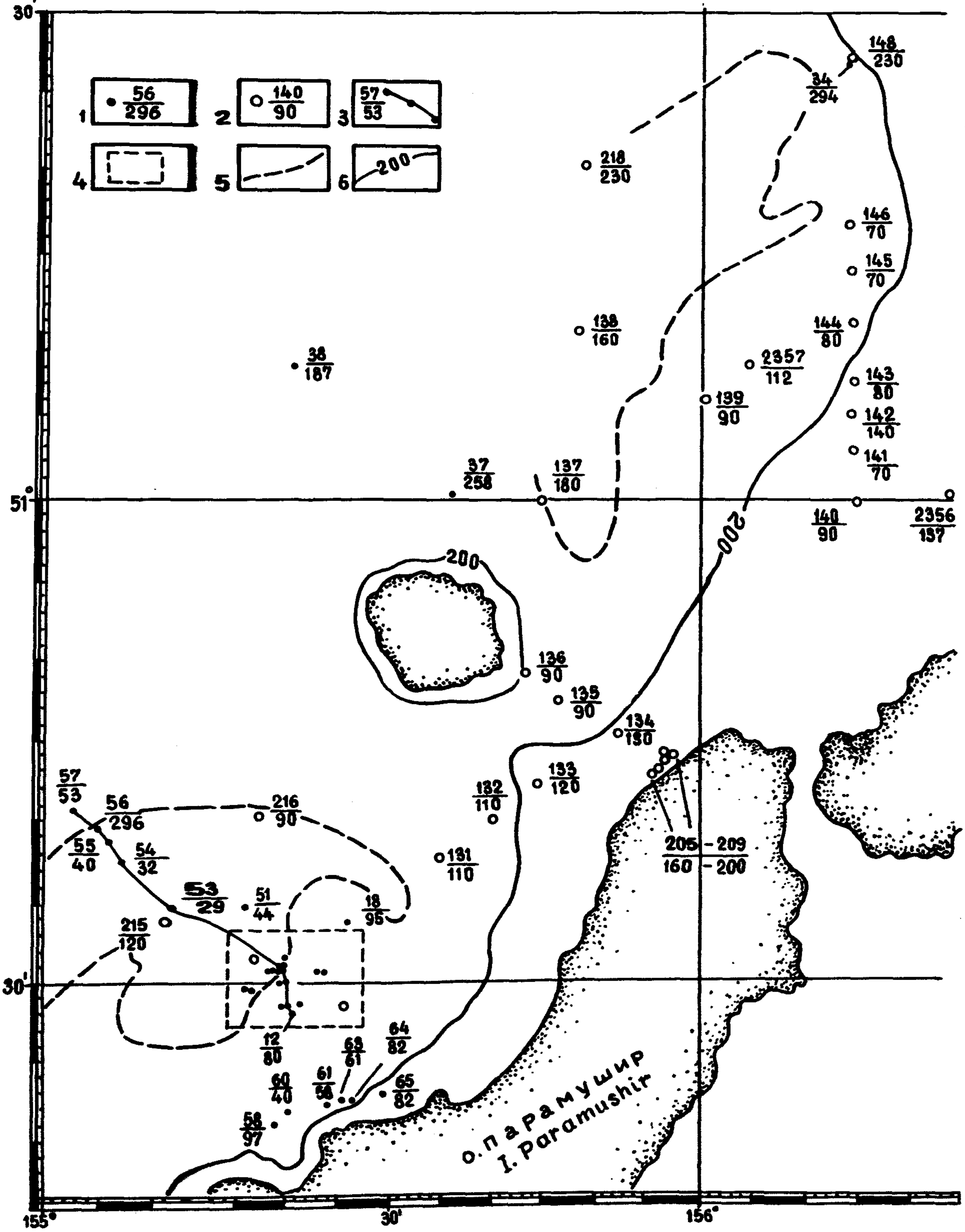


Fig. 3.4.3. Concentration of methane in the northern Kuril backarc area (1-2 = water sampling stations which were obtained on this cruise and on earlier cruises, upper number indicates number of station, lower number indicates methane concentration (nl/l); 3 = geochemical profile shown in Fig. 3.4.2; 4 = area of detailed investigation; 5 = boundary of BSR; 6 = contour 200 m).

Station	Type	Date	Latitude (N)	Longitude (E)	Depth (m)	CO2 ml/l	O2+Ar ml/l	N ml/l	CH4 nl/l	C2H6 nl/l
B37-01	B	01.10.1994	50°30'649	155°18'005	800	1,27	1,9	13,3	180	0,1
B37-03	B	02.10.1994	50°30'633	155°18'018	790	no data	no data	no data	218	0,1
B37-05	B	03.10.1994	50°30'832	155°18'440	790	1,36	2	13,5	486	0,1
B37-06	C	03.10.1994	50°30'750	155°18'398	790 (68-75cm)	no data	no data	no data	18500	0,5
B37-08	B	05.10.1994	50°28'790	155°21'351	710	1,34	1,9	11,6	180	0,1
B37-10	B	05.10.1994	50°28'444	155°20'328	765	1,86	2,1	11,8	206	0,1
B37-12	B	05.10.1994	50°27'843	155°20'956	710	1,55	2,7	11,8	80	0,1
B37-14	B	05.10.1994	50°28'241	155°19'775	736	1,37	1,9	11,5	252	0,1
B37-15	B	05.10.1994	50°29'448	155°16'862	730	1,41	1,7	11,5	104	0,1
B37-17	B	05.10.1994	50°29'772	155°16'200	735	1,29	1,4	10,9	11,3	0,1
B37-18	B	06.10.1994	50°33'824	155°25'295	680	1,41	2	11	95	0,1
B37-22	B	06.10.1994	50°31'474	155°20'541	773	1,62	2	11,7	864	0,1
B37-23	B	06.10.1994	50°30'839	155°18'438	793	1,52	1,4	9,6	1000	0,1
B37-25	B	06.10.1994	50°30'074	155°18'824	780	no data	no data	no data	598	0,1
B37-29	B	06.10.1994	50°30'106	155°19'268	780	1,62	2,1	11,7	510	0,1
B37-30	B	06.10.1994	50°30'965	155°22'912	695	1,55	1,9	10,6	198	0,1
B37-33	B	06.10.1994	50°30'803	155°23'467	680	1,73	1,9	11,5	169	0,1
B37-34	B	08.10.1994	51°27'056	156°14'083	250	0,94	5,2	12,7	294	0,1
B37-37	B	08.10.1994	51°00'348	155°35'415	700	1,71	1,8	11,8	258	0,1
B37-38	B	08.10.1994	51°08'704	155°20'683	843	1,68	1,3	11,5	187	0,1
B37-40	B	09.10.1994	50°30'862	155°18'446	790	no data	no data	no data	805	0,1
B37-41	B	09.10.1994	50°30'807	155°18'375	803	no data	no data	no data	735	0,1
B37-42	B	12.10.1994	50°29'854	155°22'292	670	2,68	2,8	14,7	186	0,1

Station	Type	Date	Latitude (N)	Longitude (E)	Depth (m)	CO_2 ml/l	O_2+Ar ml/l	N ml/l	CH_4 nl/l	C_2H_6 nl/l
B37-44	B	12.10.1994	50°30'326	155°21'388	693	1,86	2,2	13,1	291	0,1
B37-45	B	12.10.1994	50°31'389	155°20'065	782	3,01	2,1	13,9	165	0,1
B37-48	B	12.10.1994	50°31'243	155°19'543	773	1,92	1,8	12,2	831	0,1
B37-49	B	13.10.1994	50°32'457	155°18'541	820	1,75	1,8	11,8	183	0,1
B37-51	B	13.10.1994	50°34'651	155°15'900	930	2,08	1,9	12,2	44	0,1
B37-52	C	13.10.1994	50°34'734	155°16'278	915 (85-90cm)	no data	no data	no data	130880	0,1
B37-53	B	13.10.1994	50°34'996	155°11'070	990	2,1	1,4	11,2	29	0,1
B37-54	B	13.10.1994	50°37'749	155°07'522	1067	1,85	1,6	11,6	32	0,1
B37-55	B	13.10.1994	50°38'610	155°05'807	1100	1,92	1,5	12	40	0,1
B37-56	B	13.10.1994	50°39'442	155°04'509	1125	1,93	1,6	12,9	296	0,1
B37-57	B	13.10.1994	50°40'169	155°02'122	1230	1,68	1,4	12,6	53	0,1
B37-58	B	15.10.1994	50°21'455	155°18'604	570	1,61	3	13,6	97	0
B37-60	B	15.10.1994	50°22'246	155°20'19	400	1,46	3,6	12,5	40	0
B37-61	B	15.10.1994	50°22'728	155°23'784	370	1,42	4,2	12,7	58	0
B37-63	B	15.10.1994	50°22'989	155°25'067	380	1,36	4,6	13,2	61	0
B37-64	B	15.10.1994	50°22'955	155°26'061	220	0,98	5,4	13,3	82	0
B37-65	B	15.10.1994	50°23'465	155°29'178	250	1,38	5,4	13,1	82	0

Table 3.4.1. List of water sampling stations and results of analysis.

3.5 Sedimentology

(E. Basov, S. Kinsey, A. Derkachov)

Sediment sampling is an important part of the research process during this investigation, as careful examination of sediment cores, drag and grab samples can support and clarify the findings obtained by the seismic, side-scan sonar, water and gas-geochemistry groups. Furthermore this work together with detailed analyses of sediments and the fauna contained within, can lead to an understanding of recent and past oceanic, climatic and sedimentary conditions and processes which are of importance in the generation and behaviour of vents.

The Sea of Okhotsk is an important area as it acts as a source of deep water renewal for the North Pacific. This in turn acts as a control on the circulation and distribution of nutrients, carbon dioxide and oxygen throughout the Pacific, as well as playing an important part in the global CO_2 budget and circulation.

Although the main task of the group was principally concerned with venting activity near the island of Paramushir, careful study of the sediments by such methods as the analysis of carbon and oxygen isotopes, calculation of accumulation rates and the analysis of gas hydrates and changes in foraminiferal assemblages can not only lead to a better understanding of the process of venting within the Sea of Okhotsk but may also enable us to obtain a clearer picture of the changes that have occured in such parameters as palaeoproductivity and climate, ice volume and CO_2 changes and changes in deep and surface currents in the past. Further knowledge of the function carried out by the Sea of Okhotsk now and in the past may also contribute not only to an understanding of the role of greenhouse gases in global warming,.but also to the processes and properties of a converging plate system.

The Sea of Okhotsk today is an area of high productivity - 90-180gC/m^2/1000yrs (Koblenz-Mishke et al. 1970) and the Holocene rate around Paramushir has been calculated as 100-200mm/1000yrs (Astrakhov et al. 1988). Sedimentation in the area is not only affected by the high productivity but also by the venting systems, fluid circulation within the sediments and tectonic activity in the area which causes earthquakes, tsunamis and volcanic eruptions.

Sediment cores have been investigated by Pashkina (1993) and Soloviev and Ginsburg (1993). In general the sediments found so far have mainly consisted of reduced diatomaceous muds, often containing gas hydrates which quickly dissolve on contact with air once the core is cut. Carbonate interlayers and carbonized mollusc shells are also common features in the sediments (Pashkina 1993; Soloviev & Ginsburg 1993)

The gas hydrates have been found to consist mainly of Methane - ca. 97%, other minor components being propane, CO_2, and water. Analysis of the water shows that it contains `heavy´

oxygen and hydrogen in comparison with the surrounding water. It has been postulated from the isotopic composition of the gas that it may be mainly of microbial origin (Soloviev & Ginsburg 1993) although a component may also be due to volcanism in the surrounding area (Pashkina 1993).

Numerous carbonate crusts have also been seen on the sea floor around the area of venting, another common feature around the vents themselves are large numbers of the Thyarsirid mollusc Conchecele, which contains bacterial symbiotes within its tissues High numbers of polychaete worms are also common. These and other fauna found around the vents may be a specialized fauna being adapted to exist, at least partially, on photo- and chemosynthetic food sources (Galkin 1993).

Preliminery Results

The area of investigation was mapped by single-channel seismic profiling before sampling, and station localities were determined after interpretation of this data. The sediments were obtained using gravity coring, grabbing and dredging techniques (12, 13 and 2 stations, respectively) and standard descriptive methods were applied (Appendix III). In addition, 100 wet subsamples were taken for further study onshore. Some subsamples were taken and washed and dried to study mineralogy and foramininferal assemblages on board. 73 smear slides were also prepared and described on board for sediment characteristics

From the lithological study of sediments obtained, two main types of deposits, which are characterised by different environments of sedimentation were distinguished. The first type is represented by `normal´ Sea of Okhotsk sediments. The second is characterised by deposits located in the seeping area.

Type A. Mainly Holocene greyish olive green (5GY 3/2), olive grey (5Y 372), and olive black (5Y 271) diatomaceous sandy mud, diatomaceous muddy sand and diatom ooze (stations B37-04G, 09C, 11C, 13G, 16C, 19G, 24C, 26C, 27G, 28G, 31G, 35G, 36G, 39G, 43C, 47C, 52C, 59G and 62G) (Fig. 3.5.1). A terrigeneous component is represented by pyroclastic material, namely quartz, feldspar, dark minerals, mica, pyrite, gematite, volcanic glass, chemogenic minerals - calcite, aragonite, glauconite, and by rock fragments. Organic components consist of diatoms, benthic and planktonic foramenifera, echinoid spines, sponge spicules, pteropods, gastropods, bivalves, coccoliths, radiolarians, starfish, worms and plant debris.

The Holocene sediments are, as a rule, structureless but sometimes bedded as a result of colour changes both with sharp and gradational contact.s In addition, lenses and layers of pyroclastic material of silt and sand fractions were recorded in some cores. The uppermost part of this sediment is always characterised by the occurence of live organisms, such as worms, gastropods, bivalves, echinoids and starfish. Another important component of the Holocene sediments in this

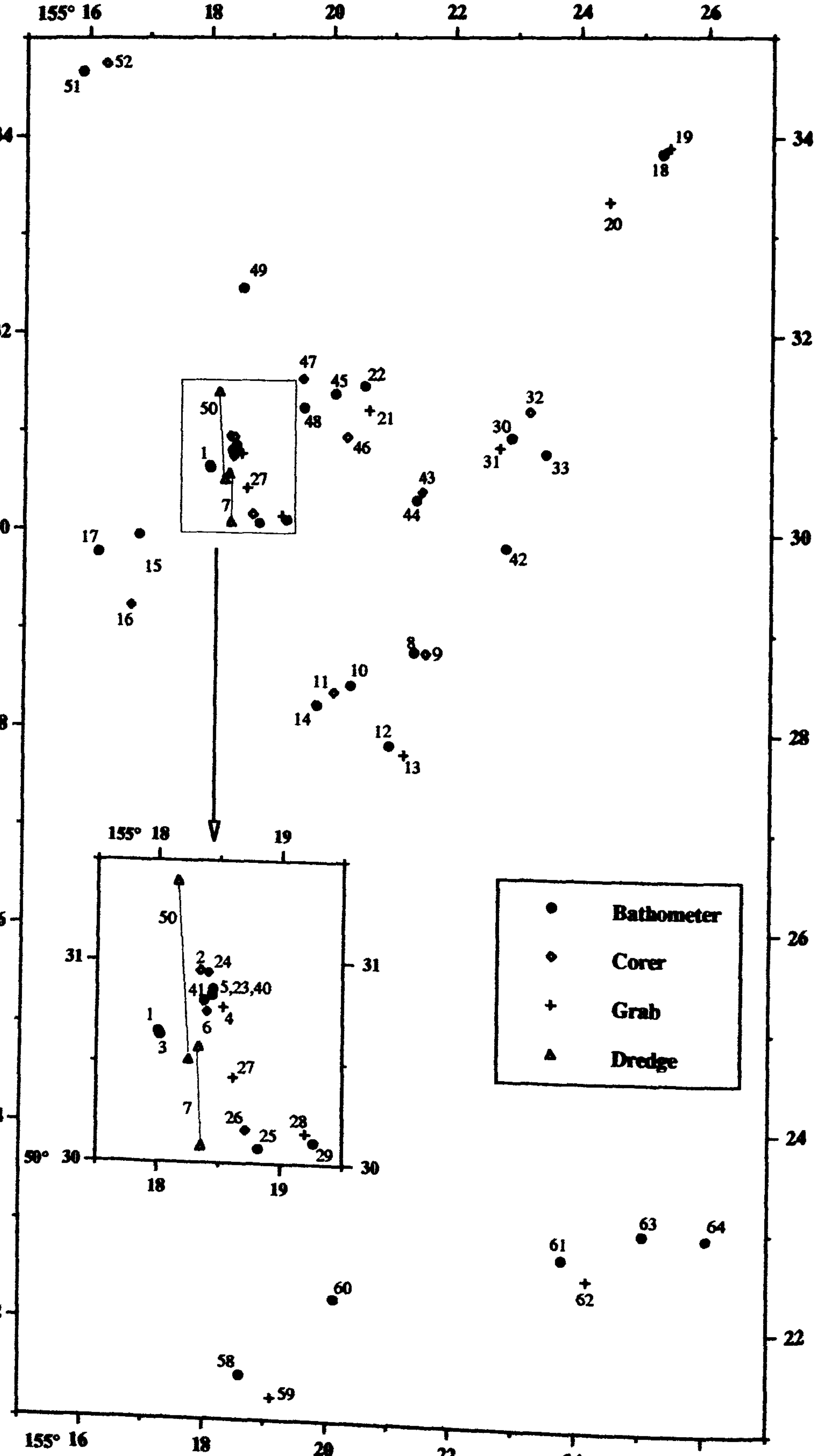


Figure 3.5.1 Location map of sampling stations.

area, is the existence of aragonite aggregates recorded during smear slide description. These aggregates are formed of crystals of various lengths and are characterised by both normal and curved or wave shaped crystals. It is obvious that these have a chemogenic origin, but at the moment the conditions and causes of their formation are not clear. In three stations taken on rises, which based on seismic data are interpreted to be ancient volcanoes, coarse sand, very coarse sand and sometimes granules were recorded. At station and B37-19G (foot of slope) very coarse glauconitic sand was recovered and at stations B37-20G (on slope of rise) and B37-21G (top of rise) - coarse volcanogenic sand was recorded.

At two stations (B37-11C and B37-32C), older sediments were recorded and dated as possibly Pleistocene in age. They were identified as very hard sandy mud with diatoms and mudstone with an abundance of carbonate.

Type B. Based on sampling results only four stations (B37-2C; B37-6C, B37-7D and B37-50D) recovered sediments close to the seeping area.

The core B37-06C consists of the usual diatom ooze in its upper part (to 73 cm) with a downcore decrease in the number of diatoms and with bedded structures seen in the sediment due to colour changes (from 5G Y2/1 to 10Y 4/2). These are probably related to the enrichment or depletion (respectively) of sediments in the reduced form of Fe, namely in pyrite and/or hydrotroilite. Additionally, the sediment had a strong smell of H_2S . The main patterns seen in this core are the existence of light carbonatised mud and carbonate nodules (up to 5 cm in diameter) at 5-15 cm (section B). This carbonatised mud contains less diatoms than the over- and underlying layers. The carbonate nodules contain about 10-20% of diatoms, and the similar terrigenic admixture to that of type A sediments points to a diagenetic, authigenic origin of the nodules.

The sediments taken at station B37-02C are represented by diatom ooze together with the characteristic terrigenous material of the normal Holocene deposits of this area. At the same time, the smell of H_2S, the presence of Polichaete worms and Conchocele shells indicate a proximity to the seeping area. Also, carbonatised mud with large amounts of aragonite was recorded from a Conchocele shell down section. The study of the smear slides revealed an interesting pattern in this sediment, namely, the occurence of a lot of amorphous silica (opal) mainly in upper part of the section, while its content in background sediments is very low to zero. It must be noted that the concentration of diatoms in these sediments decreases with increasing amounts of amorphous silica. This is probably related to dissolution of diatoms and transformation of the silica into its amorphous mineral phase, therefore this process possibly also characterizes the sedimentation in the seeping area.

One core (B37-52C) was possibly taken from the seeping area and recovered diatom ooze with a strong smell of H_2S. It must be mentiond that in previous cruises gas hydrates were recovered here. This may indicate that there is a relationship between gas hydrates and seeping areas.

The sediments from stations B37-07D and B37-50D were taken using a dredge and as a result carbonate crusts, shells of Conchocele and few rock fragments were recovered. The carbonate crusts are represented by two main types: The first and most numerous type are from 1-3cm in length, greyish green and relatively soft, with a sub-rounded almost pebble like appearence. Shell fragments and worm tubes are incorporated into the crusts. The second type are larger and have a \`knotted´ appearence with a high number of lithified(?) worm tubes and shell fragments being an intergral part of the crust. This type is also significantly harder and heavier than the the first.

Conclusions

Based on the lithological study of the sediments, several patterns of sedimentation in the seeping area can be distinguished:

1. The dark colour of the sediments indicate reducing conditions leading to the formation of such minerals as pyrite and hydrotroilite (an excellent example of this can be seen in the Black Sea deposits).

2. The smell of H_2S is also a good indicator of reducing conditions below the sediment surface.

3. The carbonate crusts, carbonatised mud and carbonate nodules are characteristic for seeping areas and demonstrate the result of methane oxidation by sulphate-reducing bacteria (Jørgensen 1992):

$$CH_4 + SO_4^{2-} \wedge HS^- + HCO_3^- + H_20$$

It must be noted, that the concentration of diatoms is different in carbonate crusts sampled from surface of the seafloor and in carbonate nodules recorded from the sediments themselves (up to 3% and 10-20%, respectively).

4. The occurence of a specialized faunal assembledge including Conchocele and polichaete worms.

5. The existence of amorpheous silica, probably as a result of reducing conditions produced by methane escape.

3.6 Micropalaeontology

(V. Annin, S. Kinsey)

During sediment sampling on board, some sub-samples were taken to study their foraminiferal content. Each sample was washed through a 0.005cm sieve, dried and then a split was examined to gain an initial impression of the abundance and diversity of any foraminifera present. Only a small fraction of the total number of samples were examined as time (and the weather!) did not allow any further work.

Brief overview of foraminiferal assemblages

In total four recent and four older samples, one possibly Pleistocene in age, were examined for their benthic foraminiferal content. The number of planktonic forams was recorded so that an estimate of the planktic:benthic ratio could be made, but they were not examined in detail. The planktonic foraminifera most often seen were *Neogloboquadrina pachyderma*(s) and *Globigerina bulloides*. Calcareous benthic foraminifera greatly outnumber agglutinated ones, the largest number of agglutinated forms being seen in the recent samples. This may be due to the poor preservation potential of many agglutinated foraminifera.

The small number and narrow depth range of the samples studied makes it difficult to identify any clear changes within assemblages, however, some patterns do emerge (Tab. 3.6.1).

Apart from sample 36G which was taken at the foot of the Alaid volcano, the other samples all lie on the slope off Paramushir, in an area betwen 50°27'N; 155°16E and 50°34'N; 155°24'E. The four grab samples (20G, 36G, 13G and 04G) are all recent/Holocene and the depth ranges from 652m to 810m. One of the most frequently seen foraminifera, *Uvigerina parvacostata*, does show an increase in numbers with depth from 2-5% at 652m to 21-40% at 810m. *Nonionella japonica*(?) another frequently seen species shows a slight decrease with depth as does *Stainforthia loeblichi*. The genera Buccella and Cassidulina are in general more frequent in the sandy diatomaceous mud samples than in the volcanic sand, which may point to an environmental preference. Agglutinated foraminifera are generally more abundant with depth and this would seem to be the case here.

The sample 36G (coarse volcanic sand) shows a few, quite different features to the other grab samples. It has an overall lower diversity and as well as very few Buccellas and Cassidulinas, the genera Globobulimina and Bulimina do not appear at all. The assemblage is greatly dominated by *Uvigerina parvacostata* which also has a greater abundance at greater depths. This may indicate that this species has a wide tolerence range of environments, and may be an `opportunistic´ type species, able to exist in conditions where other species cannot. Agglutinated species are also a more important part of this assemblage perhaps because the diversity is in general low. The proximity of this sample to the volcano also explains the extremely low planktic:benthic ratio (1:15).

Within the core only one sample was taken from each core chiefly as an aid to identifying litholog and dating. However, an increase in *Uvigerina parvacostata* with horizon depth can also be seen and in 52C, a diatom ooze, it is again dominant which may also point to its being a more `adaptable´ species. In 32C there are no individuals of this species, however this core is probably older than the others (Pleistocene) and was the shallowest and most nearshore core. This may also explain the low diversity within this core, only 14 species were seen, and the very low planktic:benthic ratio (1:45)

From this brief look at the foraminifera, it is obvious that a more indepth and extensive study could produce some very interesting and more conclusive results.

A short description of each sample follows.

Core	**B37-04G**	
Location	**Lat:** 50°30'773 N	**Long**: 155°18'534 E
Waterdepth	810m	
Sediment type	Diatomaceous fine muddy sand	
Age	recent	
Description	A diverse fauna of benthic foraminifera with over 20 species seen. Four agglutinated species are present	
Planktic:benthic ratio	3:2	
Most abundant species	*Uvigerina parvacostata* - 29.7%	
	Nonionella japonica (?)- 18.7%	
	Cassidulina subacuta - 17.2%	
	Buccella limpida - 12.5%	
	Eggerella scrippsi - 9.4%	

Station	**B37-11C**	
Location	**Lat:** 50°28'372 N	**Long**:155°20'054 E
Waterdepth	770m	
Sediment type	Sandy diatomaceous mud	
Age	Holocene	
Sample level	9cm	
Description	A relatively diverse fauna with over 18 benthic species present. As in all samples calcareous foraminifera are dominant with only one agglutinated species observed.	
Planktic:benthic ratio	3:4 (high)	
Most abundant species	*Stainforthia loeblichi* - 37%	
	Epistominella pacifica - 26%	
	Globobulimina hanzawi - 11.4%	
	Retroelphidium subgranulosum - 7.3%	

Station	B37-13G	
Location	**Lat:** 50°27'760 N	**Long**: 155°21'195 E
Waterdepth	705m	
Sediment type	muddy diatomaceous sand	
Age	recent	
Description	This is a very diverse and abundant fauna with about 26 species of benthic foraminifera, 6 of these are agglutinated species	
Planktic:benthic ratio	1:2	
Most abundant species	*Uvigerina parvacostata* - 17.8% *Nonionella japanica* (?)- 8.9% *Retroelphidium subcrispum* 8.9% *Cassidulina subacuta* - 6.5% *Cibicides lobatulus* - 6.5%	

Station	B37-20G	
Location	**Lat:** 50°33'335 N	**Long**: 155°24'448 E
Waterdepth	652m	
Sediment type	Coarse muddy sand	
Age	recent	
Description	The most diverse sample with over 27 species, around 5 of these being agglutinated foraminifera.	
Planktic:benthic ratio	11:20.	
Most abundant species	*Brizalina pacifica* - 13.5% *Cibicides lobatulus* - 7.3% *Nonionella japonica* (?)- 6.2% *Globobulimina elongata* - 6.2 %	

Station	B37-24C	
Location	**Lat:** 50°30'944 N	**Long**: 155°18'409 E
Waterdepth	783m	
Sediment type	Fine diatomaceous muddy sand.	
Age	Holocene	
Sample level	1m	
Description	An abundant and diverse fauna with over 20 species found. Calcareous benthic species again dominate, with only one agglutinated species found.	
Planktic:benthic ratio	7:5 (high)	
Most abundant species	*Stainforthia loeblichi* - 28% *Uvigerina parvacostata* - 18% *Nonionella japonica* (?)- 17% *Cassidulina subacuta* - 8%	

Station	B37-32C	
Location	**Lat:** 50°31'231 N	**Long**: 155°23'204 E
Waterdepth	750m	
Sediment type	Mudstone.	
Age	Pleistocene (?)	
Sample level	12cm	
Description	A less diverse fauna with around 15 species recorded, abundance is also lower than in the previous samples studied and the fauna is dominated by the two most abundant species. Two agglutinated species are present the other benthic species being calcareous	
Planktic:benthic ratio	1:45 (very low)	
Most abundant species	*Nonionella japonica* (?)- 58.7% *Stainforthia loeblichi* - 44 % *Buccella morishimae* - 4.%	

Station	B37-36G	
Location	**Lat:** 51°00'508 N	**Long**: 155°35'583 E
Waterdepth	700m	
Sediment type	coarse volcanogenic sand	
Age	Holocene/recent	
Description	Again a relatively low abundance fauna, possibly due to the nature of the sediment, diversity is also relatively low with only 16 species seen. There is an extremely high dominance of one species - *Uvigerina parvacostata*, with the other species being present in much lower percentages. Within the assemblage four agglutinated forms were recognized	
Planktic:benthic ratio	1:15	
Most abundant species	*Uvigerina parvacostata* - 61.2% *Nonionella japonica* (?)- 8.7% *Brizalina pacifica* - 3.7% *Buccella morishimae* - 3.7% *Retroelphidium subgranulosum* 3.7%	

Station	B37-52C	
Location	**Lat:** 50°34'734 N	**Long**: 155°16'278 E
Waterdepth	915m	
Sediment type	Diatom ooze with layers of hydrotroilite	
Age	Holocene	
Sample level	1.27m	
Description	Although the sample is dominated by diatoms 14 species of benthic foraminifera were seen, all of them being calcareous	
Planktic:benthic ratio	3:1	
Most abundant species	*Uvigerina parvacostata* - 66% *Nonionella japonica* -(?) 18.7% *Retroelphidium subgranulosum* - 5% *Cassidulina subacuta* - 3.6% *Stainforthia loeblichi* 3.6%	

04G	13G	36G	20G	52C	24C	32C	11C	Station
810	705	700	652	915	783	750	770	Waterdepth (m)
				127	100	12	9	Sample level (cm)
—	●	—	●	▬	—	■		Nonionella japonica (Asano)
					•			Nonionella globosa. Ishiwada
•		●	o	o	●		•	Nonionella digitata (Norvang)
▬	—	█	o	█	—		o	Uvegerina parvacostata. Saidova
	o	●	o				•	Trifarina kokozurensis. Asano
o	o			o		•	—	Globobulimina hanzawi. Asano
	●		●	•		o		Globobulimina elongata (Cushman)
o					•	o	o	Bulimina tenuata (Cushman)
•	o			•	•	•	•	Buliminella elegantissima (Orbigny)
	●	—	—	•	o	o	o	Brizalina pacifica (Cushman and McCulloch)
●	o		o		▬	▬	▬	Stainforthia loeblichi (Feyling-Hanssen)
o	●		o	o	●		•	Brizalina sp.
●	o	o			o		•	Cribroelphidium batiale (Saidova)
		•	o	•				Elphidiella flos. Troitskaja
	●	—	o	o	o			Retroelphidium subcrispum (Nakomara)
	●		o					Retroelphidium subranulosum (Asano)
	o							Cribroelphidium subarcticum (Cushman)
			o		o	•	o	Cribrononion incertes (Williamson)
								Cribroelphidium sp.
o	●		●					Cibicides lobatulus (Walker and Jons)
				•			▬	Epistominella pacifica (Cushman)
—	●		o	o	●	o	•	Cassidulina subacuta (Gudina)
	o	—	o		o	o		Buccella morishimae. Chiji
	•	•	o			•		Buccella inusitata. Andersen
	o		●					Bucella hannai arctica. Voloschinova
▬	o			•				Buccella limpida. Levtchuk
o			o	•	o	•	o	Buccella sp.
—			o				o	Cassidulina sp.
	•	•						Pullenia apertula. Cushman
•								Pullenia sphaeroides (Orbigny)
			•					Lagena semilineata. Wright
•					•			Lagena distoma. Parker and Jons
			•		•			Lagena sp.
o				•	•			Fissurina semimarginata (Reuss)
			•		•	•		Fissurina sp.
		o	•					Oolina sp.
							o	Quinqueloculina sp.
							•	Miliammina kononori. Furssenko
	•					•		Milliammina sp.
	o		•					Recurvoidella parkerae. Uchio
		●						Trochammina inflata (Montagne)
●	o	●	o		o			Eggerella scrippsi. Uchio
o								Spiroplectammina typica. Lacroix
	•							Alvelophragmium sp.
•		•						Rhabdammina sp.
						o		Rhizammina sp.
•	•							Textularia sp.
			•					Labrospira sp.
o	o	o	o	o	o	o	o	others

- • <=1 %
- o 2-5 %
- ● 6-10 %
- — 11-20 %
- ▬ 21-40 %
- ■ 41-60 %
- █ 61-100 %

Tab. 3.6.1
Foraminiferal Frequencies in Selected Sediment Samples.

3.7 Sound Velocity and Density of Sediments

(R. Freitag, A. Svininnikov)

Sound velocity and bulk density are very important for the estimation of bottom sediment impedance, calculation of thermodynamic environments in the sediments, geoacoustical modeling and also for the estimation of volume of escaped pore water from deposits as a result of sediment compaction during diagenesis and catagenesis.

The sound velocity and density of the main sediment types were measured on board. The results were compared with earlier data obtained from the North Pacific area. Unfortunately, it was impossible to study the coarse type of sediments and gas saturated sediments.

Methods

The wet-bulk density of sediment was determined from the weight of a 50 cm^3 sample with undisturbed fabric and water saturation (volume of inner cylinder of the core is 50 cm^3). Sound velocity was measured by the impulse transmission method. A set of devices including UK-10P, UK-16P and lead-zirconate-titanate tranducers with resonance frequencies of 60kHz were used, tranducers were fixed on sliding calipers to facilitate measurement of distances between them to an accuracy of 0.05 mm. The error in reading the onset of the signal arrival was - 0.01-0.1 microseconds (mcs). Instruments were calibrated by velocity measurements in standards of KOU-2 set, plexiglass, and water samples of know temperature.

P-wave velocity in porous materials such as most sediments and rocks are greatly influenced by water saturation. Filling of pores with water causes an increase in velocity. Sediment samples were kept isolated from air by a waterproof cover. Temperature of the samples recovered aboard changed from an initial 2.3°C to 20-25°C, thus causing a velocity increase of 5%. To enable corrections to be made, temperature was controlled during the measurements. A mercury thermometer was used, scaled with a 0.02°C interval. Velocity dependence on temperature was estimated by heating samples that had been refrigerated.

P-wave velocity measurements in sediments were made through a polyethylene film (0.05 mm thick) enveloping the sample. The outer surface of the film was covered with a liquid lubricant or water at the contact with the transducers. The accuracy of determination of density and sound velocity was 0.02 g/cm^3 and 1%, respectively.

Results

Physical properties including compressional wave-velocity and wet bulk density were measured on sands, semi-siliceous sandy silts and diatomaceous ooze samples from five stations: B37-4G, B37-16C, B37-43C, B37-47C, and B37-52C (water depth from 695 to 915m).

Maximum velocity and density (1606-1594m/s and 1.67-1.63 g/cm^3) were recordered in silty sands (Samples 43C-5cm, and 43C-15cm). Somewhat lower values (1571-1559m/s, and 1.55-1.50 g/cm^3) were recorded in semi-siliceous sandy silts (samples 4G-2cm, and 47C-2, 5, 15, 25, and 30 cm). Sediments sampled out of the polygon had maximum sample depths (Samples 52C-35cm, and 52C-75 cm) and showed high velocities at relatively low densities (1544-1525 m/s and 1.27-1.29 g/cm^3 respectively). These sediments are diatomaceous silts with rare horizons enriched in volcanogenic material (i.e. Samples 52C-15cm, 20cm; and 60cm). Paramushir slope sediments can therefore be divided into three groups; one without diatoms and two with a siliceous component.

From the above results it can be said that sound velocity in sediments is strongly affected by the diatomaceous content of sediments. Sediments enriched by diatom remnants have rigid frame structure and high velocities and relatively low densities (Fig. 3.7.1). As the quantitative estimation of mineral composition and grain size of sediments was not performed in the present study, the quantity of clay fraction and the grain composition of deposits is not yet established. Sound velocity and density values however seem to be closely related with depth (Fig. 3.7.2).

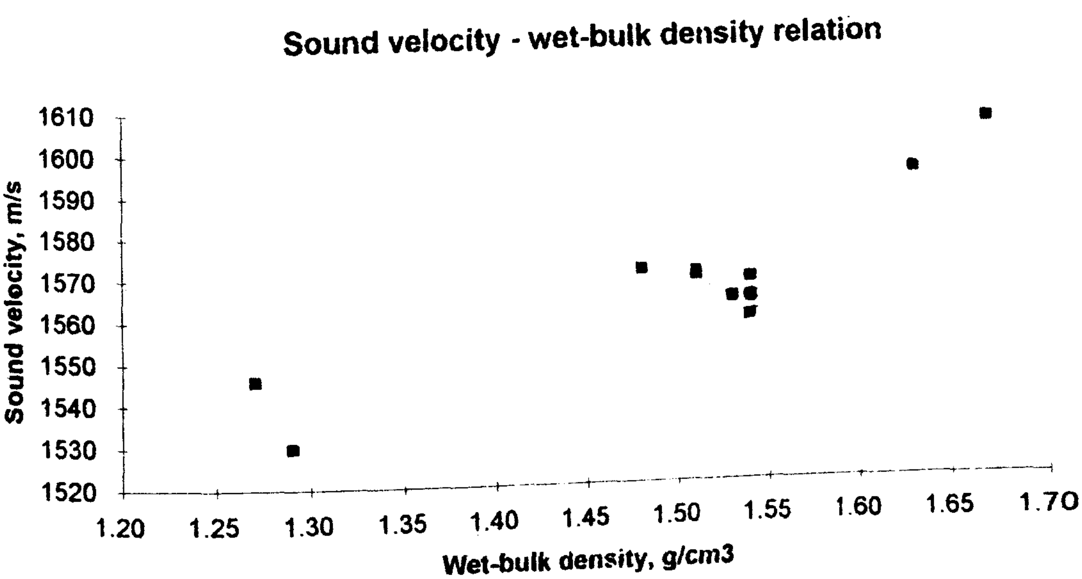


Fig. 3.7.1. Sound velocity versus wet-bulk density of sediments from the west slope off Paramushir island.

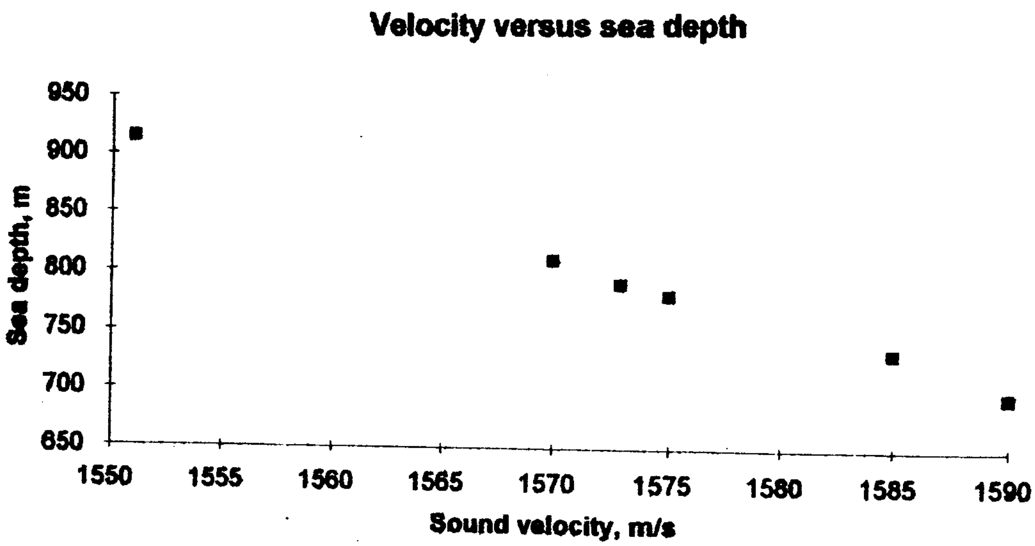


Fig. 3.7.2. Relation between P-wave velocity and waterdepth.

Conclusion

From P-wave propagation, velocity and density investigations of the major types of sediments of Paramushir island slopes, the following facts became clear:

1. The siliceous sediments are characterised by high velocity P-wave and low densities. This is the result of the rigid frame structure of silts and oozes.
2. A strong relation between sound velocity in sediments versus depth is established.
3. Enrichment of pyroclastic layers in silts and diatomaceous oozes are responsible for acoustic quasy-anisotropy of sediments.

4. Conclusion

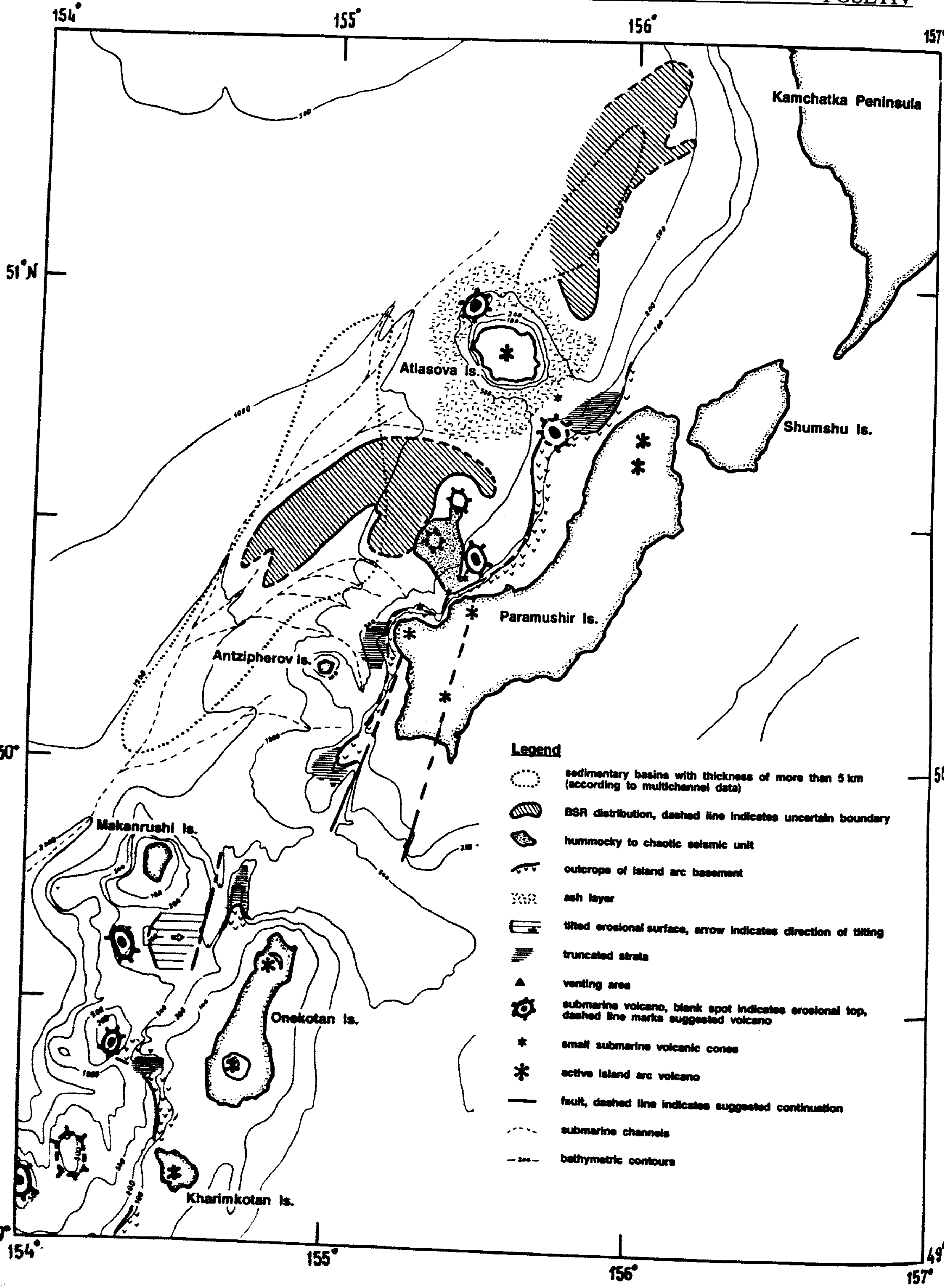
(Shipboard Scientific Party)

Three different sedimentary and tectonic provinces are to be distinguished in the area of investigation:

- the northern area off the southwestern tip of Kamchatka consists of well stratified sediments without significant deformation. According to single channel seismic profiling volcanic activity is absent in this area. In small areas the BSR is a common feature. Gas discharge onto the seafloor is shown by transparent seismic facies patterns as well as by pull down of seismic velocity. Gas seeping leads to methane concentrations in bottom water of up to 294 nl/l where the background level is estimted as 40 to 50 nl/l.
- the backarc area of Onekotan, south of Paramushir, is of complex volcanic and tectonic origin. The numerous submarine volcanoes and the absence of well developed sedimentary basins in this area must be investigated with lower frequency seismic devices in order to receive higher penetration and thus, to examine the tectonic evolution of this part of the Kuril Island arc. In the uppermost sedimentary strata no BSR was found which could lead to vent phenomena in this area.
- the main area of interest west off Paramushir was surveyed in detail by single-channel seismic, as well as bottom water and sediment sampling. This area can be subdivided in two parts.

Discussion

As is pointed out above, the area of venting west of Paramushir is characterised by active volcanic intrusions into the sedimentary column. This may cause a higher heatflow in this area up to 100 mW/m^2 (Sergeyev & Krasny 1987) and more. As a result, the pressure/temperature conditions are changed. This affects the stability field of gas hydrates. The depth of the BSR below sediment surface which marks this stability field decreases at active vent sites. This leads to the assumption that the gas hydrates become instable and mobilized, thus resulting in expulsion onto the seafloor, where large fields of active vents are generated. However, venting seems not to be restricted to small `spots´ where large amounts of methane rich fluids are visible as eruption flares on echo sounding records, corresponding with methane concentrations of up to more than 1000 nl/l in bottom water samples, but is expelled in a discrete and diffuse manner over the whole area. This idea is supported by the up to two times higher `background´ concentration of methane in the bottom water samples. Nevertheless, according to the structural pattern of the area (Fig. 4.1), the vent fields with the highest concentrations of methane seems to be related to tectonic features. To evaluate the regional tectonic processes which were found in the seismic profiles further compilation of all data including multichannel seismic profiles is necessary.


154°
155°
156°
157°
51°N
50°
49°
Kamchatka Peninsula
Atlasova Is.
Shumshu Is.
Paramushir Is.
Antzipherov Is.
Makanrushi Is.
Onekotan Is.
Kharimkotan Is.
Legend
sedimentary basins with thickness of more than 5 km (according to multichannel data)
BSR distribution, dashed line indicates uncertain boundary
hummocky to chaotic seismic unit
outcrops of island arc basement
ash layer
tilted erosional surface, arrow indicates direction of tilting
truncated strata
venting area
submarine volcano, blank spot indicates erosional top, dashed line marks suggested volcano
small submarine volcanic cones
active island arc volcano
fault, dashed line indicates suggested continuation
submarine channels
bathymetric contours

It can therefore be summarized that west of Paramushir the venting of methane rich fluids is contolled

1. by the presence of gas hydrates which are visible as a bottom simulating reflector in seismic images.
2. the change of p/T conditions due to recent volcanic intrusions, which act as a heat source, to break down these hydrates and
3. less importantly, by regional tectonic movements related to plate boundary processes as well as local processes related to volcanism.

In the other areas of investigation the regional geological conditions show no evidence for this kind of venting.

Fig. 4.1. Distribution of BSR, seismic units and some structural features of the northern Kuril backarc area.

5. Literature

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Appendix I.

List of Seismic Profiles

POSETIV - Paramushir-Okhotsk Sea Expedition To Investigate Venting
R/V Professor Bogorov, Cruise 37, September/October 1994

Profile	Date	Time	Latitude (N)	Longitude (E)	Equipment	Remarks
B37-01	30.09.1994	21:36 start	15°50,90'	155°05,90'	single-channel seismic	(no data)
		02:21 stop	50°30,45'	154°36,00'		
B37-02	01.10.1994	03:50 start	50°24,31'	154°36,85'	single-channel seismic	
		07:00 stop	50°11,34'	154°53,40'		
B37-03	01.10.1994	10:00 start	50°05,24'	155°00,90'	single-channel seismic	
		12:30 stop	50°30,97'	155°08,75'		
B37-3A	01.10.1994	13:00 start	50°31,80'	155°09,80'	single-channel seismic	
		14:08 stop	50°30,35'	155°22,40'		
B37-04	02.10.1994	03:24 start	50°30,19'	155°16,15'	single-channel seismic	(no data)
		04:30 stop	50°26,80'	155°22,46'		
B37-05	02.10.1994	04:30 start	50°26,80'	155°22,46'	single-channel seismic	
		04:51 stop	50°27,95'	155°23,90'		
B37-06	02.10.1994	04:56 start	50°28,36'	155°24,10'	single-channel seismic	
		06:01 stop	50°31,98'	155°17,91'		
B37-07	02.10.1994	06:14 start	50°31,71'	155°17,91'	single-channel seismic	
		06:45 stop	50°33,42'	155°20,80'		
B37-08	02.10.1994	06:56 start	50°33,19'	155°21,11'	single-channel seismic	
		07:54 stop	50°29,52'	155°26,88'		
B37-09	02.10.1994	08:03 start	50°29,67'	155°26,98'	single-channel seismic	
		08:26 stop	50°30,55'	155°23,86'		
B37-10	02.10.1994	08:26 start	50°30,55'	155°23,86'	single-channel seismic	
		09:00 stop	50°32,94'	155°20,24'		
B37-11	02.10.1994	09:15 start	50°32,16'	155°20,09'	single-channel seismic	
		09:50 stop	50°30,01'	155°23,51'		
B37-12	02.10.1994	10:15 start	50°29,67'	155°22,98'	single-channel seismic	
		10:55 stop	50°32,39'	155°18,46'		

Appendix I. List of seismic profiles.

Profile	Date	Time	Latitude (N)	Longitude (E)	Equipment	Remarks
B37-13	02.10.1994	11:12 start 11:58 stop	50°32,59' 50°28,68'	155°17,28' 155°22,09'	single-channel seismic	
B37-14	02.10.1994	12:25 start 13:09 stop	50°28,87 50°31,46	155°21,24' 155°17,13'	single-channel seismic	
B37-15	02.10.1994	13:30 start 14:15 stop	50°31,10' 50°28,55'	155°17,00' 155°21,00'	single-channel seismic	
B37-16	02.10.1994	14:52 start 15:36 stop	50°28,31' 50°30,70'	155°20,29' 155°16,40'	single-channel seismic	
B37-17	02.10.1994	15:50 start 16:05 stop	50°29,97' 50°28,89'	155°17,01' 155°17,75'	single-channel seismic	
B37-18	02.10.1994	16:20 start 17:15 stop	50°28,96' 50°31,32'	155°17,72' 155°24,08'	single-channel seismic	
B37-19	02.10.1994	17:20 start 17:39 stop	50°31,58' 50°32,50'	155°24,25' 155°22,89'	single-channel seismic	digital
B37-20	02.10.1994	17:41 start 18:42 stop	50°32,51' 50°29,88'	155°22,69' 155°15,98'	single-channel seismic	digital
B37-4A	02.10.1994	18:52 start 19:19 stop	50°29,57' 50°27,81	155°16,86' 155°19,86'	single-channel seismic	digital
B37-21	02.10.1994	19:25 start 20:00 stop	50°27,85' 50°26,90'	155°19,95' 155°15,68'	single-channel seismic	digital
B37-22	02.10.1994 03.10.1994	22:11 start 07:20 stop	50°25,55' 50°39,11'	155°12,62' 155°39,35'	side-scan sonar, 3,5kHz	digital (sometimes no data)
B37-23	04.10.1994 05.10.1994	23:15 start 00:22 stop	49°56,25' 49°56,40'	155°09,24' 154°58,89'	single-channel seismic	digital
B37-24	05.10.1994	00:39 start 04:23 stop	49°55,22' 50°16,85'	154°58,67' 155°09,82'	single-channel seismic	digital
B37-25	05.10.1994	04:26 start 09:05 stop	50°17,04' 50°34,16'	155°09,52' 154°34,84'	single-channel seismic	digital
B37-26	05.10.1994	10:00 start 14:06 stop	50°35,81' 50°29,82'	154°36,12' 155°15,42'	single-channel seismic	digital

Appendix I. List of seismic profiles.

Profile	Date	Time	Latitude (N)	Longitude (E)	Equipment	Remarks
B37-27	06.10.1994	01:35 start	50°28,84'	155°19,89'	single-channel seismic	digital
		02:41 stop	50°30,01'	155°29,82'		
B37-28	06.10.1994	02:45 start	50°30,29'	155°29,77'	single-channel seismic	digital
		04:18 stop	50°35,43'	155°19.52'		
B37-29	06.10.1994	05:02 start	50°37,71'	155°22,98'	single-channel seismic	digital
		07:23 stop	50°28,96'	155°39,77'		
B37-30	06.10.1994	07:52 start	50°31,27'	155°42,79'	single-channel seismic	digital
		10:15 stop	50°40,94'	155°26,27'		
B37-31	06.10.1994	23:00 start	50°36,73'	155°40,14'	single-channel seismic	digital
	07.10.1994	00:20 stop	50°41,36'	155°31,28'		
B37-32	07.10.1994	00:26 start	50°41,23'	155°31,41'	single-channel seismic	digital
		01:29 stop	50°41,18'	155°41,47'		
B37-33	07.10.1994	01:33 start	50°41,44'	155°41,49'	single-channel seismic	digital
		02:30 stop	50°44,88'	155°35,88'		
B37-34	07.10.1994	02:40 start	50°44,90'	155°36,26'	single-channel seismic	digital
		03:51 stop	50°47,52'	155°45,84'		
B37-35	07.10.1994	04:03 start	50°47,43'	155°46,71'	single-channel seismic	digital
		05:10 stop	50°43,19'	155°52,52'		
B37-36	07.10.1994	05:15 start	50°43,21'	155°52,84'	single-channel seismic	digital
		06:11 stop	50°49,11'	155°52,51'		
B37-37	07.10.1994	06:18 start	50°49,20'	155°52,46'	single-channel seismic	digital
		07:01 stop	50°48,62'	155°59,32'		
B37-38	07.10.1994	07:05 start	50°48,81'	155°59,20'	single-channel seismic	digital
		12:25 stop	51°09,78'	155°17,00'		
B37-39	07.10.1994	13:06 start	51°07,01'	155°13,00'	single-channel seismic	digital
		14:18 stop	51°01,89'	155°06,28'		
B37-40	07.10.1994	14:22 start	51°01,59'	155°06,71'	single-channel seismic	digital
		16:30 stop	50°53,86'	155°22,16'		
B37-41	07.10.1994	16:33 start	50°53,82'	155°22,60	single-channel seismic	digital
		18:30 stop	51°00,58'	155°35,31'		

Appendix I. List of seismic profiles.

Profile	Date	Time	Latitude (N)	Longitude (E)	Equipment	Remarks
B37-42	07.10.1994	18:40 start	51°00,72'	155°35,32'	single-channel seismic	digital
		21:09 stop	51°01,03'	156°01,03'		
B37-43	07.10.1994	21:26 start	51°01,75'	155°59,78'	single-channel seismic	digital
		23:15 stop	51°06,72	155°47,53'		
B37-44	07.10.1994	23:25 start	51°06,61'	155°47,53'	single-channel seismic	digital
	08.10.1994	02:58 stop	51°10,44'	156°20,34'		
B37-45	08.10.1994	03:39 start	51°08,87'	156°18,96'	single-channel seismic	digital
		05:44 stop	51°20,07'	156°05,92'		
B37-46	08.10.1994	05:48 start	51°20,00'	156°05,91'	single-channel seismic	digital
		07:30 stop	51°26,48'	156°18,69'		
B37-47	08.10.1994	07:33 start	51°22,66'	156°18,78'	single-channel seismic	digital
		10:16 stop	51^28,56'	155°52,53'		
B37-48	08.10.1994	10:21 start	51°28,28'	155°52,43'	single-channel seismic	digital
		11:30 stop	51°24,05'	155°59,96'		
B37-49	08.10.1994	11:45 start	51°24,92'	156°01,35'	single-channel seismic	digital
		13:12 stop	51°32,37'	156°09,82'		
B37-50	08.10.1994	13:22 start	51°32,25'	156°09,82'	single-channel seismic	digital
		14:36 stop	51°26,09'	156°14,68'		
B37-51	09.10.1994	02:06 start	50°54,77'	155°00,07	single-channel seismic	digital
		04:10 stop	50°41,58'	155°00,20'		
B37-52	09.10.1994	04:15 start	50°41,67'	155°00,75'	single-channel seismic	digital
		07:00 stop	50°30,75'	155°19,01'		
B37-53	09.10.1994	07:09 start	50°30,62'	155°19,18'	single-channel seismic	digital
		07:24 stop	50°28,92'	155°18,94'		
B37-54	09.10.1994	07:34 start	50°29,03'	155°19,04'	single-channel seismic	digital
		07:45 stop	50°29,57'	155°17,64'		
B37-55	09.10.1994	07:50 start	50°29,56'	155°17,59	single-channel seismic	digital
		08:27 stop	50°33,11'	155°19,41'		
B37-56	09.10.1994	20:47 start	49°45,27'	154°43,48'	single-channel seismic	digital, stop profile due to bad weather condition
	10.10.1994	02:07 stop	49°36,97'	154°09,80'		

Appendix I. List of seismic profiles.

Profile	Date	Time	Latitude (N)	Longitude (E)	Equipment	Remarks
B37-57	11.10.1994	13:21 start	49°03,77'	154°23,04	single-channel seismic	digital, waves affecting quality of record
		17:00 stop	49°13,22'	153°55,78'		
B37-58	11.10.1994	19:02 start	49°09,38'	153°55,98'	single-channel seismic	digital
		22:00 stop	48°59,02'	154°20,07'		
B37-59	11.10.1994	22:15 start	48°59,61'	154°19,07	single-channel seismic	digital
	12.10.1994	01:40 stop	49°15,48'	154°06,06'		
B37-60	12.10.1994	01:48 start	49°15,23'	154°06,58'	single-channel seismic	digital
		04:26 stop	49°12,02'	154°30,04'		
B37-61	12.10.1994	04:31 start	49°12,17'	154°30,11'	single-channel seismic	digital
		08:21 stop	49°29,90'	154°11,06'		
B37-62	12.10.1994	09:33 start	49°34,01'	154°11,34'	single-channel seismic	digital
		13:30 stop	49°41,98'	154°47,19'		
B37-63	13.10.1994	04:30 start	50°27,21'	155°12,96'	side-scan sonar	digital
		08:55 stop	50°32,95'	155°22,44'		
B37-64	13.10.1994	21:01 start	50°39,66'	154°55,78'	single-channel seismic	digital
	14.10.1994	02:28 stop	50°22,84'	155°26,53'		
B37-65	14.10.1994	02:31 start	50°22,98'	155°26,78'	single-channel seismic	digital
		06:50 stop	50°43,65'	155°50,69'		
B37-66	14.10.1994	15:25 start	50°22,45'	155°29,58'	single-channel seismic	digital
		17:15 stop	50°19,74'	155°13,18'		
B37-67	14.10.1994	17:37 start	50°20,90'	155°13,45'	single-channel seismic	digital
		19:24 stop	50°23,58'	155°29,98'		
B37-68	14.10.1994	19:37 start	50°24,69'	155°29,81'	single-channel seismic	digital
		21:30 stop	50°22,02'	155°13,76'		
B37-69	14.10.1994	22:00 start	50°22,98'	155°13,34'	single-channel seismic	digital
		23:51 stop	50°25,67'	155°30,00'		
B37-70	15.10.1994	00:00 start	50°25,78'	155°29,67'	single-channel seismic	digital
		01:45 stop	50°24,56'	155°17,91'		
B37-71	15.10.1994	01:51 start	50°24,06'	155°19,97'	single-channel seismic	digital
		02:24 stop	50°21,43'	155°18,06'		

Appendix I. List of seismic profiles.

Profile	Date	Time	Latitude (N)	Longitude (E)	Equipment	Remarks
B37-72	15.10.1994	02:28 start	50°21,41'	155°20,46'	single-channel seismic	digital
		03:27 stop	50°22,78'	155°29,04'		
B37-73	15.10.1994	03:47 start	50°23,83'	155°28,75'	single-channel seismic	digital
		04:32 stop	50°22,90'	155°23,12'		
B37-74	15.10.1994	09:35 start	50°22,55'	155°23,86'	single-channel seismic	digital
		10:25 stop	50°24,40'	155°23,12'		
B37-75	15.10.1994	10:27 start	50°24,32'	155°23,03'	side-scan sonar, digital	change direction at 10:50
		12:20 stop	50°25,49'	155°17,24'		(50°23,48' - 155°22,84')

Appendix I. List of seismic profiles.

Appendix II.

List of Sampling Locations

Station	Date	Latitude	Longitude	Depth (m)	Recovery (cm)	Lithology	Age	Samples	Remarks
B37-01B	01.10.94	50°30'649	155°18'005	800				Bottom water	CH4-180 nl/l
B37-02C	02.10.94	50°30'952	155°18'346	790	12	Diatom fine muddy sand	Holocene	ws: 6-8cm G ws: 0-5cm N SM top+bottom ws: 10-12cm G ws: 9-12cm N	H2S smell Abundance of amorphous silica
B37-03B	02.10.94	50°30'633	155°18'018	790				Bottom water	CH4-218 nl/l
B37-04G	03.10.94	50°30'773	155°18'534	810	Surface sediment	Diatom ooze	Recent	SM ws: N+G G- 5ml. foram sub-sample .	
B37-05B	03.10.94	50°30'832	155°18'440	790				Bottom water	CH4-486 nl/l
B37-06C Section A	03.10.04	50°30'750	155°18'398	790	67	Diatom ooze Hydrotroilite	Holocene	SM:2,5,8.5,14, 18,37,64 cm ws: N: 0-3; 17-19;36-42cm ws: G:0-5;11-13; 32-34;52-54cm	H2S smell
Section B					20 Total - 87	Diatom ooze Carbonatised mud Carbonate nodules Diatom ooze	Holocene	SM:9,12,14,19cm ws: N:5-8;9-12cm ws: G:0-4;9-12; 18-20cm.	Subsample 0.5cm taken for gas analysis
B37-07D	03.10.94	st:50°30'578 fi:50°30'084	st:155°18'330 fi:155°18'357	790	Surface sediment	Rock fragments Fragments of Conchocele shells Carbonate crusts Echinoid fragments		Various crusts and shells G+N SM from crusts	st.- start fi.- finish
B37-08B	05.10.94	50°28'790	155°21'351	710				Bottom water	CH4-180 nl/l
B37-09C	05.10.94	50°28'779	155°21'545	707	36	Fine muddy sand with diatoms Diatom fine muddy sand	Holocene	SM:2,33 cm ws: N 3-10;25-32 ws: G 0-3;15-18; 32-36cm	
B37-10B	05.10.94	50°28'444	155°20'328	765				Bottom water	CH4-206 nl/l
B37-11C	05.10.94	50°28'372	155°20'054	770	9	Sandy mud with diatoms Silt layers	Holocene Pleistocene ?	SM:0,1.5,5.5,9cm ws: N+G: 0-4.5; 4.5-9 cm	Very dense sediment. Erosional surface.
B37-12B	05.10.94	50°27'843	155°20'956	710				Bottom water	CH4 - 80 nl/l
B37-13G	05.10.94	50°27'760	155°21'195	705	Surface sediment	Fine diatom muddy sand	Recent	SM; ws: N+G	
B37-14B	05.10.94	50°28'241	155°19'775	736				Bottom water	CH4-252 nl/l

Appendix II. Summary of sampling data in investigated area. G - grab sampler, B - bathometer, C - gravity corer, D - dredge. Subsampling: SM - smear slides, ws - wet samples: N - taken for NIOZ, G - taken for GEOMAR.

Station	Date	Latitude	Longitude	Depth (m)	Recovery (cm)	Lithology	Age	Samples	Remarks
B37-15B	05.10.94	50°29'448	155°16'862	730				Bottom water	CH4- 104 nl/l
B37-16C Section A	05.10.94	50°29'232	155° 16'737	732	73	Diatom silty sand Silt layer	Holocene	SM:3,23,39,62cm ws: G: 3-7;23-26; 38-40;62-64 ws: N: 0-3;26-29; 45-49	
Section B					15,5 Total - 88.5	Diatom silty sand	Holocene	SM: 12cm ws: G: 10-12 ws: N: 12-15.5	
B37-17B	05.10.94	50°29'772	155°16'200	735				Bottom water	CH4- 113 nl/l
B37-18B	06.10.94	50°33'824	155°25'295	650				Bottom water	CH4 - 95 nl/l
B37-19G	06.10.94	50°33'885	155°25'403	700	Surface sediment	Coarse glauconitic volcanogenic sand Coarse volcanogenic sand	Recent	SM; ws: N+G	
B37-20G	06.10.94	50°33'335	155°24'448	652	Surface sediment	Medium-coarse volcanogenic sand	Recent	ws: N+G	
B37-21G	06.10.94	50°31'228	155°20'615	782	Surface sediment	Med. muddy diatom-volcanogenic sand	Recent	ws: N+G	
B37-22B	06.10.94	50°31'474	155°20'541	773				Bottom water	CH4- 864 nl/l
B37-23B	06.10.94	50°30'839	155°18'438	793				Bottom water	CH4~1000 nl/l
B37-24C Section A	06.10.94	50°30'944	155°18'409	783	74	Fine diatom muddy sand	Holocene	SM:4,13,24,51cm ws: G: 0-5;10-15; 30-35 ws: N: 5-10;10-13; 25-30	
Section B					27,5 Total - 101.5	Fine diatom muddy sand	Holocene	SM: 14cm ws: G: 5-10;22-25 ws: N: 0-3; CC	
B37-25B	06.10.94	50°30'074	155°18'824	780				Bottom water	CH4- 598 nl/l
B37-26C	06.10.94	50°30'166	155°18'717	790	16	Fine diatom muddy sand	Holocene	SM:10 cm. ws: G: 13-16 ws: N: 10-13	
B37-27G	06.10.94	50°30'427	155°18'617	784	Surface sediment	Diatom muddy sand	Recent	SM; ws: N+G	
B37-28G	06.10.94	50°30'152	155°19'202	800	Surface sediment	Fine diatom muddy sand	Recent	SM; ws: N+G	
B37-29B	06.10.94	50°30'106	155°19'268	780				Bottom water	CH4- 510 nl/l
B37-30B	06.10.94	50°30'965	155°22'912	695				Bottom water	CH4- 198 nl/l
B37-31G	06.10.94	50°30'863	155°22'729	650	Surface sediment	Fine diatom muddy sand	Recent	SM; ws: N+G	
B37-32C	06.10.94	50°31'231	155°23'204	750	13	Diatom ooze Mudstone (carbonate in silt fraction)	Holocene Pleistocene ?	SM:0cm,11cm ws:0-13cm N+G	Erosional contact.
B37-33B	06.10.94	50°30'803	155°23'467	680				Bottom water	CH4- 169 nl/l
B37-34B	08.10.94	51°27'056	156°14'083	250				Bottom water	CH4- 294 nl/l

Appendix II. Summary of sampling data in investigated area. G - grab sampler, B - bathometer, C - gravity corer, D - dredge. Subsampling: SM - smear slides, ws - wet samples: N - taken for NIOZ, G - taken for GEOMAR.

Station	Date	Latitude	Longitude	Depth (m)	Recovery (cm)	Lithology	Age	Samples	Remarks
B37-35G	08.10.94	51°27'126	156°14'127	240	Surface sediment	Fine diatom muddy sand	Recent	SM; ws: N+G	Pebbles
B37-36G	08.10.94	51°00'508	155°35'583	700	Two layers	Very coarse volcanogenic sand Fine diatom muddy sand	Recent Holocene	SM; ws: N+G	
B37-37B	08.10.94	51°00'348	155°35'415	700				Bottom water	CH4- 258 nl/l
B37-38B	08.10.94	51°08'704	155°20'683	843				Bottom water	CH4- 181 nl/l
B37-39G	08.10.94	51°08'708	155°20'085	842	Surface sediment	Diatom ooze	Recent	SM; ws: N+G	Carbonate
B37-40B	08.10.94	50°30'862	155°18'446	790				Bottom water	CH4- 805 nl/l
B37-41B	08.10.94	50°30'807	155°18'375	803				Bottom water	CH4- 735 nl/l
B37-42B	12.10.94	50°29'854	155°22'833	670				Bottom water	CH4- 186 nl/l
B37-43C	12.10.94	50°30'412	155°21'481	695	25	Diatom sandy mud	Holocene	SM:0;5;20cm ws: G: 2-5;20-25 ws: N: 5-8;17-20	
B37-44B	12.10.94	50°30'326	155°21'388	697				Bottom water	CH4- 291 nl/l
B37-45B	12.10.94	50°31'389	155°20'065	782				Bottom water	CH4- 165 nl/l
B37-46C	12.10.94	50°30'952	155°20'255	795	0	Rock fragments		SM: N	Empty core
B37-47C	12.10.94	50°31'537	155°19'530	780	38	Fine diatom muddy sand	Holocene	SM:5,36cm ws: G: 5-10;35-38 ws: N:10-15;30-35	
B37-48B	12.10.94	50°31'243	155°19'543	773				Bottom water	CH4- 831 nl/l
B37-49B	13.10.94	50°32'457	155°18'547	820				Bottom water	CH4- 183 nl/l
B37-50D	13.10.94	st50°31'400 fi50°30'515	155°18'154 155°18'250	805 795		Conchocela shells,echinoids and gastropods.		Echinoid taken for biologist	st=start fi=finish
B37-51B	13.10.94	50°34'651	155°15'900	930				Bottom water	CH4 - 44 nl/l
B37-52C Section A	13.10.94	50°34'734	155°16'278	915	85	Diatom ooze,hydrotroilite Fine volcanogenic sand, diatom ooze, Silt layers, diatom ooze	Holocene	SM:2,13,18,46,80 ws: G:22-25;59-61 ws: N:0-3;10-15; 20-22;30-33;40-42;45-47;50-53; 58-59;61-64;70-73;80-83 cm	Smell of H2S Sample for gas analysis: POI: 85-90cm
Section B/CC					45 total - 130	Diatom ooze, hydrotroilite	Holocene	ws: G:20-23;43-45 ws: N:5-7;15-18; 40-43(cc).SM: CC	Smell of H2S
B37-53B	13.10.94	50°34'996	155°11'070	900				Bottom water	CH4 - 29 nl/l
B37-54B	13.10.94	50°37'749	155°07'522	1067				Bottom water	CH4 - 32 nl/l
B37-55B	13.10.94	50°38'610	155°05'807	1100				Bottom water	CH4 - 40 nl/l
B37-56B	13.10.94	50°39'442	155°04'509	1125				Bottom water	CH4- 296 nl/l
B37-57B	13.10.94	50°40'169	155°02'122	1230				Bottom water	CH4 - 53 nl/l

Appendix II. Summary of sampling data in investigated area. G - grab sampler, B - bathometer, C - gravity corer, D - dredge. Subsampling: SM - smear slides, ws - wet samples: N - taken for NIOZ, G - taken for GEOMAR.

Station	Date	Latitude	Longitude	Depth m	Recovery cm	Lithology	Age	Samples	Remarks
B37-58B	15.10.94	50°21'455	155°18'604	570				Bottom water	CH4 - 97 nl/l
B37-59G	15.10.94	50°21'231	155°19'101	478	Surface sediment	Diatom muddy sand	Recent	SM; ws: N+G	
B37-60B	15.10.94	50°22'246	155°20'129	400				Bottom water	CH4 - 40 nl/l
B37-61B	15.10.94	50°22'728	155°23'784	370				Bottom water	CH4 - 58 nl/l
B37-62G	15.10.94	50°22'521	155°24'184	320	Surface sediment	Diatom muddy sand	Recent	SM; ws: N+G	
B37-63B	15.10.94	50°22'989	155°25'067	380				Bottom water	CH4 - 61 nl/l
B37-64B	15.10.94	50°22'955	155°26'061	220				Bottom water	CH4 - 82 nl/l
B37-65B	15.10.94	50°23'465	155°29'179	250				Bottom water	CH4 - 82 nl/l

Appendix II. Summary of sampling data in investigated area. G - grab sampler, B - bathometer, C - gravity corer, D - dredge. Subsampling: SM - smear slides, ws - wet samples: N - taken for NIOZ, G - taken for GEOMAR.

Appendix III.

Discription of Cores

B.37 CRUISE CORE 02.C SECTION WATER DEPTH 790m

LAT 50°31'952 LONG 155°18'346 Observer...EB + SK Date........02.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0–12				* *		Greyish olive green 5GY 3/2	1-12cm diatomaceous fine structureless muddy sand with large shell fragments(1-7cm) and polychate worm tubes. Strong H2S smell. (from core catcher)
12–100				WS:EB 0-5; 9-12cm. SK. 6-8; 10-12cm.			Foraminifera. A. Benthics: Nonionella japonica N. globosa Uvigerina akitaensis Cribroelphidium batiale Elphidium advenum depressulum (?) Bulimina tenuata Globobulimina hanzami Lagena elongata L. sulcata (?) Cassidulina sp. B. Planktonic: Globigerina bulloides Neogloboquadrina pachyderma (S) * smear slide. ws. wet sediment sample.

REMARKS:

Appendix III Description of the cores

B 37

CRUISE | CORE 06C | SECTION A | WATER DEPTH 790 m

LAT 50°30'750 | LONG 155°18'398 | Observer...EB + SK. Date........03.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws.0-3 EB * 2cm ws.0-5 SK * 5cm		5GY 3/2 Greyish olive green	0-8 cm. dark green sandy mud. Top 3 cm surface seds. Starfish seen.
10				* 8.5cm ws.11-13 SK * 14cm * 18cm		10Y 4/2 5GY 2/1 10Y 4/2 Greyish olive	8-8.5 cm. olive grey sed. composition same as above 8.5-11 cm. darker seds. 11-16 cm return to olive seds. 12 cm gastropod found.
20				ws.17-19 EB		5GY 2/1 Greenish black 10Y 4/2	16-30 cm. darker seds. with thin olive band at 24-26 cm.
30				ws.32-34 SK		5GY 3/2	30-51 cm another dark green layer with an olive band at 44-44.5 cm
40				* 37cm ws.36-42 EB		10Y 4/2	
50				ws.52-54 SK		5GY 2/1	51-67 cm. dark sediment with thin lenses of olive sed. at 52; 56 and 58 cm.
60				* 64cm			
70							In general, structurless Diatomaceous ooze (sandy mud), the same composition throughout. The sand componant is very fine. It is distinguished only by some colour changes within the sediment. Throughout a smell of Hydrogen Sulphide especially on cutting the core. In total section A and B together make a length of 87 cm. * smear slide ws. wet sediment sample
80							
90							
100							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE | CORE 06C | SECTION B | WATER DEPTH 790

LAT 50°30'750 | LONG 155°18'398 | Observer...EB + SK. Date........03.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws.0-4.SK ws. 5-8.EB ws.9-12. EB+SK.		5GY 3/2 Greyish olive green	0-10 cm diatomaceous ooze (sandy mud) same composition as 06C (A), with lenses of olive sediment in lower half.
10			◉	* 9 cm *12 cm *14 cm		5GY 5/2 Dusky yellow green	Harder yellowy sediment, with small carbonate crusts of up to 2 cm in length.
20				~~*19 cm~~		5GY 3/2	Dark green sediment, similar to that from 06C (A).
30							Smell of Hydrogen sulphide.
40							A continuation of the sediment found in 06C (A). Structureless diatomaceous ooze. Distinguishrd by the harder yellow band containing carbonate crusts. Again a smell of Hydrogen Sulphide was noticeable.
50							
60							
70							
80							* smear slide ws. wet sediment sample △Ca carbonate crust
90							
100							

REMARKS:

Appendix III Description of cores

B 37

CRUISE CORE 09C SECTION WATER DEPTH 707m

LAT 50°28'779 LONG 155°21'545 Observer....EB+SK.. Date........05.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* 2cm ws.0-3.SK ws.3-10.EB * 8cm		Greyish olive green 5GY 3/2	0-36cm. Structureless muddy fine sand
10				ws.15-18.SK ws.16-18.EB			
20				ws.25-32.EB			
30				ws.32-36.SK * 33cm			
40							
50							
60							
70							
80							* smear slide ws. wet sediment sample
90							
100							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE | CORE: 11C | SECTION: | WATER DEPTH: 770

LAT 50°28'372 | LONG 155°20'054 | Observer...EB+SK... Date........05.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* 0 cm * 1.5 cm * 5.5 cm * 9.0 cm		Greyish black. N2 Olive grey 5Y 3/2	0-9 cm. Structureless muddy fine sand with uneven upper surface. 'harder' ie. more lithified than previous sediments. Broke into two fragments 1. 0-4.5 cm 2. 4.5-9 cm 0.9-1.0 cm a greyish black coarser sand layer containing a starfish. Irregular lower boundary. ca. 1.8 - 2.0 cm a lens of grey medium sand 4.5-5.5 cm greyish black fine sand layer at break, with irregular boundaries.
2							
4							
6							
8							
10							
12							
14							
16							
18							* smear slide ws. wet sediment sample
20							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE | **CORE** 16C | **SECTION** A | **WATER DEPTH** 732

LAT 50°29'232 | LONG 155°16'737 | Observer...EB - SK. Date........05.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* 3cm ws: 0-3.EB ws.3-7. SK		Olive black 5Y 2/1	Diatomaceous structureless silty sand. 0-5 cm: surface: High water content. Probably sediments. 5-ca. 40 cm: silty sand slightly more consolidated.
10						Olive grey 5Y 4/1	
20				ws.23-26.SK * 23 cm ws.26-29.EB			
30							
40				ws.38-40. SK * 39 cm			sloping sharp contact 37-40cm.
				ws.45-49.EB			Silty sand, slightly darker in colour
50						Olive grey 5Y 3/2	
60				* 62 cm ws. 62-64 SK			
70							
80							In total section A +B = 88.5 cm.
90							* smear slide ws. wet sediment sample
100							

REMARKS:

B 37

CRUISE | CORE 16C | SECTION B | WATER DEPTH 732

LAT 50°29'232 | LONG 155°16'737 | Observer...EB + SK.. Date.......05.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws. 10-12.SK ws. 1-15.5 EB * 12 cm.		Olive grey 5Y 3/2	0 - 15.5 cm: structureless silty sand a continuation of the last unit in 16C (A)
10							
20							
30							
40							
50							
60							
70							
80							
90							* smear slide ws. wet sediment sample
100							

REMARKS:

Appendix III Descriptions of the cores

B 37

CRUISE | CORE 24C | SECTION A | WATER DEPTH 783m

LAT 50°30'944 LONG 155°18'409 Observer...EB+SK... Date.........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws:0-5 SK * 4cm ws:5-10.EB ws:10-13.EB ws:10-15.SK		Olive black 5Y 2/1	Fine muddy sand. 0-4cm: higher water content (surface seds?) 4-11cm: firmer seds. Grades gradually into lighter less firm sediments by 15 cm.
10				* 13cm.		Olive grey 5Y 3/2	
20							
30				* 24 cm. ws.25-30.EB ws:30-35.SK			
40						'darker' olive grey 5Y 3/2	42-74 cm:Colour change to darker seds. seen, but no change in lithology.
50				* 51 cm.			
60							
70							
80							In total section A + B = 101.5cm.
90							* smear slide ws. wet sediment sample
100							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE	CORE	24C	SECTION	B	WATER DEPTH	783m

LAT 50°30'944 LONG 155°18'409 Observer....EB + SK Date.........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0						Olive grey 5Y 3/2	0-20 cm; A continuation of the last unit of 24C (A)
10				ws:10-13.EB ws:13-16.SK * 14 cm.			
20						Olive black 5Y 2/1	20-25 cm: darker firmer sediments
30			⊗	* CC			Core catcher ca. 2cm.
40							
50							
60							
70							
80							
90							* smear slide ws. wet sediment sample
100							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE | CORE 26C | SECTION | WATER DEPTH 790m

LAT 50°30'166 | LONG 155°8'717 | Observer...EB + SK. Date.........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0						Olive green 5Y 3/2	0-16 cm: slightly muddy structureless sand
10				* 10 cm. ws:10-13.EB ws:13-16.SK			
20							shell fragments and small pebbles in CC.
30							
40							
50							
60							
70							
80							* smear slide ws. wet sediment sample
90							
100							

REMARKS:

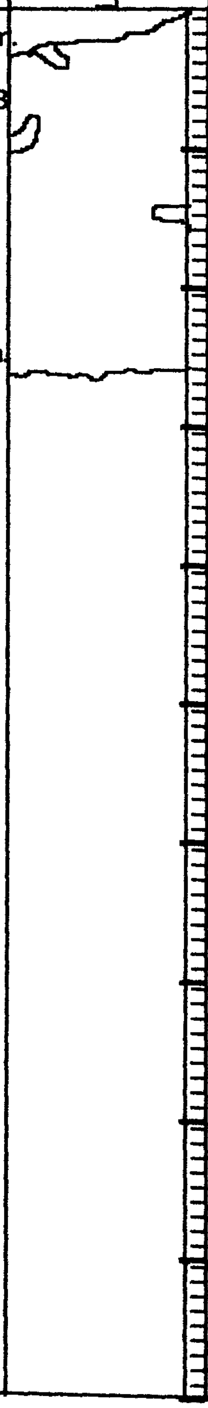
Appendix III Description of the cores

B 37

CRUISE | CORE 32C | SECTION | WATER DEPTH 750m

LAT 50°31'231 | LONG 155°23'204 | Observer...EB + SK.. Date... 06.10.94..........

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* 0 cm.		olive grey 5Y 3/2	Hard clay/mudstone.
				ws:0-13.EB +SK		olive grey 5Y 4/1	uneven top surface. 1-1.5cm: mud and coarse sand surface layer. 1-8cm: bioturbation, burrows contain coarse sand.
5							
10				* 11cm.			
15							
20							
25							
30							
35							
40							* smear slide
45							ws. wet sediment sample
50							



REMARKS:

Appendix III Description of the cores

B 37

CRUISE | CORE: 43 C | SECTION: | WATER DEPTH: 695

LAT 50°30'412 LONG 155°21'481 Observer: EB + SK Date: 12.10.1994

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				0 cm 5 cm ws 2-5 SK ws 5-8 EB		olive grey 5Y 3/2	Sandy mud 5cm-5.2cm:slightly lighter layer
10							
20				20cm ws17-20 EB ws20-23 SK		25 cm	
30							
40							
50							
60							
70							
80							* smear slide ws. wet sediment sample
90							
100							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE | CORE 46 C | SECTION | WATER DEPTH 795 m

LAT 50°30'952 | LONG 155°20'255 | Observer.....EB + SK Date..........12.10.1994

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0							Small amount of material from core catcher only
10				sm Carb. sm mudst			1. Tephra - hard, black up to1.5 cm length
20							2. Carbonate
30							3. Mudstone
40							
50							
60							
70							
80							
90							* smear slide ws. wet sediment sample
100							

REMARKS:

Appendix III Description of the cores

B 37

CRUISE CORE 47 C SECTION WATER DEPTH 780 m

LAT 50°31'537 LONG 155°19'530 Observer....EB + SK. Date..........12.10.1994

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws: 5-10 SK ws: 10-15EB		olive Grey 5Y 4/1	Diatomaceous muddy sand structurless
10							
20							
30				ws: 30-35 EB ws: 35-38 SK			
38							38 cm
40							
50							
60							
70							
80							* smear slide ws. wet sediment sample
90							
100							

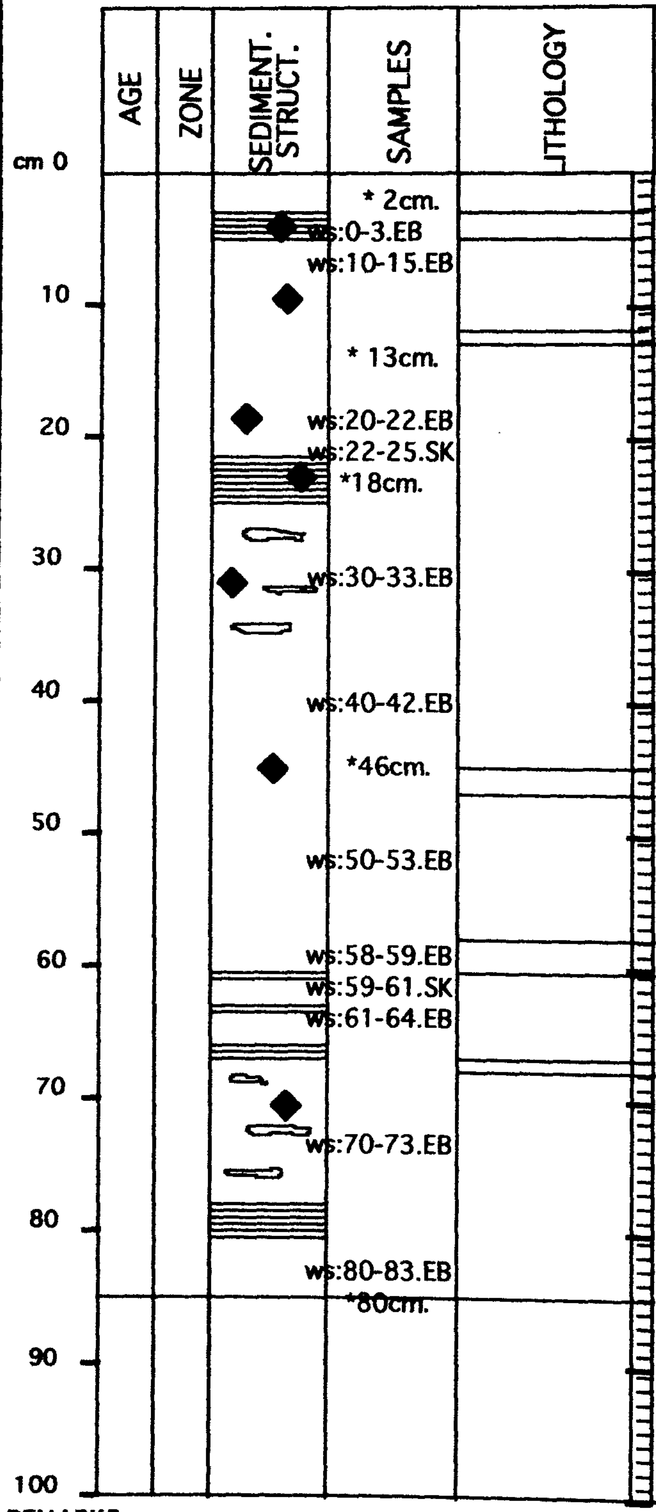
REMARKS:

Appendix III Description of the cores

B 37

CRUISE | **CORE** 52C | **SECTION** A | **WATER DEPTH** 915m

LAT 50°34'734 LONG 155°16'278 Observer: EB + SK Date: 13.10.94



COLOUR	LITHOLOGIC DESCRIPTION
Greyish olive green. 5Gy 3/2	0-3cm.Diatom ooze - higher water content (surface seds.)
	3-5cm.Laminae (black) of hydrotroilite and diatom ooze.
	5-12cm.Diatom ooze +spots of hydrotroilite
	12-13cm.Black hydrotroilite.
	13-45cm.Diatom ooze with thin laminae of black silty material at 17 and 19 cm.
	22-25cm.laminations of ooze + hydrotroilite.
	25-45cm.spots and lenses of darker (hydrotroilite?) in diatom ooze.
Olive black 5Y 2/1	45-47cm.Dark layer of silty to f.sand
	47-58cm.Diatom ooze + lenses and spots of hydrotroilite(?).
	58-60.5cm coarse dark silty sand
	60.5-66cm. Diatom ooze + thin laminae and lenses of dark silty material (hydrotroilite?).
	66-67cm coarse dark silty sand
	67-85cm.Diatom ooze + spots and thin laminae of hydrotroilite with large number of laminae between 78-81cm.

Section A + B + CC = 130cm in total.

* smear slide
ws. wet sediment sample

REMARKS:

Strong smell of Hydrogen sulphide.

Appendix III Description of the cores

B 37

CRUISE | CORE 52C | SECTION B | WATER DEPTH 915m

LAT 50°34'734 | LONG 155°16'278 | Observer....EB + SK Date.........13.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0–30				ws:5-7.EB ws:15-18.EB ws:20-23.SK		Greyish olive green. 5GY 3/2	Same composition as the last unit in 52C (A) ie. diatom ooze with spots and lenses of black hydrotroilite.
30–100				ws:10-13.EB * 13cm. ws:13-15.SK			Core Catcher. 0-15cm: as above.

Depth scale (cm): 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

* smear slide
ws. wet sediment sample

REMARKS:

CRUISE | CORE 04G | SECTION | WATER DEPTH 810m

LAT 50°30'773 | LONG 155°18'534 | Observer..EB.±.SK.. Date.......03.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws. 5ml. foram subsample		Olive grey 5Y 3/2	Ca. 4cm thickness of sediment recovered Sandy diatomaceous mud. Starfish and echinoids seen on surface and within sediment.
10							
20							

CRUISE | CORE 13G | SECTION | WATER DEPTH 705m

LAT 50°27'760 | LONG 155°21'195 | Observer...EB.+SK.. Date.......05.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws: SK + EB		Greyish olive green 5GY 3/2	Muddy diatomaceous sand. mollusc shells and starfish seen.
10							
20							

* smear slide
ws. wet sediment sample

CRUISE | CORE 19G | SECTION | WATER DEPTH 700m

LAT 50°33'885 | LONG 155°25"403 | Observer...EB.+.SK. Date.........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws: EB+SK No SM. as very coarse material.		greenish black 5G 2/1 to olive black 5Y 2/1	Grab sample. Coarse glauconitic sand possibly of volcanic origin, together with med to coarse muddy sand. Some small pebbles ca. 1cm in length seen plus worms
10							
20							

CRUISE | CORE 20G | SECTION | WATER DEPTH 652m

LAT 50°33'335 | LONG 155°24'448 | Observer....EB + SK Date.............06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws. SK + EB	Greenish black 5GY 2/1		Surface sediments med. to coarse muddy sand with: echinoid. gastropods. starfish. worms. shrimp?
10							
20							

* smear slide
ws. wet sediment sample

Appendix III Description of the cores

B 37

CRUISE CORE 21G SECTION WATER DEPTH 782m

LAT 50°31'228 LONG 155°20'615 Observer...EB.+.SK. Date........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws:SK+EB		Greenish black 5GY 2/1	Medium to coarse muddy sand with some worms etc.
10							
20							

CRUISE CORE 27G SECTION WATER DEPTH 784m

LAT 50°30'427 LONG 155°18'617 Observer..EB.+.SK.. Date........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws:SK+EB		Greenish black 5GY 3/2	Diatomaeous sandy mud. lower part of sediment in grab darker and greyer. starfish and worms seen.
10							
20							

* smear slide
ws. wet sediment sample

Appendix III Descrption of the cores

B 37

CRUISE | CORE 28G | SECTION | WATER DEPTH 800m

LAT 50°30'152 | LONG 155°19'202 | Observer...EB + SK. Date.........06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws:EB+SK.		Greenish black 5GY 2/1	Muddy fine sand. worms, tubes and small shells seen.
10							
20							

CRUISE | CORE 31G | SECTION | WATER DEPTH 650m

LAT 50°30'863 | LONG 155°22'729 | Observer...EB + SK. Date..............06.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws:SK+EB		Greenish olive green 5GY 3/2	Muddy fine sand. worms seen.
10							
20							

* smear slide
ws. wet sediment sample

Appendix III Description of the cores

CRUISE CORE 35G SECTION WATER DEPTH 240m

LAT 51°27'126 LONG 156°14'127 Observer..EB.±SK... Date..........08.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0					* ws:SK+EB	Greyish olive green 5GY3/2	Dark muddy sand. starfish. worms shell fragments various tubes up to .7cm in diameter and 8cm long seen.
10							
20							

CRUISE CORE 36G SECTION WATER DEPTH 700m

LAT 51°00'508 LONG 155°35'583 Observer...EB.±SK... Date..........08.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
				* ws:SK+EB		Olive grey 5Y 3/2	fine to medium muddy sand. covered by coarse sand to gravel. pyroclastic, probably from last explosion of Alaid volcano. starfish. gastropod worm tubes
10							
20							

* smear slide
ws. wet sediment sample

Appendix III Description of the cores

B 37

CRUISE CORE 39G SECTION WATER DEPTH 842m

LAT 51°08'708 LONG 155°20'085 Observer..EB.+SK... Date........08.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws:SK+EB		olive grey 5Y 3/2	sandy mud with worm tubes.
10							
20							

CRUISE CORE 59G SECTION WATER DEPTH 478m

LAT 50°21'231 LONG 155°19'101 Observer....EB + SK. Date...........15.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				* ws: SK + EB		Olive grey 5Y 3/2	Two layers recovered from grab sampler. 1: Slightly muddy sand, fine to medium grained with shells,small pebbles,granules and worm tubes.
10				* ws: EB		Greenish black 5GY 2/1	2: Muddy sand, medium to coarse grained.
20							

* smear slide
ws. wet sediment sample

B 37

CRUISE CORE 62G SECTION WATER DEPTH 320m

LAT 50°22'521 LONG 155°24'184 Observer EB + SK Date 15.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0				ws: SK+EB *		Olive grey 5Y 3/2	Muddy sand, fine to medium grained with some coarser grains. worm tubes pebbles shrimp.
10							
20							

CRUISE CORE SECTION WATER DEPTH

LAT LONG Observer............... Date.............

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
10							
20							

* smear slide
ws. wet sediment sample

Appendix III Description of cores

B 37

CRUISE **CORE** 07D **SECTION** **WATER DEPTH** 790m

LAT Start: 50°30'578 Finish: 50°30'084 LONG Start: 155°18'330 Finish: 155°18'357 Observer....EB + SK Date........03.10.94

cm	AGE	ZONE	SEDIMENT. STRUCT.	SAMPLES	LITHOLOGY	COLOUR	LITHOLOGIC DESCRIPTION
0							Carbonate crusts recovered from Drag sampler. Size ranges from .5cm - 10cm in length. Numerous shell fragments of Conchecella were also recovered plus two pebbles, some worm tubes and echinoid fragments.
10							
20							Three main types of crust were distinguished.
30						10 GY 5/2	A. The majority of crusts (ca. 90%). Avarage 3-4cm in length, with a rounded to sub—rounded appearence. Relatively soft, can be broken by hand. Greyish green in colour with small shell fagments and worm ubes incorporated into the crust.
40							
50						N4	B. (ca. 5%). 'Vesiculated' appearence probably due to numerous worm tubes. medium dark grey in colour. Harder than type A.
60						N4	C. one large piece found (ca. 10cm in length) Very 'heavy' (dense?). Similar in appearence to B. Shell fragments were also seen incorporated into the body of the crust. Red material was also seen.
70							
80							
90							
100							

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