KOMEX

KURILE OKHOTSK SEA MARINE EXPERIMENT

CRUISE REPORT

RV PROFESSOR GAGARINSKY CRUISE 32
SERENADE

SEISMO-STRATIGRAPHIC RESEARCH OFF NORTHERN SAKHALIN AND IN THE DERUGIN BASIN

VLADIVOSTOK - PUSAN - SEA OF OKHOTSK - PUSAN - VLADIVOSTOK
AUGUST 31 - SEPTEMBER 29, 2001

Edited by
Thomas Lüdmann, Boris Baranov, and Boris Karp

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the Pacific Oceanological Institute (POI), Vladivostok,
Hamburg University,
and the GEOMAR Research Center for Marine Geosciences, Kiel

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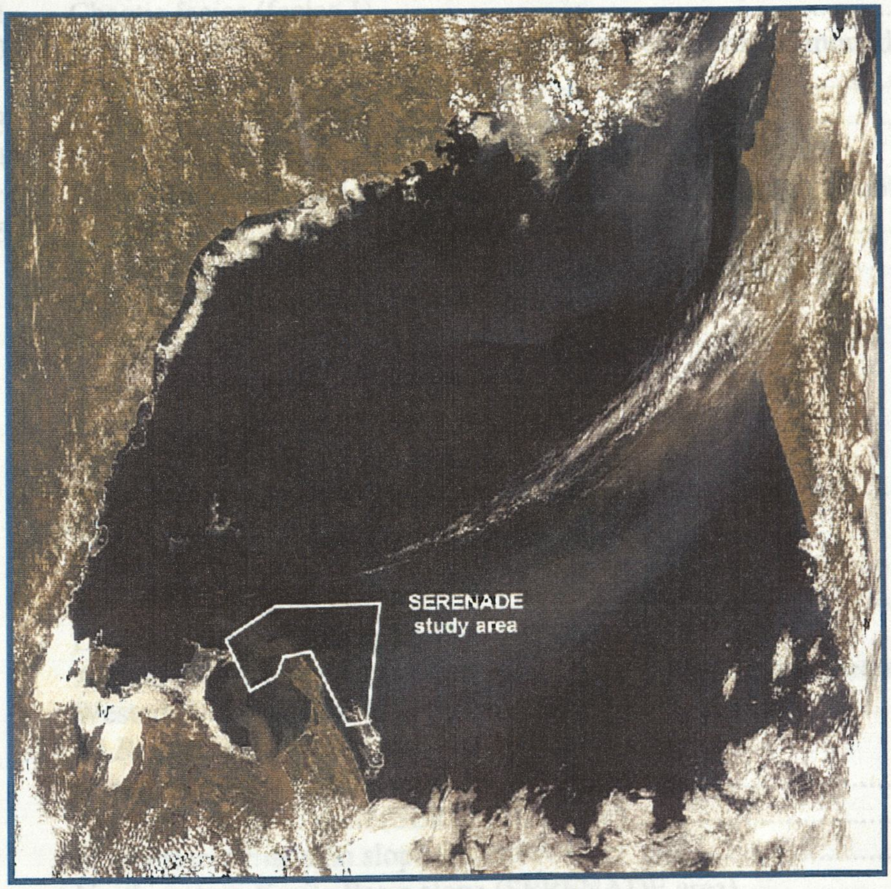
KOMEX

RV *PROFESSOR GAGARINSKY* Cruise 32

SERENADE

*Se*ismo-stratigraphic *Re*search off *N*orthern Sakhalin *A*nd in the *De*rugin Basin



VLADIVOSTOK – PUSAN –SEA OF OKHOTSK – PUSAN – VLADIVOSTOK

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1. INTRODUCTION AND BACKGROUND

(T. Lüdmann and B. Baranov)

The second phase of the KOMEX project is dedicated to a continuation of the studies of the first phase, *viz.* the reflection seismic studies of the INESSA cruise in 1998 (Biebow and Hütten, 1999) and the SAKURA cruise in 1999 (Biebow et al., 2000). For this purpose, the cruise reported here concentrates on the seismo-stratigraphy off northern Sakhalin and in the Derugin Basin. To follow our tradition of assigning each expedition with a certain name, the 32nd cruise of the R/V PROF. GAGARINSKY is named SERENADE (*SE*ismo-stratigraphic *RE*search off *N*orthern Sakahlin *A*nd in the *DE*rugin Basin).

Results of the previous studies show that this region possibly plays a key role in the generation of the Okhotsk Sea intermediate water layer. It has a complex circulation pattern, with strong bottom currents that produced drift sediments over a large area on the continental margins of North Okhotsk and northeastern Sakhalin. The currents seem to be controlled by thermohaline convection and tidal forces. Reworking by currents and mass wasting are the dominant sedimentation processes within the northwestern Okhotsk Sea. The main targets of this cruise are: (1) to fill in the profile gaps of the previous studies so as to allow a better spatial correlation between seismic profiles and (2) to extend our studies closer to the mouth of the Amur River which might be the main supplier of sediment within this region. During sea-level lowstands, the Amur River could have entered the Okhotsk Sea north of Sakhalin or it could have flowed in the opposite direction into the Sea of Japan via the Tartar Strait. Seismic lines at the present mouth of the Amur River should provide information on this open question.

Another area of interest was the northeastern continental margin of Sakhalin. Here the continental slope is overprinted by a right-lateral shear zone and is characterised by different seismic facies. It is subdivided by a transition zone which has not been studied in detail during the first phase of KOMEX. An objective was to intensify the investigation within this region so as to better understand the processes responsible for this diversity. From the northeastern continental margin of Sakhalin, we crossed the western Derugin Basin where we tried to trace the basement structures mapped during the GERDA expedition in the east into the west.

Because the SERENADE cruise was mainly devoted to studies of the seismic facies and the sedimentary regime, except for two profiles on the slope of the Kurile Basin obtained during the transit to and from the main study area, there have been no special profiles planned for tectonics purposes only. Nevertheless, the data obtained provide information important for an understanding of the tectonic structure and regime especially on the northeastern slope of Sakhalin (INESSA area). The density of the track lines on the continental slope off northeastern Sakhalin was increased and additional profiles were run on the northern continental margin of Sakhalin during this cruise. From the tectonic point of view, this region is of interest because it is the suggested junction between the Sakhalin and Kashevarov shear zones. In a broader sense, it is relevant to the location of the boundary between the Okhotsk and Amur plates. This boundary is a transform fault and it continues for a distance of about 2000 km from the eastern Japan Sea to the northernmost Sakhalin Island (Savostin et al., 1983; Jolivet et al., 1990). Its continuation to the north from Sakhalin is obscure and is presumed in two different models (see Fig. 1, insert).

Worrall et al. (1996) suggest that the dextral Kashevarov Shear Zone can be considered a northward continuation of the Okhotsk/Amur plate boundary. These authors assume that this shear zone continues up to the eastern slope of the Sakhalin, but clear evidence for this continuation in the recent tectonics has not been found during our investigations in the INESSA and SAKURA cruises (Biebow and Hütten, 1999; Biebow et al., 2000). On the other hand, the tectonic structure of the continental slope off northeastern Sakhalin Island, at least in the northern INESSA study area, is found to be controlled by a system of thrusts and reverse faults oriented in a NW-SE direction and connected with the Sakhalin Shear Zone. But the abundance of these faults at the continental slope was poorly known and therefore a decrease in the spacing between track lines could help to clarify this question.

The adjacent Derugin Basin where several track lines have been planned was investigated during two KOMEX cruises (GERDA and SAKURA) and it is of special interest to the tectonics of the Sakhalin Shear Zone as well. This basin is one of the deep water basins of the Okhotsk Sea, it was formed as a result of extension processes and an understanding of its structure would be useful in developing tectonic models for the entire Okhotsk Sea.

The survey tracks of the SERENADE expedition covered the areas at the eastern slope off norther Sakhalin Island to the north of Sakhalin and in the Derugin Basin. The geophysical survey of this cruis has the following main objectives:

- to obtain regional seismic cross-sections for seismic facies and sequence analyses
- to elaborate on the tectonic pattern of the Sakhalin continental slope
- to prepare recommendations for the forthcoming geological cruise with the R/V AKADEMI LAVRENTIEV (summer 2002) as to the choice of the best sites for TV observations, coring and wat sampling at the continental slope of Sakhalin.

2. CRUISE NARRATIVE

(T. Lüdmann)

The 32nd cruise of the R/V PROFESSOR GAGARINSKY (Fig. 1) was carried out with 15 scientists (6 German and 9 Russian), officers and the crew, and one military observer on board. The ship with two compressors and a streamer winch at the aft is specially designed for seismic investigations. The port of call was Pusan (South Korea). The ship arrived on 3rd September 2001 at ca. 9 a.m. and left the port after bunkering and loading of the equipment at ca. 9 p.m. local time. Transit to the study area off northern Sakhalin lasted ca. 6 days. This time was used to prepare the seismic equipment and laboratories for its later use and to establish a preliminary working plan together with the Institute of Biogeochemistry and Marine Chemistry (Hamburg), the Shirshov Institute of Oceanology (Moskow), the Pacific Oceanological Institute (Vladivostok) and the Pacific Oceanography Expedition (Nakhodka).

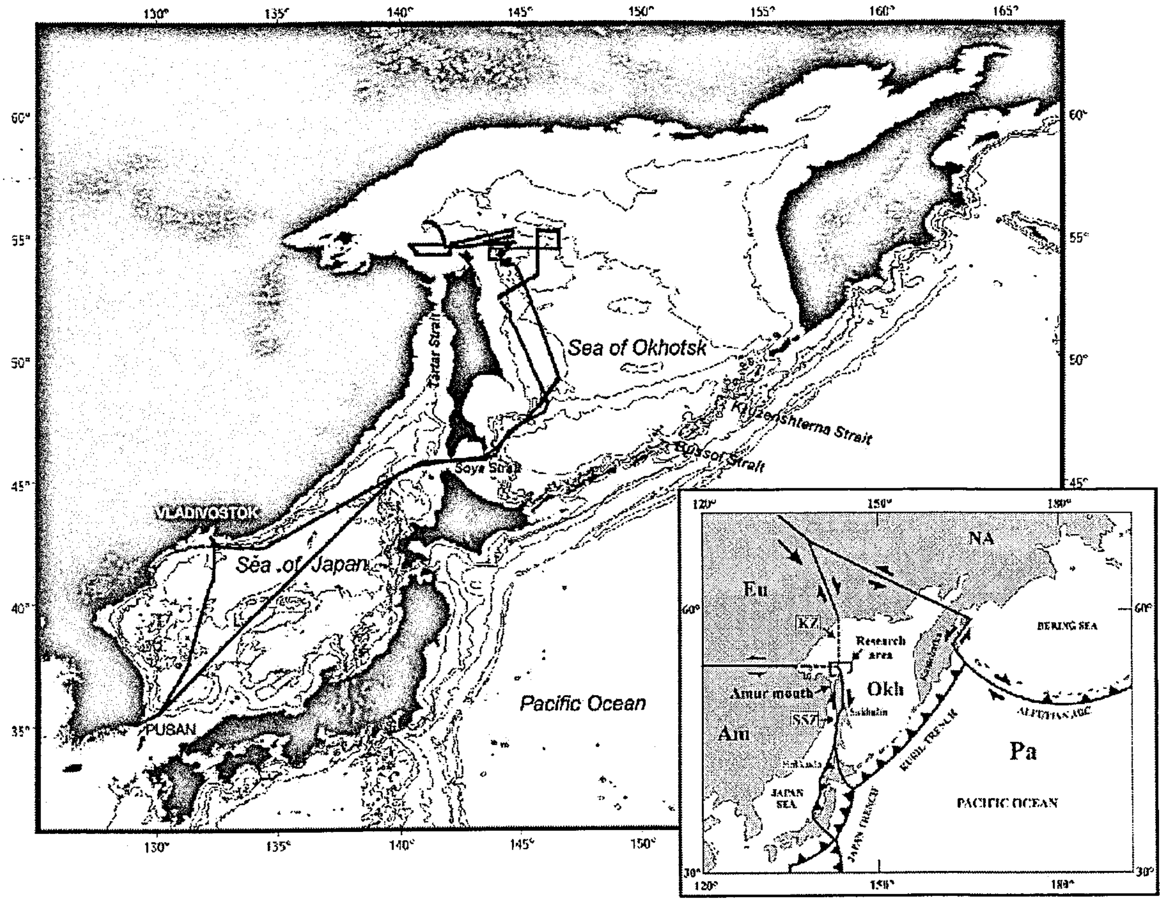

Fig. 1: Track lines of the SERENADE cruise (September 3-26, 2001), starting and ending in Pusan harbour (South Korea). Insert shows the location of the SERENADA study area and the recent plate boundaries of the northwestern Pacific. The Okhotsk plate corresponds to the Okhotsk Sea and parts of the adjacent land areas. Lines with teeth mark subduction zones and with arrows strike-slip boundaries. Plates: PA = Pacific, NA = North-American, EU = Eurasian, Am = Amur, Okh = Okhotsk. Shear zones: KZ = Kashevarov, SSZ = Sakhalin.

After 2 days a sailor got seriously ill. After further discussion with the Pacific Oceanological Institute (POI), it was decided to bring the person to Vladivostok where he could be taken immediately to a hospital. On 6th September we arrived in Vladivostok. A small boat came alongside the PROF. GAGARINSKY and picked up the sick sailor. This procedure lasted ca. 1 hour and hereafter we proceeded with our transit to the study area. On the morning of 9th September, the Russian scientists obtained a test profile using their new equipment. The profile was run along the way to our study area, therefore the ship could continue on its way without any notable interruption. The seismic profile was completed in the late evening.

On 11th September we arrived at our study area on the shelf off northeastern Sakhalin. For the subsequent investigations, equipment of the German group was used exclusively. Profiling started after a test line of 3 hours under fair weather conditions. The first seismic tracks crossed the continental slope of Northeast Sakhalin in NE direction and continued to the North within the Derugin Basin (see Fig. 1). These profiles should fill the gap in the western Derugin Basin left by the GERDA, INESSA and SAKURA data. Profiling ceased on the morning of 13th September.

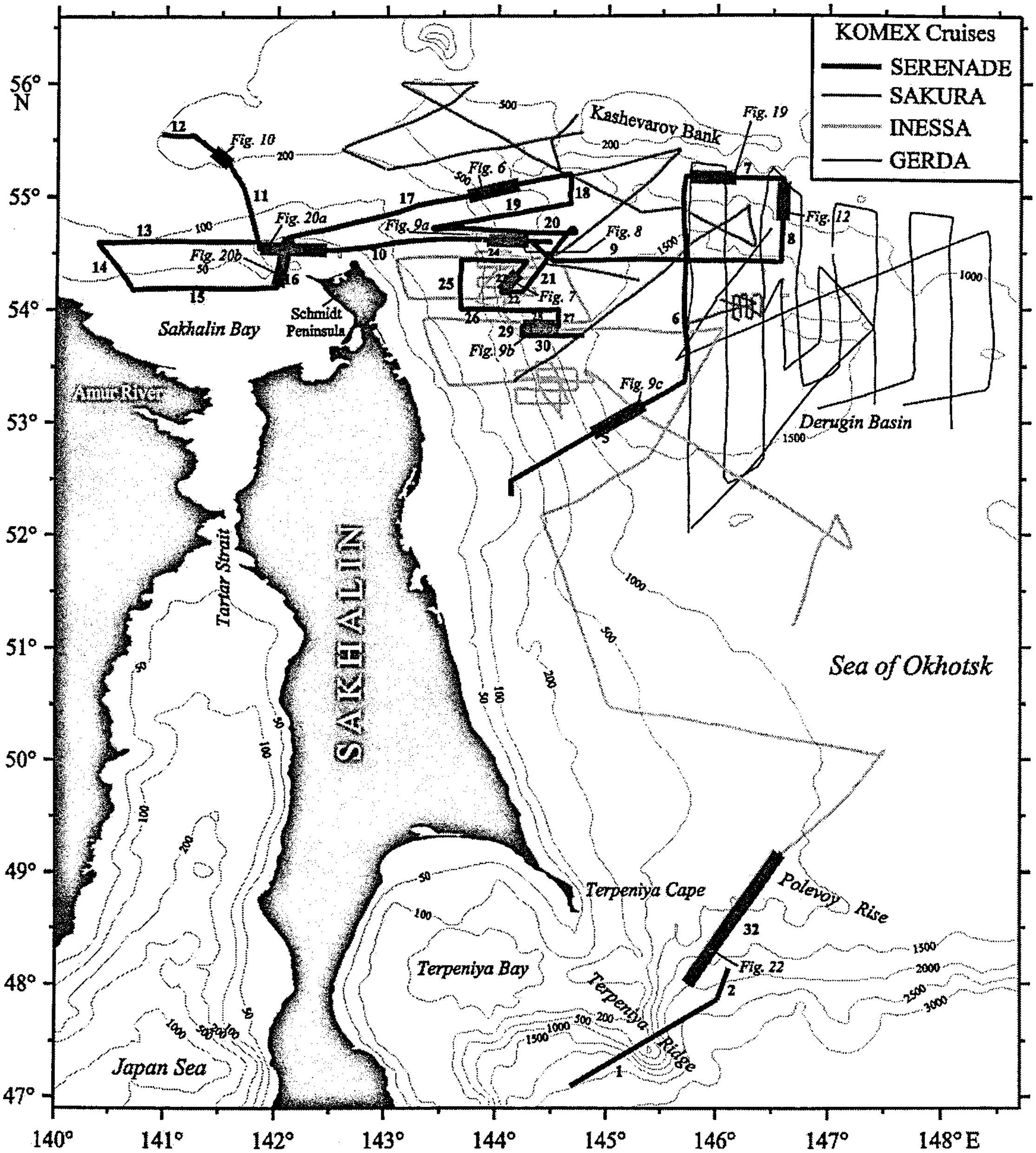

Fig. 2: Seismic profiles of the SERENADE and former cruises carried out within the framework of the KOMEX project. Marked are the SERENADE lines with numbers and the example profiles (thick grey lines).

After the first part (deep water study) on 13th September the seismic equipment was taken out of the water and maintained. Additionally, the air gun system was re-configured for shallow water investigations. Five hours later, profiling continued by crossing the northern continental margin of Sakhalin in the east-west direction. Meanwhile the weather started to deteriorate, the sky became cloudy and a strong wind appeared. The second part (shallow water study) was planned to study the influence of the

Amur River on the sedimentation processes off northern Sakhalin and in the Derugin Basin as well as to close the gap between the SAKURA and INESSA profiles within the Staretsky Trough (see Fig. 2).

On 14th September we were forced to change course from 270° to ca. 350° due to heavy swell. After steaming ca. 75 km outside of the research area, the storm worsened and we decided to retrieve the equipment (so as not to endanger them) because data quality had become unacceptable. When the storm calmed down, we turned and steamed back to the point where we deviated from the east-west profile. On 16th September, we continued with our seismic investigations close to the mouth of the Amur River north of the Tartar Strait. Now that the storm was over, the Okhotsk Sea was absolutely calm and we could catch up the lost time by profiling at a higher speed.

On 17th September we stopped for maintenance of the air guns and started 2.5 hours later the third part - the investigation of the northeastern continental margin of Sakhalin. The objective was to add some profiles in the northern INESSA study area to better define the shape of the slope fan. Moreover, we planned to close the gap between the northern and southern INESSA areas. On 19th September at 10 p.m., we stopped our work in the northern Sakhalin region to steam back to Pusan.

On 21st September a short seismic profile (32) was obtained east of Cape Terpeniya on the way back to Pusan (Fig. 2). It is the prolongation of a seismic line shot during the INESSA cruise. The profiling lasted ca. 12 hours after which all equipment was taken out and the return trip continued. Meanwhile the equipment was prepared for transport and a first draft of the cruise report was compiled by all the participating scientists. On 26th September the ship arrived at the port of Pusan in the late evening. The next morning the equipment was unloaded and around noon the German scientists disembarked.

3. METHODS AND INSTRUMENTS

(T. Lüdmann and B. Karp)

During cruise 32 of the R/V PROFESSOR GAGARINSKY, the following equipment was used:

- a seismic reflection system consisting of a two-GI-gun array, an 8 channel mini-streamer, a multi-channel digital data acquisition system, an air gun trigger unit and a pressurized air distribution board. A single-channel digital data acquisition system permits real-time data monitoring (quality control) on screen and profile hard-copy printout on a line printer. The two S.S.I. GI-guns were used in two different configurations depending the water depth. For the survey within the deep western Derugin Basin, a total volume of 280 in^3 (4.59 *l*) was chosen by firing a mini-GI gun and a standard-GI gun simultaneously in a 2-gun array. The mini-GI gun was configured in the harmonic mode, whereby the generator and injector of equal volume (35 in^3 each) were triggered time delayed to minimize oscillations of the bubble pulse. The second gun was also configured in the harmonic mode but with chamber sizes of 105 in^3. This permits a penetration of 2 seconds subbottom. For high-resolution studies off northern Sakhalin, we operated the mini-GI gun in the harmonic mode with chamber volumes of 13 in^3 (total: 26 in^3) and the standard-GI gun in the true GI mode with a 105 in^3 injector and a 45 in^3 generator, thus allowing a near total suppression of the bubble oscillations.

Normally the two guns were used in combination, only in shallow water of less than 200 m was the mini-GI gun used alone. The two-gun array was pressurized nominally at 150 bar, towed ca. 10 m behind the ship and triggered every ca. 25 m along prescribed profiles with pulses generated by a master clock. Each seismic channel of the GECO PRAKLA 8-channel mini-streamer has a length of 12.5 m. An active section with a length of 25 m (2 channels) is separated by an inactive section of 25 m, leading to a total length of 175 m of the mini-streamer. The towing depth was 5 m and the offset was 200 m in deep water but only 50 m in shallow water.

The operational characteristics of the multi-channel seismic reflection system are summarized in Tab. 1. The diagram of the multi-channel seismic acquisition system is shown in Fig. 3.

Tab. 1: Operational characteristics of the multi-channel seismic reflection system.

Source	
Type	2 × GI-guns
Pressure	150 bar nominal
Firing interval	ca. 25 m
Source depth	2 m
Streamer	
Streamer depth	5 m
First channel offset	50 or 200 m
No. of channels	8
Length of active section	12.5 m
Length of inactive section between active sections	25 m
Recording	6-8 sec
Recording length	1000 Hz
Sampling frequency	20-400 Hz
Bandpass analog filter	

The signals from the eight channels are separately digitized via a PC-based A/D converter board, multiplexed, and written onto hard disk. A back up copy was made on MO-disk. Back in the home laboratory, the data will be demultiplexed and transformed to the standard SEGY format. Later on it will be processed using the *iXL* seismic processing software package of Mercury International Incorporation. The main processing steps will include sorting, digital filtering, NMO-correction, stacking, deconvolution and migration. Parallel to multi-channel digital recording, the analog signals from the different channels of the streamer are summed, amplified, bandpass filtered (15-350 Hz), and displayed online by a single-channel digital data acquisition system for monitoring and data storage;

- a Russian single channel seismic reflection system made up of a 3.4 *l* air gun, a streamer, and a single-channel digital data acquisition system based on a commercial sound card (Sound Blaster 16, 32, Vibra) which writes the analog signal on the hard disk of a Pentium-PC. The recorded traces are displayed on the computer monitor. Backup copies are made on magneto-optical disks. The GPS unit is connected to the serial port of the PC. Recording and adjustment of the dynamic range of the seismic signal are controlled on the PC monitor by software developed for this purpose.

Specification of the single-channel data acquisition system:

- data format: SEG-Y files, 16 bit
- sampling rate: 1 or 2 ms, here: 1 ms
- length of trace: 4-6 sec
- software: acquisition, filtering, viewing, printing, testing

The single-channel seismic acquisition system is shown in Fig. 4.

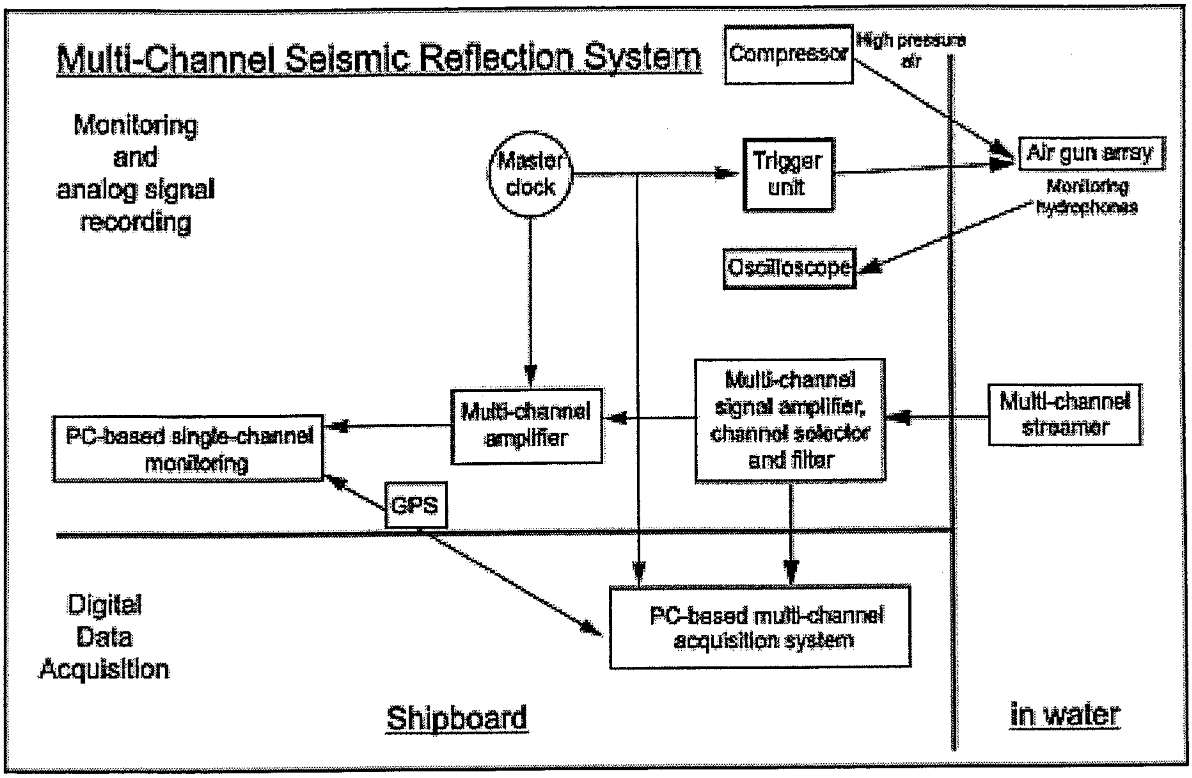

Fig. 3: Sketch of the multi-channel seismic acquisition system of the Institute of Biogeochemistry and Marine Chemistry of Hamburg University.

- a Russian, surface-towed, MBM-1™ marine proton magnetometer for magnetic total intensity measurements. This magnetometer has a measuring range of 20,000-100,000 nT and an accuracy of 2-4 nT over its entire measuring range. The magnetometer sensor was towed by a non-magnetic cable at a distance of 250 m behind the ship. The magnetic data were written on an analogue recorder for visual display and stored on an IBM PC-386 at a sampling rate of 10 seconds;

- a Russian shipboard gravity meter consisting of four highly-damped, spring-type GMN™ marine gravimeters mounted on GMS-2™ gyro-stabilized platforms installed in a special laboratory on board. The gravimeters achieved an accuracy of 0.8 mgal. In order to reduce cross-coupling errors, a straight-line model of two gravimeters was used. The gravity data were written on an analogue recorder for visual inspection and stored on an IBM PC-386 at a sampling rate of 4 seconds. Gravity observations were started at the pier in Vladivostok at a gravity base station three days before the beginning of the cruise;

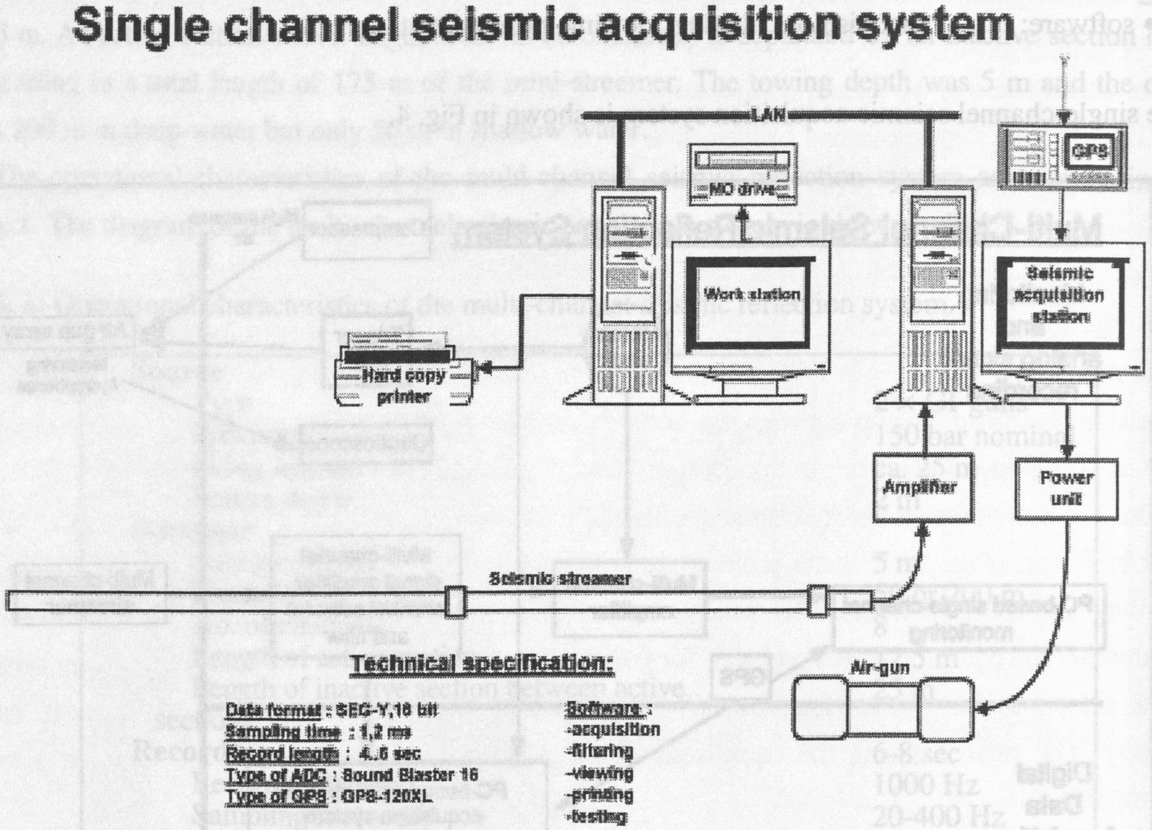

Fig. 4: Sketch of the single-channel seismic acquisition system of the seismic of the Pacific Oceanological Institute in Vladivostok.

- a Russian GEL-3™ wide-beam echo-sounder for bathymetric measurements. This echo-sounder has a measuring range of up to 10 km water depth and operates at a frequency of 12.4 kHz. The water depths were recorded on an analogue echograph which was then sampled manually every 5 minutes; and

- a shipboard global positioning system.

4. PRELIMINARY RESULTS

4.1 Reflection Seismics

4.1.1 Northwestern Okhotsk Sea

(T. Lüdmann)

The interpretation of reflection seismic profiles in the northwestern Okhotsk Sea selected during the KOMEX I phase allowed the classification of 7 seismic facies types. Due to the improved quality of the seismic data obtained during the SERENADE cruise, we had to reinterpreted our previous results and a new facies type has been added. The distribution of the seismic facies is illustrated in Fig. 5. The different types will now be discussed in detail.

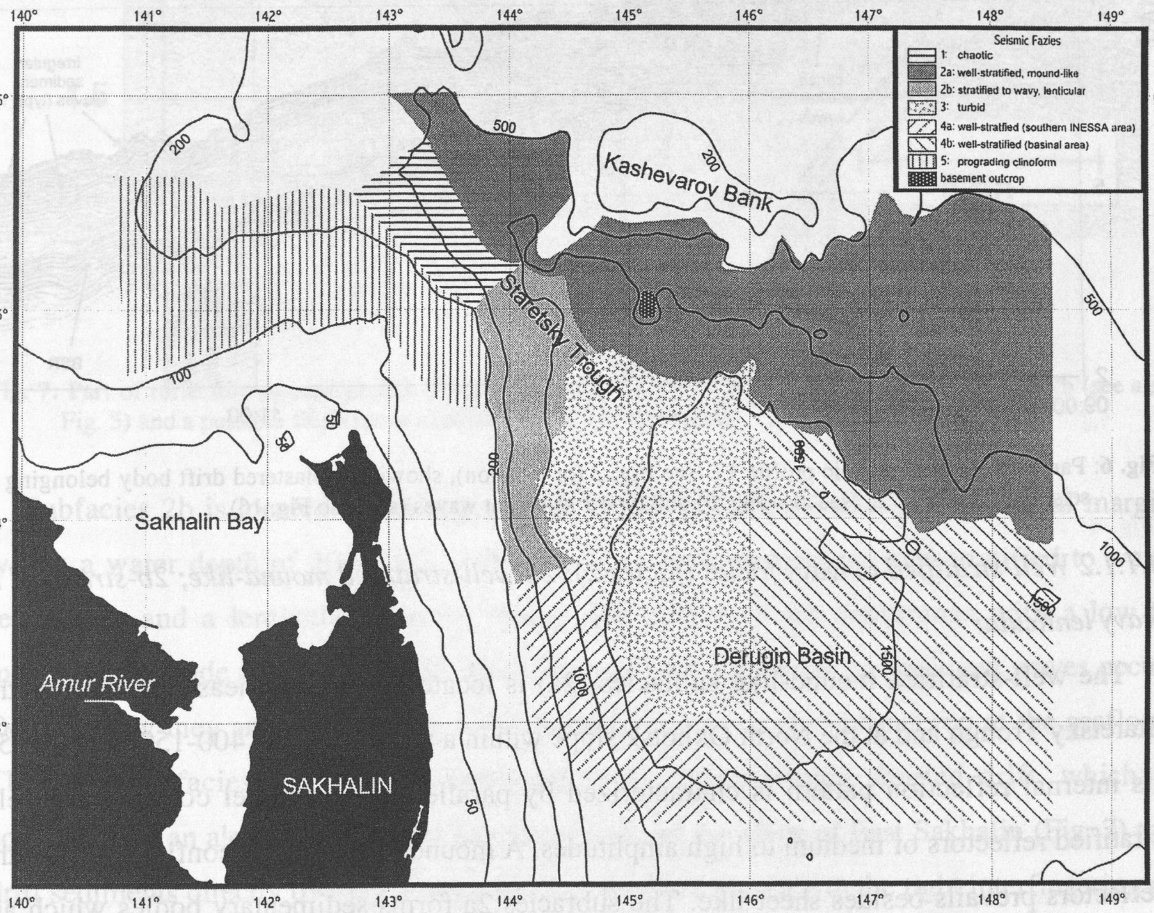

Fig. 5: Seismic facies types mapped in the northwestern Okhotsk Sea. See text for explanation.

4.1.1.1 Chaotic facies (facies 1)

The distribution of the seismic facies type 1 is limited to the northwestern part of the Staretsky Trough within a water depth range of 250 and 700 m (Fig. 5). The internal reflection configuration shows a chaotic to hyperbolic pattern, in places the reflections wavy to subparallel. The occurrence of large sand waves and megaripples point to the influence of strong bottom currents. The chaotic seismic facies can be interpreted as sediments deposited under the regime of strong bottom currents.

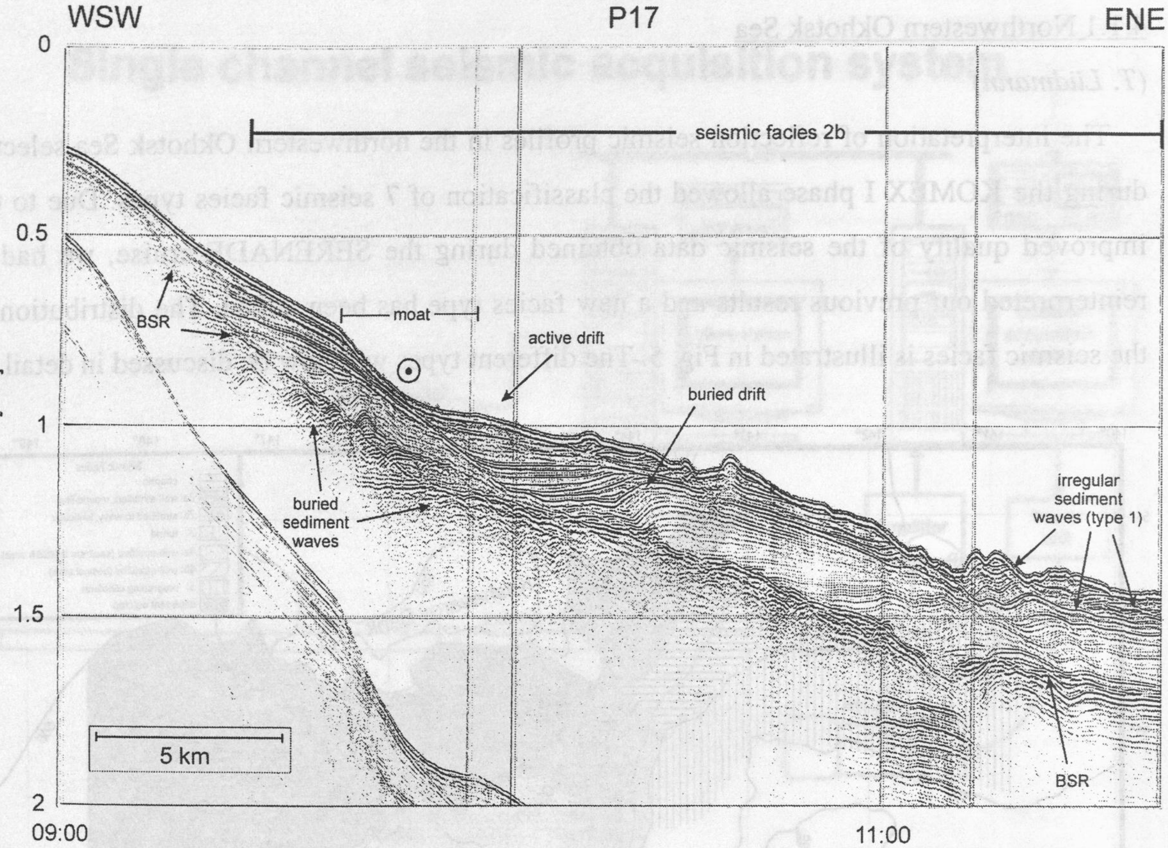

Fig. 6: Part of reflection seismic profile 17 (see Fig. 2 for location), showing a plastered drift body belonging to seismic facies type 2a (see also Fig. 5) and type 1 sediment waves (see also Fig. 16).

4.1.1.2 Well-stratified to wavy facies (facies 2): 2a-well-stratified mound-like; 2b-stratified to wavy lenticular

The well-stratified mound-like subfacies (2a) is located at the northeastern flank of the Staretsky Trough and at the North Okhotsk slope within a water depth of 400-1500 m (Fig. 5). Its internal reflection pattern is characterized by parallel to subparallel continuous, well-stratified reflectors of medium to high amplitudes. A mound-like external configuration of the reflectors prevails besides sheet-like. The subfacies 2a forms sedimentary bodies which are marked by internal erosional discontinuities. Together with the reflection configuration these discontinuities can be interpreted as indication for drift sedimentation. Strong bottom currents leading to the creation of drift bodies confined between uplifted basement blocks. Periods of sedimentation alternate with erosion and non-deposition, are controlled by changes in current regime.

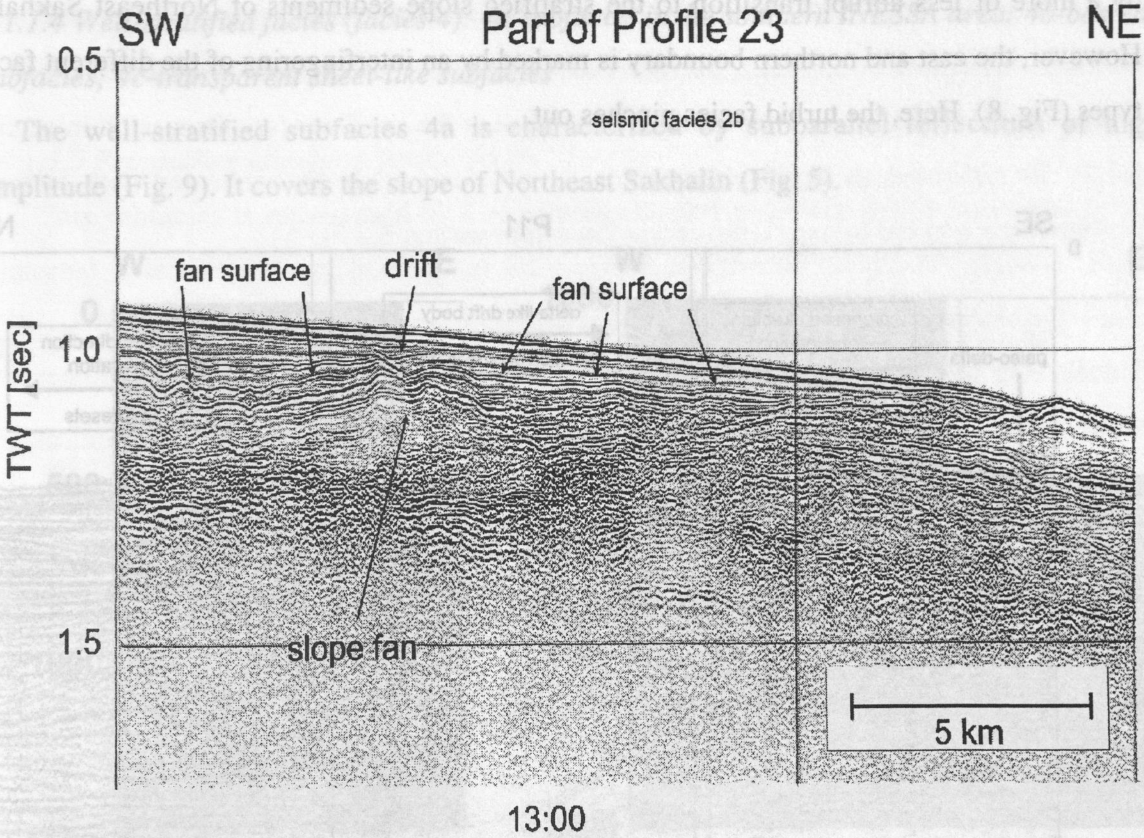

Fig. 7: Part of reflection seismic profile 23 (see Fig. 2 for location) illustrating seismic facies type 2b (see also Fig. 5) and a possible slope fan covered by recent drift sediments.

Subfacies 2b is located at the upper slope of the Northeast Sakhalin continental margin within a water depth of 200-1000 m (Fig. 5). It is characterized by well-stratified to wavy reflections and a lenticular external shape. The reflectors are continuous with a low to medium amplitude (Fig. 6, 7 and 8). Here, in contrast to subfacies 2a, sediment waves occur. Occasionally they are buried under well-stratified sediments or they outcrop at the seafloor. This seismic facies type can be attributed to a slope-plastered sheeted drift, which is controlled by an alongslope bottom current regime. At the slope of East Sakhalin (Fig. 7) the drift sediments directly overlay a slope fan-like structure pointing to the tight interfingering of downslope and alongslope sedimentation processes (see discussion in section 5.1.3).

4.1.1.3 Turbid facies (facies 3)

The turbid facies is found within the northwestern Derugin Basin (Fig. 5). Distinguishing feature of this facies type is the lack of internal structure. The reflection are short, discontinuous and irregular distributed, leading to an overall chaotic impression. The amplitude is medium to high. In places subparallel reflection occur. Its western boundary is characterised by a more or less abrupt transition to the stratified slope sediments of Northeast Sakhalin. However, the east and northern boundary is marked by an interfingering of the different facies types (Fig. 8). Here, the turbid facies pinches out.

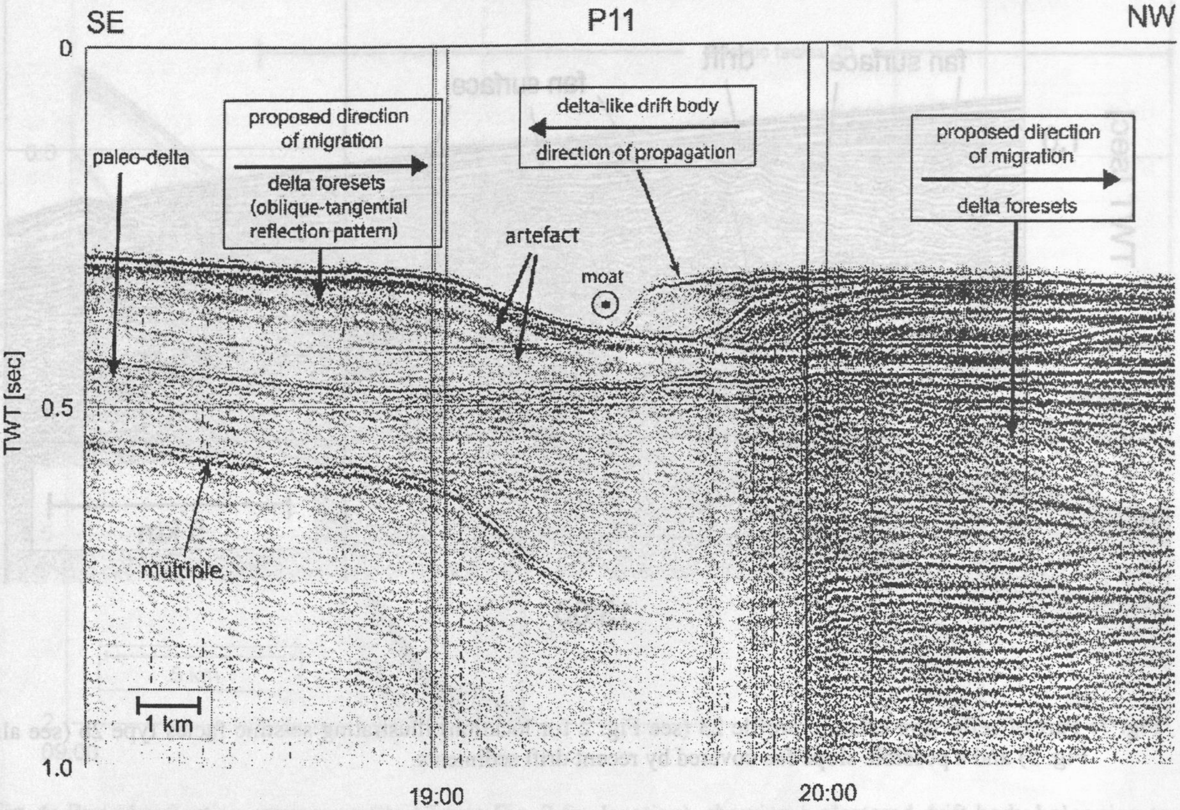

Fig. 8: Part of reflection seismic profile 10 (see Fig. 2 for location) showing parallel to subparallel drift sediments of seismic facies type 2b (see also Fig. 5) which interfinger at the eastern end of the profile with the turbid seismic facies 3.

Due to the seismic characteristics and spatial distribution the turbid facies might be interpreted as mass wasting deposits. The slumps and debris flows originated at the slope and have been transported into the Derugin Basin where they possibly pass over into turbidites at their distal parts. This processes could have dominated during sea-level lowstands when the depocenter shifted close to the present shelf edge. Subparallel reflection form layers within the turbid facies which can be attributed to hemi-pelagic sedimentation, preferably occurring during interglacial times when the sea-level is high. Only within the distal part of the turbid facies can a BSR be recognized within greater depth, however, in its central part it is beyond our seismic penetration (up to 3 s). Its great thickness suggests that these processes may have occurred several times during the Pleistocene sea-level fluctuations.

4.1.1.4 Well-stratified facies (facies 4): 4a-subfacies in the southern INESSA area; 4b-basinal subfacies; 4c-transparent sheet-like subfacies

The well-stratified subfacies 4a is characterized by subparallel reflections of high amplitude (Fig. 9). It covers the slope of Northeast Sakhalin (Fig. 5).

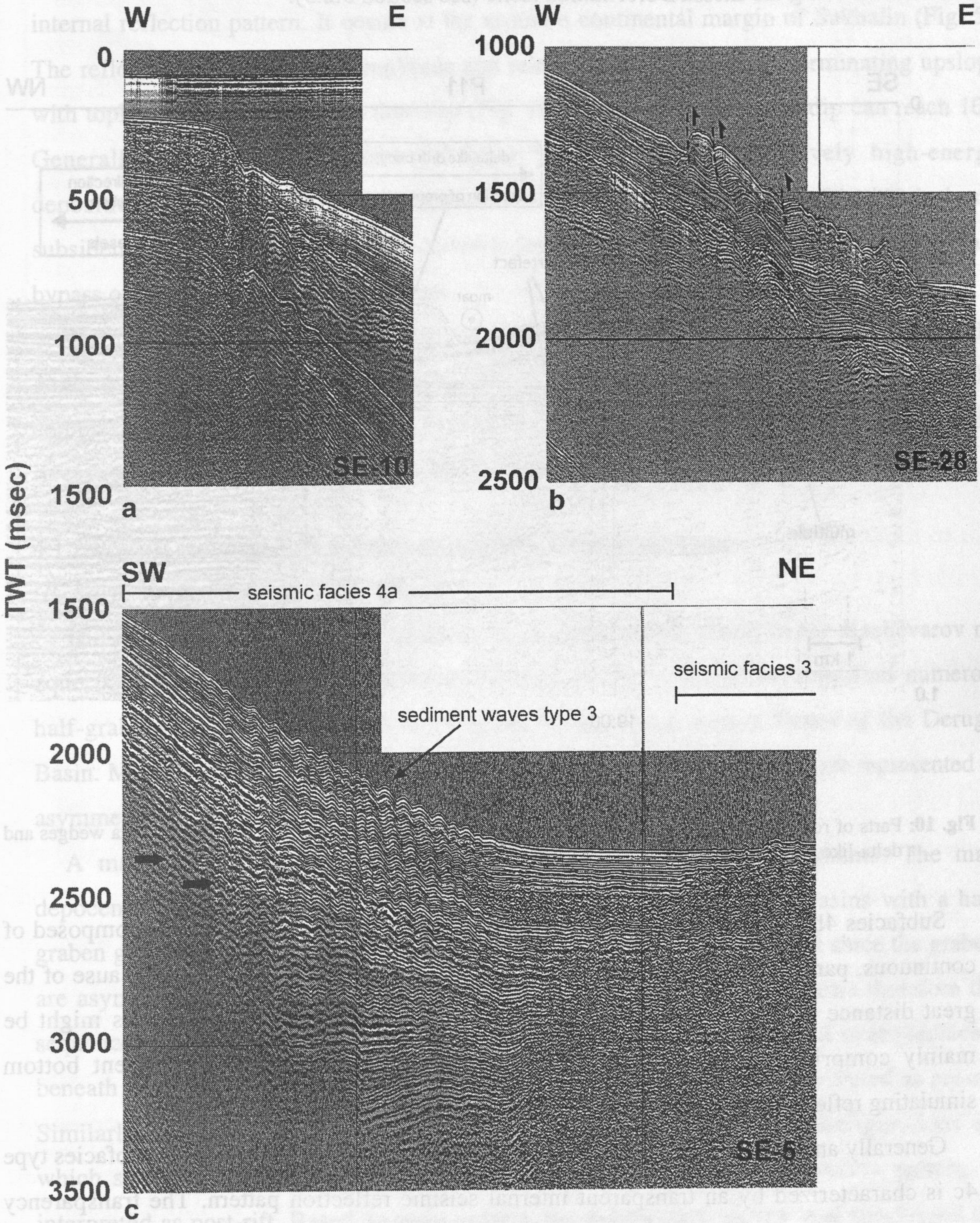

Fig. 9: Parts of reflection seismic profiles 10 (a), 28 (b) and 5 (c) (see Fig. 2 for locations), showing changes in the structure of the INESSA deformation zone from south to north. Seismic facies types 4a and 3 (see also Fig. 5) as well as type 3 sediment wave (see also Fig. 16) are indicated.

The seismic facies exhibit a downslope diverging internal reflection pattern which may indicate a differential Subsidenz, that increases basinward. At the upper slope this facies type is represented by the occurrence of sediment waves at the sea floor (see discussion in section 5.1.2). Its transition to the turbid faces is sharp which might be connected with tectonic movements along the Inessa Deformation Zone (see section 5.2.3).

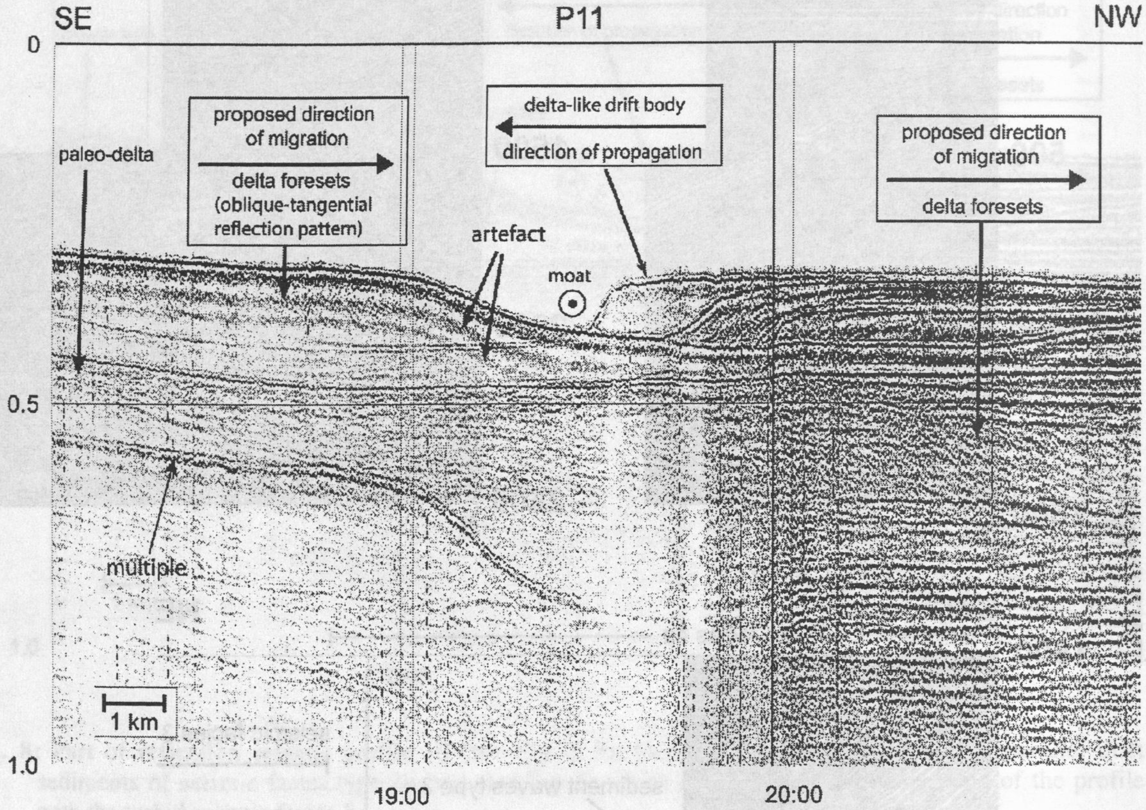

Fig. 10: Parts of reflection seismic profile 11 (see Fig. 2 for location). Indicated are prograding delta wedges and a delta-like elongated drift body.

Subfacies 4b found in the southern and eastern Derugin Basin (Fig. 5). It is composed of continuous, parallel to subparallel reflectors with high to medium amplitude. Because of the great distance to the depocenters at the continental margins this seismic facies might be mainly comprised of hemipelagic deposits and ice-rafted debris. A prominent bottom simulating reflector can be identified wherever this facies type occurs.

Generally another subfacies type found above the BSR of subfacies 4b. This subfacies type 4c is characterized by an transparent internal seismic reflection pattern. The transparency might be closely related to the gas hydrate below this facies type. Gas hydrate, perhaps is situated within the pore space of sediments above the BSR, where it is still within the gas hydrate stability zone. This cementation leads to an homogenization of the original strata and prevent the generation of seismic reflections.

4.1.1.5 Prograding clinoform facies (facies 5)

This subfacies is represented by a clinoform external geometry with a tangential oblique internal reflection pattern. It occurs at the northern continental margin of Sakhalin (Fig. 5). The reflectors are of medium amplitude and relatively steeply-dipping, terminating upslope with toplap and basinward with downlap (Fig. 10). In places the angle of dip can reach 10°. Generally the oblique clinoform reflection pattern implicates relatively high-energy depositional conditions with a combination of high sediment supply, no or little basin subsidence and a stillstand of the sea-level, leading to a rapid basin fill and sedimentary bypass of the upper depositional surface.

We interpret the oblique clinoform reflection pattern as prograding delta wedges of the Amur River. Whether the recent Amur River should be classified as a regressive delta complex or a transgressive estuary is unclear. At present the main depocenter is located at the river mouth which we could not study for the lack of a research permit.

4.1.2 Postrift sedimentation in the Derugin Basin northeastern slope

(B. Karp, V. Karnaukh, and V. Prokudin)

The northeastern and eastern slopes of the Derugin Basin belong to the Kashevarov rift zone (Gnibidenko, 1990). The Russian–German GERDA expedition identified numerous half-grabens bounded by normal faults at the northern and eastern slopes of the Derugin Basin. Most of the half-grabens show a strong asymmetry. Rift mountains are represented by asymmetric (tilted) blocks.

A major part of the eastern Derugin Basin is blanketed by sediments. The main depocenters include the acoustic basement depressions. In extensional basins with a half-graben geometry such as the eastern Derugin Basin, it is often assumed that since the grabens are asymmetric, the syn-rift sequences must be divergent in form. It follows therefore that sequences which exhibit a parallel stratal configurations and are observed stratigraphically beneath a sequence with divergent internal reflection pattern must be interpreted as pre-rift. Similarly, sequences that exhibit parallel to slightly-divergent stratal configurations and which stratigraphically overlie a sequence with divergent internal reflection pattern are interpreted as post-rift. Based on these criteria, the sedimentary section was subdivided into three main units: pre-, syn- and post-rift units. They are separated from each other by two prominent unconformities.

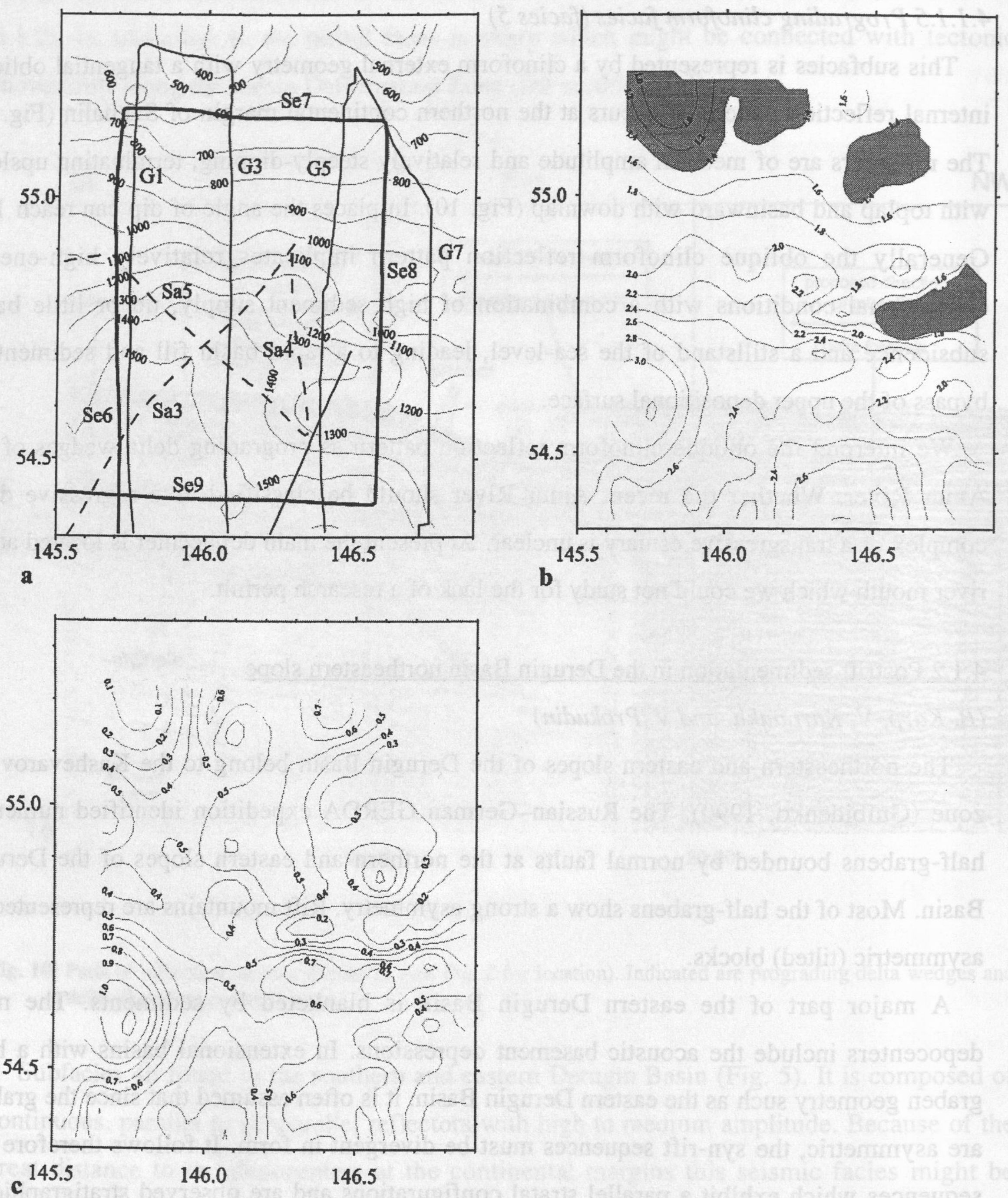

Fig. 11: (a) Seismic reflection lines of the GERDA (G), SAKURA (Sa) and SERENADA (Se) expeditions at the northeastern slope of the Derugin Basin. G3, 5, 7 are GERDA profiles, Sa3, 4, 5 are SAKURA profiles, and Se6, 7, 8, 9 are SERENADE profiles. (b) Depth to the base of the post-rift deposits (in too-way travel time) at the northeastern slope of the Derugin Basin in 0.2 sec TWT intervals. (c) Thickness of the post-rift deposits at the northeastern slope of the Derugin Basin in 0.1 sec TWT intervals.

A major part of the sedimentary layer is composed of syn-rift deposits. They fill half-grabens, show a wedge-shaped geometry and have a maximum thickness exceeding 1.5 sec two-way travel time. The wedge front typically lies on the hanging wall dip-slope. The thickness of the post-rift deposit is 0.1–0.4 s TWT in most part of the study area.

During the SERENADA expedition reflection seismic profiling was carried out on the northeastern slope of the Derugin Basin where seismic reflection data have previously been obtained during the GERDA and SAKURA cruises. As a result there is now relatively dense grid of seismic profiles in this area (Fig. 11a).

The northeastern slope of the Derugin Basin is fairly smooth and dips gently from approximately 600 m water depth to over 1500 m in the south where the slope joins the basin floor. Most of the study area is blanketed by post-rift sediments. The acoustic basement only crops out on the steep side of some tilted blocks. In general, the morphology of the acoustic basement is reflected in the depth to the base of the post-rift deposits (Fig. 11b). Areas where this depth reaches a maximum correspond to half-grabens. Three large tilted blocks are recognized on the base map (Fig. 11b, shaded areas).

The thickness of the post-rift deposits varies between 0.1 s to more than 0.7 s in the study area. It generally reaches a minimum on top of the tilted blocks. The main features of the isopach map of the post-rift deposits (Fig. 11c) correspond to the elevated part of tilted blocks and the deep part of half-grabens. This suggests that the sediment supply is insufficient to infill accommodation produced by fault-controlled subsidence. The post-rift deposits are composed of several seismic facies, each of which is the result of sediment accumulation in a specific sedimentary environment.

The well-stratified seismic facies (facies 1) can be subdivided into the subfacies 1a, 1b and 1c (Fig. 12). Subfacies 1a is characterized by high-amplitude, low-frequency, subparallel, continuous reflections. Its external form is generally sheeted drape-like when this subfacies outcrops at the seafloor. Where subfacies 1b occurs in the middle and lower part of the post-rift deposits, it is mounded and lenticular in external shape. For sheeted drapes, onlap terminations are common. For mounded and lenticular shapes, downlap terminations are common. Subfacies 1a is interpreted either as a result of basinal hemipelagic deposition interrupted by episodic turbidity current activity (sheeted drapes) or as slope-plastered sheeted drifts which are formed under the influence of downward flowing bottom currents.

Subfacies 1b (Fig. 12) is characterized by high-to-moderate amplitude, high-frequency, parallel and subparallel, continuous reflections. Its external form is generally sheeted drape and trough fill-like. Sediments of subfacies 1b are deposited within bathymetric lows and onlap and pinch out against positive relief areas on the sedimentation surface. Subfacies 1b is interpreted as hemipelagic deposits interrupted by submarine fan sedimentation.

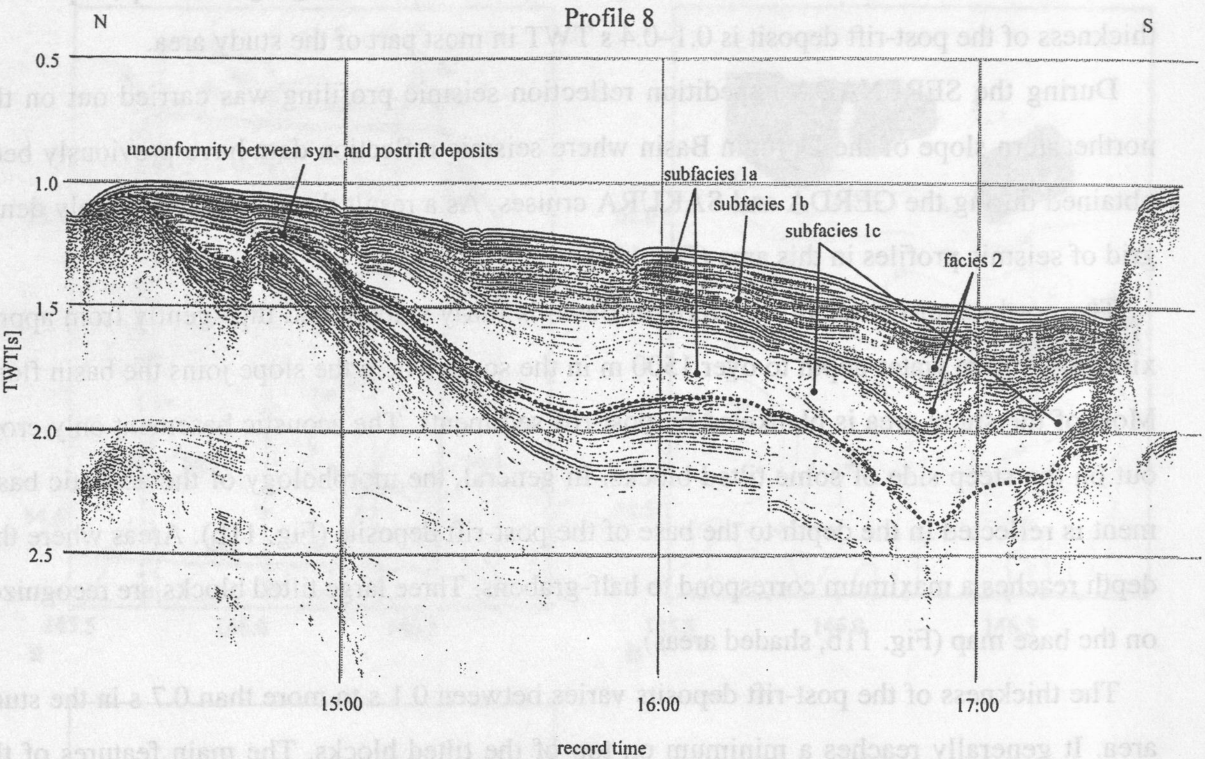

Fig. 12: Part of reflection seismic profile 8 (see Fig. 2 for location), showing the seismic subfacies 1a, 1b, 1c and 2. See text for explanation.

Subfacies 1c (Fig. 12) is characterized by subparallel, variable-amplitude, low-frequency reflectors with complex sigmoid-oblique configurations. It locally contains chaotic seismic reflection patterns. For this subfacies, onlap and downlap reflector terminations are common. Its external form is distinctly lens- or wedge-shaped. Subfacies 1c occurs against relatively sharp positive relief on the base surface. We interpret subfacies 1c as a separated drift. This drift accumulation progrades upslope and the dip of the internal reflectors at its frontal zone increases gradually in that direction.

The structureless to chaotic facies with a distinct lens-shaped external form (facies 2) is characterized by randomly orientated, low-to-moderate amplitude, short reflectors. Facies 2 is interpreted as lowstand fan deposits which is a result of debris flow deposition.

Post-rift sedimentation in the northeastern slope of the Derugin Basin was controlled by different processes depending on age. The lower deposits are generally represented by facies 1a and 1c and have been deposited as paleo-drifts. These contourite drifts include slope-plastered sheeted drifts and separated drifts. Separated drifts occur against emerged tilted blocks and sharp positive features of the unconformity separating syn-rift and post-rift deposits, and are the result of the progradation of footwall-derived material into deeper waters. The middle part of the post-rift section generally includes subfacies 1b and facies 2. The existence of facies 1b and facies 2 shows that lowstand-fan deposition have been predominant in this time. It is known that lowstand-fan deposition occurs when a relative sea-level fall occurs. This fact can help to determine the age of the onset of their deposition. The upper part of the post-rift sediments are drift deposit and have been formed under the influence of bottom currents.

For the lack of time, the contents of the last two contributions have not yet been synchronized. Thus, the seismic facies types discussed here cannot yet be compared with those of section 4.1.1, and the proposed sedimentation processes do not agree with the discussion in sections 4.1.1 and 5.1.

4.2 Magnetics and Gravimetry

(S. Nikolaev and T. Kolpashikova)

Gravity and magnetic measurements were carried out simultaneously with the bathymetric and seismic reflection survey in the northern part of the Derugin Basin and on the northern shelf of Sakhalin Island. They include regional and detailed profiles within the study areas. The regional profiles are oriented in the north-south direction parallel to Sakhalin Island, and the detailed profiles in the east-west direction across the structures studied. In this report, we present preliminary results of gravimetric and magnetic data analyses along profiles 9, 10 and 13 (see Fig. 2 for location). These profiles form a composite E-W section that runs approximately parallel to the latitude of 54.5°, starting with profile 9 in the east to 13 in the west. It crosses the main morpho-structures of the region: the northern part of the Derugin Basin, as well as the northern slope and shelf of Sakhalin Island. Final processing of the geophysical data will be carried out subsequent to the cruise.

The gravimetric and magnetic fields vary more-or-less synchronously along profile 9 (Fig. 13). The data can be divided into an eastern and a western part. The eastern part is characterized by a sharp increase in the gravity, reaching a maximum of ca. 25 mgal and subsequently decreasing gently westward. The accompanying magnetic field shows only minor fluctuations. Local gravity and magnetic anomalies mark the seismically recognized uplifted and tilted blocks of the acoustic basement on the eastern slope of the Derugin Basin. The western part of profile 19 is characterized by an almost constant gravimetric and magnetic field. This might be the result of the occurrence of a deep acoustic basement depression filled by sediments.

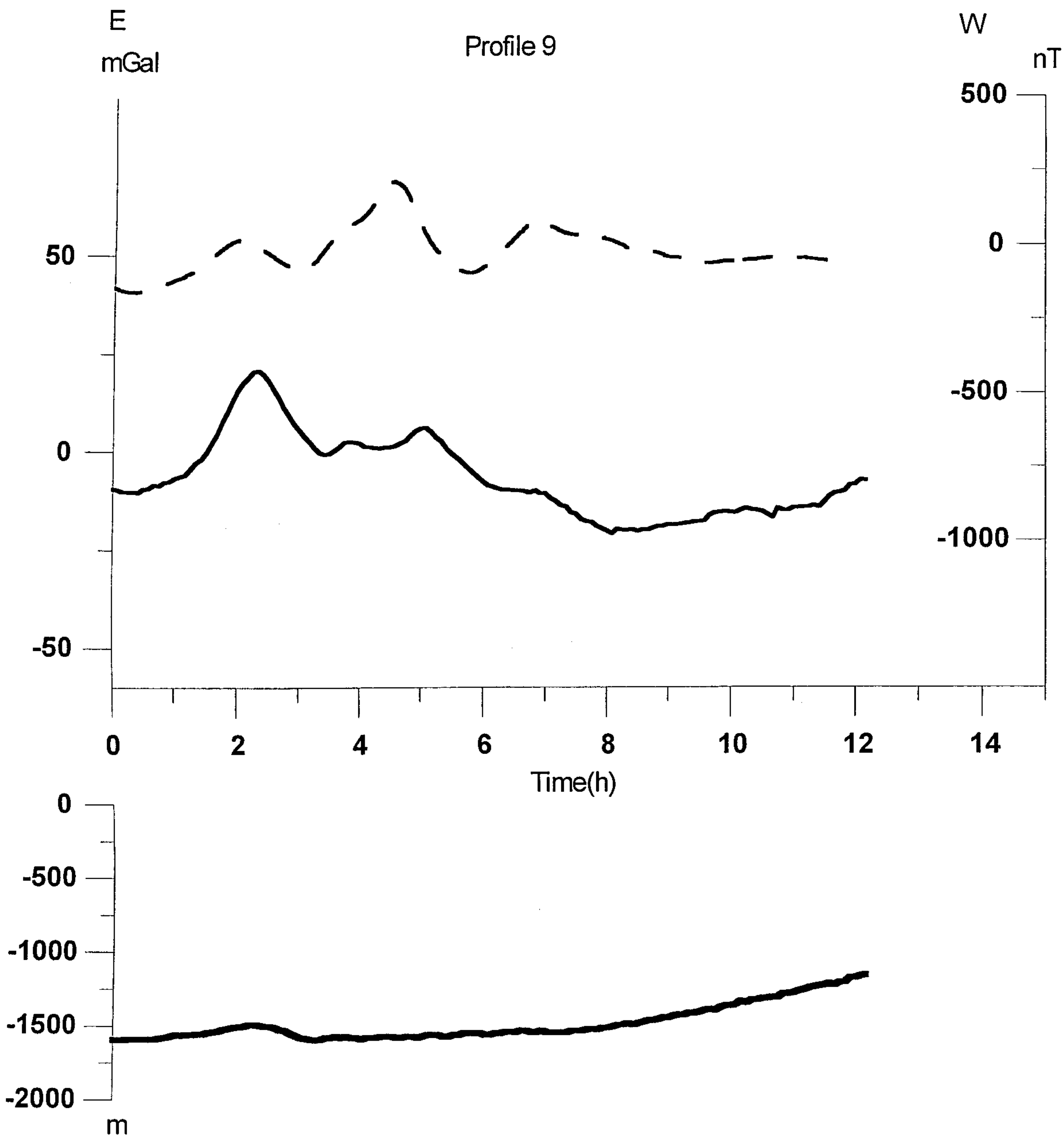

Fig. 13: Preliminary gravity (solid line, top) and magnetic (dashed line, top) anomalies and the bathymetry (bottom) along profile 9. See Figure 2 for profile location.

The gravity and magnetic fields are different in shape along profile 10 (Fig. 14). The magnetic field increases gently at the eastern end of the profile and decreases in a similar manner towards its western end. In between there are two pronounced local magnetic anomalies.

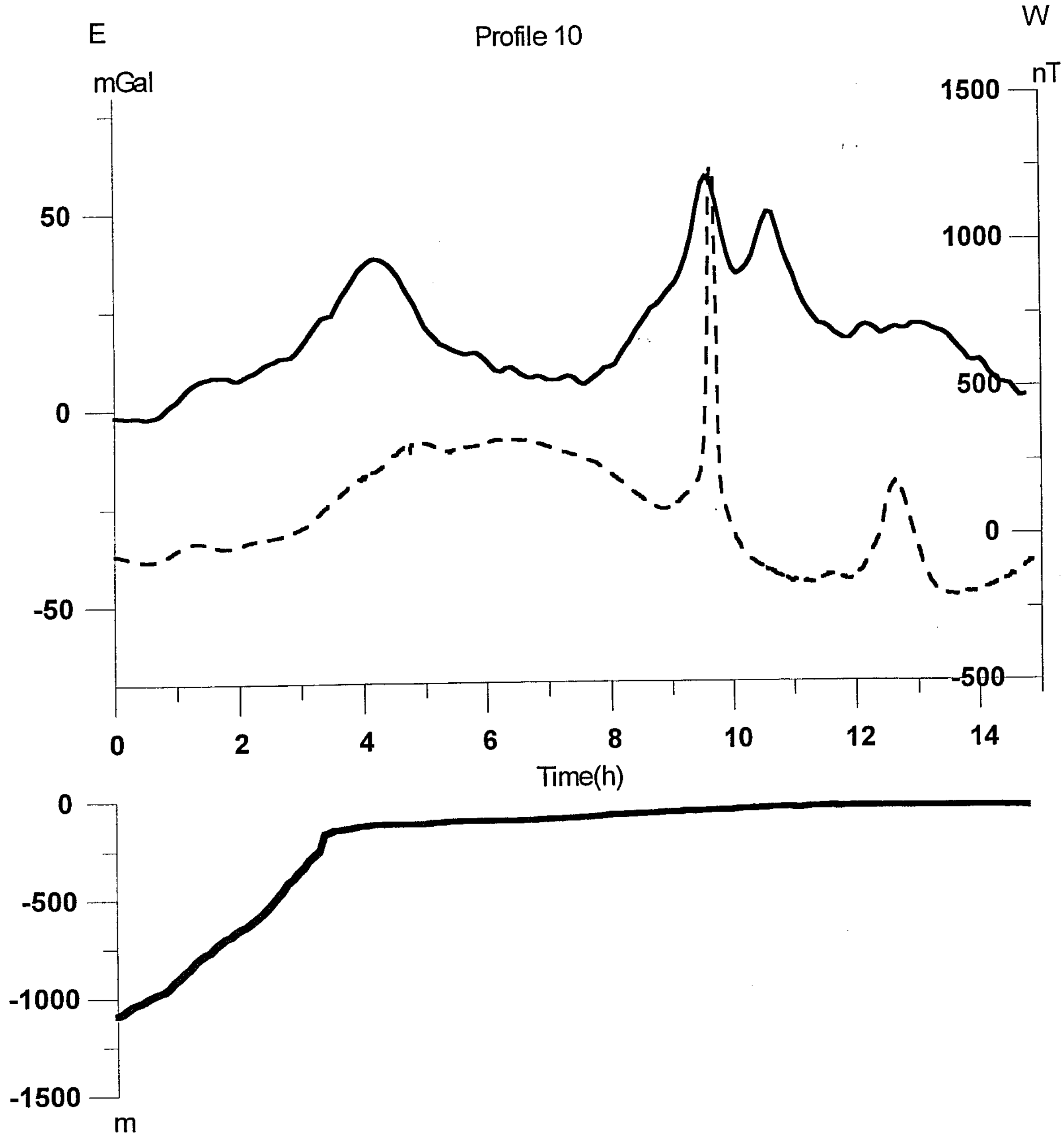

Fig. 14: Preliminary gravity (solid line, top) and magnetic (dashed line, top) anomalies and the bathymetry (bottom) along profile 10. See Figure 2 for profile location.

The eastern anomaly has a relative amplitude of 1200 nT, which probably marks a fault zone filled with volcanic rocks (the same magnetic anomaly is observed at beginning of profile 17). This fault is accompanied by a local negative gravity anomaly with a relative amplitude of –20 mgal. The western magnetic anomaly with a relative amplitude of 400 nT coincides with a sedimentary shelf basin observed on the seismic profile. In contrast to the magnetic field, the gravity field variation shows two wide local anomalies with relative amplitudes of 40-50 mgal. It is possible that these gravity anomalies mark the extensions of the geological structures of Sakhalin onto the shelf and at the shelf-break.

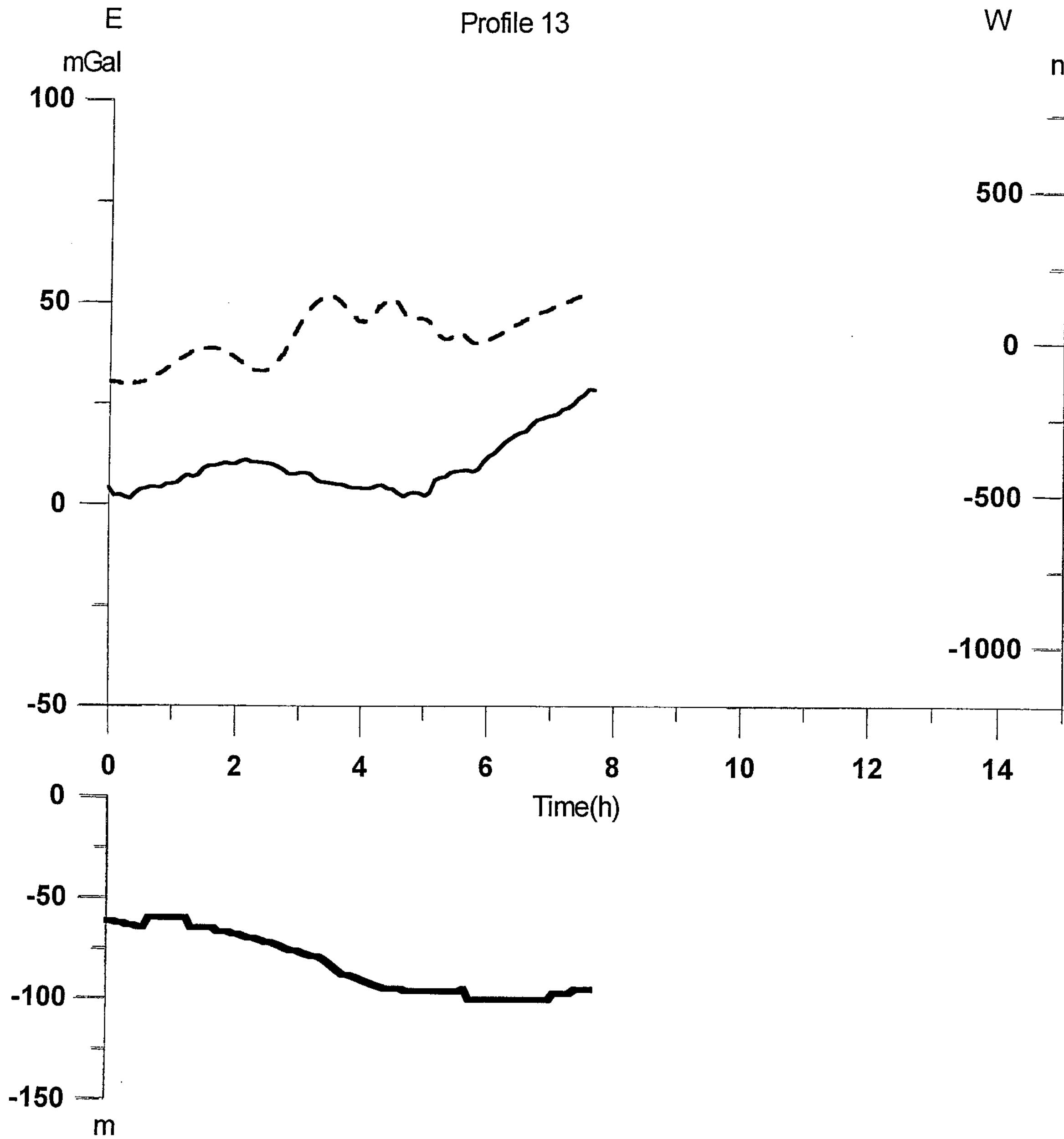

Fig. 15: Preliminary gravity (solid line, top) and magnetic (dashed line, top) anomalies and the bathymetry (bottom) along profile 13. See Figure 2 for profile location.

The sedimentary basin located on the northern Sakhalin shelf may be responsible for the local negative gravity anomaly on the western end of profile 10 (Fig. 14) and in the middle of profile 13 (Fig. 15). The local magnetic anomaly on profile 13 marks the western flank of this sedimentary basin. The overall increase of the geophysical fields on profile 13 to the west might be due to the influence of continental geological structures.

In general, the gravity and magnetic fields increase gently from east to west, from the Derugin Basin to the continental margin. Analyses of the curvature of the magnetic and gravimetric fields and their correlation will provide constraints for the interpretation of the geological structures within the study area.

5. DISCUSSIONS

5.1 Sedimentation processes within the northwestern Okhotsk Sea

(T. Lüdmann)

A study of the reflection seismic profiles reveals that the sedimentation processes within the northwestern Okhotsk Sea are mainly controlled by strong bottom currents. There are three possible types of bottom currents: year-round cyclonal isobath-parallel currents, a pronounced downslope thermohaline convection during the winter when the sea is covered by ice, and perennial tide-induced currents and vertical mixing. These current-controlling factors will now be discussed.

The present current regime is governed mainly by the special hydrographical constellation of the Okhotsk Sea, which is a marginal sea enclosed on three sides by land (Fig. 1). A connection to the Japan Sea occurs via two shallow straits: the Soya Strait (40 m sill depth) and the Tartar Strait (10 m sill depth) (Favorite et. al., 1976). It is suggested by Talley (1991) that the salt flux through these straits is important since it increases the density of the shelf water in the Okhotsk Sea. Through the Kurile Islands the Okhotsk Sea is connected to the North Pacific via two deep straits: (1) the Bussol Strait (sill depth 2300 m) and (2) the Kruzenshterna Strait (sill depth 1900 m) (Fig. 1). The general circulation within the Okhotsk Sea consists of a broad cyclonic gyre. North Pacific waters (NPW) enter through the Kruzenshterna Strait, flow counterclockwise around the sea and exit through the Bussol Strait (Kitani, 1973; Favorite, et al. 1976; Alfultis and Martin, 1987; Talley and Nagata, 1995).

75 % of the Okhotsk Sea is covered by sea ice with an average thickness of ca. 1 m in the winter. The ice formation and the subsequent brine release produces cold saline waters which lead to the formation of the basin-wide 100-m-thick subzero dichothermal layer with waters colder than about –1.5 °C extending between 50 to 150 m in depth (Kitani, 1973; Talley and Nagata, 1995). Therefore, in addition to the Gulf of Alaska (You et al., 2000), the Okhotsk Sea is considered a possible source area for the North Pacific Intermediate Water (NPIW;

Talley, 1991; Freeland et al., 1998). The oxygen-rich Okhotsk Sea Intermediate Water (SOIW), found between depths of 200 and 1000 m (Wong et al., 1998), flows into the Pacific Ocean and ventilates the Pacific subpolar gyre (Talley, 1991; Freeland et al., 1998). The formation of the SOIW during the summer months might be associated with the inflow of the saline Tushima Current from the Japan Sea through the Soya Strait (Fig. 1; Wanatabe and Wakatsuchi, 1998). During the winter months, however, the formation of sea ice leads to the creation of dense, saline shelf waters, especially along the northwestern shelf (Kitani, 1973; Talley and Nagata, 1995). These waters move off the shelf and sink to a depth of 600 m (Wong et al., 1998). An example of such water movements is the dense water formed during the winter in two prominent polynya regions on the northern shelf of the Okhotsk Sea which moves to the west as a gravity-driven slope current (Gladyshev et al., 2000).

Potential vorticity calculations along a hydrological transect from the North Pacific through the Bussol Strait across the Derugin Basin to the northwestern shelf shows that the Okhotsk Sea may be separated vertically into four zones by the vorticity of its water mass (Freeland et al., 1998). Within the Derugin Basin, the highest vorticities occur from the water surface down to a depth of ca. 200 m (zone 1). This zone is underlain by a region of low vorticity extending down to a depth of perhaps 450 m (zone 2). Zone 3 between a water depth of 450 and 650 m exhibits an increase in vorticity with depth, whereas zone 4 (>650 m) is characterised by a steady decrease in vorticity. Below 1000 m, high silicate and low oxygen values indicate that the deep Derugin Basin is an old water mass with little exchange with waters above it (Freeland et al., 1998).

Tides can also lead to year-round current formation in the Okhotsk Sea, as well as to the development of polynyas along the coast and above submarine basement highs. Polyakov & Martin (2000) demonstrated that during the winter season, diurnal tides produce a pronounced polynya above the Kashevarov Bank (200 m water depth) (Fig. 2).

5.1.1 Amur River

The main sources of sediment input into the northwestern Okhotsk Sea are: the Amur River, the broad northwestern shelf, ice-rafted debris and shells of micro-organisms (especially diatoms). The Amur River delivers 68 % (315 km^3/yr) of the total continental freshwater runoff into the Okhotsk Sea (Zuenko & Yurasov, 1997). The total drainage area of the Okhotsk Sea is 2.6×10^6 km^2, of which again about 68 % is contributed by the Amur. In terms of sediment load, the Amur transports an average of 52×10^6 t/yr into the Okhotsk Sea

(Milliman & Meade, 1983). Today, this river enters the sea in the North through Sakhalin Gulf and in the South through Tartar Strait. (Fig. 2).

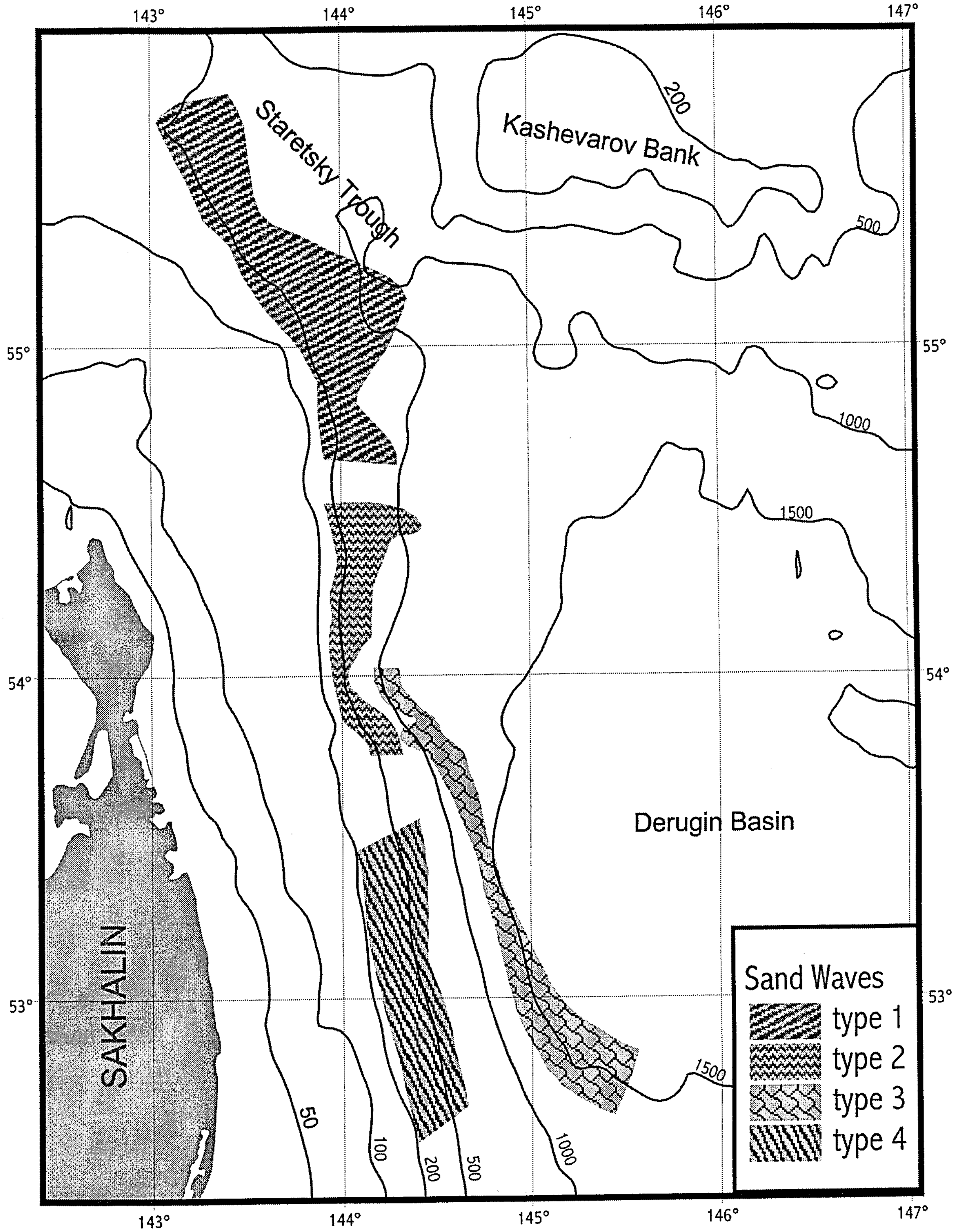

Fig. 16: Sediment waves types 1-4 mapped in the northwestern Okhotsk Sea. See text for explanation.

Our seismic profiles near the mouth of the Amur at a water depth of ca. 220 m show northward prograding clinoforms with an oblique-tangential reflector configuration (Fig. 10). The dip of the reflectors decrease gradually in the lower part of the forset beds, forming concave-upward strata which pass into gently-dipping bottomset beds. This seismic pattern implies a depositional regime with some combination of high sediment supply, slow-to-no basin subsidence and a sea-level stillstand to allow a rapid basin infill and sedimentary bypass of the upper depositional surface (Mitchum et al., 1976). The basinward progradation of the offlap break suggests a regression of the shoreline. We interpret this prograding clinoform pattern to mark a delta wedge deposited during a slow relative sea-level fall or a stillstand. There is a stacking of several generations of delta wedges, indicating several cycles of sea level change (Fig. 10).

Subsequent to the Holocene sea level rise when the depocenter retrograded to its present position at the Amur river mouth, a new sedimentation process was established. Profile 11 shows that the last delta wedge is overlain by another delta wedge-like structure with an oblique-tangential reflection pattern but prograding southward in a direction opposite to the fluvial progradation (Fig. 10). A similar sedimentary body was identified during the SAKURA cruise (1999) of KOMEX phase I. It lies within the Staretsky Trough at a water depth of ca. 340 m, prograding southwestward up the slope of the North Sakhalin continental margin. We interpreted this feature as a contouritic separated drift. Despite a distance of ca. 80 km between them, these bodies might belong to the same structure, namely an elongated drift on the North Sakhalin slope at depth range of 200-340 m. We suggest that this drift deposit was formed by strong alongslope bottom currents which entered the Straretsky Trough from the northwest, north of Sakhalin Bay. Here the trough is at its narrowest, so that the bottom currents must accelerate. Flowing southeastward these currents are deflected to the right by the Coriolis force, leading to a prominent upslope and a subordinate alongslope migration of the drifts on the southwestern flank of Staretsky Trough (see section 5.1.3 for further discussions).

5.1.2 Sediment waves

A prominent feature at the northern continental margin of northeastern Sakhalin are sediment waves. They vary in dimension (amplitude and wavelength), shape and their local distribution. The additional seismic data of this cruise allow a better correlation between different wave fields than was possible with data from KOMEX phase I alone. Fig. 16 shows the regional extent of the fields which group into the three water depth ranges of 200-700 m, 400-900 m and 900-1600 m. The wave fields in the depth range of 400 to 900 m can be subdivided those within the Staretsky Trough and those at the continental margin of northeastern Sakhalin. They are separated by an area devoid of sediment waves (Fig. 16, types 1 and 2). Here we use the wave classification scheme of Faugéres et al. (1999), in which several criteria were used to distinguish between turbidite and contourite waves as well as slope sediment ridges.

According to these criteria, our type 1 waves can be interpreted as contourite waves with wavelengths of ca. 380 to >770 m and amplitudes of 10-35 m (Figs. 6 and 16). Their migration exhibits variable character form slight upstream to slight downstream and standing waves may occur. Moreover, they show no regular downstream changes in dimension and depositional geometry but distinct irregular geometry variations within the stratigraphic column. Some waves are on the surface and are possibly active, others are buried under by sediments.

Type 2 waves are composed of sediment waves with wavelengths of ca. 400 to >800 m and amplitudes of 10-20 m (Fig. 16). Upslope migration prevails with decreasing wave sizes downslope. Their occurrence is limited to a water depth of 400-900 m. Generally these sediment waves are buried, indicating that they are at present no longer active. They are either due to slope-parallel currents or to constant strain-induced plastic creep which leads to slope shortening and plastic deformations. However, an association with recent tectonics along the Inessa Deformation Zone (see section 5.2.3) appears unlikely because the compressional deformation would then involve the entire sedimentary column as is the case for type 3 sediment waves.

Upslope migrating sediment waves of ca. 400 to >1130 m wavelengths and amplitudes of 15-20 m are typical for type 3 waves (Figs. 9 and 16). These waves are more-or-less slope parallel and have sinuous or curvilinear crests. They are restricted to the continental rise between 900-1600 m. Obviously their amplitude and wavelength decrease with decreasing slope gradient. Thus, they can be interpreted as slope sediment ridges associated with compressional movements along the continental rise of the southwestern Derugin Basin (see section 5.2.3).

Type 4 consists of more-or-less symmetric sediment waves with wavelengths of ca. 500 m and amplitudes of ca. 15 m (Fig. 16). They parallel the slope, have a sinuous geometry but no distinct migration trend. They are confined to a depth range of 200-700 m. Contour currents may have contributed to their occurrence.

5.1.3 Downslope vs. alongslope processes

Sedimentation at continental margins is often influenced by the complex interaction between gravitational downslope and current-controlled alongslope transport mechanisms. Such interactions have been described on passive continental margins such as those found in the North, West and South Atlantic (Heezen, 1966; Hollister & Heezen, 1972), the Indian Ocean and around the Antarctic, as well as on active margins such as in the Sumba Basin and near New Zealand (Reed et al., 1987; Carter & McCave, 1994). The influence of bottom currents on sediment accumulation and erosion at the seafloor is particularly strong in areas where a highly complex bottom morphology leads to a deflection or focusing of these currents and with it an intensification of the flow (Stoker, 1998).

The reflection seismic investigations carried out within the framework of the KOMEX project show that alongslope sedimentation processes are dominant within the northwestern Okhotsk Sea. They seem to prevail year-round and are controlled by strong bottom currents. The seismic facies types 1, 2a and 2b (Fig. 5) can be interpreted as drift sediments. Their distribution in the northwestern Okhotsk Sea is concentrated on the continental slopes. Sediments deposited by downslope processes can also be recognized interfingering with the sediment drift. They imply possibly earthquake-triggered mass movements or basinward shifts of the depocenters during sea-level lowstands.

Seismic profile 23 oblique to the strike of the northeastern slope of Sakhalin (Fig. 7) shows an example for the occurrence of alongslope and downslope sedimentation processes during different geological times at the same location. In the southwestern part of the section is a channel-levee-complex with a central channel and its bounding levees as well as distal well-stratified overbank deposits (water depth ca. 720 m). It is interpreted as a slope fan accumulated during a period of relative sea-level fall, when the depocenter shifted close to the present shelf-break, bypassing the shelf areas and funneling clastic material via this slope fan into the Derugin Basin. On top of the buried fan a drift body can be clearly identified. It is characterized by wavy subparallel reflectors of high-to-medium amplitude downlapping on the southwestern flank of the fan channel. This reflection pattern indicates a current flow along the contour-oblique trend of the slope fan channel with erosion to the southwest and deposition to the NE leading to a combined alongslope and downslope migration of the drift. Its relative position above the slope fan implies that during the accompanying relative sea-level rise, downslope processes may have replaced the alongslope transport of sediment, thereby establishing the present depositional regime.

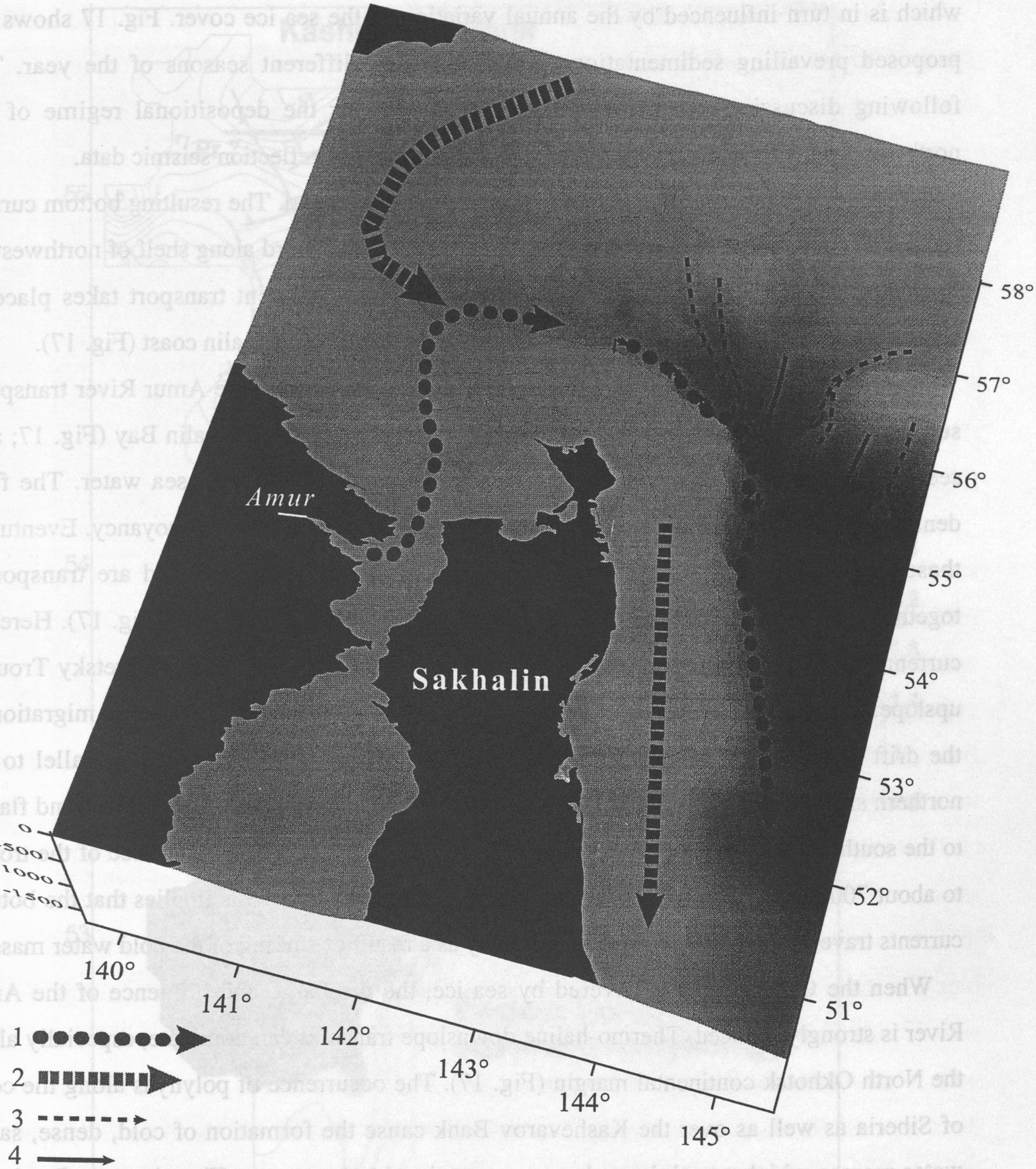

Fig. 17: Sketch showing recent current-controlled sedimentation processes in the northwestern Okhotsk Sea. (1) sediment-laden Amur River runoff during the warm season (2) year-round cyclonal isobath-parallel surface current; (3) downslope-currents during the cold season (sea ice cover); (4) direction of drift migration. See text for explanation.

5.1.4 Annual variations in sedimentation processes within the northwestern Okhotsk Sea

Our seismic investigations of KOMEX phases I and II demonstrate that the sedimentation processes within the northwestern Okhotsk Sea are at present mainly controlled by the action of bottom currents. These currents are a result of the hydrographic regime of the Okhotsk Sea, which is in turn influenced by the annual variation of the sea ice cover. Fig. 17 shows the proposed prevailing sedimentation processes during different seasons of the year. The following discussion summaries possible scenarios for the depositional regime of the northwestern Okhotsk Sea based on the interpretation of our reflection seismic data.

Cyclonic circulation of the surface waters occurs year-round. The resulting bottom current transports the accumulated material as sediment waves southward along shelf of northwestern Sakhalin. Moreover, an important southward longshore sediment transport takes place as attested to by barrier-lagoon complexes along the northeastern Sakhalin coast (Fig. 17).

Starting with the snowmelt and during the sea ice-free season, the Amur River transports suspension load as over- or interflow far from its mouth into the Sakhalin Bay (Fig. 17; also see satellite image of the cover page). Here this flow is mixed with sea water. The flow density increases and the particles in suspension sink because of loss in buoyancy. Eventually these particulates are drawn into the near-bottom cyclonal currents and are transported together with detritus from the shelf off Siberia into the Staretsky Trough (Fig. 17). Here the currents are deflected by the Coriolis force to the right (SW flank of the Staretsky Trough) upslope. This leads to an upslope erosion combined with an up- and alongslope migration of the drift sediments. Our seismic profiles show that moats have developed parallel to the northern slope of Sakhalin and the SW flank of the Staretsky Trough. They widen and flatten to the southeast and go from a water depth of ca. 200 m at the western entrance of the trough to about 700 m on the northwestern flank of the Derugin Basin. This implies that the bottom currents travel oblique to the isobaths probably as a result of sinking of the cold water mass.

When the Okhotsk Sea is covered by sea ice, the discharge and influence of the Amur River is strongly reduced. Thermo-haline downslope transport can dominate, especially along the North Okhotsk continental margin (Fig. 17). The occurrence of polynyas along the coast of Siberia as well as over the Kashevarov Bank cause the formation of cold, dense, saline water masses which travel downslope as a gravity-driven current. The giant confined drift bodies of the seismic facies 2a (Fig. 5) was probably created by such downslope currents. As the currents reach the floor of the Staretsky Trough, they flow down-trough until their density equals that of the surrounding water when they stop to sink. In the shallower part of the Staretsky Trough, these currents might have generated the type 1 sediment wave fields by eroding the floor of the trough axis and depositing their sediment load to the right (southward) of their flow direction (southeastward) due to the Coriolis effect (Fig.16).

Besides current-controlled sedimentation, other processes such as hemipelagic deposition of diatoms tests (abundant within the Okhotsk Sea) and ice-rafted debris are important.

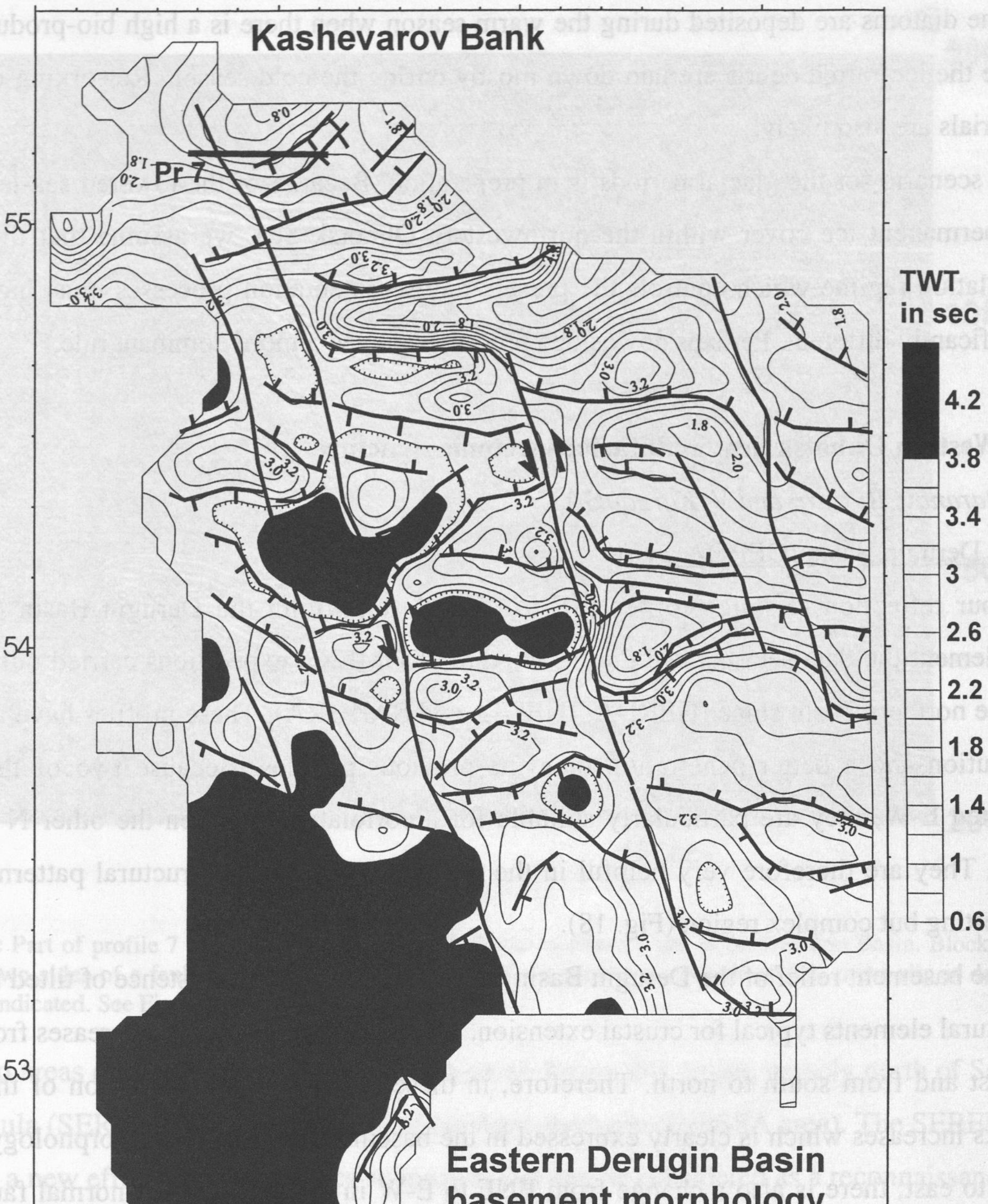

Fig. 18: Basement morphology of the eastern Derugin Basin (GERDA area). Contour interval is 0.2 sec TWT. Lines with bars show normal faults. Lines with arrows mark strike-slips.

The diatoms are deposited during the warm season when there is a high bio-productivity, while the ice-rafted debris are laid down mostly during the cold season. Reworking of these materials are also likely.

A scenario for the glacial periods is in preparation. Because of the lowered sea-level and the permanent ice cover within the northwestern Okhotsk Sea, we assume that the water circulation regime which controls the present-day sedimentation processes must have been significantly different. Perhaps downslope processes played a more dominant rule.

5.2 Western Okhotsk Sea: multifarious tectonic structure

(B. Baranov, B. Karp and V. Karnaukh)

5.2.1 Derugin Basin (GERDA area)

Four reflection seismic profiles (SE-6 – SE-9) run within the Derugin Basin (Fig. 2) supplement the data set obtained during the three KOMEX I expeditions carried out mainly on the northern basin slope (GERDA, INESSA and SAKURA). These profiles have a higher resolution and a better penetration than the previous profiles. Because two of them are oriented E-W, they are particularly suitable for a correlation between the other N-S track lines. They are therefore very helpful in the reconstruction of the structural pattern of this interesting but complex region (Fig. 18).

The basement relief of the Derugin Basin is characterized by the existence of tilted blocks - structural elements typical for crustal extension. The amount of extension decreases from west to east and from south to north. Therefore, in these directions the dimension of the tilted blocks increases which is clearly expressed in the basement and sea floor morphology. From west to east, there is also a change from ENE to E-W in the strike of the normal faults and with it that of the blocks which they bound on one side or on both sides. Sometimes both directions (ENE and E) are observed at the same place and this leads to development of triangle-shaped blocks or troughs.

There are relative displacements between and within the blocks along NNW-trending strike-slip faults, which appear in the basement as narrow highs or troughs (Fig. 19). Although the strike-slips are clearly recognizable, the sense of motion is obscured because both sinistral and dextral movement are observed. The dextral motions along the NNW faults correspond well with the sense of motion of the neighboring Sakhalin Shear Zone and therefore extension in the western Derugin Basin may be governed by this process. East of the Sakhalin Shear Zone, left-lateral movements gradually prevail; this may be associated with internal deformations of the interior of the Okhotsk plate due to its rotation.

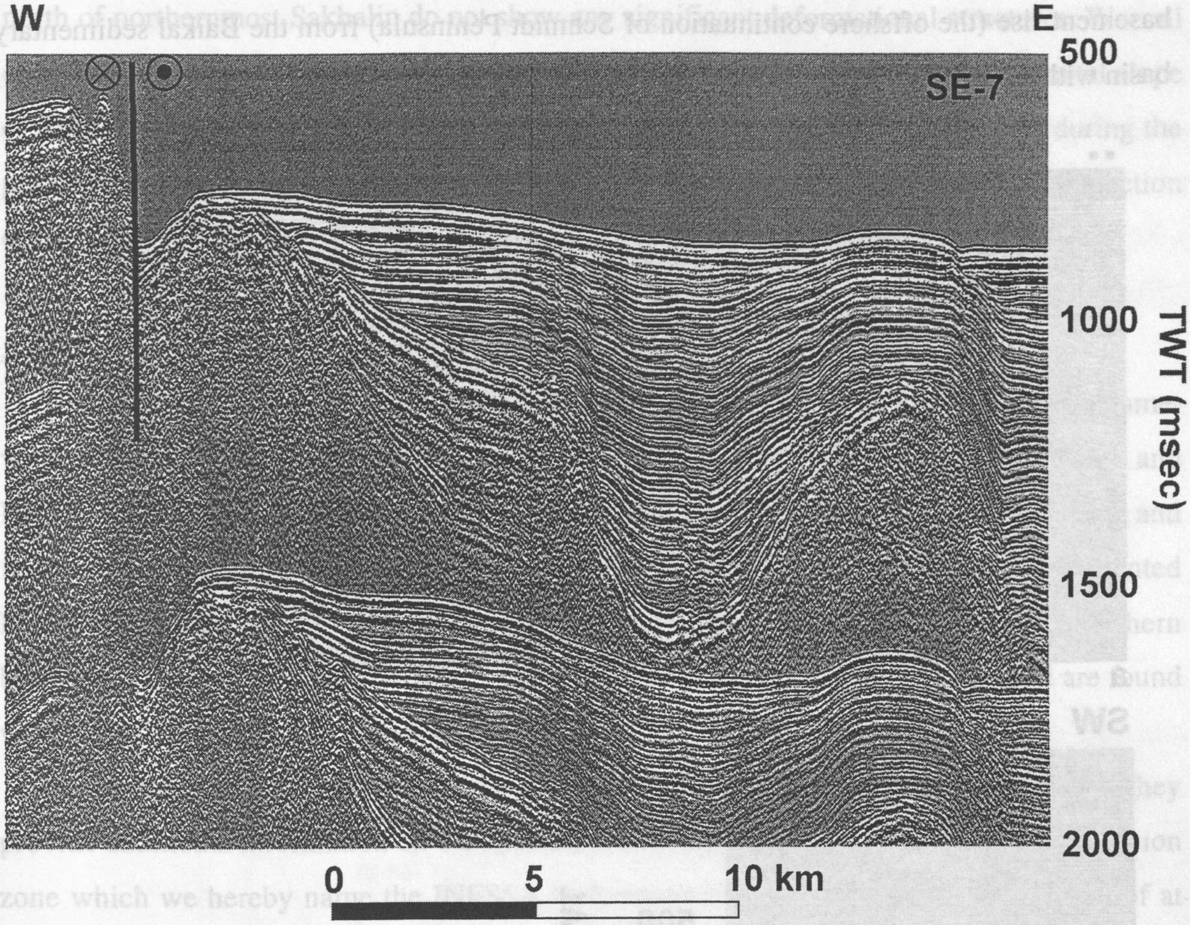

Fig. 19: Part of profile 7 showing the N-S strike-slip at the northern slope of the Derugin Basin. Blocks on the two sides of a fault tilt in opposite directions. The suggested motion along this strike-slip is dextral as indicated. See Figure 2 for profile location.

Two areas offshore Sakhalin were investigated during this cruise, namely north of Schmidt Peninsula (SERENADE area) and east of northern Sakhalin (INESSA area). The SERENADE area is a new effort for the tectonics subproject and can be considered as a reconnaissance.

5.2.2 Northern Sakhalin shelf (SERENADE area)

A system of fan thrusts with a NW to WNW strike were mapped on the northern Sakhalin shelf by Worrall et al. (1996). They postulated that it originates at the termination of the East Sakhalin Fault which is a continuation of the dextral Sakhalin Shear Zone.

The study area north of Sakhalin consists of the shelf with depths less that 200 m. Therefore, multiple reflections mask the seismic records. However, several faults could be clearly recognized on profiles 10, 16 (Fig. 20). The zone of faulting has a NW strike. It is located at the offshore continuation of the Schmidt Peninsula and corresponds in general to the zone described by Worrall et al. (1996), although the locations of individual faults may be different. This zone has a distinct western boundary marked by a fault which separates the basement rise (the offshore continuation of Schmidt Peninsula) from the Baikal sedimentary basin with a basement depth of more than 7 km (Svarichevsky, 1999).

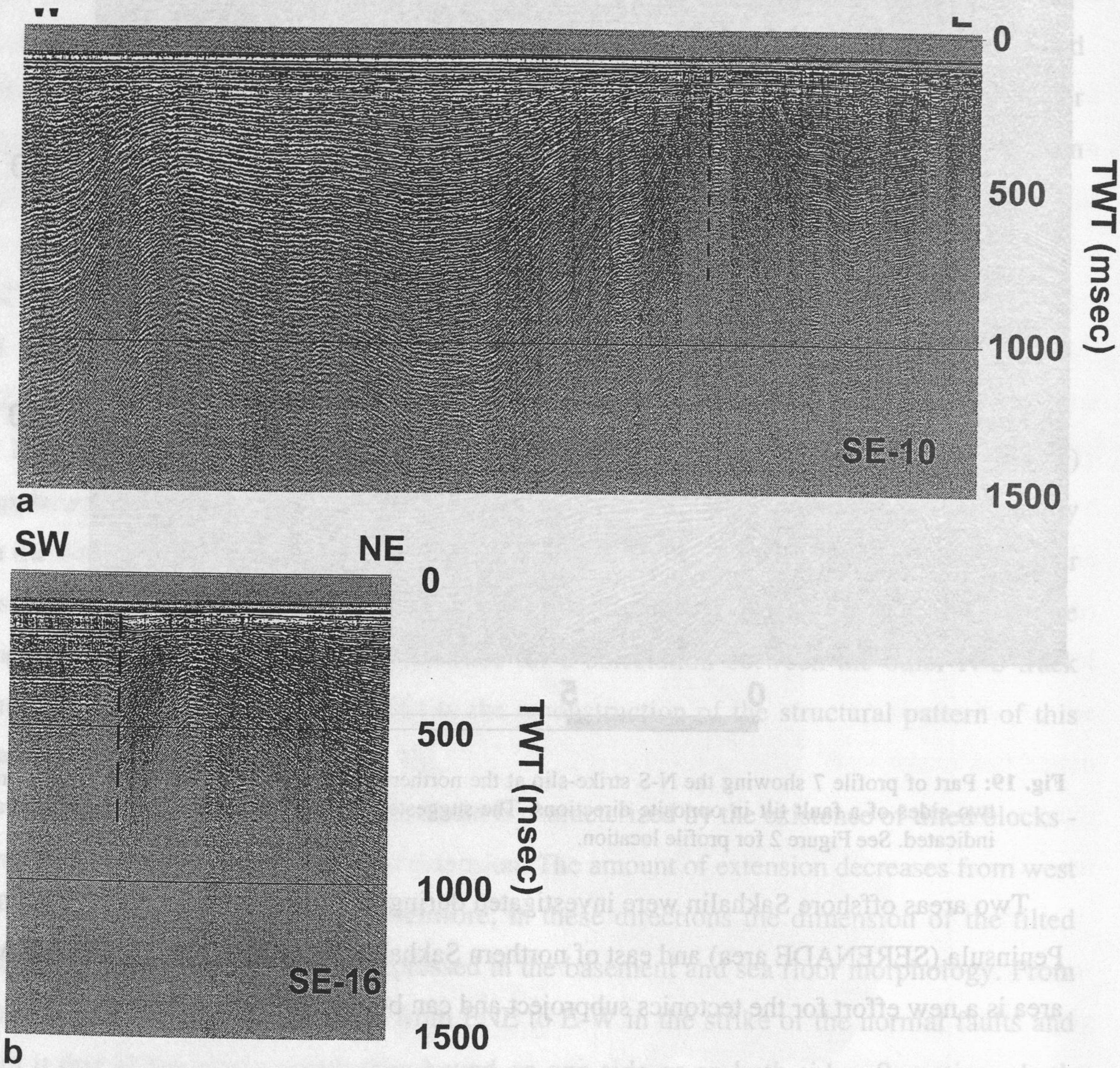

Fig. 20: Part of seismic profiles 10 (a) and 16 (b) (see Fig. 2 for location) showing sediment deformations associated with a system of thrusts at the northern termination of the Sakhalin Shear Zone as suggested by Worrall et al. (1996).

The fault appears on our seismic records as an asymmetric, west-vergent fold that coincides with the dip of a reverse fault in the east as published by Worrall et al. (1996). Profiles 14 and 15 (see Fig. 2 for locations) cross several subvertical faults west of this boundary. These faults do not show any vertical displacement along their fault planes and can be regarded as minor strike-slips.

The eastern boundary of the thrust zone is located on the Sakhalin shelf following the offshore continuation of Schmidt Peninsula. Track lines which cross the continental slope north of northernmost Sakhalin do not show any significant deformational structures. Worrall et al. (1996) suggested that the Kashevarov Shear Zone continues up to the continental slope of Sakhalin and stops at 54° N. Neither does the present data nor the data collected during the previous KOMEX cruises support this assumption. Hence, the question about the connection of the Kashevarov and Sakhalin shear zones remain unanswered.

5.2.3 Northeastern Sakhalin slope (INESSA area)

The INESSA area was investigated in 1998 and 1999 during two cruises within the framework of KOMEX phase I. Data from the INESSA and SAKURA expeditions (Biebow and Hütten, 1999, Biebow et al., 2000) show that the recent compressional structures (thrusts and folds) continue along the Sakhalin slope for a distance of at least 200 km. They are oriented NW-SE and can be traced from the southern boundary of the INESSA area to the northern boundary. The deformation zones are oriented oblique to the strike of the slope and are found within the depth range of 1,450-1,250 m to the south and of 800-600 m to the north.

During the SERENADE cruise, nine profiles across the continental slope were run. They provide additional information on the structure and morphology of this important deformation zone which we hereby name the INESSA Deformation Zone. This zone has an extent of at least 200 km as already mentioned starting between profiles SE-5 and IN-41 and ending somewhat north of profile SE-10 (Fig. 21). However, its continuation further to the north and its connection with the Kashevarov Shear Zone remain unclear.

The INESSA Deformation Zone strikes in general in a NNW-SSE direction (340°) slightly oblique to the isobaths of the continental slope and is located within the depth interval of 1,290-1,723 m in the south (profile SE-5) and 286-375 m in the north (profile SE-10) narrowing northward. It consists of two segments marked by a change in strike and with it a change in structural pattern. The segment boundary lies between profiles IN-16 and SE-26 and coincides with the change in strike of the lower slope.

The southern segment is located on the lower slope within the depth interval of 1,290-1,723 m at southern end of SE-5 and 1,053-1,215 m at the northern end of IN-16. It has a Z-shaped outline. On the three southern profiles SE-5, IN-4 and SA-3 (Fig. 21), this segment coincides with the field of regular sediment waves. The number of waves and width of the field increase from north to south (Fig. 16, type 3 sediment wave; Fig. 21). We suggest that these sediment waves have mainly a tectonic rather than a sedimentary origin for two reasons. Firstly, the thickness of the wave layer on profile SE-5 reaches up to 1 sec TWT (more than 1 km) (Fig. 9, profile SE-5). For a sedimentary origin, that would imply a constant water circulation regime for a long time period, perhaps several million years. This scenario seems unlikely for a marginal sea such as the Okhotsk Sea with its rapidly-changing environmental conditions. Secondly, subvertical or inclined planes which displace and deform the reflectors are clearly visible on the seismic records (Fig. 9, profiles SE-5 and SE-28). They planes may be considered reverse faults or thrusts which would imply that the sediment waves are mainly folds connected with a compressional regime.

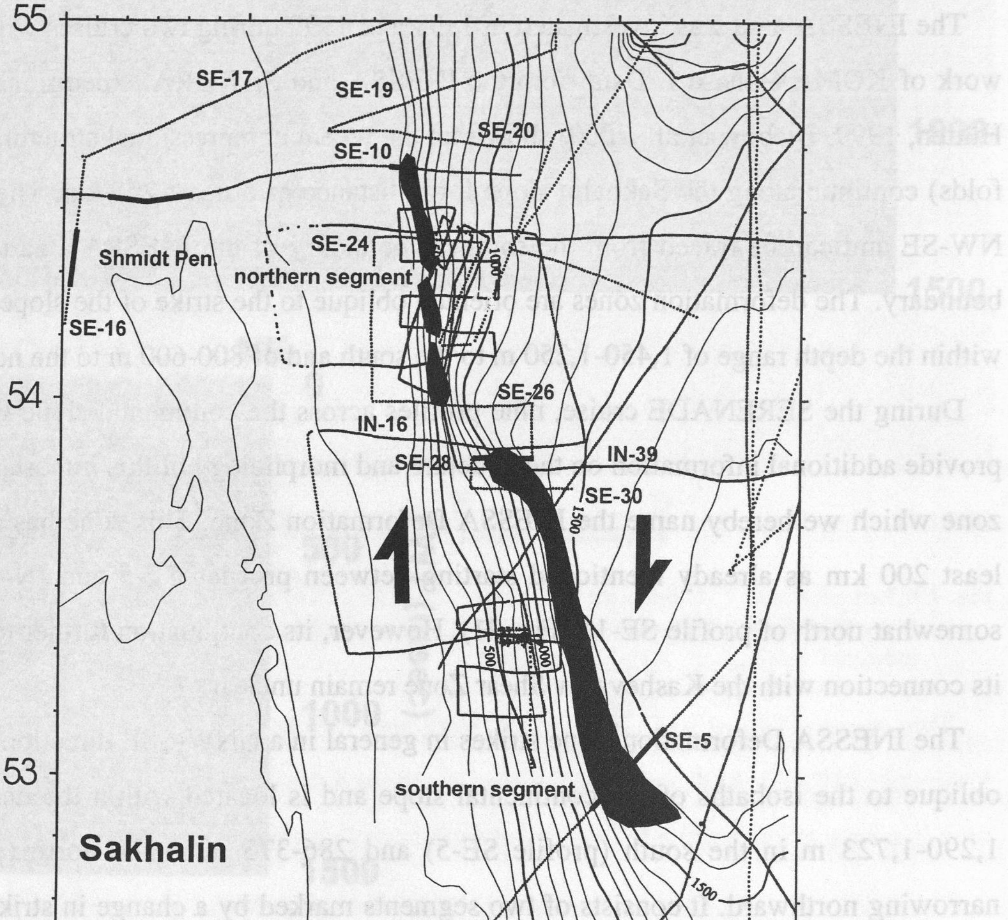

Fig. 21: Schematic outlines of the INESSA deformation zone (gray). The Z-shape of its southern segment and the dextral *en echelon* arrangement of the northern segment account for dextral shearing as indicted by the arrows. The isobath interval is 100 m. Thin gray lines show track lines of the KOMEX expeditions. Thick black lines mark location of profiles shown in Figs. 9 and 20 (see also Fig. 2 for location).

To the north, the structural pattern of the southern segment changes significantly from one profile to another and compared with the pattern of the regular "sediment waves" observed to the south. Here the planes are more clearly visible and it is possible to distinguish two to three thrusts that extend to the sea floor (Fig. 9, profile SE-28). Profile IN-39 (Fig. 21) obtained during the INESSA cruise (1998) shows sediments which are pushed upslope along a shallow thrust, leading to underplating of the same reflector. Hence, the compressional stress is possibly higher than in the southern part of the southern segment.

The northern segment is displaced upslope and consists of several dextral *en echelon* faults. This part of the deformation zone is located within shallower water depths and is less pronounced. It appears as a belt of folds which only weakly budge the sea floor (Fig. 9, profile SE-10). Here, the reverse faults can be distinguished only in isolated cases.

The specific features of the deformation zone, namely the Z-shaped form of the southern segment and dextral *en echelon* arrangement of the northern segment, show that this region is formed under dextral movements and therefore has a genetic relationship with the Sakhalin Shear Zone. This zone is probably significant also for the occurrence of methane seeps in this area.

5.2.4 Northwestern Kurile Basin slope (SERENADE area)

Two profiles (SE-1 and SE-32) were run outside the main study area for a reconnaissance of the structure of the northern Kurile Basin slope (Fig. 22, insert shows SE-1, not SE-2). The structure of the northern and southern flanks of the Kurile Basin is very interesting from the point of view of its opening mode. Many authors (Kimura & Tamaki, 1986; Maeda, 1990; Gnibidenko et al., 1995; Takeuchi et al., 1999) suggested that this basin opened in the NW-SE direction. However, new seismic data obtained within the framework of the KOMEX project strongly support the suggestion (Baranov et al., 1995) that the direction of extension was oriented SW-NE. It was found that the structural pattern of the eastern part of the northern slope of the Kurile Basin is characterized by the existence of normal faults oriented oblique to the general northeastern trend of the slope (Baranov et al., 1999). These observations constitute strong evidence for an initial opening of the Kurile Basin along-strike rather than across-strike. This mode of opening most likely continued throughout the phase of oceanic crust generation. KOMEX data on the NNW-oriented basement high (the Sakura Rise) in the central part of the basin show a clear rift imprint. This rift structure is recognizable as a NNW-striking symmetric system of outwardly tilted blocks bounded by inward-facing fault scarps (Baranov et al., submitted).

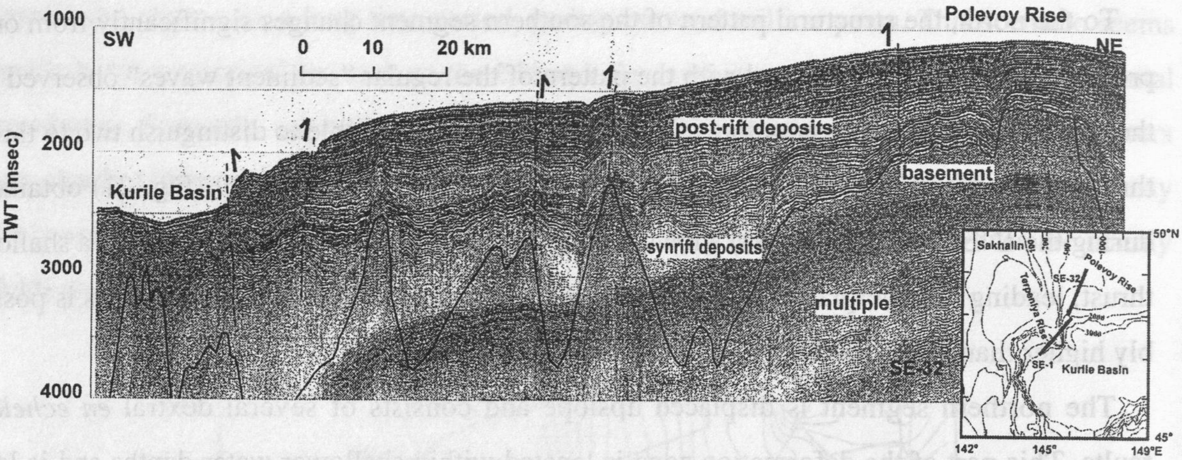

Fig. 22: Seismic profile 32 across the northwestern slope of the Kurile Basin. Its basement consists of several tilted blocks. The blocks and limited normal faults strike in the NW-SE direction. Dashed lines indicate recent reverse faults (insert shows the location of the profile; see also Fig. 2).

The first profile (SE-1) crosses the Terpeniya Ridge. Although its quality and penetration was inadequate, it is obvious that this ridge can be regarded as a NNW-striking, eastward-dipping tilted block. On this cross section, its top lies at a water depth 174 m and it has a flat surface indicative of erosion and subsequently block subsidence.

The second profile (SE-32), 144 km long, starts on top of the Polevoy Rise (water depth 804 m) and ends at the base of the Terpeniya Ridge at a water depth of 1932 m (Fig. 2). Here the slope is concave and is determined by the N-S-striking Terpeniya Ridge to the west and by the N-W-striking Polevoy Rise to the east. The depth to basement increases from 1.6 sec to more than 4 sec TWT from northeast to southwest. The basement itself consists of several tilted blocks (Fig. 22), the largest of which corresponds to the Polevoy Rise and is tilted to the west. Normal faults cut the top of the block to form a horst structure. Smaller tilted blocks appear downslope; they face to the east or west and develop grabens and half-grabens in the basement. The basement high, which has a different morphology than that of the titled blocks, is located at the southwestern the end of this profile. Its top consists of three peaks, which can be considered as volcanic edifices.

The minimum sediment thickness (about 0.5 sec TWT) is observed on top of the Polevoy Rise. The maximum thickness of >2 sec is observed on the foot of the rise. The sediment cover consists of several seismic units. In some places, an unconformity which separates the syn-rift from the post-rift deposits is clearly distinguishable. Recent compressional deformations of the sedimentary cover appear as gentle folds. Additionally, reverse fault are observed along the entire profile and their abundance increases from east to the west towards the basin.

According to the satellite altimetry map and the basement map of Svarichevsky (1999), the Polevoy Rise and other basement highs are represented by tilted blocks striking in the NW direction which is orthogonal to the general strike of the Kurile Basin. These data together with data obtained on the northeastern slope of the Kurile Basin (GREGORY area) support the idea of NE-SW extension in the Kurile Basin, at least during its rifting stage. The time of rifting is unclear because of the absence of age dating for the unconformity separating the syn- and post rift deposits. This area is under compression in Recent times as indicated by folding and reverse faulting expressed on the sea floor as steps or moats. Evidence for compression within the Derugin Basin was provided by the seismic data of the previous KOMEX cruises (GERDA and SAKURA) and apparently compression governs the present tectonic regime of the entire Okhotsk Sea.

6. REFERENCES

Alfultis and Martin, 1987. Satellite passive microwave studies of the Sea of Okhotsk ice cover and its relation to oceanic processes, 1978-1982. J. Geophys. Res., **92** (C12): 13,013-13,028.

Baranov B. V., Dozorova K. A. & Svarichevsky A. S. 1995. Kurile Basin and Okhotsk Rift System: Kinematics of opening. Third International Conference on Asian Marine Geology. Abstracts, 13-14. October 17-21, 1995, Cheju, Korea.

Baranov B. V., Dozorova K. A., Karp B. Ya. & Karnaukh V. A. 1999. Geometry of the Kurile Basin opening. Papers of the Russian Academy of Sciences **367**, 376-379 (in Russian).

Baranov, B., Wong, H.K., Dozorova, K., Karp, K., Lüdmann, T. and Karnaukh, V., submitted. Opening geometry of the Kurile Basin (Okhotsk Sea) as inferred from structural data. The Island Arc.

Biebow, N. & Hütten, E., 1999. KOMEX: Kurile-Okhotsk Sea Marine Experiment. Cruise Reports: KOMEX I and KOMEX II, R/V Professor Gagarinsky cruise 22 and R/V Akademik M.A. Lavrentyev cruise 28. GEOMAR Report 82, 377 pp.

Biebow, N., Lüdmann, T., Karp, B. & Kulinich, R., 2000. KOMEX: Kurile-Okhotsk Sea Marine Experiment. Cruise Reports: KOMEX V and KOMEX VI, R/V Professor Gagarinsky cruise 26 and M/V Marshal Gelovany cruise 1. GEOMAR Report 88, 296 pp.

Carter, L. & McCave, I.N., 1994. Development of sediment drifts approaching an active margin under the SW Pacific Deep Western Boundary Undercurrent. Paleoceanography, **9**(6): 1061-1085.

Faugères, J.-C., Stow, D.A.V., Imbert, P. & Viana, A., 1999. Seismic features diagnostic of contourite drifts. Marine Geology, **162**: 1-38.

Favorite, F.A., Dodimead, A.J. and Nasu, K., 1976. Oceanography of the Subarctic Pacific Regio*n*, 1960-1976. Int. N. Pac. Fish. Comm., **33**, 187 pp.

Freeland, H.J., Bychkov, A.S., Whitney, F., Taylor, C., Wong, C.S. and Yurasov, G.I., 1998. WOCE section P1W in the Sea of Okhotsk - 1. Oceanographic data description. Journal of Geophysical Research, **103**(C8): 15,613-15,623.

Gladyshev, S., Martin, S., Riser, S. & Figurkin, A., 2000. Dense water production on the northern Okhotsk shelves: comparison of ship-based spring-summer observations for 1996 and 1997 with satellite observations. J. Geophys. Res., **105**(C11): 26,281-26,299.

Gnibidenko H.S.,1990. The Rift System of the Okhotsk Sea. Proceedings of the First International Conference on Asian Marine Geology, China Ocean Press, Beijing: 73-81.

Gnibidenko h. S., Hilde T. W. C., Gretskaya E. V. & Andreev A. A. 1995. Kurile (South Okhotsk) backarc basin. In Taylor B. ed., *Backarc Basins: Tectonics and Magmatism*, Plenum Press, New York: 421-449.

Heezen, B.C., Hollister, C.D. & Ruddiman, W.F., 1966. Shaping of the continental rise by deep geostrophic bottom currents. Science, **152**: 502-508.

Hollister, C.D. & Heezen, B.C., 1972. Geological effects of ocean bottom currents: western North Atlantic. In: Gordon, A.L., Studies in Physical Oceanography, 2: Gordon and Breach, New York, 37-66.

Jolivet L., Davy P. & Cobbold P. 1990. Right-lateral shear along the northwest Pacific margin and the India-Eurasia collision. Tectonics, **9**: 1409-1419.

Kimura G. & Tamaki K. 1986. Collision, rotation, and backarc spreading in the region of the Okhotsk and Japan Seas. Tectonics, **5**: 386-401.

Kitani, K., 1973. An oceanographic study of the Sea of Okhotsk particularly in regard to cold waters. Bull. Far Seas Fish. Res. Lab., **9**: 45-77.

Maeda, J. 1990. Opening of the Kurile Basin deduced from the magmatic history of Central Hokkaido, North Japan. Tectonophysics, **174**: 235-255.

Milliman, J.D. & Meade, R.H., 1983. World-wide delivery of river sediment to the oceans. J. Geol., **91**: 1-22.

Mitchum, R.M., Vail, P.R. & Sangree, J.B., 1977. Seismic stratigraphy and global changes of sea level, part 6: stratigraphic interpretation of seismic reflection patterns in depositional sequences. In: Payton, C.E., (ed.) Seismic Stratigraphy – Application to Hydrocarbon Exploration. AAPG Memoir **26**: 117-143.

Polyakov, I. & Martin, S., 2000. Interaction of the Okhotsk Sea diurnal tides with the Kashevarov Bank. J. Geophys. Res., **105**(C2): 3281-3294.

Reed, D.L., Meyer, A.W., Silver, E.A., & Prasetyo, H., 1987. Contourite sedimentation in an intraoceanic forearc system: eastern Sunda Arc, Indonesia. Marine Geology, 76(3-4), 223-242.

Savostin L. A., Zonenshain L. P. & Baranov B. V. 1983. Geology and plate tectonics of the Sea of Okhotsk. In Hilde T. W. H. & Uyeda S. eds. Geodynamics of the Western Pacific. AGU Geodynamics Series, **11**: 189-221. Washington D.C.

Stoker, M.S., 1998. Sediment drift development on the Rockall continental margin off NW Britain. In: Stoker, M.S., Evans, D. & Cramp, A., Geological Processes on Continental Margins: Sedimentation, Mass-Wasting and Stability, 129: Geol. Soc., London, 229-254.

Svarichevsky A. S. Morphology of the acoustic basement in the Okhotsk Sea. In: Tectonic problems of the West Pacific transitional zone. Vladivostok, Dalnayka, 122 pp. (in Russian)

Takeuchi T., Kodama K. & Ozawa T. 1999. Paleomagnetic evidence for block rotations in central Hokkaido-south Sakhalin, Northeast Asia. Earth and Planetary Science Letters, **169**: 7-21.

Talley, L.D., 1991. An Okhotsk Sea water anomaly: Implications for ventilations in the North Pacific. Deep Sea Res., Part A, **38**, suppl. 1: 171-190

Talley, L.D. and Nagata, Y., 1995. The Okhotsk Sea and Oyashio region. 2. North Pacific Marine Science Organisation (PICES), PICES Scientific Rept. No. 2, Rept. of Working Group 1, 227 pp.

Wanatabe, T. and Wakatsuchi, M., 1998. Formation of 26.8-26.9 water in the Kurile Basin and the Sea of Okhotsk as possible origin of the North Pacific Intermediate Water. J. Geophys. Res., **103**(C8): 2849-2865.

Wong, C.S., Matear, R.J., Freeland, H.J., Whitney, F.A. and Bychkov, A.S., 1998. WOCE line P1W in the Sea of Okhotsk 2. CFCs and the formation rate of intermediate water. J. Geophys. Res., **103**(C8): 15,625-15,642.

Worrall D.M., Kruglyak V., Kunst F., Kuznetsov V., 1996. Tertiary tectonics of the Sea of Okhotsk, Russia: Far-field effects of the India-Eurasia collision. Tectonics, **15**(4): 813-826.

You, Y., Suginohara, N., Fukasawa, M., Yasuda, I., Kaneko, I., Yoritaka, H. & Kawamiya, M., 2000. Roles of the Okhotsk Sea and Gulf of Alaska in forming the North Pacific Intermediate Water. J. Geophys. Res., **105**(C2): 3253-3280.

Zuenko, Y.I. and Yurasov, G.I., 1997. Structure of the coastal waters of the Sea of Okhotsk. Russian Meteorol. Hydrol., **3**: 32-37.

APPENDIX 1: LIST OF PARTICIPANTS

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APPENDIX A2: LIST OF PROFILES

	Start of Profile				End of Profile							
Profile No.	Date	Time (UTC)	Latitude ((N)	Longitude (E)	Date	Time (UTC)	Latitude (N)	Longitude (E)	Profile Duration	Distance (nm)	Distance (km)	TYPE
1	09.09.2001	09:30	47°05.780'	144°40.490'	09.09.2001	19:00	47°51.780'	146°01.150'	9:30	73.09	135.44	SC, GM
2	09.09.2001	19:01	47°51.910'	146°01.210'	09.09.2001	20:58	48°08.080'	146°07.500'	1:57	15.93	29.52	SC, GM
3-4	09.09.2001	21:30	48°11.240'	146°08.960'	11.09.2001	00:50	52°18.420'	144°09.130'	27:20	256.50	475.29	GM
5	11.09.2001	02:54	52°28.935'	144°08.388'	11.09.2001	14:40	53°21.581'	145°42.576'	11:46	76.43	141.62	MC,GM
6	11.09.2001	15:00	53°13.724'	145°42.931'	12.09.2001	09:01	55°09.965'	145°42.861'	18:01	109.90	203.64	MC,GM
7	12.09.2001	09:09	55°10.196'	145°44.461'	12.09.2001	13:40	55°08.887'	146°33.918'	4:31	30.74	56.96	MC,GM
8	12.09.2001	13:51	55°08.431'	146°35.723'	12.09.2001	21:00	54°25.556'	146°34.442'	7:09	43.61	80.81	MC,GM
9	12.09.2001	21:15	54°24.779'	146°32.721'	13.09.2001	09:41	54°25.694'	144°30.108'	12:26	81.35	150.74	MC,GM
10	13.09.2001	14:50	54°35.622'	144°28.030'	14.09.2001	06:10	54°32.333'	141°51.282'	15:20	94.25	174.65	MC,GM
11	14.09.2001	06:15	54°32.333'	141°51.282'	15.09.2001	05:15	55°32.985'	140°57.516'	23:00	66.90	123.97	MC,GM
12	15.09.2001	05:22	55°32.826'	140°58.231'	15.09.2001	07:00	55°26.961'	140°55.93'	1:38	10.17	18.85	MC,GM
13	15.09.2001	22:42	54°35.933'	141°48.200'	16.09.2001	06:51	54°35.602'	140°23.002'	8:09	50.81	94.15	MC,GM
14	16.09.2001	06:59	54°34.809'	140°23.455'	16.09.2001	11:12	54°10.515'	140°42.567'	4:13	28.24	52.33	MC,GM
15	16.09.2001	11:14	54°10.523'	140°43.775'	16.09.2001	17:40	54°11.619'	142°00.299'	6:26	46.14	85.50	MC,GM
16	16.09.2001	17:52	54°12.807'	142°00.984'	16.09.2001	21:24	54°38.240'	142°06.593'	3:32	26.96	49.96	MC,GM
17	17.09.2001	00:05	54°38.374'	142°06.980'	17.09.2001	14:12	55°11.613'	144°38.873'	14:07	96.84	179.44	MC,GM
18	17.09.2001	14:24	55°10.496'	144°39.245'	17.09.2001	16:22	54°56.081'	144°39.304'	1:58	16.48	30.54	MC,GM
19	17.09.2001	16:24	54°55.995'	144°39.146'	17.09.2001	22:50	54°42.690'	143°25.653'	6:26	45.70	84.68	MC,GM
20	17.09.2001	23:02	54°42.621'	143°27.070'	18.09.2001	04:45	54°40.336'	144°38.115'	5:47	43.95	81.44	MC,GM
21	18.09.2001	06:18	54°42.336'	144°39.217'	18.09.2001	11:14	54°09.073'	144°13.674'	4:56	37.33	69.17	MC,GM
22	18.09.2001	11:18	54°08.956'	144°12.915'	18.09.2001	12:08	54°08.791'	144°02.678'	0:50	6.76	12.53	MC,GM
23	18.09.2001	12:18	54°09.556'	144°02.857'	18.09.2001	14:46	54°24.896'	144°15.896'	2:28	18.45	34.19	MC,GM
24	18.09.2001	14:47	54°25.057'	144°15.835'	18.09.2001	18:02	54°25.650'	143°40.749'	3:15	20.67	38.30	MC,GM
25	18.09.2001	18:10	54°24.497'	143°40.788'	18.09.2001	21:52	53°59.907'	143°40.731'	3:42	26.50	49.10	MC,GM
26	18.09.2001	21:57	53°59.761'	143°41.731'	19.09.2001	02:28	53°59.661'	144°32.998'	4:33	31.00	57.44	MC,GM
27	19.09.2001	02:31	53°59.417'	144°33.110'	19.09.2001	03:52	53°50.960'	144°33.252'	1:21	8.74	16.20	MC,GM
28	19.09.2001	03:55	53°50.831'	144°32.757'	19.09.2001	05:36	53°50.849'	144°13.710'	1:41	11.70	21.68	MC,GM
29	19.09.2001	05:49	53°49.537'	144°13.526'	19.09.2001	06:21	53°46.125'	144°13.261'	0:32	5.00	9.27	MC,GM
30	19.09.2001	06:24	53°45.974'	144°13.723'	19.09.2001	09:12	53°46.007'	144°46.865'	2:48	19.87	36.82	MC,GM
31	19.09.2001	10:00	53°40.770'	144°49.920'	20.09.2001	13:50	49°13.710'	146°32.820'	27:50	276.84	512.98	GM
32	20.09.2001	14:38	49°08.740'	146°34.800'	21.09.2001	02:23	48°00.280'	145°44.920'	11:45	77.58	143.76	MC,GM
SC = single channel seismics; MC = multi-channel seismics; GM = gravity and magnetics										**89.02**	**164.95**	**SC total**
										1132.07	**2097.73**	**MC total**
										1754.43	**3250.96**	**GM total**

GEOMAR REPORTS

1 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. BERICHT FÜR DIE JAHRE 1987 UND 1988. 1989. 71 + 6 pp. In German

2 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1989. 1990. 96 pp. In German and English

3 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1990. 1991. 212 pp. In German and English

4 ROBERT F. SPIELHAGEN
DIE EISDRIFT IN DER FRAMSTRASSE WÄHREND DER LETZTEN 200.000 JAHRE. 1991. 133 pp.
In German with English summary

5 THOMAS C. W. WOLF
PALÄO-OZEANOGRAPHISCH-KLIMATISCHE ENTWICKLUNG DES NÖRDLICHEN NORDATLANTIKS SEIT DEM SPÄTEN NEOGEN (ODP LEGS 105 UND 104, DSDP LEG 81). 1991. 92 pp. In German with English summary

6 SEISMIC STUDIES OF LATERALLY HETEROGENOUS STRUCTURES – INTERPRETATION AND MODELLING OF SEISMIC DATA. Ed. by ERNST R. FLUEH
Commission on Controlled Source Seismology (CCSS), Proceedings of the 8th Workshop Meeting, held at Kiel – Fellhorst (Germany), August 27-31, 1990. 1991. 359 pp. In English

7 JENS MATTHIESSEN
DINOFLAGELLATEN-ZYSTEN IM SPÄQUARTÄR DES EUROPÄISCHEN NORDMEERES: PALÖKOLOGIE UND PALÄO-OZEANOGRAPHIE. 1991. 104 pp. In German with English summary. Out of print

8 DIRK NÜRNGERG
HAUPT- UND SPURENELEMENTE IN FORAMINIFERENGEHÄUSEN – HINWEISE AUF KLIMATISCHE UND OZEANOGRAPHISCHE ÄNDERUNGEN IM NÖRDLICHEN NORDATLANTIK WÄHREND DES SPÄTQUARTÄRS. 1991. 117 pp. In German with English summary. Out of print

9 KLAS S. LACKSCHEWITZ
SEDIMENTATIONSPROZESSE AM AKTIVEN MITTELOZEANISCHEN KOLBEINSEY RÜCKEN (NÖRDLICH VON ISLAND). 1991. 133 pp. In German with English summary. Out of print

10 UWE PAGELS
SEDIMENTOLOGISCHE UNTERSUCHUNGEN UND BESTIMMUNG DER KARBONATLÖSUNG IN SPÄTQUARTÄREN SEDIMENTEN DES ÖSTLICHEN ARKTISCHEN OZEANS. 1991. 106 pp.
In German with English summary

11 FS POSEIDON. EXPEDITION 175 (9.10.-1.11.1990)
175/1:OSTGRÖNLÄNDISCHER KONTINENTALRAND (65°N)
175/2: SEDIMENTATION AM KOLBEINSEYRÜCKEN (NÖRDLICH VON ISLAND).
Hrsg. von J. MIENERT und H.-J. WALLRABE-ADAMS. 1992. 56 pp. + app. In German with some English chapters

12 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1991. 1992. 152 pp. In German and English.
Out of print

13 SABINE E. I. KÖHLER
SPÄTQUARTÄRE PALÄO-OZEANOGRAPHISCHE ENTWICKLUNG DES NORDPOLARMEERES UND EUROPÄISCHEN NORDMEERES ANHAND VON SAUERSTOFF- UND KOHLENSTOFF-ISOTOPENVERHÄLTNISSEN DER PLANKTISCHEN FORAMINIFERE *Neogloboquadrina pachyderma* (sin.).
1992. 104 pp. In German with English summary

14 FS SONNE. FAHRTBERICHT SO78 PERUVENT: BALBOA, PANAMA - BALBOA, PANAMA, 28.2.1992-16.4.1992
Hrsg. von ERWIN SUESS. 1992. 120 pp. In German with some English chapters. Out of print

15 FOURTH INTERNATIONAL CONFERENCE ON PALEOCEANOGRAPHY (ICP IV): SHORT- AND LONG-TERM GLOBAL CHANGE: RECORDS AND MODELLING. 21-25 SEPTEMBER 1992, KIEL/GERMANY.
PROGRAM & ABSTRACTS. 1992. 351 pp. In English

16 MICHAELA KUBISCH
DIE EISDRIFT IM ARKTISCHEN OZEAN WÄHREND DER LETZTEN 250.000 JAHRE. 1992. 100 pp.
In German with English summary

17 PERSISCHER GOLF: UMWELTGEFÄHRDUNG, SCHADENSERKENNUNG, SCHADENSBEWERTUNG AM BEISPIEL DES MEERRESBODENS; ERKENNEN EINER ÖKOSYSTEMVERÄNDERUNG NACH ÖLEINTRÄGEN. Schlußbericht zu den beiden BMFT-Forschungsvorhaben 03F0055 A + B. 1993. 108 pp. In German with English summary

18 TEKTONISCHE ENTWÄSSERUNG AN KONVERGENTEN PLATTENRÄNDERN / DEWATERING AT CONTINENTAL MARGINS. Hrsg. von/ed. by ERWIN SUESS. 1993. 196 + 32 + 68 + 16 + 22 + 38 + 4 + 19 pp.
Some chapters in English, some in German

19 THOMAS DICKMANN
DAS KONZEPT DER POLARISATIONSMETHODE UND SEINE ANWENDUNGEN AUF DAS SEIMISCHE VEKTORWELLENFELD IM WEITWINKELBEREICH. 1993. 121 pp. In German with English summary

20 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1992. 1993. 139 pp. In German and English

21 KAI UWE SCHMIDT
PALYNOMORPHE IM NEOGENEN NORDATLANTIK - HINWEISE ZUR PALÄO-OZEANOGRAPHIE UND PALÄOKLIMATOLOGIE. 1993. 104 + 7 + 41 pp. In German with English summary

22 UWE JÜRGEN GRÜTZMACHER
DIE VERÄNDERUNGEN DER PALÄOGEOGRAPHISCHEN VERBREITUNG VON *Bolboforma* - EIN BEITRAG ZUR REKONSTRUKTION UND DEFINITION VON WASSERMASSEN IM TERTÄR. 1993. 104 pp.
In German with English summary

23 RV PROFESSOR LOGACHEV. Research Cruise 09 (August 30 - September 17, 1993): SEDIMENT DISTRIBUTION ON THE REYKJANES RIDGE NEAR 59°N. Ed. by H.-J. WALLRABE-ADAMS & K.S. LACKSCHEWITZ. 1993. 66 + 30 pp.
In English

24 ANDREAS DETTMER
DIATOMEEN-TAPHOZÖNOSEN ALS ANZEIGER PALÄO-OZEANOGRAPHISCHER ENTWICKLUNGEN IM PLIOZÄNEN UND QUARTÄREN NORDATLANTIK. 1993. 113 + 10 + 25 pp. In German with English summary

25 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1993. 1994. 69 pp. In German and English

26 JÖRG BIALAS
SEISMISCHE MESSUNGEN UND WEITERE GEOPHYSIKALISCHE UNTERSUCHUNGEN AM SÜD-SHETLAND TRENCH UND IN DER BRANSFIELD STRASSE - ANTARKTISCHE HALBINSEL. 1994. 113 pp.
In German with English summary

27 JANET MARGARET SUMNER
THE TRANSPORT AND DEPOSITIONAL MECHANISM OF HIGH GRADE MIXED-MAGMA IGNIMBRITE TL, GRAN CANARIA: THE MORPHOLOGY OF A LAVA-LIKE FLOW. 1994. 224 pp. In English with German summary. Out of print

28 GEOMAR LITHOTHEK. Ed. by JÜRGEN MIENERT. 1994. 12 pp + app. In English. Out of print

29 FS SONNE. FAHRTBERICHT SO 97 KODIAK-VENT: KODIAK - DUTCH HARBOR - TOKYO - SINGAPUR, 27.7.-19.9.1994. Hrsg. von ERWIN SUESS. 1994. Some chapters in English, some in German. Out of print

30 CRUISE REPORTS:
RV LIVONIA CRUISE 92, KIEL-KIEL, 21.8.-17.9.1992: GLORIA STUDIES OF THE EAST GREENLAND CONTINENTAL MARGIN BETWEEN 70°AND 80°N
RV POSEIDON PO200/10, LISBON-BREST-BREMERHAVEN, 7.-23.8.1993: EUROPEAN NORTH ATLANTIC MARGIN: SEDIMENT PATHWAYS, PROCESSES AND FLUXES
RV AKADEMIK ALEKSANDR KARPINSKIY, KIEL-TROMSÖ, 5.-25.7.1994: GAS HYDRATES ON THE NORTHERN EUROPEAN CONTINENTAL MARGIN
Edited by JÜRGEN MIENERT. 1994. 186 pp.
In English; report of RV AKADEMIK ALEKSANDR KARPINSKIY cruise in English and Russian

31 MARTIN WEINELT
BECKENENTWICKLUNG DES NÖRDLICHEN WIKING-GRABENS IM KÄNOZOIKUM - VERSENKUNGSGESCHICHTE, SEQUENZSTRATIGRAPHIE, SEDIMENTZUSAMMENSETZUNG. 1994. 85 pp.
In German with English summary

32 GEORG A. HEISS
CORAL REEFS IN THE RED SEA: GROWTH, PRODUCTION AND STABLE ISOTOPES. 1994. 141 pp.
In English with German summary

33 JENS A. HÖLEMANN
AKKUMULATION VON AUTOCHTHONEM UND ALLOCHTHONEM ORGANISCHEM MATERIAL IN DEN KÄNOZOISCHEN SEDIMENTEN DER NORWEGISCHEN SEE (ODP LEG 104). 1994. 78 pp.
In German with English summary

34 CHRISTIAN HASS
SEDIMENTOLOGISCHE UND MIKROPALÄONTOLOGISCHE UNTERSUCHUNGEN ZUR ENTWICKLUNG DES SKAGERRAKS (NE NORDSEE) IM SPÄTHOLOZÄN. 1994. 115 pp. In German with English summary

35 BRITTA JÜNGER
TIEFENWASSERERNEUERUNG IN DER GRÖNLANDSEE WÄHREND DER LETZTEN 340.000 JAHRE / DEEP WATER RENEWAL IN THE GREENLAND SEA DURING THE PAST 340,000 YEARS. 1994. 6 + 109 pp.
In German with English summary

36 JÖRG KUNERT
UNTERSUCHUJNGEN ZU MASSEN- UND FLUIDTRANSPORT ANHAND DER BEARBEITUNG REFLEXIONSSEISMISCHER DATEN AUS DER KODIAK-SUBDUKTIONSZONE, ALASKA. 1995. 129 pp.
In German with English summary

37 CHARLOTTE M. KRAWCZYK
DETACHMENT TECTONICS DURING CONTINENTAL RIFTING OFF THE WEST IBERIA MARGIN: SEISMIC REFLECTION AND DRILLING CONSTRAINTS.1995. 133 pp. In English with German summary

38 CHRISTINE CAROLINE NÜRNBERG
BARIUMFLUSS UND SEDIMENTATION IM SÜDLICHEN SÜDATLANTIK - HINWEISE AUF PRODUKTIVITÄTSÄNDERUNGEN IM QUARTÄR. 1995. 6 + 108 pp. In German with English summary

39 JÜRGEN FRÜHN
TEKTONIK UND ENTWÄSSERUNG DES AKTIVEN KONTINENTALRANDES SÜDÖSTLICH DER KENAI-HALBINSEL, ALASKA. 1995. 93 pp. In German with English summary

40 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1994. 1995. 125 pp. In German and English.
Out of print

41 FS SONNE. FAHRTBERICHT / CRUISE REPORT SO 103 CONDOR 1 B: VALPARAISO-VALPARAISO, 2-21.7.1995.
Hrsg. von ERNST R. FLUEH. 1995. 140 pp. Some chapters in German, some in English

42 RV PROFESSOR BOGOROV CRUISE 37: CRUISE REPORT "POSETIV": VLADIVOSTOK-VLADIVOSTOK, September 23 - October 22, 1994. Edited by CHRISTOPH GAEDICKE, BORIS BARANOV, and EVGENY LELIKOV. 1995. 49 + 33 pp. In English

43 CHRISTOPH GAEDICKE
DEFORMATION VON SEDIMENTEN IM NANKAI-AKKRETIONSKEIL, JAPAN. BILANZIERUNG TEKTONISCHER VORGÄNGE ANHAND VON SEISMISCHEN PROFILEN UND ERGEBNISSEN DER ODP-BOHRUNG 808. II + 89 pp. In German with English summary

44 MARTIN ANTONOW
SEDIMENTATIONSMUSTER UM DEN VESTERIS SEAMOUNT (ZENTRALE GRÖNLANDSEE) IN DEN LETZTEN 250.000 JAHREN. 1995. 121 pp. In German with English summary

45 INTERNATIONAL CONGRESS: CORING FOR GLOBAL CHANGE - ICGC '95. KIEL, 28 - 30 June, 1995. Edited by JÜRGEN MIENERT and GEROLD WEFER. 1996. 83 pp. In English

46 JENS GRÜTZNER
ZUR PHYSIKALISCHEN ENTWICKLUNG VON DIAGENETISCHEN HORIZONTEN IN DEN SEDIMENTBECKEN DES ATLANTIKS. 1995. 96 pp. In German with English summary

47 INGO A. PECHER
SEISMIC STUDIES OF BOTTOM SIMULATING REFLECTORS AT THE CONVERGENT MARGINS OFFSHORE PERU AND COSTA RICA. 1996. 159 pp. In English with German summary

48 XIN SU
DEVELOPMENT OF LATE TERTIARY AND QUATERNARY COCCOLITH ASSEMBLAGES IN THE NORTHEAST ATLANTIC. 1996. 120 pp. +7 pl. In English with German summary

49 FS SONNE - FAHRTBERICHT/CRUISE REPORT SO108 ORWELL: SAN FRANCISCO - ASTORIA, 14.4. - 23.5.1996 Edited by ERNST R. FLUEH and MICHAEL A. FISHER. 1996. 252 pp. + app. In English with German summary

50 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1995. 1996. 93 pp. In German and English

51 THOMAS FUNCK
STRUCTURE OF THE VOLCANIC APRON NORTH OF GRAN CANARIA DEDUCED FOM REFLECTION SEISMIC, BATHYMETRIC AND BOREHOLE DATA. 1996.VI, 144 pp. In English with German summary

52 PETER BRUNS
GEOCHEMISCHE UND SEDIMENTOLOGISCHE UNTERSUCHUNGEN ÜBER DAS SEDIMENTATIONSVERHALTEN IM BEREICH BIOSTRATIGRAPHISCHER DISKONTINUITÄTEN IM NEOGEN DES NORDATLANTIK, ODP LEG 104, SITES 642B UND 643A. 1996. V, 73 pp. In German with Engllish summary

53 CHRISTIANE C. WAGNER
COLD SEEPS AN KONVERGENTEN PLATTENRÄNDERN VOR OREGON UND PERU: BIOGEOCHEMISCHE BESTANDSAUFNAHME. 1996. 108, XXXVI pp. In German with English summary

54 FRAUKE KLINGELHÖFER
MODEL CALCULATIONS ON THE SPREADING OF SUBMARINE LAVA FLOWS. 1996. 98 pp. In English with German summary

55 HANS-JÜRGEN HOFFMANN
OBJEKTORIENTIERTE ANALYSE UND MIGRATION DIFFRAKTIERTER WELLENFELDER UNTER VERWENDUNG DER STRAHLENMETHODE UND DER EDGE-WAVE-THEORIE. 1996. XXI, 153 pp. In German with English summary

56 DIRK KLÄSCHEN
STRAHLENSEISMISCHE MODELLIERUNG UNTER BERÜCKSICHTGUNG VON MEHRFACHDIFFRAKTIONEN MIT HILFE DER EDGE-WAVES: THEORIE UND ANWENDUNGSBEISPIELE 1996. X, 159 pp. In German with English summary

57 NICOLE BIEBOW
DINOFLAGELLATENZYSTEN ALS INIKATOREN DER SPÄT- UND POSTGLAZIALEN ENTWICKLUNG DES AUFTRIEBSGESCHEHENS VOR PERU. 1996. IV, 100, 17, 14 (7 pl.) pp. In German with English summary

58 RV SONNE. CRUISE REPORT SO109: HYDROTRACE ASTORIA-VICTORIA-ASTORIA-VICTORIA. MAY 23 - JULY 8, 1996. Ed. by PETER HERZIG, ERWIN SUESS, and PETER LINKE. 1997. 249 pp. In English

59 RV SONNE. CRUISE REPORT SO110: SO - RO (SONNE - ROPOS). VICTORIA-KODIAK-VICTORIA. JULY 9 - AUGUST 19, 1996. Ed. by ERWIN SUESS and GERHARD BOHRMANN. 1997. 181 pp. In English

60 RV AKADEMIK M. A. LAVRENTYEV CRUISE 27. CRUISE REPORT: GREGORY. VLADIVOSTOK-PUSAN-OKHOTSK SEA-PUSAN-VLADIVOSTOK. SEPTEMBER 7 - OCTOBER 12, 1996. Ed. by DIRK NÜRNBERG, BORIS BARANOV, and BORIS KARP.1997. 143 pp. In English

61 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT / ANNUAL REPORT 1996. 1997. 169 pp. In German and English

62 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO123: MAMUT (MAKRAN MURRAY TRAVERSE - GEOPHYSIK PLATTENTEKTONISCHER EXTREMFÄLLE). Maskat - Maskat, 07.09 - 03.10.1997. Ed. by ERNST R. FLUEH, NINA KUKOWSKI, and CHRISTIAN REICHERT. 1997. 292 pp. In English with German summary

63 RAINER ZAHN
NORTH ATLANTIC THERMOHALINE CIRCULATION DURING THE LAST GLACIAL PERIOD: EVIDENCE FOR COUPLING BETWEEN MELTWATER EVENTS AND CONVECTIVE INSTABILITY. 1997. 133 pp. In English

64 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO112 HIRESBAT (HIGH RESOLUTION BATHYMETRY). Victoria, B.C., Canada - Apra Harbor, Guam. 17.09 - 08.10.1996. Hrsg. von WILHELM WEINREBE. 1997. 90 pp. Some chapters in German, some in English

65 NIELS NØRGAARD-PEDERSEN
LATE QUATERNARY ARCTIC OCEAN SEDIMENT RECORDS: SURFACE OCEAN CONDITIONS AND PROVENANCE OF ICE-RAFTED DEBRIS. 1997. 115 pp. In English with German summary

66 THOMAS NÄHR
AUTHIGENER KLINOPTILOLITH IN MARINEN SEDIMENTEN - MINERALCHEMIE, GENESE UND MÖGLICHE ANWENDUNG ALS GEOTHERMOMETER. 1997. 119, 43 pp. In German with English summary

67 MATTIAS KREUTZ
STOFFTRANSPORT DURCH DIE BODENGRENZSCHICHT: REGIONALISIERUNG UND BILANZIERUNG FÜR DEN NORDATLANTIK UND DAS EUROPÄISCHE NORDMEER. 1998. IV, 166 pp. In German with English summary

68 AMIT GULATI
BENTHIC PRIMARY PRODUCTION IN TWO DIFFERENT SEDIMENT TYPES OF THE KIEL FJORD (WESTERN BALTIC SEA). 1998. 139 pp. In English with German summary

69 RÜDIGER SCHACHT
DIE SPÄT- UND POSTGLAZIALE ENTWICKLUNG DER WOOD- UND LIEFDEFJORDREGION NORDSPITZBERGENS. 1999. 123 pp. + app. In German with English summary

70 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1997. 1998. 155 pp. In German and English

71 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO118 BIGSET (BIOGEOCHEMICAL TRANSPORT OF MATTER AND ENERGY IN THE DEEP SEA). MUSCAT (OMAN) - MUSCAT (OMAN). 31.03.-11.05.1997. Ed. by OLAF PFANNKUCHE and CHRISTINE UTECHT. 1998. 188 pp. In English

72 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO131 SINUS (SEISMIC INVESTIGATIONS AT THE NINETY EAST RIDGE OBSERVATORY USING SONNE AND JOIDES RESOLUTION DURING ODP LEG 179). KARACHI - SINGAPORE. 04.05-16.06.1998. Ed. by ERNST R. FLUEH and CHRISTIAN REICHERT. 1998. 337 pp. In English

73 THOMAS RICHTER
SEDIMENTARY FLUXES AT THE MID-ATLANTIC RIDGE: SEDIMENT SOURCES, ACCUMULATION RATES, AND GEOCHEMICAL CHARACTERISATION. 1998. IV, 173 + 29 pp. In English with German summary

74 BARBARA MARIA SPRINGER
MODIFIKATION DES BODENNAHEN STRÖMUNGSREGIMES UND DIE DEPOSITION VON SUSPENDIERTEM MATERIAL DURCH MAKROFAUNA. 1999. 112 pp. In German

75 SABINE JÄHMLICH
UNTERSUCHUNGEN ZUR PARTIKELDYNAMIK IN DER BODENGRENZSCHICHT DER MECKLENBURGER BUCHT. 1999. 139 pp. In German

76 WOLFRAM W. BRENNER
GRUNDLAGEN UND ANWENDUNGSMÖGLICHKEITEN DER MIKRO-ABSORPTIONSPHOTOMETRIE FÜR ORGANISCH-WANDIGE MIKROFOSSILIEN. 1999. 141 pp. In German with English summary

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TERTIARY BENTHIC FORAMINIFERAL BIOSTRATIGRAPHY AND PALAEOECOLOGY OF THE HALTEN TERRACE, NORWAY. 1999. VI, 145 pp. In English with German summary

78 HEIDI DOOSE
REKONSTRUKTION HYDROGRAPHISCHER VERHÄLTNISSE IM CALIFORNIENSTROM UND IM EUROPÄISCHEN MITTELMEER ZUR BILDUNGSZEIT ORGANISCH KOHLENSTOFFREICHER SEDIMENTE. 1999. IV, 111 pp. + app. In German with English summary

79 CLAUDIA WILLAMOWSKI
VERTEILUNGSMUSTER VON SPURENMETALLEN IM GLAZIALEN NORDATLANTIK: REKONSTRUKTION DER NÄHRSTOFFBILANZ ANHAND VON CADMIUMKONZENTRATIONEN IN KALKSCHALIGEN FORAMINIFEREN. 1999. 86, XXI pp. In German with English summary

80 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO129. BIGSET (BIOGEOCHEMICAL TRANSPORT OF MATTER AND ENERGY IN THE DEEP SEA). PORT SULTAN QUABOOS - DUBAI. JANUARY 30 - MARCH 9, 1998. Ed. by OLAF PFANNKUCHE and CHRISTINE UTECHT. 1999. 107 pp. In English

81 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO138. GINCO-2 (GEOSCIENTIFIC INVESTIGATIONS ON THE ACTIVE CONVERGENCE ZONE BETWEEN THE EAST EURASIAN AND AUSTRALIAN PLATES ALONG INDONESIA). JAKARTA - JAKARTA. 29.12.1998 - 28.01.1999. Ed. by ERNST R. FLUEH, BERND SCHRECKENBERGER, and JÖRG BIALAS. 1999. 333 pp. In English

82 CRUISE REPORTS: KOMEX I and II (KURILE OKHOTSK SEA MARINE EXPERIMENT)
RV PROFESSOR GAGARINSKY CRUISE 22
RV AKADEMIK M. A. LAVRENTYEV CRUISE 28
VLADIVOSTOK - PUSAN - OKHOTSK SEA - PUSAN - VLADIVOSTOK. 7 JULY - 12 SEPTEMBER 1998. Ed. by NICOLE BIEBOW and EDNA HÜTTEN. 1999. 188, 89 pp. In English

83 GREGOR REHDER
QUELLEN UND SENKEN MARINEN METHANS ZWISCHEN SCHELF UND OFFENEM OZEAN. REGIONALE VARIABILITÄT UND STEUERNDE PARAMETER DER METHANVERTEILUNG UND DER AUSTAUSCH MIT DER ATMOSPHÄRE. 1999. 161, 20 pp. In German with English summary

84 SVEN-OLIVER FRANZ
PLIOZÄNE ZEITREIHEN ZUR REKONSTRUKTION DER TIEFENWASSERZIRKULATION UND DER SILIZIKLASTISCHEN AMAZONASFRACHT IM ÄQUATORIALEN WESTATLANTIK (CEARA SCHWELLE, ODP LEG 154). 1999. 183 pp. In German with English summary

85 SYLKE HLAWATSCH
Mn-Fe-AKKUMULATE ALS INDIKATOR FÜR SCHAD- UND NÄHRSTOFFFLÜSSE IN DER WESTLICHEN OSTSEE. 1999. 132 pp. In German with English summary

86 BETTINA GEHRKE
ZUSAMMENSETZUNG UND VERTEILUNG DER LITHOGENEN FEINFRAKTION IN SPÄTQUARTÄREN SEDIMENTEN DES MITTELATLANTISCHEN REYKJANES RÜCKENS (59°N) - TONMINERALE ALS INDIKATOREN FÜR LIEFERGEBIETE, TRANSPORTMECHANISMEN UND ABLAGERUNGSPROZESSE. 1999. 102 pp.
In German with English summary

87 JENS GREINERT
REZENTE SUBMARINE MINERALBILDUNGEN: ABBILD GEOCHEMISCHER PROZESSE AN AKTIVEN FLUIDAUSTRITTSSTELLEN IM ALEUTEN- UND CASCADIA-AKKRETIONSKOMPLEX. 1999. 196, XX pp.
In German with English summary

88 CRUISE REPORTS: KOMEX V and VI (KURILE OKHOTSK SEA MARINE EXPERIMENT)
RV PROFESSOR GAGARINSKY CRUISE 26
MV MARSHAL GELOVANY CRUISE 1
VLADIVOSTOK - PUSAN - OKHOTSK SEA - PUSAN - VLADIVOSTOK. 30 JULY - 5 SEPTEMBER, 1999.
Ed. by NICOLE BIEBOW, THOMAS LÜDMANN, BORIS KARP, and RUSLAN KULINICH. 2000. 296 pp. In English

89 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO136. TASQWA (QUATERNARY VARIABILITY OF WATER MASSES IN THE SOUTHERN TASMAN SEA AND THE SOUTHERN OCEAN, SW PACIFIC SECTOR). WELLINGTON - HOBART. OCTOBER 16 - NOVEMBER 12, 1998. Ed. by JÖRN THIEDE, STEFAN NEES et al. 1999. 78, 106 pp. In English

90 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO142. HULA (INTERDISCIPLINARY INVESTIGATIONS ON THE TIMING OF THE HAWAII-EMPEROR BEND AND THE ORIGIN OF LITHOSPHERIC ANOMALIES ALONG THE MUSICIAN SEAMOUNT CHAIN. MIDWAY - HONOLULU. MAY 30 - JUNE 28, 1999. Ed. by ERNST R. FLUEH, JOHN O'CONNOR, JASON PHIPPS MORGAN, and JOCHEN WAGNER. 1999. 224 pp. In English

91 J. HAUSCHILD, T. GINDLER, D. RISTOW, A. BERHORST, C. BÖNNEMANN, K. HINZ
DFG-FORSCHUNGSPROJEKT *„KRUSTENSPLITTER"*. 3D-MAKRO-GESCHWINDIGKEITSBESTIMMUNGEN UND 3D-TIEFENMIGRATION DES SEISMISCHEN 3D-COSTA-RICA-DATENSATZES. 1999. 85 pp.
In German with English summary

92 FS AKADEMIK MSTISLAV KELDYSH. Fahrtbericht Reise Nr. 40: Norwegisch-Grönländische See, 27.6.-29.7.1998. Hrsg. von J. MIENERT, A. OMLIN, T. GÖLZ, D. LUKAS, J. POSEWANG. 1999. 65, 7 pp. In German

93 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO143 TECFLUX. Ed. by GERHARD BOHRMANN, PETER LINKE, ERWIN SUESS, and OLAF PFANNKUCHE. 2000. 243 pp. In English

94 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO144-1&2. PAGANINI (PANAMA BASIN AND GALAPAGOS "PLUME" - NEW INVESTIGATIONS OF INTRAPLATE MAGMATISM). SAN DIEGO - CALDERA. SEPTEMBER 7 - NOVEMBER 7, 1999. Ed. by JÖRG BIALAS, ERNST R. FLUEH, and GERHARD BOHRMANN. 1999. 437 pp. + app.
In English

95 CHRISTIAN MATTHIAS HÜLS
MILLENNIAL-SCALE SST VARIABILITY AS INFERRED FROM PLANKTONIC FORAMINIFERAL CENSUS COUNTS IN THE WESTERN SUBTROPICAL ATLANTIC. 2000. 81 pp. + app. In English with German summary

96 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO146-1&2. GEOPECO (GEOPHYSICAL EXPERIMENTS AT THE PERUVIAN CONTINENTAL MARGIN - INVESTIGATIONS OF TECTONICS, MECHANICS, GASHYDRATES, AND FLUID TRANSPORT). ARICA - TALCAHUANO. MARCH 1 - MAY 4, 2000. Ed. by JÖRG BIALAS and NINA KUKOWSKI. 2000. 508 pp. In English

97 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 1998/1999. 2000. 261 pp. In German and English

98 RV SONNE. CRUISE REPORT SO148. TECFLUX-II-2000 (TECTONICALLY-INDUCED MATERIAL FLUXES. VICTORIA - VICTORIA - VICTORIA. 20.07.-15.08.2000. Ed. by PETER LINKE and ERWIN SUESS. 122 pp. In English

99 GEOMAR FORSCHUNGSZENTRUM FÜR MARINE GEOWISSENSCHAFTEN DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL. JAHRESBERICHT/ANNUAL REPORT 2000. 2001. 180 pp. In German and English

100 FS POSEIDON. FAHRTBERICHT/CRUISE REPORT POS 260 BIGSET (BIOGEOCHEMICAL TRANSPORT OF MATTER AND ENERGY IN THE DEEP SEA). LEIXOES/OPORTO (PORTUGAL) - GALWAY (IRELAND) - CORK (IRELAND). 26.04.-23.06.2000. Ed. by OLAF PFANNKUCHE and CHRISTINE UTECHT. 2001. 67 pp. In English

101 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO159. SALIERI (SOUTH AMERICAN LITHOSPHERIC TRANSECTS ACROSS VOLCANIC RIDGES). GUAYAQUIL - GUAYAQUIL. AUGUST 21 - SEPTEMBER 17, 2001.
Ed. by ERNST R. FLÜH, JÖRG BIALAS, and PHILIPPE CHARVIS. 2001. 256 pp. In English

102 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO161-1&4. SPOC (SUBDUCTION PROCESSES OFF CHILE).
ANTOFAGASTA - VALPARAISO. OCTOBER 9 - OCTOBER 15, 2001 &
VALPARAISO - VALPARAISO. NOVEMBER 30 - DECEMBER 23, 2001.
Ed. by ERNST R. FLÜH, HEIDRUN KOPP, and BERND SCHRECKENBERGER. 2002. 383 pp. In English

103 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO162. INGGAS TEST (INTEGRATED GEOPHYSICAL CHARACTERISATION AND QUANTIFICATION OF GAS HYDRATES - INSTRUMENT TEST CRUISE).
VALPARAISO - BALBOA. FEBRUARY 21 - MARCH 12, 2002.
Ed. by TIMOTHY JOHN RESTON and JÖRG BIALAS. 2002. In English

104 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO158. MEGAPRINT (MULTIDISCIPLINARY EXAMINATION OF GALÁPAGOS PLUME RIDGE INTERACTION). ISLA DE PASCUA - GUAYAQUIL. JULY15 - AUGUST 20, 2001.
Ed. by REINHARD WERNER. 2002. 53 pp + app. In English

105 CRUISE REPORT : KOMEX (KURILE OKHOTSK SEA MARINE EXPERIMENT)
RV PROFESSOR GAGARINSKY CRUISE 32. SERENADE. SEISMO-STRATIGRAPHIC RESEARCH OFF NORTHERN SAKHALIN AND IN THE DERUGIN BASIN. VLADIVOSTOK - PUSAN - SEA OF OKHOTSK - PUSAN - VLADIVOSTOK. AUGUST 31 - SEPTEMBER 29, 2001.
Ed. by THOMAS LÜDMANN, BORIS BARANOV, and BORIS KARP. 2002. 42 pp. In English

106 FS SONNE. FAHRTBERICHT/CRUISE REPORT SO163. SUBDUCTION I. MULTI-SYSTEM ANALYSIS OF FLUID RECYCLING AND GEODYNAMICS AT THE CONTINENTAL MARGIN OFF COSTA RICA.
SO163-1. BALBOA- CALDERA. MARCH 13 - APRIL 20, 2002
SO163-2. CALDERA - BALBOA. APRIL 20 - MAY 21, 2002
Ed. by WILLI WEINREBE and ERNST R. FLÜH. 2002. In English