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No. 5

Cruise Report

RV "SONNE" Cruise SO82 1992

SO82A:
Geophysical investigations along the Reykjanes Ridge, North Atlantic
Balboa - Reykjavik, 29.09.-16.10.1992

SO82B:
Sedimentation pattern of the Reykjanes Ridge, North Atlantic
Reykjavik - Bremerhaven, 17.10.-31.10.1992

Edited by
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with contributions of the cruise members

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1993

Content

1. Introduction

(R. Endler, K.S.Lackschewitz)

Since October 01, 1991, the GEOMAR Marine Research Center Kiel, the Institute of Baltic Sea Research Warnemuende and the geological department of the University of Greifswald perform investigations of sedimentation processes of in the Mid Atlantic Ridge (MAR), with special emphasis on the central part of the Reykjanes Ridge. This joint research project is supported by the "Federal Minister for Research and Technology". It is closely connected to the international Mid Ocean Ridge - research programs "Ridge" - USA, "Bridge" - UK and the new European "InterRidge" activity.

At the beginning of 1992 the possibility came up of using the research vessel "Sonne" for marine geological and geophysical investigations within the framework of the MAR - project. RV "Sonne", which is one of the most advanced German research vessels, offers good working conditions especially for the investigation of the unregular sea bottom structures and the small sediment ponds of the MOR regions.

The research cruise "Sonne - 82" (SO82) was planned to start in Balboa (Panama) on September 29, and to finish in Bremerhaven (Germany) on October 31, 1992. Because of the long transfer from Balboa to the area of interest the cruise was divided in two parts.

The task of the first part (SO82A - transfer from Balboa, Panama, September, 29 to Reykjavik, Iceland, October, 16) was to carry out a methodic - geophysical program with the aim to adapt advanced acoustic subbottom profiling systems of very high resolution to the acoustically difficult conditions in the MAR area. In order to solve this task a new joint research project "Sedimentation in the Reykjanes ridge: sediment - echosounding" was established under the leadership of the University of Rostock (Prof. Wendt). This program is supported by the "Federal Minister for Research and Technology". As a result of this program the advanced acoustic systems required for the complicated tasks to be solved during part SO82B would become available. Furthermore, using the multibeam echosounder Hydrosweep, the central part of the Mid Atlantic Ridge (MAR) between 53°N and 61°N was planned to be mapped in order to achieve information on its tectonic history and subdivision in area of different developments.

The second part (SO82B) was to be focused on the investigation of sedimentation processes and its spatial and temporal variability in the central part of the Reykjanes Ridge near 59°N. The methods used include acoustic profiling, sediment sampling and complex (sedimentological, geochemical, physical, biological) investigations of recovered samples. The results will be used to build a model of the genesis of the distributive province "Reykjanes Ridge".

2. Part I (SO82A)

2.1. Research program and cruise track

(R.Endler, K.S.Lackschewitz)

The task of the first part of the cruise (SO82A) was to use the transfer from Balboa to Reykjavik for a small methodical and geophysical program with the main aim to install and prepare the required acoustic equipment for the investigations during the second part of the cruise (SO82B). The program was divided into two parts.

The first part was a survey of the central part of the MAR between 53°N and 61°N (see Fig. 2.1.-1) using the multi beam echosounder HYDROSWEEP. In close cooperation with the University of Hamburg, Institute of Geophysics, (Prof. Weigel)

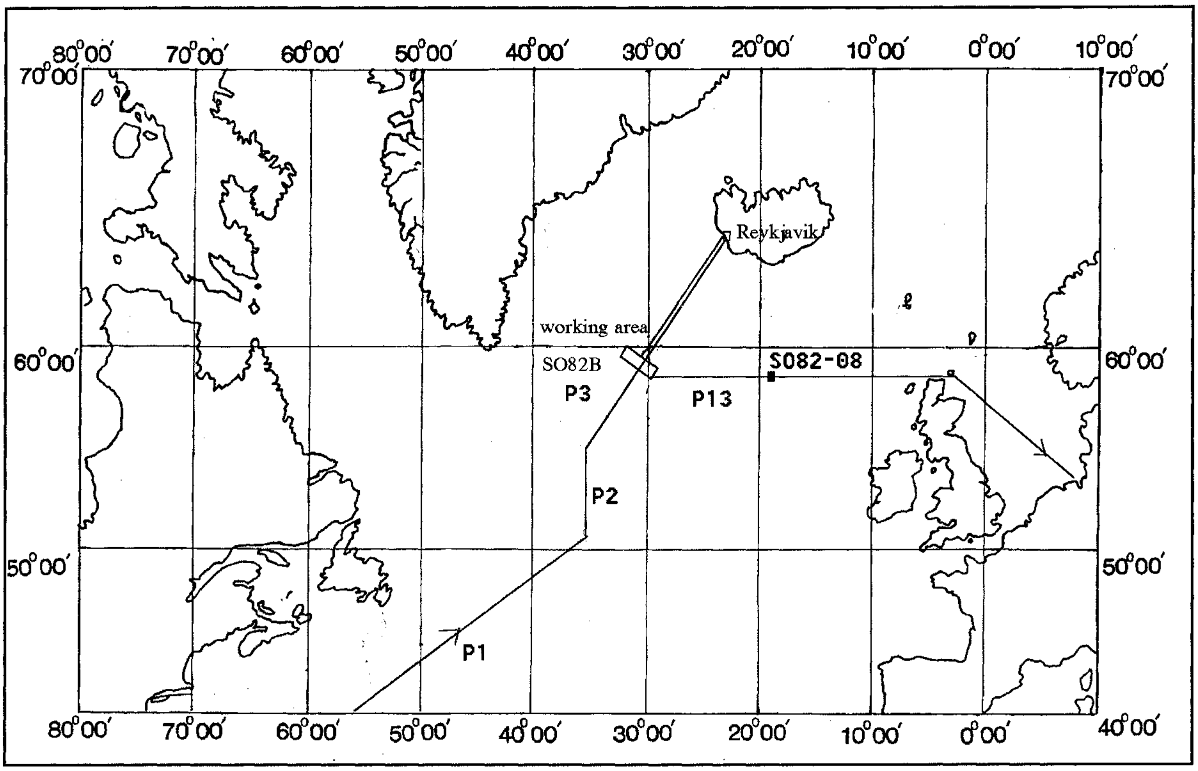


Fig.2.1.-1 Tracks and study area of cruise No. SO82 (P1 - 13 seismoacoustic lines, SO82-8 sampling station out of working area SO82B)

this data will be used for the first interpretation of the tectonic history of the northern MAR.

The second part was to install and to test high resolution acoustic profiling systems required for the investigation of the complicated morphology and sediment cover of the Reykjanes Ridge during part B. The narrow beam echosounder Parasound often fails to work properly in regions with rough morphology of the sea bottom (MOR) or at continental margins. As the slope angle of the seafloor exceeds the acoustic beam angle of the echosounder, the sound pulses are reflected away from the ship and therefore not properly received thus the recordings become of poor quality. Furthermore, the installation of the PARASOUND equipment at that time only permitted an on-line registration (black/white) of the echo signals on a DESO25 thermo-printer omitting the registration of a large amount of acoustic information. However, for sedimentological and sedimentphysical studies on the Reykjanes Ridge it was essential to record the complete information of the echo signals digitally, so that after postprocessing the spatially small and strongly organized sedimentary structures could be resolved and separated. These data is meant to be added to a complex sedimentological / sediment - physical model of MOR.

It was therefore decided to install and connect the "PARAsound DIGitalisierungs und Mehrkanal Auswertung" - System (PARADIGMA) to the PARASOUND - echosounder in order to test the integrated system in MOR regions. Furthermore, it was planned to integrate the PARASOUND - PARADIGMA system, developed by Dr.V. Spieß (Univ. Bremen), into the basic research equipment of RV "Sonne" later on. The aim of this work was to get the narrow beam echoes (non demodulated, low frequency signal) digitized and stored on tape for postprocessing. These data would specifically be used for a detailed investigation of small sediment-ponds with rather even surfaces during part SO82B.

A new deep-sea version of the multi-frequency sediment echosounder SEL90, developed by Prof. Wendt, University of Rostock, was also planned to be installed, tested and prepared for profiling during the second part of the cruise SO82B. This computer controlled subbottom profiler can operate with acoustic pulses of the frequencies of 5 kHz, 10 kHz and 20 kHz, with different pulse lengths and shapes of the acoustic beam. The wide range of the operating parameters offers the possibility of adapting the system to the demands of the different projects. Acoustic data had to be stored on magneto - optical discs and on DAT - tapes for postprocessing.

The first step of the work on board was the installation of the acoustic transducer array in the moonpool. Then, some basic measurements and tests were planned in order to improve the system. New operational modes (permitting very high pulse rates) and online data processing procedures had to be developed and to be tested under different conditions. At least the system had to be prepared for profiling during cruise part SO82B. In order to get a maximum of acoustic information about the sea bottom both echosounders (Parasound-Paradigma and SEL90) and the Hydrosweep had to be used simultaneously. Performing the test measurements the operators of the different acoustic systems had to get the necessary experience for doing this multi-sounder profiling.

2.2. Participants

Participating institutions

GeoB:	Fachbereich Geowissenschaften, Universität Bremen
IOW:	Institut für Ostseeforschung Warnemünde an der Universität Rostock
IfG-H:	Institut für Geophysik, Universität Hamburg
KGS:	Kansas Geological Survey, Kansas University, USA
URE:	Universität Rostock, Fachbereich Elektrotechnik, Institut für Nachrichtentechnik und Informationselektronik

Ships crew

M.Kull(Master)
A.Macke(2nd Mate)
Y.Msyazhenko(Doc.)
H.-J.Prüssner(2nd Eng.)
N.Guzman(2nd Eng.)
R.Duthel(Electron.)
T.Steffenhagen(Electron.)
S.Ladage(Syst. Op.)
V.Blohm(Motorman)
B.H.Bethge(Motorman)
A.Penk(2nd Cook)
W.Scheller(Steward)
K.-H.Lohmüller(Boatswain)
W.Hödl(A.B.)
W.Jahns(A.B.)
P.Schöber(A.B.)
S.Bühlow(Chief Mate)
W.Sturm(R/O)
H.-J.Neve(Ch. Eng.)
A.Rex(2nd Eng.)
W.Huxol(Electr.)
H.Voehrs(Electron.)
A.Tank(Syst. Op.)
R.Rosemeyer(Storekeeper)
M.Hoevelmann(Motorman)
H.Müller(Ch. Cook)
M.Both(Ch. Steward)
H.J.Prechtl(Steward)
D.Mahlmann(A.B.)
H.Krüger(A.B.)
P.Demba(A.B.)

Scientific crew

N.Anderson,	geophysicist,	KGS
R.Endler,	chief scientist,	IOW
T.Förster,	student,	IOW
I.Grevemeyer,	student,	IfG-H
W.D.Heinitz,	electronics engineer,	URE
R.Herber,	geophysicist,	IfG-H
G.Nickel,	geophysics technician,	IOW
Th. Rose,	student,	GeoB
V.Spieß,	geophysicist,	GeoB
Th.Warncke,	electronics engineer,	URE
G.Wendt,	electronics engineer,	URE

2.3. Cruise narrative - SO82 A
(R.Endler)

The first part of the SO82 cruise started in Balboa (Panama) on September 29, 1993, heading for the passage of the Panama chanal, the first part of the passage to Reykjavik. On the next day the ship passed Cristobal, entering the Caribbean Sea. After a small lecture about the basic behaviour and safety rules on board given by the Chief Mate the scientific work started with preparation of installing the new acoustic systems. This was done in close cooperation with the ships crew and especially with the co-workers of the "scientific - technical service" of RV Sonne.

In order to get a maximum of working time for the second part of the cruise, the shortest route to Reykjavik had to be chosen. In accordance with the "DWD / Seewetteramt" recommendations the course over Windward-Passage (October 2) and the Caicos-Passage (October 3), south of Newfoundland towards 45°N 45°W was selected (Fig.2.1.-1). Leaving the Caribbean Islands a medium swell of about 3 m from the NE direction caused strong disturbances of both the Hydrosweep and the Parasound measurements presumably due to air bubbles under the acoustic transducers. The ship's speed was 10 to 11 knots at this occasion. On October 05, the ships course was changed to 58 degrees in order to avoid a low pressure area announced by a gale warning from DWD. The swell increased to about 5 m from a wind of 6-8 Bft. from NNW heavily disturbing the measurements. On October 06, the transducer array of the SEL90 was installed in the moonpool. A safety and rescue training of the whole crew was performed on October 08. During the next days the wind increased up to 9 Bft. and the swell came up to about 6 m. On October 11, the wind changed to the east and decreased to 4-6 Bft.

On October 13 the ship arrived at the starting point of line SO82-P02 at 52°36'N 35°18'W (Fig.2.1.-1). The course was changed to 002°, following the axis of the MAR rift valley. At this line the Hydrosweep system operated permanently, mapping the central part of the MAR, while the installation- and testing- work on the sediment penetrating echosounders were continued. During the next days the course was changed in order to follow the ridge axis. Because of the small time span available the speed of the ship could not be reduced below 10-11 knots. This resulted in a lower quality of the Hydrosweep data along several sections of the line. On October 15, reaching the 200 nm border of Iceland all acoustic measurements were finished. The total length of the profiling lines amounts to about 850 nm. The first part of the cruise ended on October 16, with the arrival at Reykjavik harbour for the change of the scientific crew and embarkment of the second container containing the sampling equipment.

Table 2.3.-1 Schedule of cruise part SO82A

date time	activity
29.09.92.	
15:24	start of SO82A, Balboa harbour - Panama, passage of the Panama channel,
30.09.92	
02:18	passage Cristobal,
08:00	installation of acoustic equipment starts (PARADIGMA, SEL90)
02.10.92.	
18:00	leaving Windward-passage at 20°08,5'N 073°21,9'W
03.10.92.	
03:00	leaving Caicos-passage at 21°41,5'N 072°39,2'W
04.10.92.	
12:00	ships position: 26°22,5'N 068°42,0'W
05.10.92.	
08:00	change of course to 058° at 29°05'N 066°08'W because of gale warning
12:00	ships position: 29°28,8'N 065°25,8'W
06.10.92.	
12:00	ships position: 31°52,8'N 060°59,4'W
07.10.92.	
12:00	ships position: 34°39,2'N 057°38,7'W
08.10.92.	
12:00	ships position: 37°32,8'N 054°17,6'W
09.10.92.	
12:00	ships position: 40°22,7'N 050°53,1'W
10.10.92.	
12:00	ships position: 43°24,9'N 047°17,3'W
11.10.92.	
12:00	ships position: 46°31,7'N 043°27,3'W
12.10.92.	
12:00	ships position: 49°28,5'N 039°37,3'W

13.10.92

09:28 start of line SO82-P02 at 52°19'N 35°42'W, course 002°, with HYDROSWEEP mapping of the MAR rift valley

19:06 at 54°19,0'N 035°10,8'W change of course to 001°

14.10.92

01:07 change of course to 012° at 55°29,0'N 035°17,1'W

05:28 change of course to 040° at 56°21,0'N 034°47,0'W

14:02 change of course to 025° at 57°37,9'N 032°46,1'W

15.10.92

12:06 end of line SO82-P03 at 61°00,1'N 028°04,6'W, passage to Reykjavik

16.10.92

11:24 arrival at Reykjavik, end of part SO82A, exchange of crew, embarkation of scientific equipment.

2.4. Methods
(R.Endler)

The scientific planning and way point navigational workstation was used for **planning of the profiling tracks and the sampling stations**. The system allows the creation of a trackplot of the intended lines and stations. It calculates the distances and the travel time at a given ship speed. The results are printed and plotted. Furthermore, the data are stored in a file which is used by the ship's navigation system subsequently. The system was working very reliably and supported the planning and organization of the scientific work during the cruise.

The **positions** of the ship were estimated by GPS and processed (navigational filter) by the interface processor of the ANP 2000 navigation system. All data were calculated for the WGS 84 system. Navigational data were stored in separate files in ASCII format by the ANP2000 and the Paradigma - system.

The **multibeam echosounder** ATLAS HYDROSWEEP DS from Atlas - Elektronik GmbH, Bremen was used to map the morphology of the sea floor. The Hydrosweep system works in a similar way as an ordinary echosounder but uses a fan of 59 acoustic beams. This fan is orientated perpendicularly to the ships course. The central beam points vertically to the sea floor. Two sets of acoustic beams are directed sideways (left and right) with a maximum angle of 45 degrees. Thus, a stripe of about twice of the water depth is covered during profiling. The sound velocity profile which is necessary for the calculation of the water depths is estimated by a special procedure. During profiling the acoustic fan is rotated 90 degrees into the direction of the ships course after a certain number of measurements. Comparing and matching the depth data measured by the backward pointing beams with the depth contour estimated by the central beam during the former profiling the sound velocity can be estimated and corrected. Raw data were stored on tape and sent to the Hydro Map System 300 (HMS 300, HP 9000 / 400 workstation) for processing. Processed data were stored on optical disc. On a second workstation depth - maps and 3 dimensional views were created. The maps were plotted on a HP pen plotter and stored as HPGL files on disks. Grid data of the maps were stored on files for postprocessing too. Excluding some nonexplanable system faulures the Hydrosweep multibeam echosounder worked properly.

The main characteristics of the Hydrosweep system are:

operating frequency:	15.5 +/- 0.6 kHz
angle of transmission:	2 * 45 degrees
no of acoustic beams:	59
calibration:	manual, entering a sound velocity profile or self - calibrating using a mean sound velocity estimated from measurements along the course
corrections:	role (+/-20 deg) and pitch (+/-10deg)
max range:	central beam - 10000 m, outer beams - 7000 m
covered range:	about 2 * waterdepth
accuracy:	about 1 % (at waterdepth between 100 - 6000 m, role < 10 deg., pitch < 5 deg.

In order to investigate the highly distinctive structure and distribution of the sediments in the Reykjanes Ridge region two **acoustic profiling systems**, the extended narrow beam echosounder system Parasound - Paradigma and the SEL90 sediment penetrating echosounder, were installed and tested. The results of the measurements were digitally stored on tape / optical disc (SEL90) for postprocessing and recorded on a thermo-printer / colour-inkjet (SEL90). Both profilers and the Hydrosweep system were operated simultaniously. A more detailed description of the acoustic profiling systems is given in chapter. 2.5.1. and 2.5.2. Furthermore, a comprehensiv description of rv "Sonne" and the installed research techniques is given by BEIERSDORF et.al.(1993).

2.5. First results

2.5.1. Subbottom profiling with the Parasound System
(V.Spieß, Th.Rose)

The Parasound Echosounder System on RV "Sonne"

With the installation of three Parasound echosounder systems in the large German research vessels "Meteor", "Polarstern" and "Sonne" high-resolution seismo-acoustic studies can be extended and improved significantly. Based on special characteristics of the parametric echosounder as the narrow sound emission beam and a flexible signal control seismic data of high quality can be collected. Also the digital data acquisition system Paradigma, which was developed at the University of Bremen (SPIESS, 1992), was installed for digitization and permanent storage in standardized data formats in research vessels "Meteor" and "Polarstern" .

During the scientific cruise SO82A in transit from Panama to Iceland the Paradigma System was also installed on rv Sonne. Thereby the acquisition of high-frequency seismic data on German research vessels could be unified for all scientific users.

The operation of the Parasound System during cruise SO82A

A systematically modified and improved version of the Parasound System, based on the experience of these systems on research vessels "Meteor" and "Polarstern" for the last three years, has been installed in rv "Sonne" recently. During the transit of 2 1/2 weeks duration the echosounder system was used for continuous recording. Numerous features were tested and a number of deficits and problems could be identified and corrected or solved subsequently. Measurements on station and comparisons of different signal parameters were not possible due to a shortage of time. In general the Parasound system on rv "Sonne" provides data of a quality that is comparable to the other two systems on rv "Meteor" and rv "Polarstern". The modifications improved the system for analog as well as digital recordings.

Due to variable sea state and weather conditions in particular in the Caribbean Sea and near Bermuda Island, the surface waters were mixed to a high degree with air bubbles. These conditions probably caused the partial loss of signal energy and reflections, which was repeatedly observed in parallel for several seconds in the Parasound system as well as in records of the SEL-90 echosounder system of the University of Rostock. In addition, short intervals of extremely high noise amplitudes were measured. A possible explanation were assemblages of air bubbles, which were trapped, perhaps in a rather thick natural cover, and moved along the keel. They may cause acoustic noise and inhibit the development of the parametric signal due to high absorption. At the same time the Hydrosweep system was not able to provide any useful data at all under these circumstances. Although between 10 and 40% of the seismograms did not reveal surface and subsurface echoes, the remaining seismograms were of acceptable quality. The system operators could not report any comparable situation of data losses and therefore we assign these observations to the special weather situation, sea state and surface water conditions, which were often found particularly in the North Atlantic.

Towards the end of the cruise, north of Newfoundland, the weather became calm, and the echosounder recordings of all systems immediately improved. But still, the sea state in general controls the data quality as was observed also on R/V Meteor. Only on rv "Polarstern", with a draught of ~11 m this relationship is not valid this strictly. Possible causes related to the design of the keel and features, which can trap and accumulate air bubbles, have to be studied in greater detail during future cruises.

As expected from the physical characteristics of a narrow beam echosounder, in areas of rough topography coherent echoes from the ocean floor could not be observed. In some cases a scattering interval of more than 100 m in depth were found at steep slopes. But due to the large bandwidth of 0-10 kHz, compared to 2-6 kHz of older Parasound systems, the bottom echo could still be detected from scattered energy. The examples from the Mid Atlantic Ridge near Iceland also show some intervals of sediment cover.

Installation of the Paradigma System for digital data acquisition

The development of a system for the routine acquisition of high frequency echosounder data was started in 1988. During the following years a system was designed by the marine geophysics group at the University of Bremen specifically for recording digital Parasound seismograms and directly integrating shipboard data (SPIEß, 1992). The hardware concept of the Paradigma system (PARAsound-DIGitizing und Multichannel-Analysis System) is shown in Fig.2.5.1.-1. The two major tasks of 'Data Acquisition' and 'System Control' were assigned to two physically and logically separated hardware components. A mutual interference is thereby reduced to a minimum. Several channels can be digitized simultaneously. Trigger input and buffering of large data sets are handled by the HP3852A device, a programmable, multitasking data acquisition unit, which is connected to an IBM compatible personal computer via a IEEE-488 (HPIB) interface. Transfer of data, collection and integration of navigational and status information, data storage, graphical output and production of tables are managed by a high performance PC.

The installed Paradigma version treats only one signal line which is connected to the true Parasound seismogram. The signals are digitized with a sampling frequency of 40 kHz (max. 100 kHz). The oversampling is sufficient for detailed postprocessing of the complete amplitude and phase information. Due to the autoranging feature of the digital 13-bit voltameter a total dynamic range of ~120 dB is available. The data are stored on two internally buffered, industry compatible 1/2", 9 track magnetic tapes with a recording density of 6250 bpi. The storage format is adapted from the SEGY-Standard with minor deviations.

With this concept all major tasks of data acquisition, data transfer, programming of the digitizing parameter, internal and online control of the system can be done in parallel with extremely high data throughput and without affecting the measurement process. On PC's with a 80386/87 or 80486 processor also online processing can be added without reducing the overall system performance. The continuous data stream from Parasound and shipboard systems is integrated immediately and can be plotted on the computer screen.

The Paradigma software package

The software package Paradigma is very similar to those versions running on R/V Meteor and Polarstern and provides a uniform user interface for sediment echosounding studies on German research vessels. In addition to typical tasks of a seismic digital recording unit, several features were included for online control, data integration and graphical output. These features are:

- interactive online control of the measurement process;
- data storage on hard disk or magnetic tape;
- integration of serial lines with navigation and status information;
- tabular output of navigation and status information;
- preprocessing and graphical output of seismograms;
- graphical output of depth profiles;
- graphical output of ship's track;
- printout of colour coded seismic sections.

Digital Parasound examples from the North Atlantic and Mid Atlantic Ridge area

The primary goal of the sediment echosounding studies during cruise SO82A was the installation of the Paradigma system, some detailed tests of the Parasound echosounder and first analyses of digital Parasound data recorded on rv "Sonne". The five examples (Fig.s 2.5.1.-2 to 2.5.1.-6) shall prove a successful implementation of the Paradigma system on rv "Sonne".

Figures 2.5.1.-2 and 2.5.1.-3 represent consecutive profiles off the continental margin of North America at 42°N / 48°W. They show a high energy depositional environment with coherent subsurface reflectors and interbedded mass flow deposits. The morphology is controlled by downslope currents that cut E-W striking, erosional channels perpendicularly to the ship's track. Although the data quality is affected by disturbing weather conditions and a high electronic noise level, the post processing of the digital data provided a detailed image of the ocean floor and subbottom structures.

To verify the increased acoustic bandwidth of the signal reception part of the Parasound system, three records from the Mid-Atlantic Ridge between 53°N and 61°N are shown in Figures 2.5.1.-4 to 2.5.1.-6. Since the topography does not allow coherent reflections from a smooth surface, only diffracted energy can be received from within the sound emission cone of 4° opening angle. Steeper slopes and a rough surface cause a scattering of energy over long depth intervals up to 100 meters. Besides the obviously dominating magmatic surface rocks in Figure 2.5.1.-4 also a short interval (at UTC 16:30) is found, where higher reflection amplitudes and a coherent bottom echo indicate a sedimentary coverage. In all three examples the bottom can be tracked by the smeared interval of higher energy, which is often not possible with the 2-6 kHz bandlimited Parasound systems on rv "Meteor" and "Polarstern". Figure 2.5.1.-5 shows a typical sequence in a ridge area with some intervals of high reflection amplitude on the bottom of topographic lows. A much shorter average wavelength of the topographic features is observed in Figure 2.5.1.-6 from the Reykjanes Ridge in about 800 m water depth.

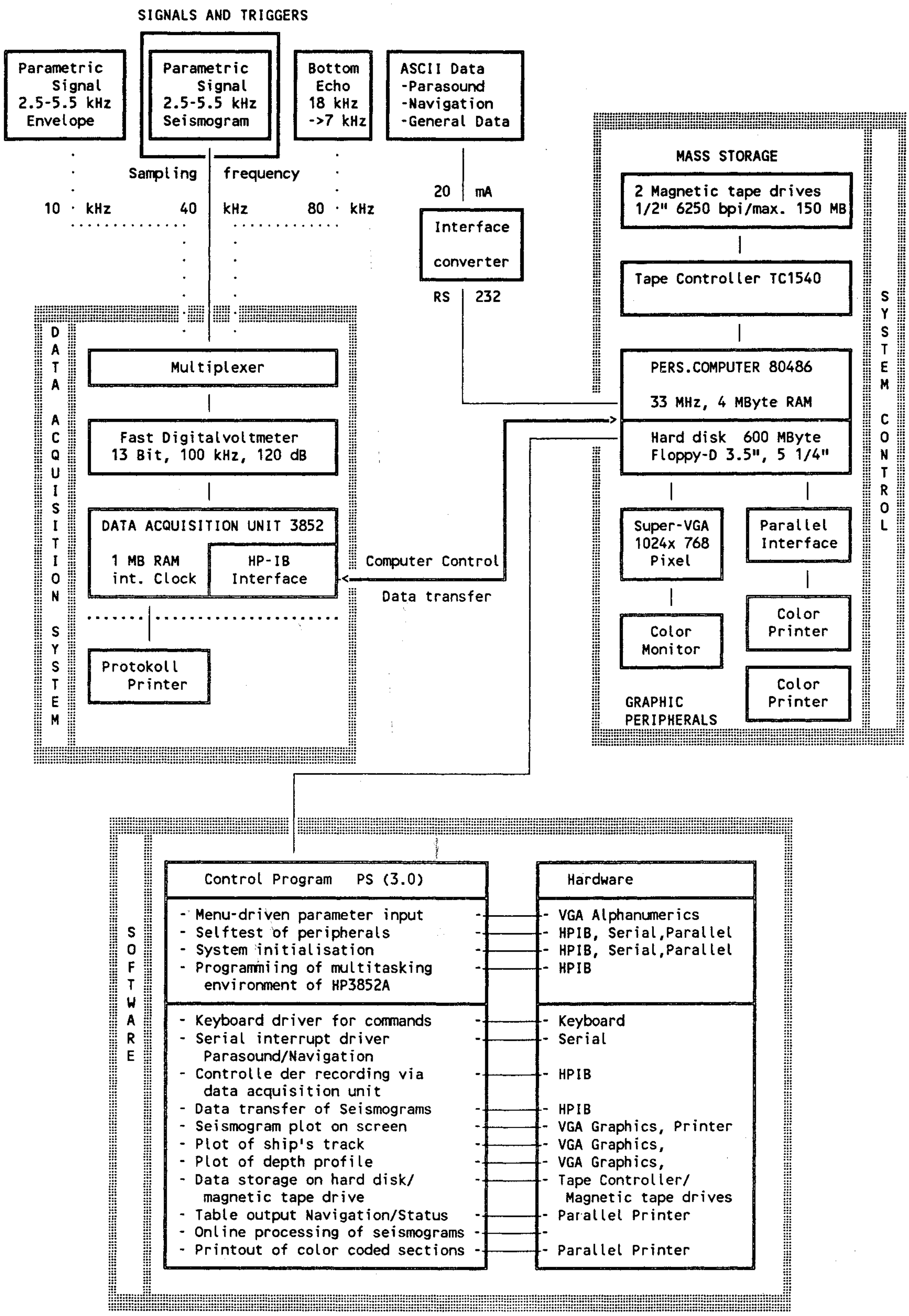


Fig. 2.5.1.-1 Hardware concept and software components of the Paradigma System (PARAsound DIGitizing and Multichannel Analysis System)

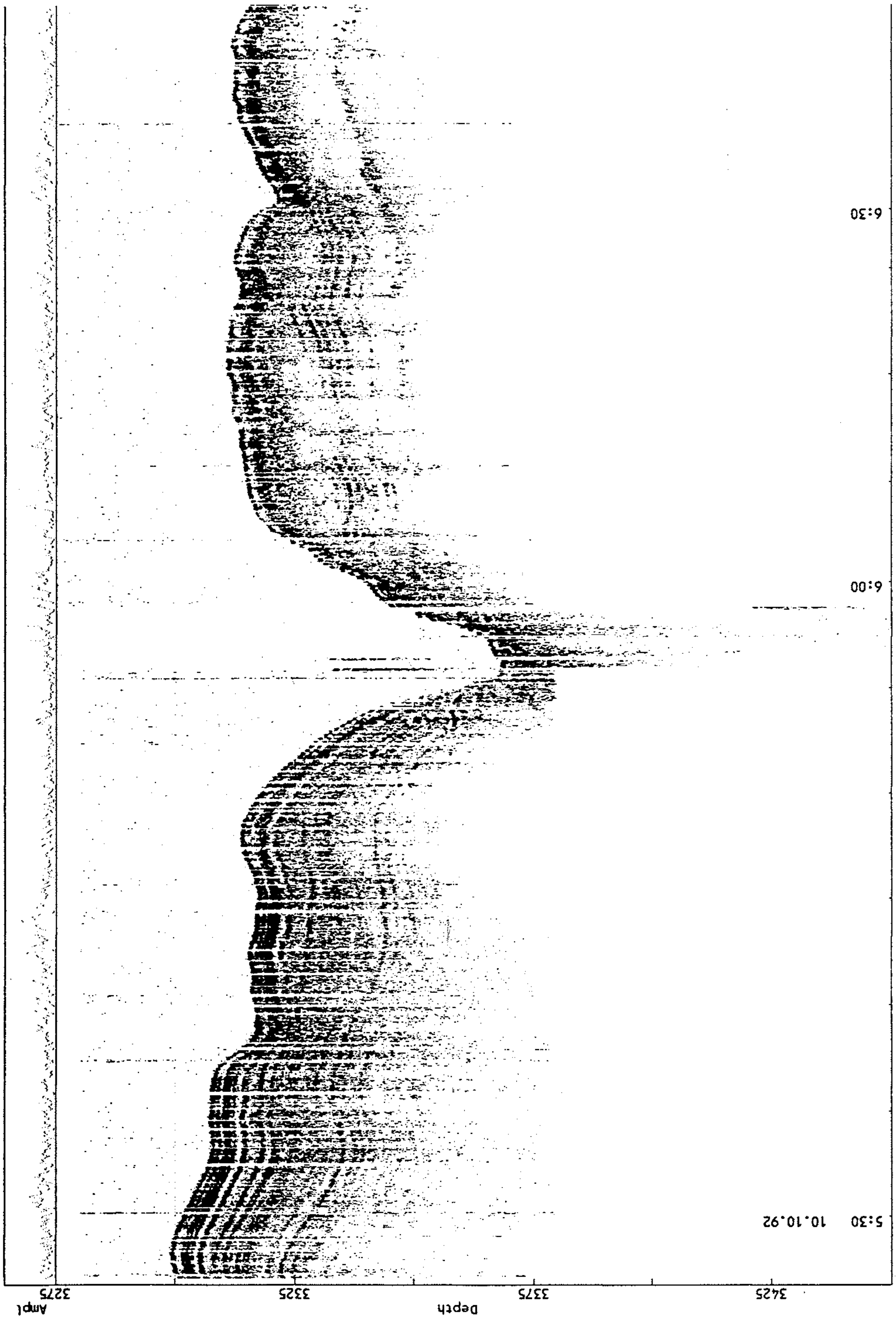


Fig. 2.5.1.-2 Digital Parasound profile from the North Atlantic at 42°N/48°W showing continuous subsurface layering with interbedded mass flow deposits and deep erosional channel cutting. Vertical scale in meters is given for a sound velocity of 1500 m/s. Horizontal scale is slightly varying with ship's speed. In general a time interval of 10 minutes represents a distance of 2 nautical miles at an average speed of 12 knots.

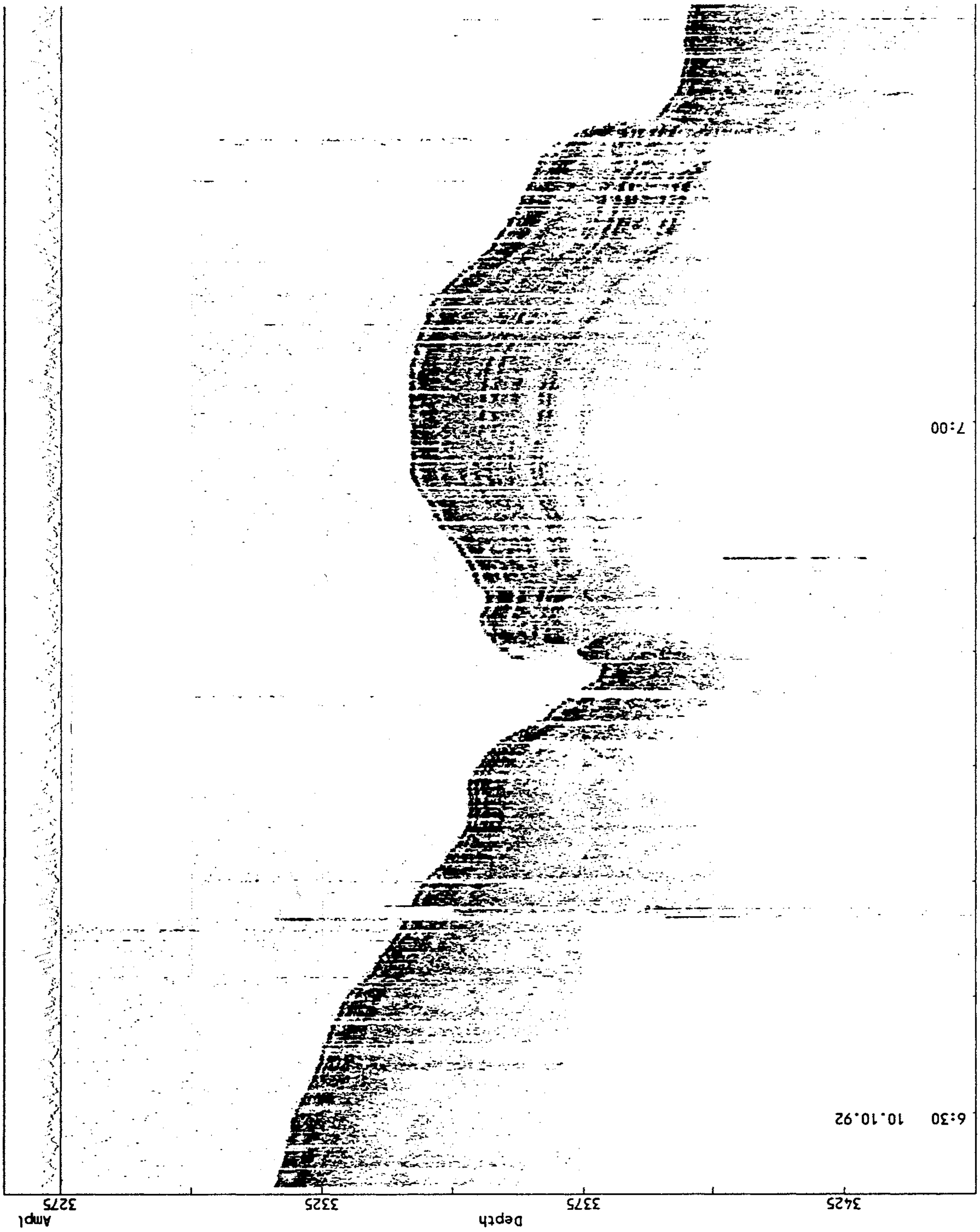


Fig. 2.5.1.-3 Continuation of the digital Parasound profile in Fig. 2.5.1.-2. See Fig. 2.5.1.-2 for further explanation.

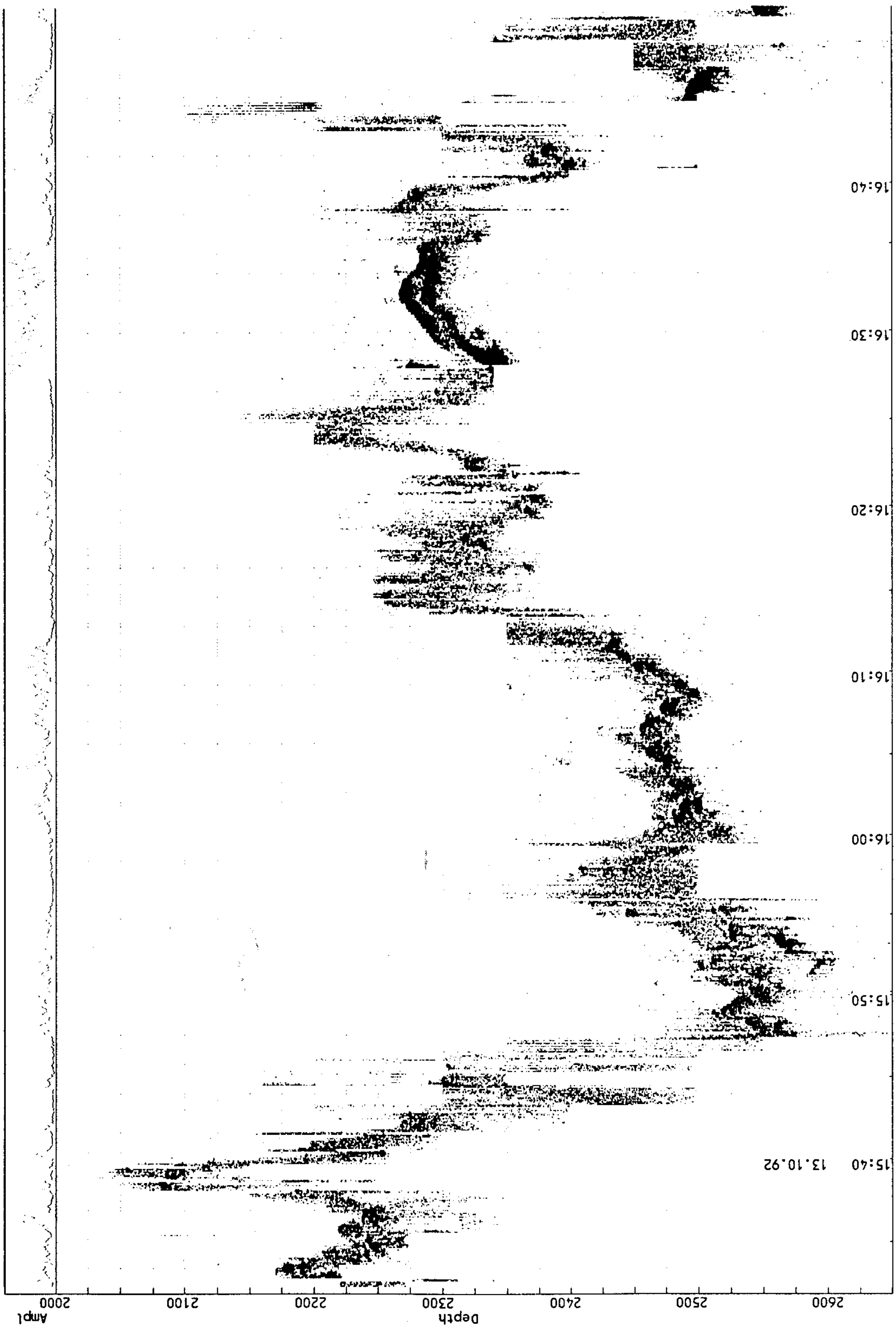


Fig.2.5.1.-4 Digital Parasound profile from the Mid Atlantic Ridge Area at 53°N/35°W. See Fig. 2.5.1.-2 for further explanation.

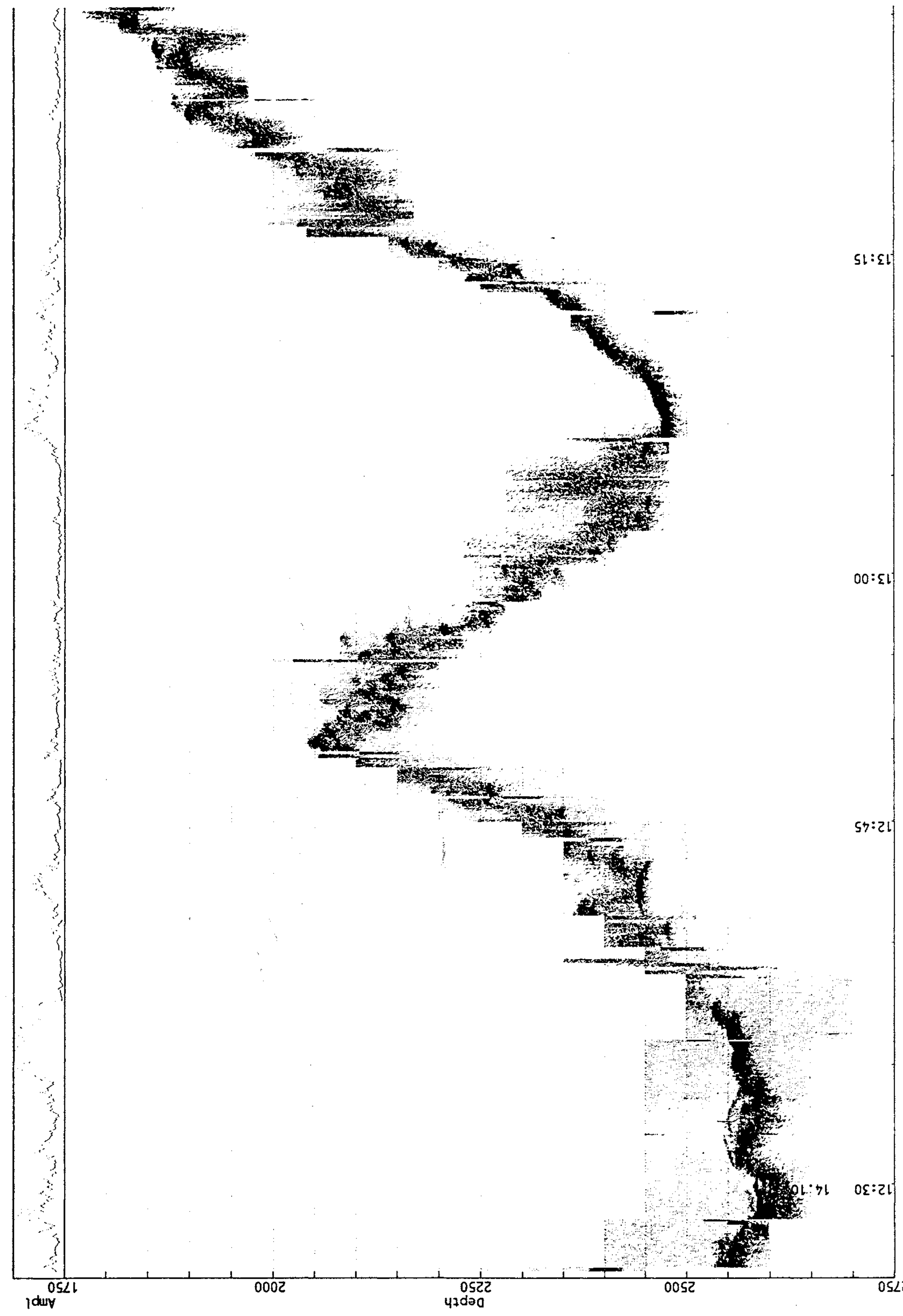


Fig.2.5.1.-5 Digital Parasound profile from the Mid Atlantic Ridge area at 57°N/33°W. See Fig.2.5.1.-2 for further explanation.

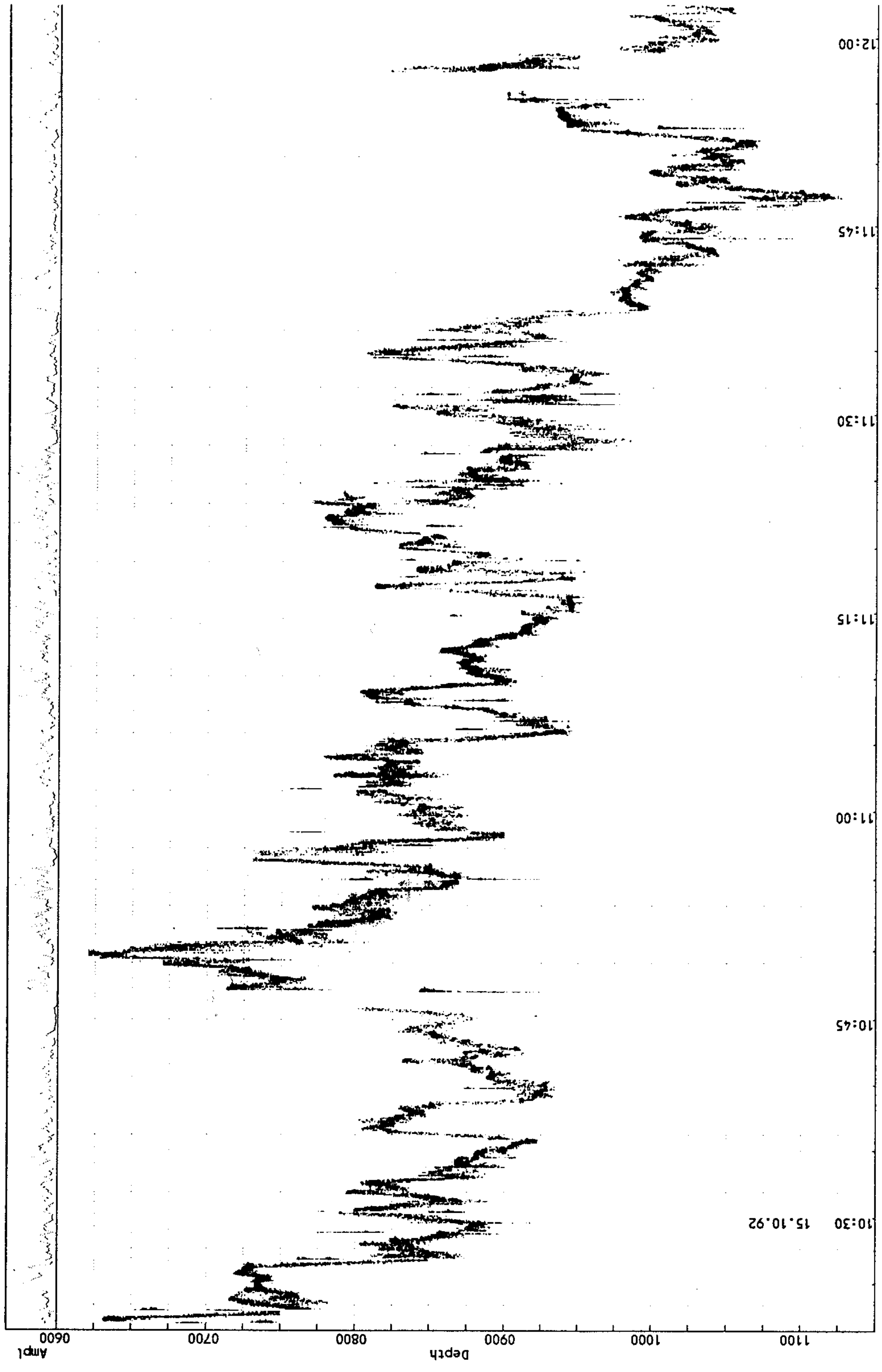


Fig.2.5.1.-6 Digital Parasound profile from the Reykjanes Ridge area at 61°N/28°W. See Fig.2.5.1.-2 for further explanation.

2.5.2. Test of the sediment penetrating echosounder SEL90

(G. Wendt, R. Endler)

To investigate in detail sediment sequences in regions like the MOR, with a rough morphology of the seabottom is a very complicated task and a challenge for the development of highly sophisticated seismoacoustic systems. Good results have been obtained with parametric echosounders like the Parasound. Using nonlinear acoustic effects these systems create a narrow acoustic beam of low frequency pulses. Because of the low acoustic efficiency of the parametric effect a high technical expense is necessary to generate the acoustic power required. With the use of low-frequency acoustic pulses deep penetration can be obtained in horizontal or slightly sloping sedimentary layers. In regions with a strongly tilted and rough sea bottom the acoustic pulses will be reflected with an angle directed away from the ship, whereby no echoes will be received by the echosounder.

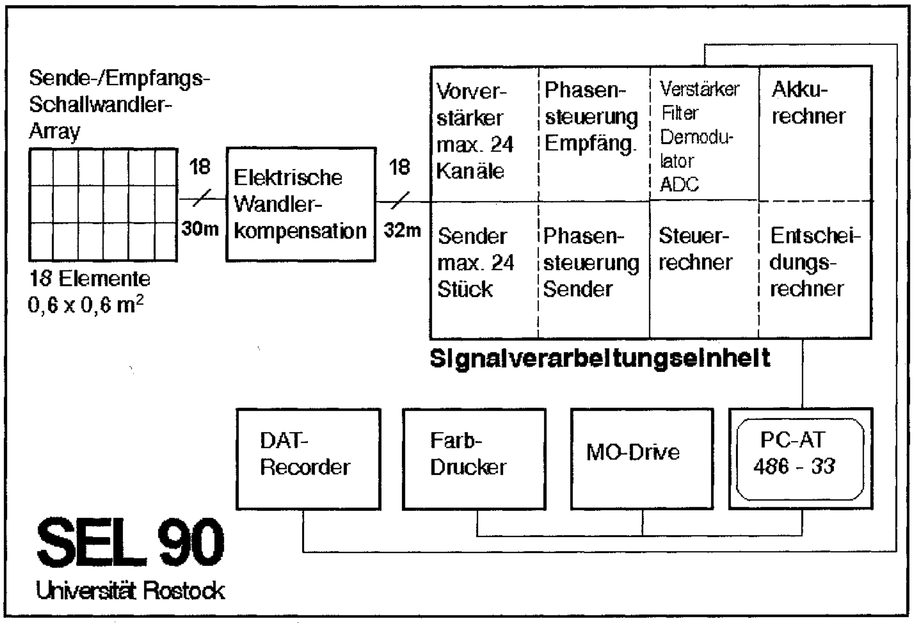


Fig. 2.5.2-1 Configuration of the sediment penetrating echosounder SEL90

Sediment penetrating echosounders like 3.5 kHz profilers operates in the linear range and have wider acoustic beams. A larger area of the seafloor is acoustically "illuminated" during profiling. This leads to a markable decrease in vertical and horizontal resolution, specifically in regions with a rough morphology of the sea bottom. Narrow beam pulses which gives a higher resolution can be generated by transducers of small dimensions only in the high frequency field. Using high frequency acoustic pulses sea bottom echoes can be received also in regions with a rough and strongly tilted morphology because of backscattering effects. But, the high attenuation of the high-frequency signals in the water column and in the sediments has prevented their use in sediment profiling systems up to now.

The SEL90 echosounder was designed to compensate these losses by increasing the transmitted acoustic energy and applying adapted online signal processing procedures. This was obtained by following arrangements:

- high shooting rate, adapted to the observed / displayed time window of the acoustic recording
- stacking of several acoustic traces in order to improve the signal vs. noise ratio
- short pulse length for high resolution
- selecting the frequency of the acoustic pulses with respect to high penetration and resolution
- use of special processing procedures for detection and resolution of scattering centers at sea bottom slopes

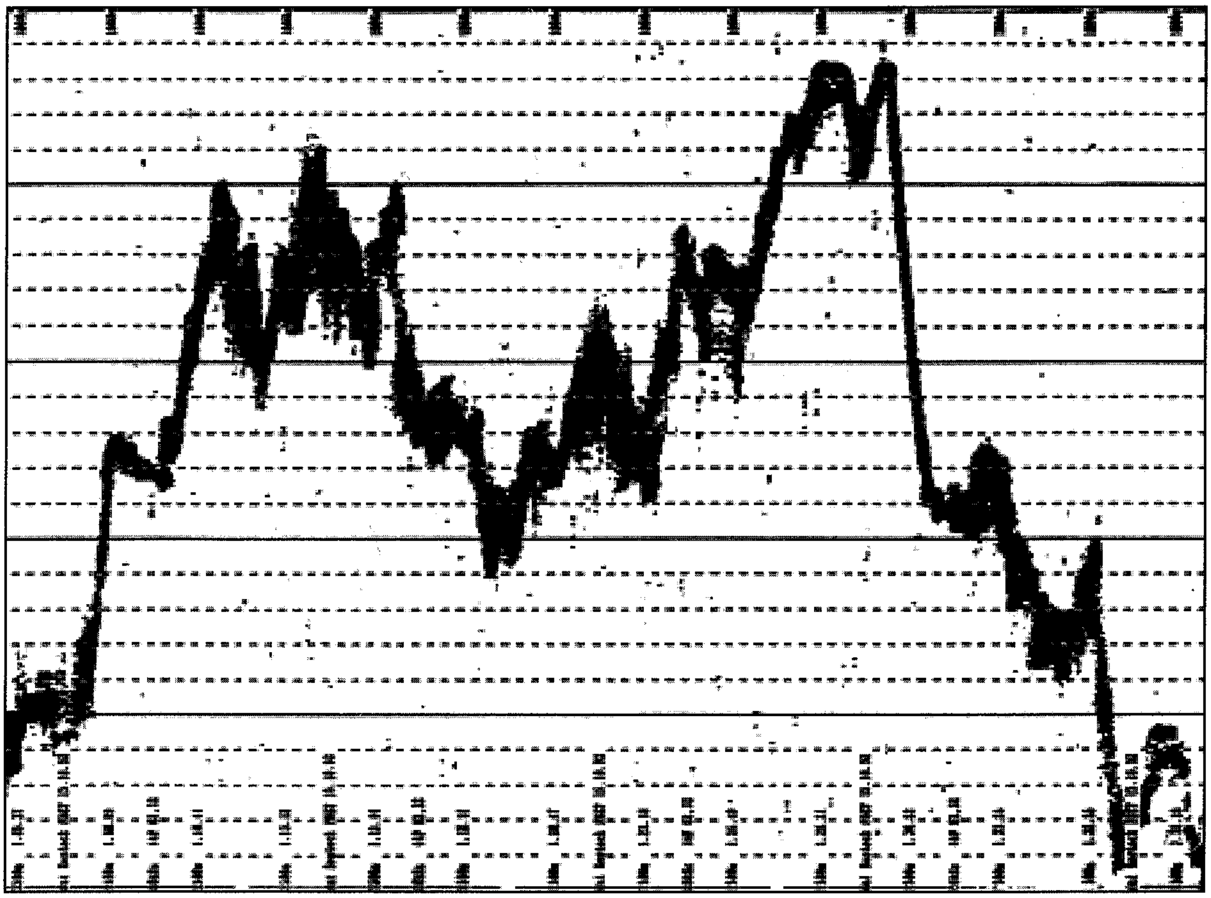


Fig. 2.5.2-2 SEL90 recording (amplitude display, 20 kHz) of a rough sea bottom with slopes up to 60°, depth range 1000 - 1500m, horizontal extension about 12 km

Fig. 2.5.2.-1 shows the configuration of the sediment echosounder SEL90 modified for deep-sea application. The

echosounder is designed for mobile use. The transducer array consist of 18 magneto-strictive elements which were mounted in the front moonpool of rv "Sonne". The noise caused by hydrodynamic turbulences was reduced by an acoustic window closing the lower end of the moonpool. At the end of the cruise on the way to Bremerhaven the acoustic damping of the window was measured. The results indicated a bad quality of

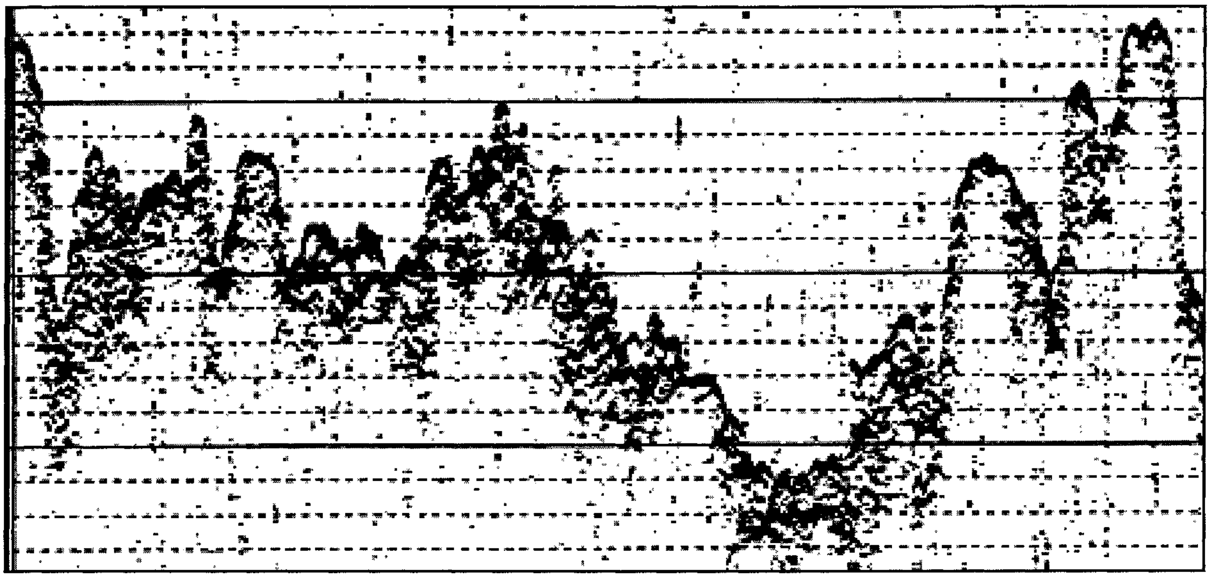


Fig. 2.5.2.-3 SEL90 recording (high resolution mode, 10 kHz) of rough sea bottom, hyperbolic echoes indicating lifted out (back scattering) features, depth range 850-1180m, horizontal extension about 5 km

the used material causing high losses of acoustic energy. Nevertheless, very good records were obtained proving the outstanding performance of the system. The equipment electronic of the SEL90 was installed in the seismic lab on the main deck. The electronics were housed in a portable rack. Simultaneously with the online processing and display of the received signals, the raw data were stored on DAT - tape (full waveform) and on optical disc (envelope) for post-processing.

After installation of the equipment an extensive working program including tests of the several hardware and software units and of different operating modes was performed. The results confirm the efficiency of the system. Some record examples from the central part of the MAR using different operational modes are shown in Fig. 2.5.2.-2 to Fig. 2.5.2.-4. Operating both the echosounder Parasound and SEL90 simultaneously, disturbances occurred in the SEL90 recordings especially when the 20 kHz mode was used. This is due to primary frequencies of about 18 kHz and the huge power (100 times higher than that of the SEL90 signals) of the Parasound pulses.

The measurements and tests suggest that further improvements of the SEL90 system can be obtained by:

- increasing the acoustic energy by higher transmitting power and special forms of the acoustic pulses (coded),
- improved filters (notch filters),
- multifrequency sounding (alternating),
- electronically controlled beam stabilizing and steering (perpendicular to the surface),
- optimizing processing and decision processes.

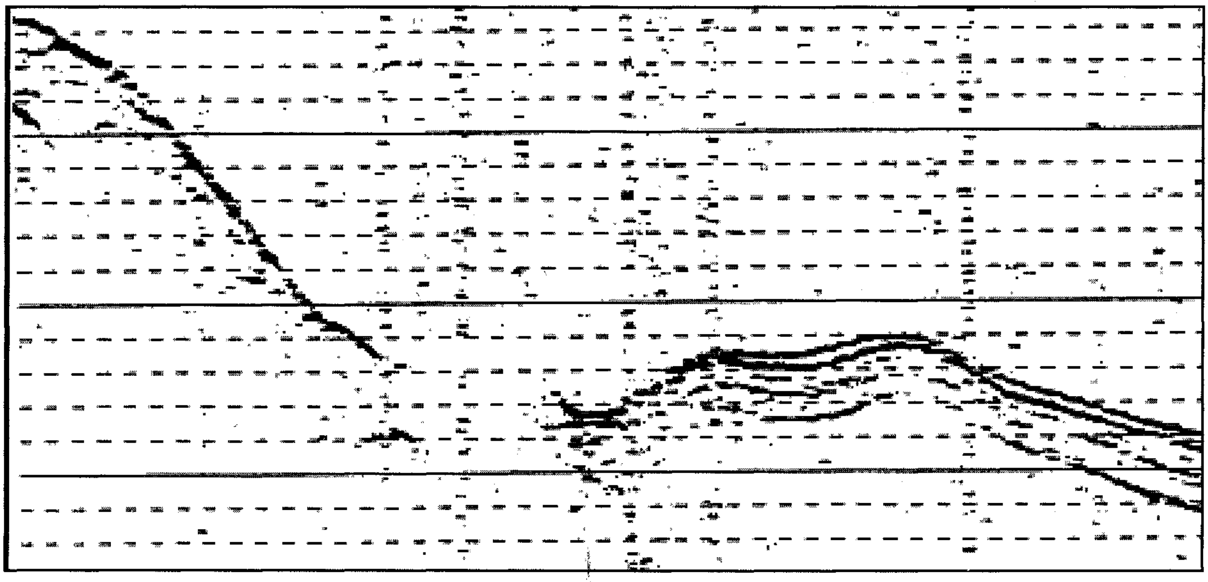


Fig. 2.5.2.-4 SEL90 recording (high resolution mode, 5 kHz) of a sediment pond with a penetration of more than 20 m, depth range 1310-1430 m, horizontal extension about 3.8 km

Taking into account that this was the first test of the SEL90 system in the deep sea, it can be stated that the project was successful. The combination of two sediment penetrating echosounders provides very useful information about the sea bottom relief and the sediment structure in regions characterized by a rough morphology and steep slopes. The data obtained during regular profiling formed the basis for the selective sampling of sediments during part SO82B. Further development of the system will be performed in the frame of joint research projects.

2.5.3. Episodic spreading at the Reykjanes Ridge

(I.Grevemeyer, R.Herber, W.Weigel)

Abstract

During the rv "Sonne" cruise SO82A a single Hydrosweep profile over the Reykjanes Ridge crest was carried out. The recorded bathymetric stripe allows a classification of two main segments. The southern segment between the Charles Gibbs Fracture Zone and the Bight Discontinuity is a typical part of the northern Mid Atlantic Ridge with rift mountains bounding a median valley. The Bight Discontinuity seems to be a transition zone between the influenced and non-influenced region of the Iceland hotspot. From this transition zone the second segment trends 36° northeastward toward Iceland. Oblique spreading and en echelon ridges are typical, striking south of 61°N perpendicularly to the spreading direction of 103°. The overall structure of the Reykjanes Ridge supports a mainly amagmatic-tectonic evolution as it is typical of episodic spreading models.

Introduction

In autumn 1992 the German rv "Sonne" carried out a single Hydrosweep profile over the central part of the Reykjanes Ridge (SO82A). This structure is part of the Mid Ocean Ridge (MOR) System. Since the acceptance of plat tectonics as a unifying model for the development and rejuvenation of oceanic crust, the prominent Mid Ocean Ridges have been attributed to these processes. Distinctive features of Mid Ocean Ridges include their bilateral morphology around a central axis, the generation of Mid Ocean Ridge basalts and the intermittent volcanism which is related to the spreading rate and the magma supply. Thus the large scale ruggedness of the seafloor topography decreases with increasing spreading velocity in combination with increasing magma production.

The volcanism of fast-spreading ridges is restricted to an axial volcanic ridge, whereas at slow-spreading ridges seamount-volcanism is common in addition to axial doming (e.g. BALLARD & ANDEL, 1977; SMITH & CANN, 1992). Detailed investigations of the MOR indicate phases of volcanic inactivity, i.e. the rift is characterized by an axial tectonic graben. These observations support the development of an episodic morphotectonic accretion model (e.g. LEWIS, 1979; KAPPEL & RYAN, 1986; GENTE, 1987), splitting the spreading in an active-volcanic and an amagmatic-tectonic phase.

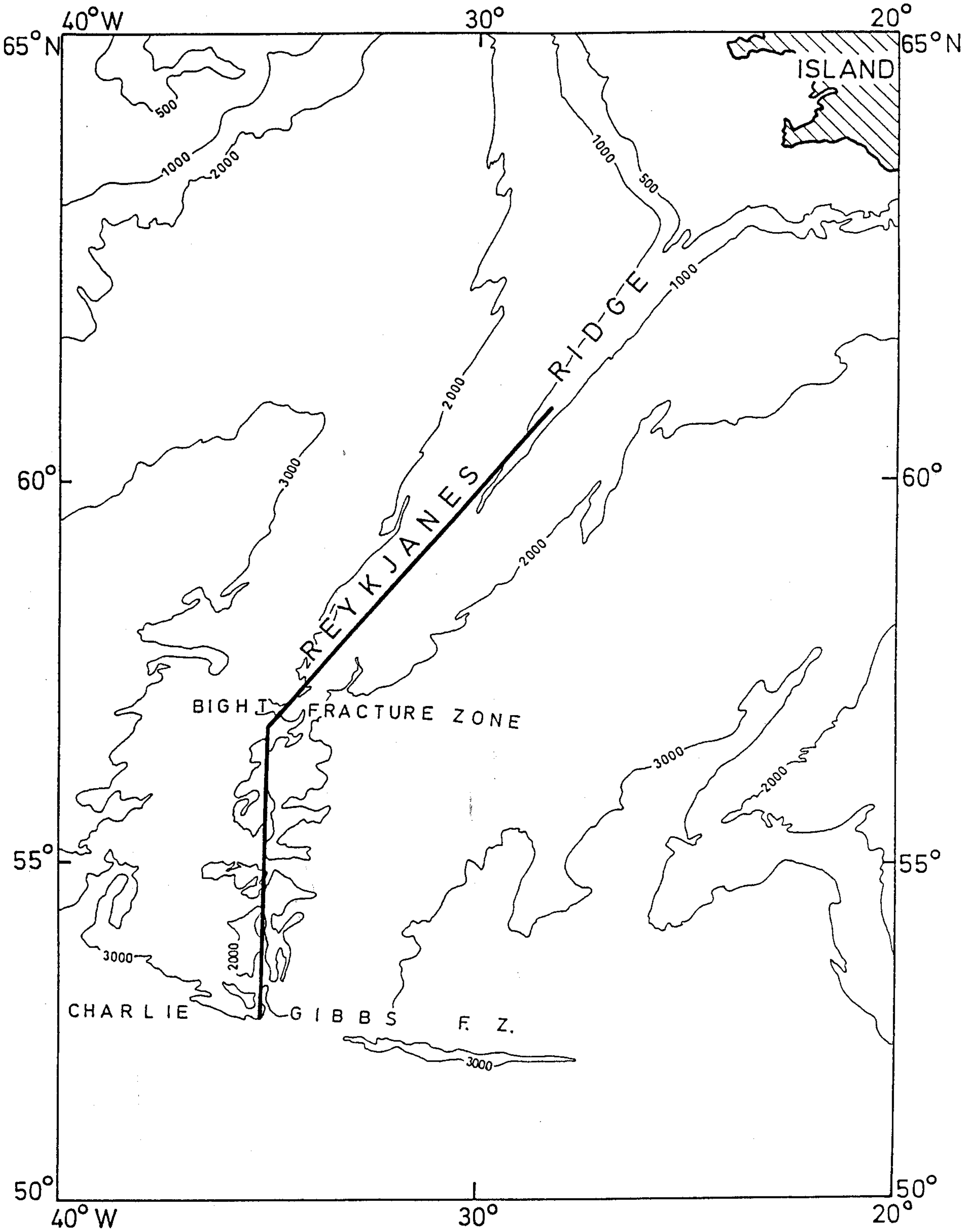


Fig. 2.5.3.-1 Course over the Reykjanes Ridge crest of the rv "Sonne" cruise SO82A

Results of the Hydrosweep - profile

According to the morphotectonic features we divided the Reykjanes Ridge into two main segments. The southern segment is bordered to the south by the Charles Gibbs Fracture Zone and to the north by the Bight Fracture Zone (Fig. 2.4.3.-1). From the Bight Discontinuity the northern segment extends to Iceland.

The southern segment shows the typical morphology of the North Atlantic MOR, i.e. an axial graben and flanking rift mountains (Fig.2.5.3.- 2A). As typical for the tectonic phase of the episodic spreading model, the rift is characterized by a tectonic graben and depressed areas, rather than by an axial volcanic ridge and an abundances of volcanoes, as commonly found along the active sections of the Mid Atlantic Ridge (BALLARD & ANDEL, 1977; SMITH & CANN, 1992). The axial zone strikes 3-4° between Gibbs Fracture Zone and 55°14.8'N.

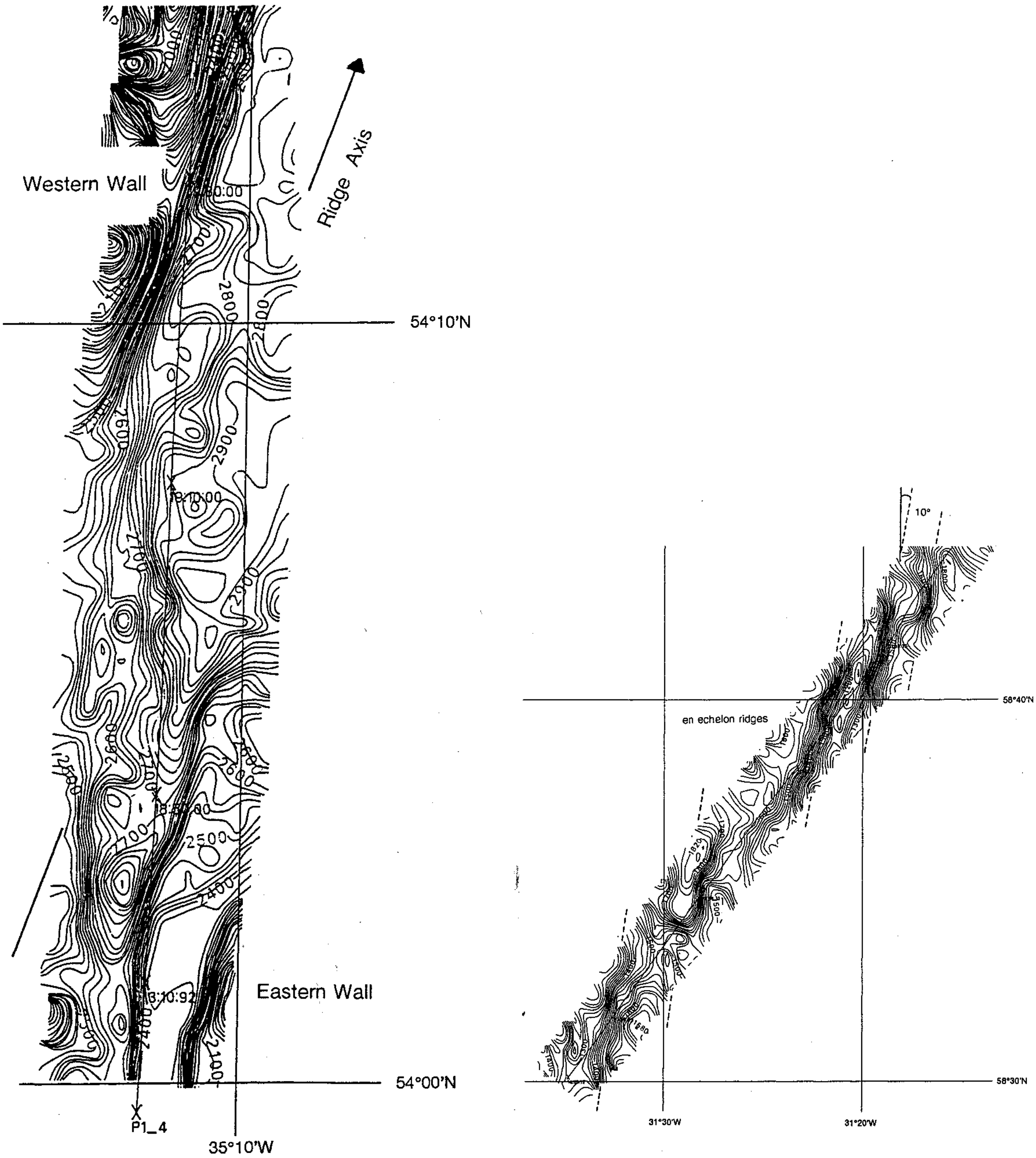
At 55°14.8'N, we observed an unforseen change in the strike of the axis. Here the rv "Sonne" left the axial zone. Near the Bight Fracture Zone the rift valley was reentered.

Today the Bight Fracture Zone seems to be a transition zone between the influenced and the non-influenced regions in relation to the Iceland hotspot, rather than a first order discontinuity with a transform valley (MACDONALD & FOX, 1990).

The northern segment of the Reykjanes Ridge, north of the Bight Discontinuity strikes northeastwards in the direction of Iceland. The general strike of the axis along this segment is 36°, although the plate motion is 103° (FLEISCHER, 1974). Therefore, unlike most spreading centers, the Reykjanes Ridge axis is not oriented to its spreading direction perpendicularly, the spreading is oblique of about 23°. The rough topography contains a series of 10° trending en echelon ridges, which are oriented to the spreading direction perpendicularly (Fig.2.5.3.- 2B).

The northern segment of the Reykjanes Ridge forms a slow-spreading ridge with a spreading rate of 1 cm yr^{-1} (TALWANI et al., 1971). Near Iceland a hilly- or horst-like profile is typical for the axis of the Reykjanes Ridge, however, and this is more consistent with the features of a fast-spreading ridge (JOHNSON & JAKOBSON, 1985). This horst-like feature reduces steadily in amplitude southwards from 61°N and changes into a median valley at about 59°N.

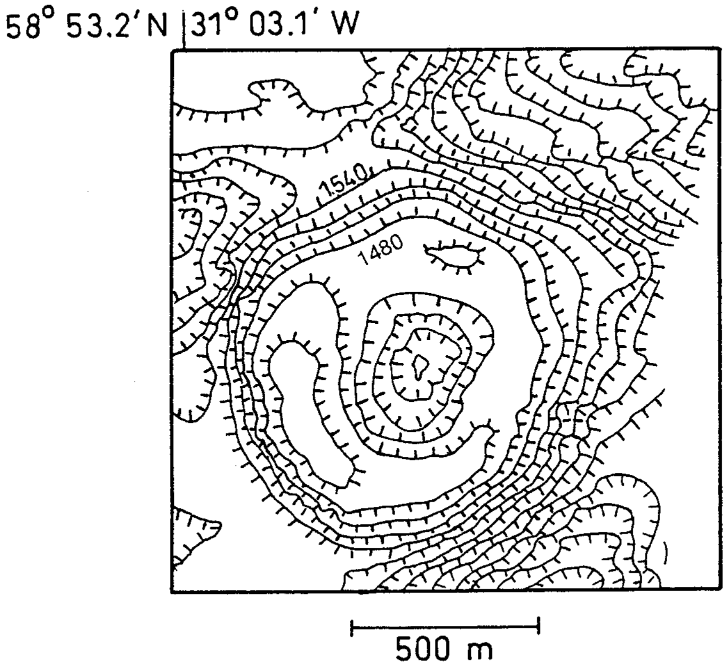
Apart from the en echelon ridges, the Hydrosweep recordings revealed a number of volcanoes. Frequently the summit of these seamounts has a crater or a depressed area like a caldera. Deep depressions, interpreted as collapsed lava ponds were observed, too (Fig.2.5.3.-3).



(A) (B)

Fig. 2.5.3.-2 Hydrosweep stripes of the Reykjanes Ridge crest, 20 m contour intervall. (A) The southern segment is characterized by a median valley and bounding rift mountains, the valley is dominated by a tectonic graben. (B) En echelon ridges, trending perpendicularly to the spreading direction, but are oblique to the strike of the axis of spreading are located in the rift valley floor of the northern segment.

(A)



(B)

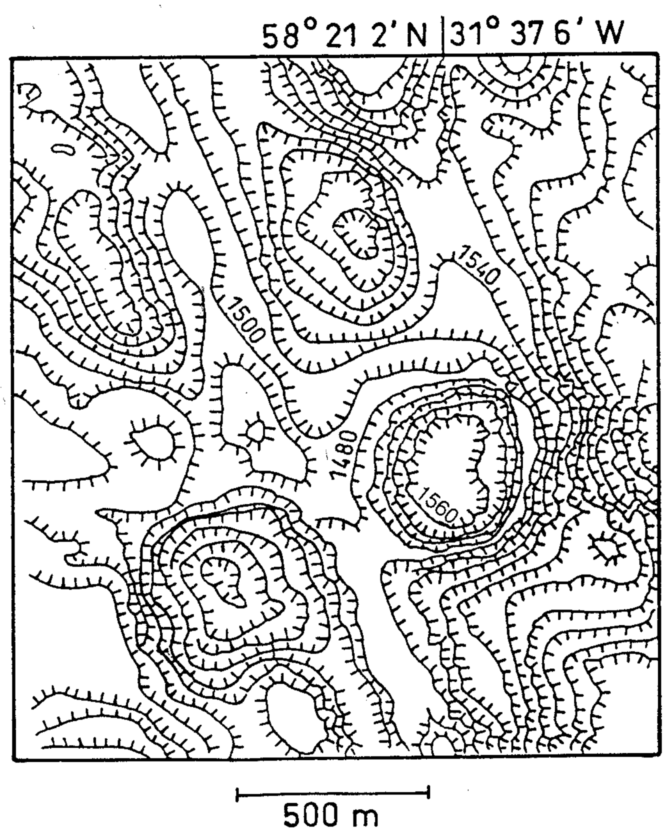


Fig. 2.5.3.-3 Bathymetric charts of depression areas at the Reykjanes Ridge, 20 m contour interval. (A) Volcano with a caldera like summit crater. (B) Small collapsed lava ponds.

Discussion

The structure of the southern segment of the Reykjanes Ridge is typical of the amagmatic-tectonic phase of episodic spreading models (e.g. GENTE, 1987), i.e. the valley is dominated by a tectonic graben and only a limited number of volcanoes. Depressional areas are present.

We assume that the change in ridge crest topography in the the Bight Discontinuity area, i.e. the transformation of the median valley to a horstlike or hilly structure, the oblique spreading and the en echelon ridges are due to the proximity of the Iceland hotspot. The axial high near Iceland possibly the result of larger magma chambers, heated by the hotspot (LAUGHTON et al., 1979). Alternatively the axial high is due to the amount of a lateral flow away from Iceland (JACOBY & GIRARDIN, 1980) in which case the hight of the structure is dependent on the distance to the hotspot. Possibly, the lateral flow away from Iceland and the global plate motion could be the origin of oblique spreading, i.e. an interaction between the flow and the upwelling under the Reykjanes Ridge could lead to the oblique strike of the axis versus the flow direction. Stretching forces, due to the global plate motion may have caused the crust to fail, initiating the intrusive and extrusive volcanism which built the en echelon ridges perpendicularly to the spreading direction.

Considering the influence of the Iceland hotspot, the overall structure of the northern segment is proposed as due to a mainly amagmatic-tectonic evolution which is also the case for the southern segment. Decisive features along the northern segment are the depression of the rift valley toward the Bight Discontinuity, the collapsed lava ponds, the calderas and, compared to the MAR (SMITH & CANN, 1992), the small amount of volcanoes.

This interpretation is also supported by the observations of an American / Russian submersible investigation near 59°50'N (CRAINE et al., 1992). At the occation the submersible "Mir" dived in an area that was within the epicentral region calculated for a 1989 seismic swarm (NISHIMURA et al., 1989). Almost no extrusive volcanic activity, but about 20 - 40 cm of sediment were observed revealing an older lava flow. From these results, CRAINE et al., (1992) concluded that the teleseismic swarm was caused by faulting or perhaps intrusive, but not extrusive, activities along the axis.

Conclusions

The Reykjanes Ridge is built up of two main segments. The southern segment between the Charles Gibbs Fracture Zone and the Bight Discontinuity shows the typical structure of the northern Mid Atlantic Ridge: a median valley and flanking rift mountains striking in axis direction.

The Bight Discontinuity is interpreted as a transition zone between the influenced and non-influenced regions of the Iceland hotspot.

The northern segment extends from Iceland southwestward toward this transiton zone. From 61°N the axial high - typical of the segment adjacent to the hotspot - decreases in amplitude, and from about 59°N a median valley is present. Additional, the segment is characterized by oblique spreading and echelon ridges that trend to the spreading direction perpendicularly.

If we consider the interaction between the Iceland hotspot and the northern segment, the overall structure of the Reykjanes Ridge could be interpreted as a result of a mainly amagmatic-tectonic evolution, as discussed by episodic spreading model (e.g. GENTE, 1987). Typical are the axial tectonic graben in the south as well as the depression area, the calderas and the collapse lava ponds.

3. Part II. (SO82B)

3.1. Research program and working area

(K.S.Lackschewitz, R.Endler)

The second period of the cruise, SO82B, (Reykjavik - Bremerhaven) was devoted to the investigation of sedimentation processes, including their spatial and temporal variability in the area of the Reykjanes Ridge. Compared with other rift systems, the Reykjanes Ridge is characterized by very low spreading rates and the climatic changes in the high latitudes result in relatively high sedimentation rates from 5 cm/1000 years to 20 cm/1000 years. According to KUPTSOV (1988) the sedimentation rates can amount to values of up to 50 cm/1000 years.

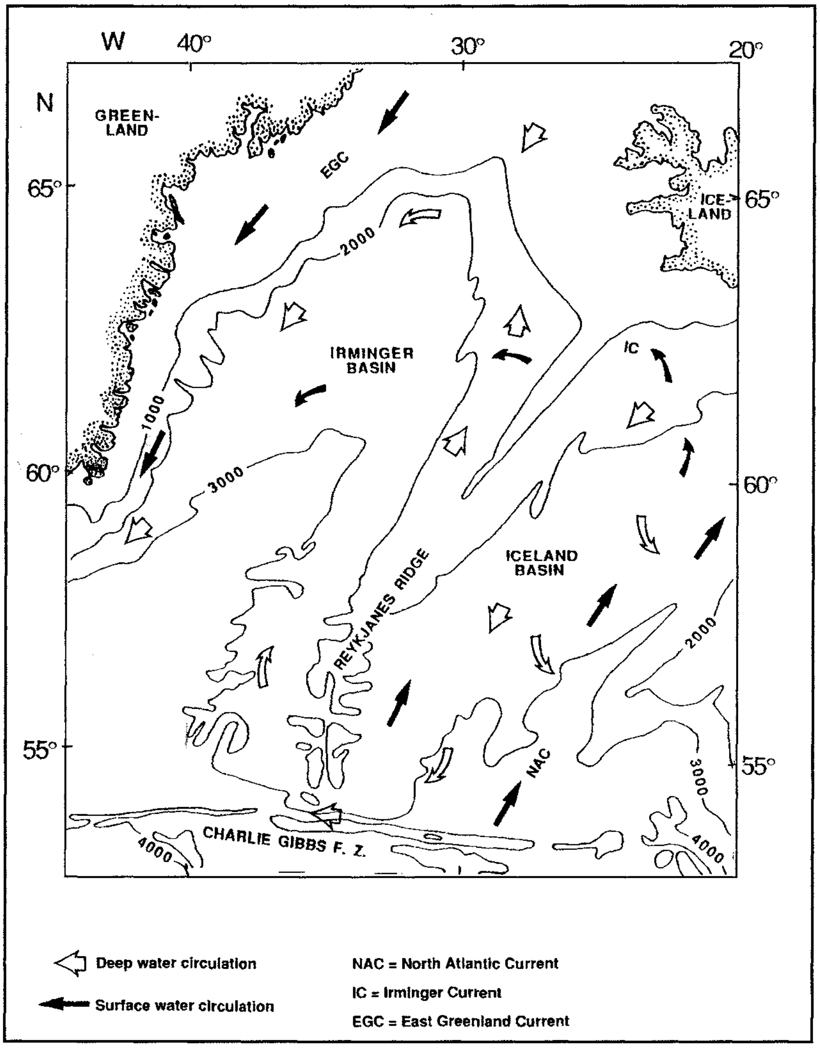


Fig.3.1.-1 Major surface water and deep water circulation pattern in the North Atlantic

The ocean area between 55°N and 65°N is characterized by complex hydrographical conditions which can be explained by the area´s extraordinarily complex climatological and morphological conditions. This leads to short- and longterm changes in the sedimentation processes. Major surface water and deep water circulation pattern in the North Atlantic is shown in Figure 3.1-1.

A small region of about 20 km * 70 km crossing the rift axis at 59°10'N was selected as main working area for the second part of the cruise. At about 58°39'N a detailed study of the tectonics, magmatism and the sedimentation processes was carried out by Russian scientists (ALMUKHAMEDOV et. al. 1990), so, a good possibility of comparing the results was provided. The program for the second part included both geophysical and sedimentological investigations. Sediment sampling along the transect at an angle to the ridge axis and subsequent investigations on the mineralogical and chemical composition as well as analyses of settling velocity and granularity will contribute to a model of the genesis of the distributive province "Reykjanes Ridge".

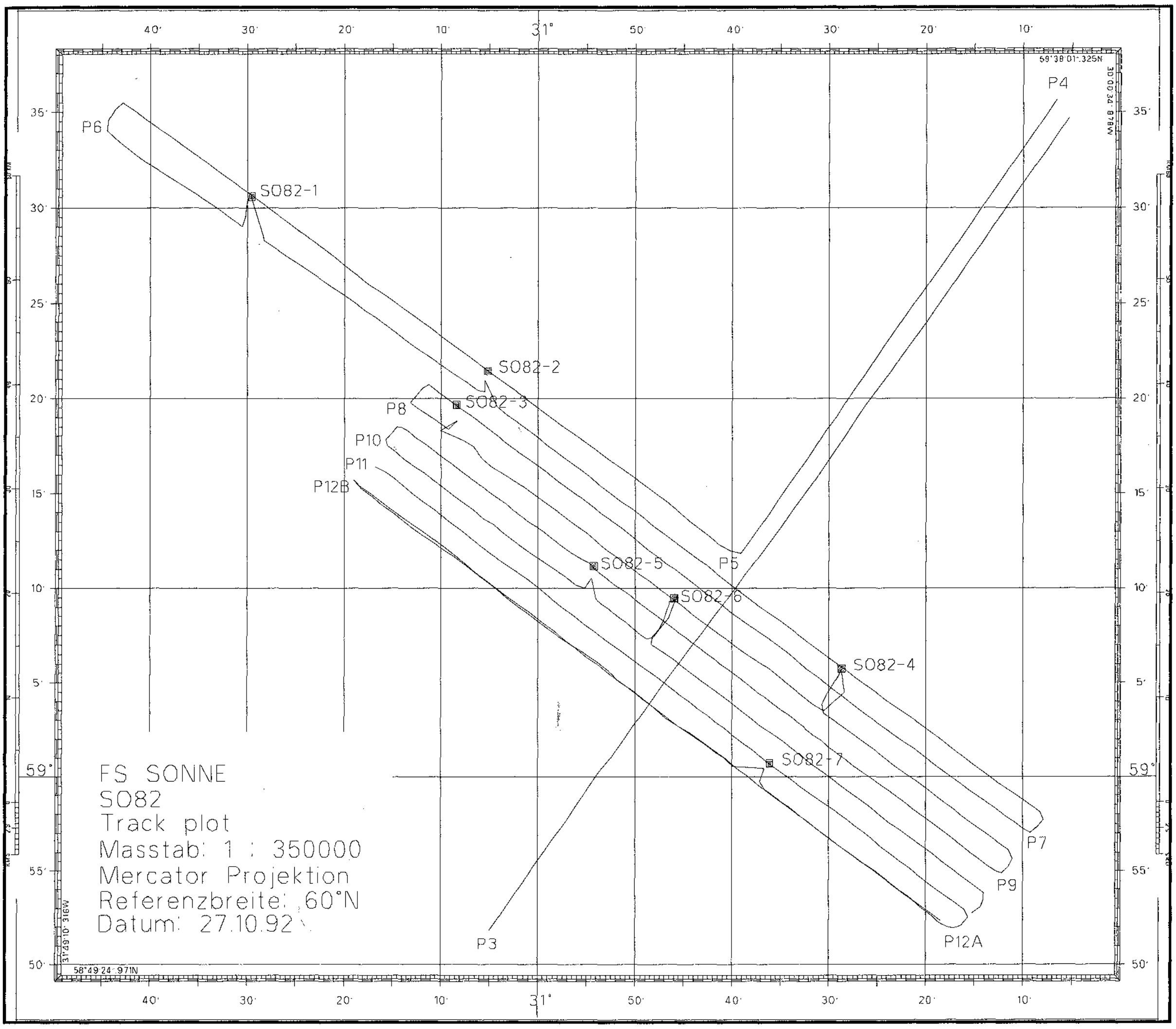


Fig.3.1.-2 Trackplot of seismoacoustic lines and sampling stations in the detailed study area, SO82B

Mapping of the research area and registration of the horizontal distribution and thickness of the sediments by means of the Hydrosweep multibeam echosounder, the Parasound - Paradigma echosounder system and the sediment echosounder SEL 90 from the University of Rostock were first carried out on several profiles at the beginning of the second part of the cruise.

The results gathered in the course of the acoustic mapping were meant to be the basis for selecting sampling stations. Fig. 3.1.-2 shows the trackplot of the profiling lines and sampling localities performed during SO82B in the detailed study area near 59°N. The program of each individual station included the following steps:

- application of the large box corer for sampling of undisturbed sediments near the surface and macro benthos,

- application of the giant gravity corer to extract long sediment cores,

- application of the gravity corer to extract sediment cores, especially for sediment - physical studies at the stations selected.

First work onboard included basic sediment - physical measurements (index properties, shear strength), sedimentological investigations and, additionally, a lithological description of the sediments as well as sampling for lab analyses on shore was supposed to provide a survey of the sediment compositions and characteristics, altogether.

3.2. Participants

Participating institutions

GEOMAR:	GEOMAR Forschungszentrum für marine Geowissenschaften der Christian - Albrechts - Universität zu Kiel
GPI:	Geologisch-Paläontologisches Institut und Museum der Christian-Albrechts-Universität zu Kiel
IOW:	Institut für Ostseeforschung Warnemünde an der Universität Rostock
KGS:	Kansas Geological Survey, Kansas University, USA
PLR:	Projektträger Material- und Rohstofforschung des Bundesministers für Forschung und Technologie
UGG:	Universität Greifswald, Fachbereich Geowissenschaften
URE:	Universität Rostock, Fachbereich Elektrotechnik, Institut für Nachrichtentechnik und Informationselektronik
UIB:	University of Iceland, Biological Institute

Ship's crew

H.Papenhagen	(Master)
A.Macke	(2nd Mate)
Y.Msyazhenko	(Doc.)
H.-J.Prüssner	(2nd Eng.)
N.Guzman	(2nd Eng.)
R.Duthel	(Electron.)
T.Steffenhagen	(Electron.)
S.Ladage	(Syst. Op.)
V.Blohm	(Motorman)
B.H.Bethge	(Motorman)
A.Penk	(2nd Cook)
W.Scheller	(Steward)
K.-H.Lohmüller	(Boatswain)
W.Hödl	(A.B.)
W.Jahns	(A.B.)
P.Schöber	(A.B.)
S.Bühlow	(Chief Mate)
W.Sturm	(R/O)
H.-J.Neve	(Ch. Eng.)
A.Rex	(2nd Eng.)
W.Huxol	(Electr.)
H.Voehrs	(Electron.)
A.Tank	(Syst. Op.)
R.Rosemeyer	(Storekeeper)
M.Hoevelmann	(Motorman)
H.Müller	(Ch. Cook)
M.Both	(Ch. Steward)
H.J.Prechtl	(Steward)
D.Mahlmann	(A.B.)
H.Krüger	(A.B.)
P.Demba	(A.B.)

Scientific crew

T.Blanz,	phys. prop. specialist	GPI
A.Bliesener	electronics engineer	IOW
G.Bublitz	sedimentologist	IOW
J.Eidam	geochemist	UGG
R.Endler	chief scientist	IOW
J.Ewert	electronics engineer	URE
A.Frahm	geology technician	IOW
B.Gehrke	sedimentologist	GEOMAR
J.Harff	geologist	IOW
P.Heinitz	electronics engineer	URE
G.Hoffmann	sedimentologist	IOW
R.Knapp	geophysicist	KGS
K.Korich	sedimentologist	UGG
K.S.Lackschewitz	2nd. ch. scientist	GEOMAR
W.Lemke	sedimentologist	IOW
F.Lindemann	student	GEOMAR
M.Moros	student	IOW
J.Mrazek	sedimentologist	UGG
S.Neufeld	geology technician	GEOMAR
G.Nickel	geophysics technician	IOW
B.Steingrobe	sedimentologist	PLR
J.Svavarson	biologist	UIB
U.Trebstein	student	UGG
R.Werner	petrologist	GEOMAR

3.3. Cruise narrative SO82B
(R.Endler)

The second part of the cruise, SO82B, started in Reykjavik. The scientific crew was exchanged and new equipment for sediment sampling was taken on board. The scientific crew visited the University of Iceland and was invited to a geological excursion in order to see the rift, i.e. the continuation of the Reykjanes Ridge, on shore. RV "Sonne" was visited by students of the university. The ship left the harbour of Reykjavik on October 17, 1993, heading to the working area at 59°N. The next day, after the usual instructions concerning behaviour and safety on board, given by the Chief Mate, the new scientific equipment was prepared for operation. The working program was specified based on the results of the first part of the cruise. Two shifts were selected. During the night shift acoustic profiling was performed. Using these recordings the positions of the sampling stations were selected. Sediment sampling was performed during day time.

On October 18, 1992 the measurements started with Hydrosweep mapping and acoustic profiling (PARASOUND-PARADIGMA, SEL90) on line SO82-P04 along the rift axis, parallel to line SO82-P03. The working area was approached on in the night of October 19, while profiling. Based on the recordings the positions of the first sampling stations were selected. Later, in the morning acoustic profiling was interrupted in order to take the samples. Undisturbed samples of the sediment surface were obtained by the large box corer. A first core, taken by the giant gravity corer, was supposed to study it's sedimentological composition as well as for subsampling. A second core was taken using an ordinary gravity corer for the investigation of physical properties later on. This "standard" procedure was carried out at all sampling localities except for the station SO82-06 (central part) where the thickness of the sediments was too small.

On October 21, the weather conditions became rough. A storm (up to 12 bft) interrupted the work for the next days. Heavy waves damaged the rails and some of the plastic core liners which were stored near by. No damage occurred in the labs or in context with other research equipment.

During late evening of October 23, the wind decreased and the normal working program was continued with profiling of line SO82-11. The program in the working area was completed on October 24 with line SO82-P12. The transfer to Bremerhaven was used for profiling, line SO82-P13. This line was interrupted at station SO82-08 were the gravity corer was used to take a core of the "Hatton drift" sediments.

Entering the North Sea the ship was stopped in order to measure the acoustic attenuation of the acoustic window of the SEL90 transducer array. On October 29, the ship approached Helgoland island and workers from the ship yard entered RV

"Sonne" in order to prepare the following repair in the shipyard of Bremerhaven.

Table 2.3.-1 Schedule of cruise part SO82A

date time	activity		
17.10.92			
17:00	start of cruise SO82B, passage to working area		
18.10.92			
12:48	start of line	P04	(61°21,461'N 27°33,639'W)
19.10.92			
03:54	end of line	P04	(59°11,957'N 30°38,914'W)
03:56	start of line	P05	(59°11,855'N 30°39,823'W)
08:16	end of line	P05	(59°35,144'N 31°41,876'W)
08:34	start of line	P06	(59°34,123'N 31°44,610'W)
09:34	break of line	P06, passage to station SO82-01	(59°29,117'N 31°30,868'W)
10:35	arrival at station SO82-01, w-depth: 1867m GKG(0,33m), KL(0,92m), SL(4,84m),		(59°30,578'N 31°29,616'W)
14:36	end of station, return to P06		(59°30,592'N 31°29,494'W)
14:52	continuation	P06	(59°29,299'N 31°30,878'W)
16:42	break, passage to station SO82-02		(59°20,236'N 31°05,866'W)
17:04	arrival at station SO82-02, w-depth: 1730m, GKG(0,40m), KL(5,75m), SL(5,56m),		(59°21,437'N 31°05,179'W)
21:40	end of station,return to P06		(59°21,409'N 31°05,223'W)
21:58	continuation	P06	(59°20,179'N 31°05,458'W)
20.10.1992			
02:20	end of line	P06	(58°58,153'N 30°08,303'W)
02:36	start of line	P07	(58°57,050'N 30°09,408'W)
08:00	end of line	P07	(59°20,711'N 31°11,239'W)
08:16	start of line	P08	(59°19,750'N 31°13,072'W)
08:34	break, passage to station SO82-03		(59°18,422'N 31°09,491'W)
09:00	arrival at station SO82-03, w-depth: 1774m, GKG(0,36m), KL(5,78m), SL(5,57m),		(59°19,639'N 31°08,358'W)
13:28	end of station, return to P08		

(59°19,679'N 31°08,554'W)

13:52 continuation P08 (59°17,987'N 31°08,369'W)
16:10 break, passage to station SO82-04
(59°06,437'N 30°38,401'W)
17:20 arrival at station SO82-04, w-depth:1503m,
GKG(0,37m), KL(5,79m), SL(5,57m),
(59°05,750'N 30°28,720'W)
21:20 end of station, return to P08
(59°05,757'N 30°28,741'W)
21:46 continuation P08 (59°03,508'N 30°30,807'W)
23:14 end of line P08 (58°55,977'N 30°11,233'W)
23:34 start of line P09 (58°55,091'N 30°13,098'W)

21.10.1992

06:14 end of line P09 (59°18,569'N 31°14,261'W)
06:34 start of line P10 (59°17,434'N 31°15,301'W)
08:08 break, passage to station SO82-05
(59°10,137'N 30°56,038'W)
08:30 arrival at station SO82-05, w-depth:1394m,
GKG(0,47m), KL(5,90m), SL(5,90m),
(59°11,179'N 30°54,265'W)
13:48 end of station, return to P10
(59°11,158'N 30°54,353'W)
14:10 continuation P10 (59°09,851'N 30°55,046'W)
15:02 break, passage to station SO82-06
(59°07,309'N 30°48,815'W)
15:30 arrival station SO82-06, w-depth:1120m,
GKG(0,18m), (59°09,455'N 30°45,951'W)
18:32 end of station, return to P10
(59°09,242'N 30°46,512'W)
19:02 continuation P10 (59°07,036'N 30°48,307'W)
21:42 end of line P10 (58°53,838'N 30°14,045'W)
22:04 start of line P11 (58°52,750'N 30°15,478'W)
22:26 break, stop working because of rough weather
conditions (58°53,723'N 30°17,955'W)

22.10.1992

00:00 bad weather conditions, work not possible,
damage of gravity corer liners

23.10.1992

00:00 bad weather conditions, working not possible
23:10 start working, passage to line P11

24.10.1992

00:00 start of line P11 (59°16,484'N 31°17,100'W)
05:18 end of line P11 (58°52,808'N 30°15,675'W)
05:56 start of line P12A (58°52,804'N 30°19,858'W)
10:48 end of line P12A (59°15,441'N 31°18,659'W)
11:00 start of line P12B (59°15,073'N 31°17,509'W)
13:02 break, passage to station SO82-07
(58°59,686'N 30°37,667'W)
14:16 arrival at station SO82-07, w-depth:1580m,
GKG(0,43m), KL(5,79m), SL(5,52m)
(59°00,705'N 30°36,117'W)
18:32 end of station, return to P12B

		(59°00,715'N 30°36,528'W)
18:42	continuation P12B	(58°59,614'N 30°37,317'W)
20:10	end of line P12B	(58°51,941'N 30°17,571'W)
20:12	start of line P13	(58°51,896'N 30°17,050'W)

25.10.1992

00:00 continuation of line P13

26.10.1992

00:00	continuation of line P13	
02:00	break of line, arrival at station SO82-08, w-depth:1941m, SL(1,2m),	(59°00,076'N 18°59,920'W)
03:34	end of station, continuation of line P13	(58°59,911'N 18°59,890'W)
23:46	end of line P13	(58°51,346'N 10°58,531'W)

27.10.1992 - 29.10.1992

passage to Bremerhaven

30.10.1992

arrival at port of Bremerhaven, unloading of the equipment, end of cruise SO82B

3.4. Methods

(R.Endler, J.Korich, S.Neufeld, A.Frahm)

As during during the first part of the cruise, the scientific planning and way point navigational workstation was used for **planning of the profiling tracks and the sampling stations**.

The morphology of the seafloor was mapped using the **multibeam echosounder** Atlas Hydrosweep DS from Atlas - Elektronik GmbH, Bremen. Raw data were stored on tape and sent to the Hydro Map System 300 (HMS 300, HP 9000/400 workstation) for processing. Processed data were stored on optical disc. On a second workstation depth - maps and 3 dimensional views were created. The maps were plotted on a HP pen plotter and stored as HPGL files on disks, too. Photos of the 3 D pictures of the morphology were taken from the screen of the workstation. Besides the processed track data, the grids were stored on files for postprocessing. Excluding some nonexplanable system failures the Hydrosweep multibeam echosounder worked properly.

The **seismoacoustic profiling systems** which were installed and tested during the first part of the cruise were used to investigate the structure and distribution of the sediments in the Reykjanes Ridge. Both systems, the extended narrow beam echosounder system Parasound - Paradigma and the SEL90 sediment echosounder (for description see chap. 2.5.1. and 2.5.2.) were working properly during the entire cruise. Besides the profiling, acoustic measurements testing several parameters (frequency, pulse length) were made at all sampling stations. The data were digitally stored on tape / optical disc (SEL90) for postprocessing and recorded on a thermo-printer / colour-inkjet (SEL90).

For **sediment sampling** following techniques were used:

A) giant box corer (Großkastengreifer, GKG)

box dimensions:	500 mm * 500 mm * 600 mm
weight:	about 900 kg
no. of stations:	7
total core recovery:	2.46 m

B) giant gravity corer (Kastenlot, KL)

box dimensions:	150 mm * 150 mm * 6000 mm
or	150 mm * 150 mm * 5000 mm
top - weight:	1000 - 1500 kg
no. of stations:	6
total core recovery:	29.9 m

C) gravity corer (Schwerelot, SL)

tube diameter:	130 mm
tube length:	5750 mm
top - weight:	900 - 1200 kg
no. of stations:	7
total core recovery:	34.2 m

All sediment samplers worked very reliably. Only at station SO82-04 the knife of the gravity corer was slightly damaged, perhaps caused by contact with volcanic rocks in the sea bed.

Core Photography

Large box core

The surface and the straightened front side of the box sampler was photographed using a daylight-slide film (24 * 36 size). The flash installed in the camera was used at bad light conditions.

Giant gravity core

The box core was placed on a sloping table and the surface was taken off and straightened subsequently. A 35 mm camera (Minolta) was fitted on a mobile and solid tripod with swivel head and was aligned with the core. Thus, 25 cm segments including their corresponding overlaps could be photographed at one time. Thanks to the special tripod, the camera could be driven along the core. A daylight - slide film was used (Agfachrome 200, Ektachrome 100). Close to the camera on the left and right hand side two video - lamps were fitted on a metal runner. For colour temperature reconciliation purposes (daylight - films and artificial light - films) a filter combination was tested prior to the cruise. These filters are colour films for the subtracted process of colour enlargements that are put in front of the video - lamps in a special support. The filter combination of crimson (colour density of 30) and of blue (colour density of 49) proved suitable to achieve natural color slides. Additionally, to avoid reflection on the wet surface of the core, a polarization filter was placed in each filter support and, together with an insolid polarization filter reflection could be minimized. However, the polarization filters are disadvantageous for the light intensity available, as photographs taken at a relatively high aperture value need an exposure time of 1/2 sec. The photographs are sharp despite the motion of the ship. Thanks to the filters applied the photographs have natural colours, however, slight differences between various film types exist.

3.5. First results

3.5.1. Morphology and sediment distribution
(R.Endler)

Hydrosweep mapping and seismoacoustic profiling were carried out to investigate the complex morphology and sediment distribution of the working area. After finishing the profiling work first the bathymetric maps of different scales were created on board. Fig.3.5.1.-1 shows a copy of such a map. (An overview of these HS - maps is included in the annex.) It can be seen that the morphology of the ridge is characterized by series of linear structures with a strike slightly diverging from the rift axis. This is a significant feature of MOR - regions with a spreading direction non perpendicularly to the ridge axis (SEMPERE et.al. 1990,

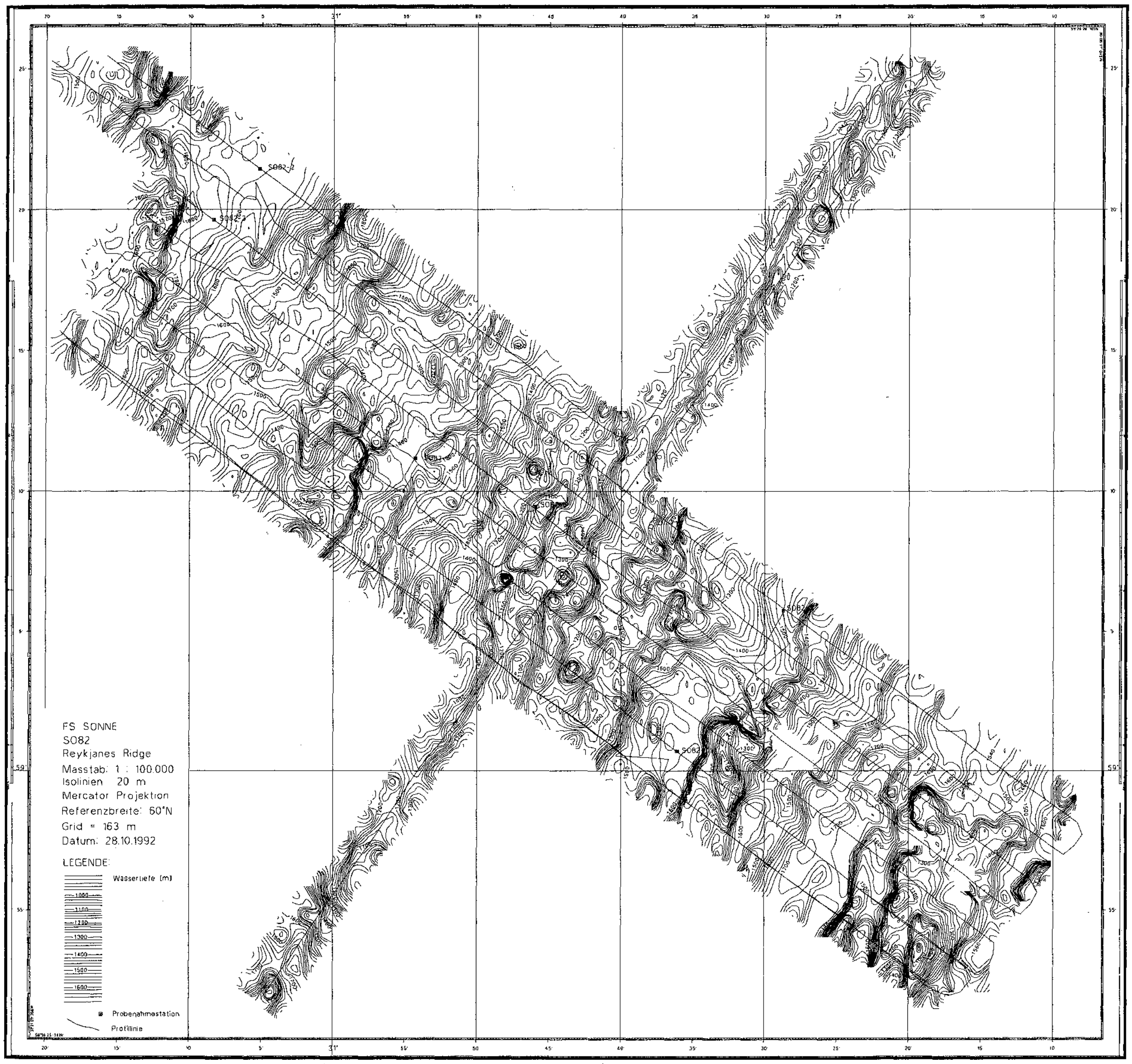


Fig. 3.5.1.-1 Topography of the Reykjanes Ridge near 59° 30'N (copy of a Hydrosweep map, created on board)

DAUTEUIL & BRUN 1993, RUDENKO 1986).

A system of elongated "en echelon" rises and valleys forms the central region of the ridge. The same features were observed at the southern part of the ridge during cruise SO82 A (see chap. 2.4.3.). The waterdepth of this ridge part ranges from about 1000 m to 1500 m. A central valley is flanked by series of elongated crests and depressions (see Fig. 3.5.1.-2) with a strike diverging from the ridge axis. In this part the topography of the sea bottom is very rough (see Fig. 5.4.1.-3) caused by blocks, crests and scarps of different size. Steep slopes made it difficult to detect and record the surface of the sea bottom using echosounders as shown in fig.3.5.1.-3. Sea bottom reflections are very weak and highly interrupted in the narrow beam echosounder PARASOUND data. The recordings of the SEL90 echosounder are characterized by

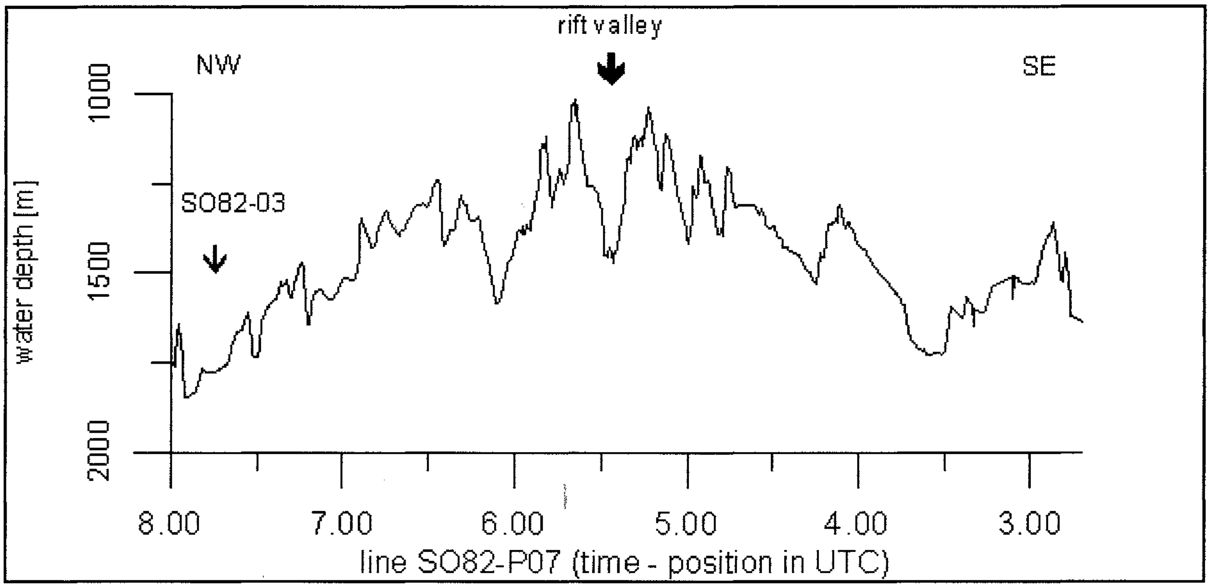


Fig. 3.5.1.-2 Relief of the central part of the Reykjanes Ridge at 59°09'N SO82-03 - location of sampling station

overlapping hyperbolic sea bottom echoes. There were no indications of sediments in these data.

Towards NW and SE the thickness of the sediment cover increases. Most of the rough volcanic surface is buried under well bedded sediments (fig.3.5.1.-4). The online recordings of the echosounders show a thickness of the layers of up to 50 m or even more. Sliding phenomena are supposed to influence the depositional processes in this region because of steep slopes and tectonic activity. It will be an important task to look for such collapse structures in the acoustic data during postprocessing. The online records were to poor in quality in order to show these features.

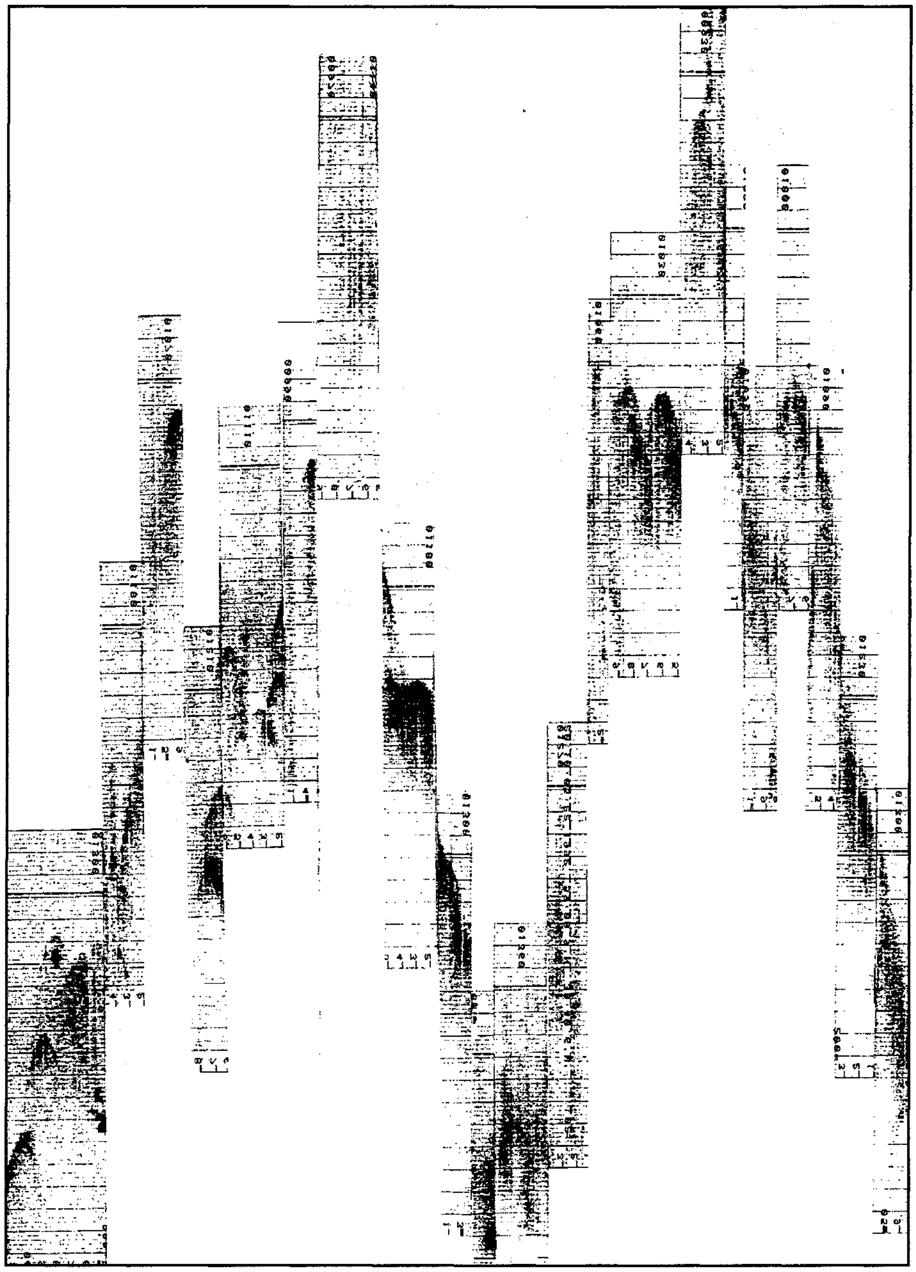


Fig. 3.5.1.-3 Parasound record of the central part of the ridge (see Fig. 3.5.1.-2, line P07 at 5:30 UTC)

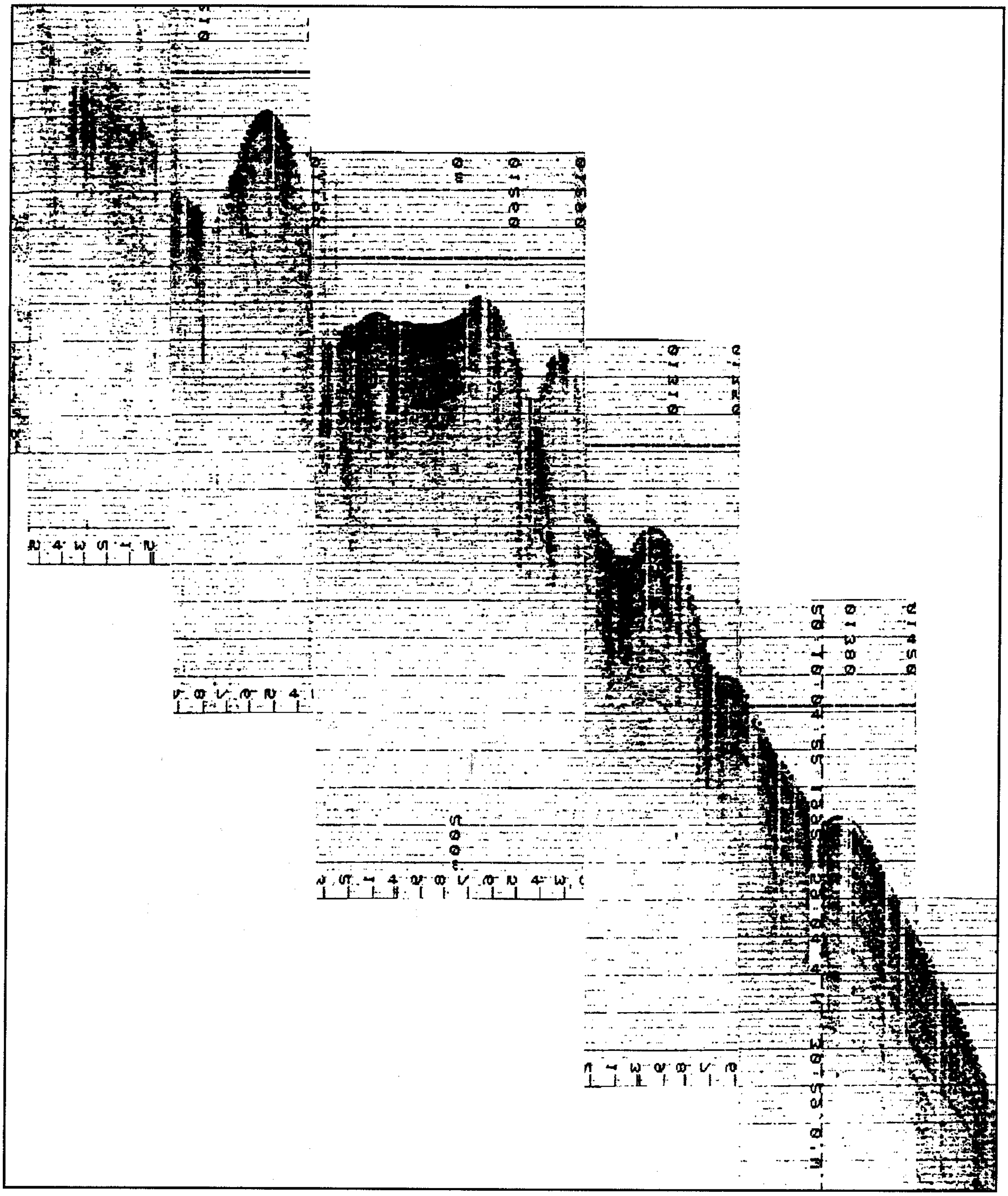


Fig. 3.5.1.-4 PARASOUND record of the eastern slope of the Ridge (see Fig. 3.5.1.-2 line P07, at 4:30 UTC)

3.5.2. Sedimentology

(B. Gehrke, G. Hoffmann, K.S. Lackschewitz, W. Lemke, R. Werner)

In the area of the Reykjanes Ridge (59-60°N, about 30°W) sediment sampling was carried out by a large box corer, a giant gravity corer (6 m), and a gravity corer (6m). The coring stations were defined by means of Parasound profiling and the Rostock sediment penetrating echosounder SEL90.

Figure 3.1.-2 shows the geographical positions of the coring localities. The detailed core descriptions are included in the appendix. Figure 3.5.2-1 gives an impression of the lithology of the giant gravity cores opened aboard.

Core description and sampling scheme (see enclosed list of stations)

The studies on the large box cores and giant gravity cores opened aboard were conducted accordingly to the set standard as follows:

A) Photograph and description of the core's surfaces and their profiles (large box core and giant gravity cores).

B) Core sub-sampling (see Fig.3.5.2.-1)

- benthological sampling at the sediment surface and down to a core depth of 10 cm (see chapter 3.5.4.),
- a surface sample of 0.5 cm to 100 cm^2, for clay mineralogy (large box core),
- a surface sample of 0.5 cm to 100 cm^2, for micropaleontology (large box core),
- a surface sample of 0.5 cm to 100 cm^2, for geochemical studies (large box core)

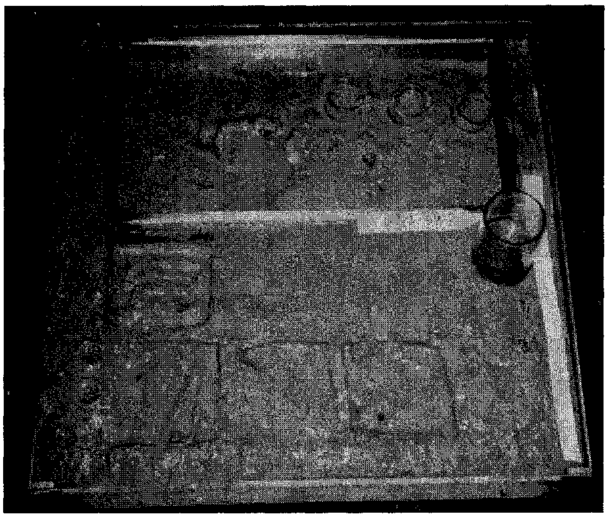


Fig. 3.5.2.-1 Sub-sampling of the large box core

- a surface sample of 0.5 cm to 100 cm^2 , for sedimentological studies (large box core),

- sampling of two cylindrical samples for soil - mechanical studies,
- sampling of radiography samples (large box core, core catcher), for studies on the sediment texture
- for the archives (GEOMAR, Kiel), for sedimentology (University of Greifswald, GEOMAR),
- sediment sampling in 0.5 m plexiglass boxes (large box core), for soil mechanics (IOW),
- sampling with the help of 10 m^3 - metal cylinder (large box core, giant gravity core), for determining the water content in archives boxes,
- sampling of bags at 2-cm intervals (giant gravity core),
- sediment sampling in 1-m plexiglass boxes (giant gravity core), for archives (GEOMAR Kiel),
- sediment sampling in 0.5 m plexiglass boxes (giant gravity core), for sedimentology and geochemistry,
- sampling of centimeter-size rock fragments of the surface and of the profile (large box core, giant gravity core),
- production of smear slides of various lithological units (large box core, giant gravity core).

The gravity cores were not opened on board.

Macroscopic description of superficial sediments (large box core)

Large diameter samples taken can be distinguished with the help of their different grain sizes, sediment color and population densities.

A) Mainly brownish sandy silts and silty sands at the surface and in the core profile were found at the large box core stations SO82-1, -3 and -6. A few greyish and brownish fine-grained lenses were detected in the core profile. The surfaces are characterized by a relatively high percentage of biogenic material: polychaetes, ophurien, poriferes, hydrozoans, foraminifers, corals, brittle stars, molluscs and pteropods.

B) Mainly silty or clayish material werte found at the large box core stations SO82-2, -4, -5 and -7. In the vertical profile, a change in color from brown to olive-grey was striking. The surfaces of these sediments were obviously softer than the surfaces of the group mentioned above.

Consequently, the surface of the large box core SO82-2 was washed away thus making another sampling necessary.

The percentage of biogenic material is considerably smaller as compared to the sandy / silty samples. It consists of: pteropods, foraminifers, gastropods, poriferes and polychaetes.

Isolated rock fragments (ϕ 0.5 - 7 cm) were observed at the sediment's surfaces and in the profiles (large box core, giant gravity core). The majority of these rock fragments is moderately and well - rounded. With the help of macroscopic and microscopic studies the following types of rocks have been identified: plutonites (among others granite, granophyre, diorite, gabbro), metamorphites (among others gneiss, amphibolite, biotite schist), volcanic rocks (among others basaltic lavas, basaltic scoria, different pyroclastics) and sedimentary rocks (among others sandstone, clay stone, clay schist).

At first sight, the smear slides (large box core, giant gravity core) seem to have only small percentages of vulcanogenic material in coarse grain fractions which is surprising considering the fact that the sampling sites are located close the Mid Atlantic Ridge.

Macroscopic description of giant gravity cores

Six giant gravity cores with a total recovery of about 30 m (SO82-1, -2, -3, -4, -5, -7 giant gravity core) were gathered. The majority of the cores are characterized by silty - clayey sediments with varying content of sand (Fig.3.5.2.-2). Large fine - sandy inclusions (layers and lenses), ranging from 1 to 10 cm in length are a characteristic feature of these sedimentary cores. Sponge spicules are found in the entire core profile. Sponge spicules are enriched and distinguished by a high shear strength in specific layers (compare chapter 3.5.3.). Some horizons with planktic foraminifers were observed in the giant gravity cores SO 82-3, -4, -5 and -7. Bioturbation on bed boundaries was identified in some cases. In the giant gravity core SO82-5 S burrows of a horizontal extension of about 20 cm (4 parallel dikes, 1 cm in diameter) were found and identified as a cross-section of a spreiten system of ichnofossil *zoophycos*. In recent sediments *zoophycos* is mostly observed close to the surface oxydation zone in the organic-carbonate rich reduced zone (EKDALE et al., 1984). The sediments mentioned above are mainly grey to olive-grey. A brown color is striking in the basal part of the cores SO82-3, -5, -7.

In contrast to the giant gravity cores mentioned before the core SO 82-1, taken at the western edge of the working area, mainly contains brownish fine-sandy silty material. The recovery is merely 92 cm. Additionally, a gravel layer in a core depth of 28 cm and individually existing calcareous

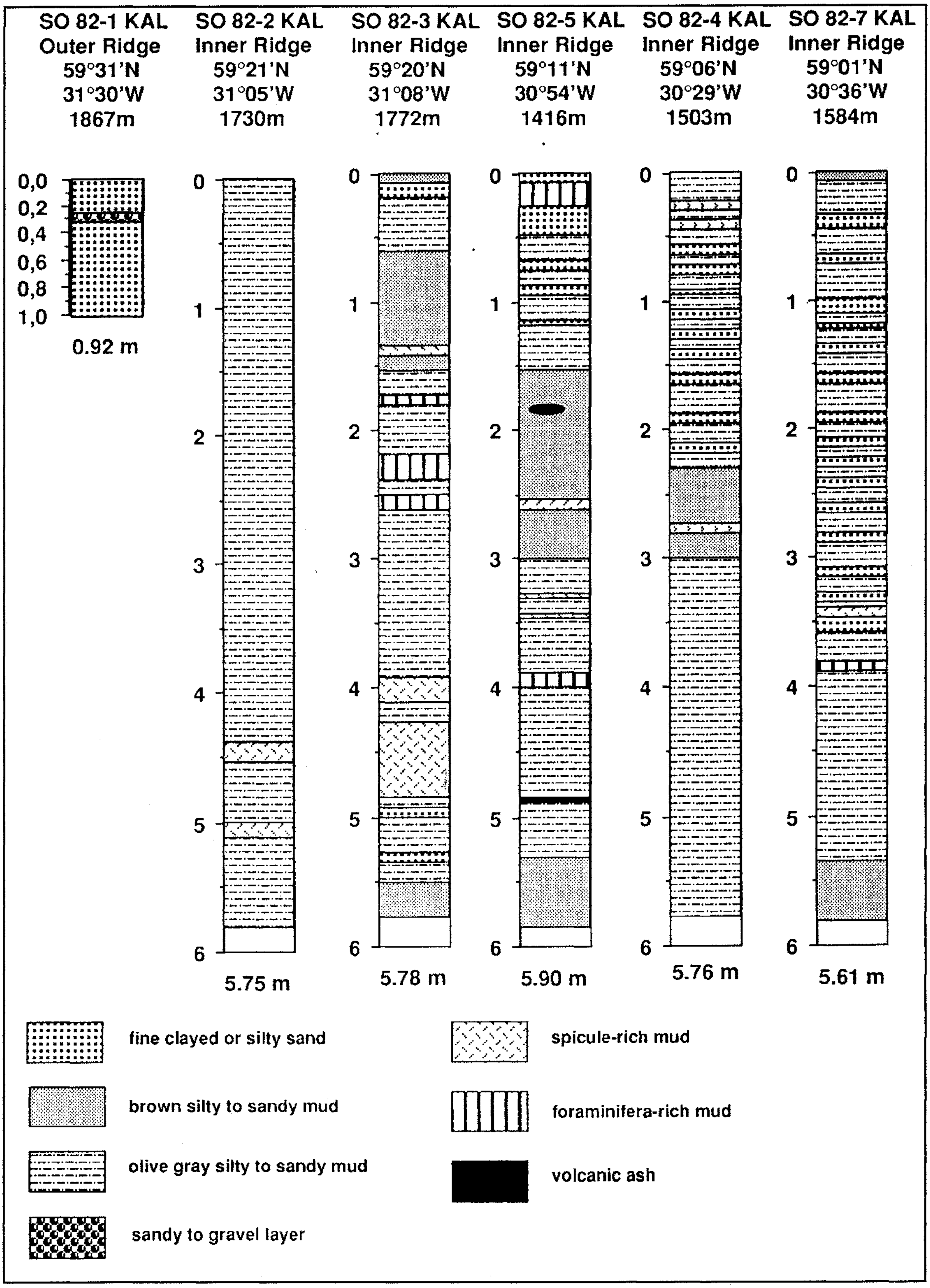


Fig. 3.5.2-2 Lithology of the giant gravity cores

fragments (among others shells and foraminifers) are striking. Few rock fragments of just one centimeter of length were found in the sediments of the box corer, altogether.

Discussion of preliminary results (large box core and giant gravity core)

In comparison with the southern Kolbeinsey Ridge (LACKSCHEWITZ 1991), the Reykjanes Ridge shows a developed relief (chap.3.5.1) also outside the central ridge area. In contrast to the Kolbeinsey Ridge, no decrease in grain size from the central to the western distal area of the ridge was observed, correspondingly neither a decrease in volcanogenic material with increasing distance from the ridge axis was recorded.

The olive-grey fine granular sediments in wide sections of the cores presumably contain - based upon Kolbeinsey Ridge results (LACKSCHEWITZ 1991) - a relatively high percentage of fine ashes differently altered.

Apart from basalts and gabbros, all the investigated coarse rock pieces must be derived from other areas than the MAR. The dropstones, coarse ice-rafted material, differ substantially from the Icelandic rock spectrum, especially in their high percentage of plutonites and metamorphites and their chemistry. Greenland probably is the source area of the majority of dropstones, especially of plutonic and metamophic rocks. The high percentage of fine sands and the special location of the core station SO82-1 close the Snorre Drift point to a superimposing bottom current as well as sand-silty inclusions in other cores point to an intensive influence of bottom currents (SHOR & POORE 1979).

Deep water, that enters from the eastern North Atlantic subbasin to the western North Atlantic subbasin across the Charlie-Gibbs-Fracture-Zone flows northwards as a contour stream along the western flank of Reykjanes Ridge. Correlation of the brownish basal core sections of SO82-3, -5 and -7 may be possible, provided they are checked on their simultaneity in time.

Summary

In the investigation area, sedimentation conditions seem to be very complex, altogether. They can be traced back to five essential sedimentation processes. Apart from pelagic sedimentation of biogenic carbonate, sedimentation of sponge spicules plays an important role. Volcanic particles are attributed to active submarine volcanism in the central Reykjanes Ridge. Additionally, input of ice-rafted detritus is recorded. However, its percentage plays only a minor role in the sediment. Moreover, sediments were partly superimposed by strong bottom currents.

3.5.3. Physical properties of the sediments

(T. Blanz, M.Moros, U.Trebstein)

During the expedition SO82B into the area of the Reykjanes Ridge southwest of Iceland 7 cores recovered by the giant box corer and 6 cores recovered by the giant gravity corer were used for sediment-physical studies. Sediment-physical properties as well as their variability with increasing depth are essential not only for soil mechanics, but also for other subfields in the marine geology, i.e., the calculation of accumulation rates. Calculating the accumulation rates and comparing them with those of other sediment types from regions elsewhere there were found considerable differences. Sediment-physical properties of ridge sediments are still insufficiently known. Interesting insights, which will be dealt with in more detail later on resulted from the first measurements of the shear strength, of the water content, and of the humid unit weight.

Shear strength

The shear strength was determined by a rotation viscosimeter RV3 (KASSENS 1990; BLANZ 1992).The rotation viscosimeter measures the undrained shear strength, that can be equated to apparent cohesion in fine-grained sediments when the angle of internal friction decreases to zero (BISHOP & BJERRUM 1961).

For the purpose of measuring the shear strength a hydrometric current meter FL-1000 (10 mm x 8.8 mm) was lowered 1 cm parallel to the bedding into the sediment and was rotated at a constant speed of 4 rotations per minute. Depending on the sediment core's lithology 2 to 3 measurements were carried out in a vertical depth interval of 5 to 10 cm to determine the natural variability at each depth.

The resistance serves as a measure of the shear strength, i.e., the shear stress that is opposed by the sediment sample with the rotation motions of the rotation wing. This shear stress is measured by means of a twist potentiometer in the probe and the measured analog values are recorded on a Rikadenski recorder. The shear strength T is calculated from the measured values (S) by means of a specific probe shear factor. The results are shown in Fig. 3.5.3.-1.

$$T = (A \times S) \quad \text{(kPa)}$$

T = shear strength
A = shear factor
S = scale parts

Natural water content and humid unit weight

Parallel to the shear strength measurements, 10 ccm of sediment was extracted by constant volume sampler to determine the water content and the humid unit weight. These defined sediment samples (10 ccm) were weighed in wet and dry form onboard (drying at 105°C in the drying cabinet). The balance onboard is a wave-compensated lab balance that according to its operating instructions weights precisely +- 1%.

The water content W (see Fig. 3.5.3.-2) is calculated as follows:

$$W = W_w / W_s \times 100 \ (\%)$$

W = natural water content (%)

Ww = water mass (g)

Ws = mass of dried sediment sample (g)

Values over 100 % can occur because the natural water content is correlated with the dry weight.

The humid unit weight is defined as follows (RICHARDS 1962):

$$W_{bd} = M / V \ (g/ccm)$$

Wbd = humid unit weight (g/ccm)

M = mass of the wet sample (g)

V = volume of the wet sample (10ccm)

Results

A) The shear strength in normal state

The shear strength increases with depth (RICHARDS 1961; ALMAGOR 1979) in normally consolidated sediments (SKEMPTON 1970). Among other things, the shear strength depends on the grain size distribution, the sediment composition, the sedimentation rate and the grade of consolidation.

The box cores (SO82-1KAL, SO82-2KAL, SO82-3KAL, SO82-4KAL, SO82-5KAL and SO82-7KAL) contain mainly grey to olive-grey, silty to clayey sediments with different contents of sand. In all core sections the occurrence of sponge needles is striking. In some horizons (see core descriptions) sponge needles are strongly accumulated. These horizons (see Fig. 3.5.3.-1) are characterized by distinct shear strength peaks with strengths of up to 22 kPa. The general increase in shear strength with depth (RICHARDS 1961) that is known from other core sites and from other sea areas (KASSENS 1990; BLANZ 1992)

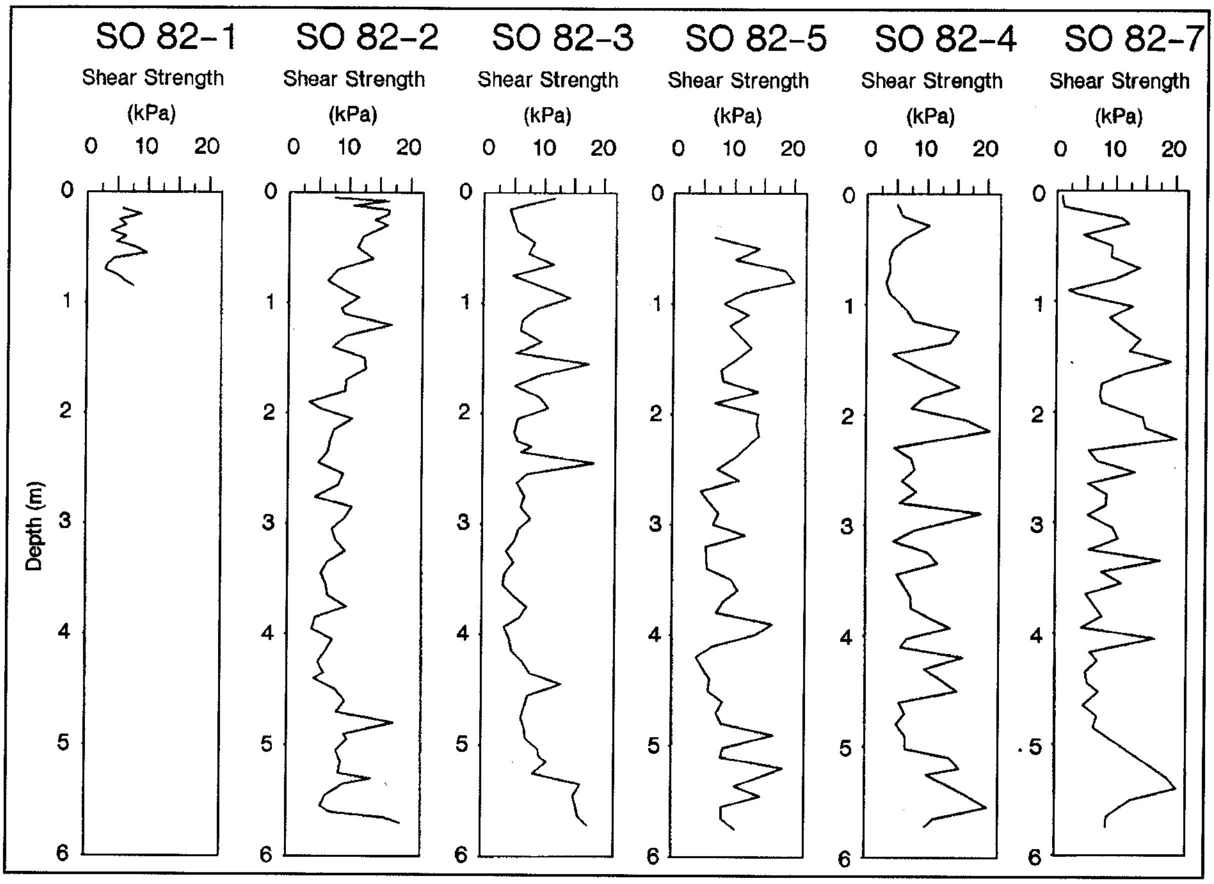


Fig. 3.5.3.-1 Shear strength of the giant gravity cores

could not exactly be determined in any of the sediment cores. The relatively "high" shear strength (from near to the bottom 10 kPa) is surprising and remains constant to the core basis with fluctuations of +- 5 kPa (RICHARDS 1962).

B) Water content

The natural water content is a criterion to assess the sediment's degree of strength (ALMAGOR 1979). Moreover, this degree depends on the degree of compaction and the sediment's composition (RICHARDS 1962).

On average, the water content profiles (see Fig. 3.5.3.-2) range from 150% to 120% without being dependent on depth, i.e., the water content does not decrease with depth and is thus correlated with the shear strength that neither depends on depth. Neither there are distinct water content profile minima nor maxima. The horizons with a high shear strength have yet a low water content (approx. 100%). However, they do not occur as distinct peaks in the water content profiles.

For a better interpretation of the curves it is necessary

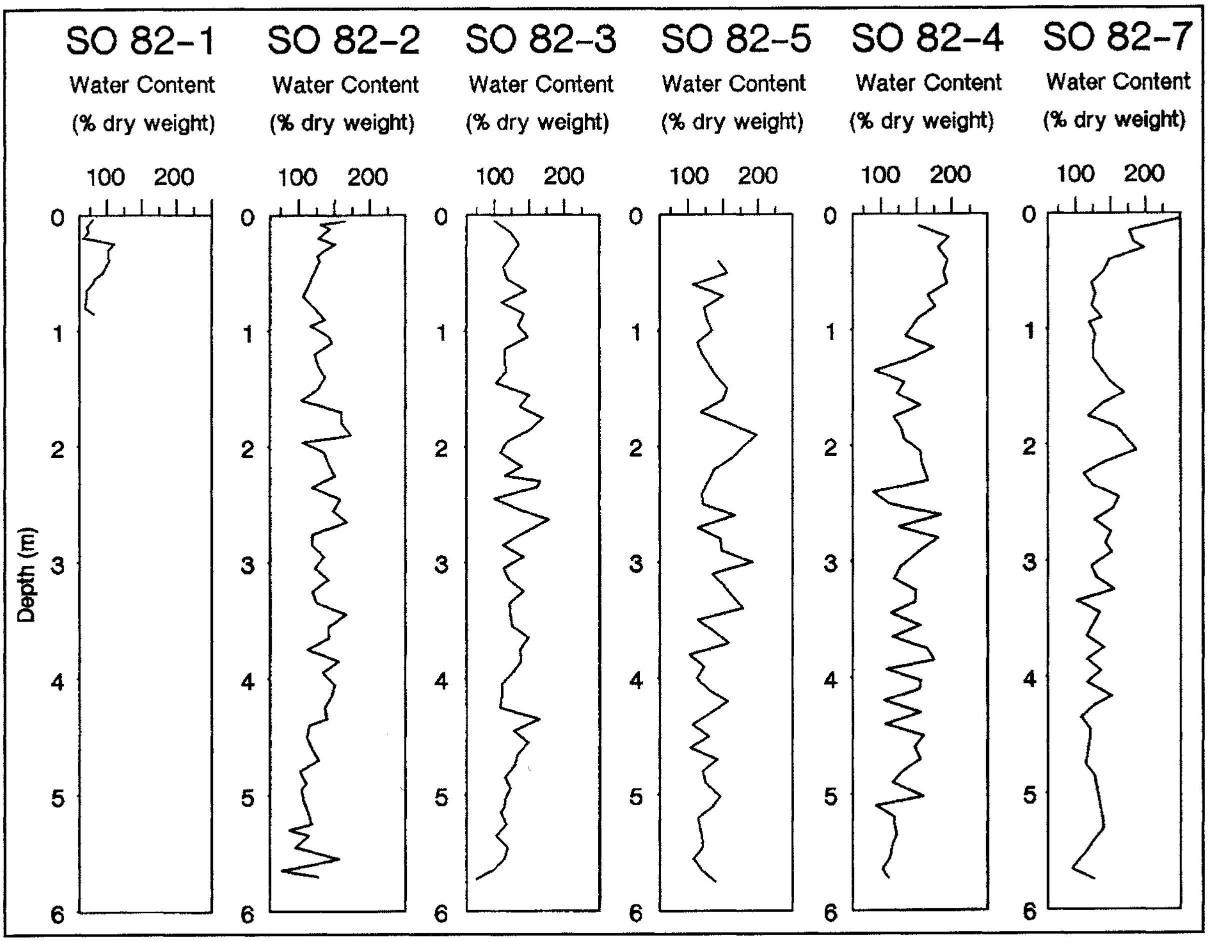


Fig.3.5.3.-2 Natural water content of the giant gravity cores

to carry out some additional investigations. Only the analyse of radiographs, grain size distributions, sediment compositions and sedimentation rates will contribute to the interpretation of the exact sedimentation history and its climatic background with concerns of the soil mechanics.

3.5.4. Benthic studies
(J.Svavarson)

The benthic fauna of the deeper, oceanic regions of the Reykjanes Ridge is still poorly known, not only in terms of its structure (species composition, biomass), but also in terms of physical and biological patterns that determine the composition of the fauna. The area is quite complex in its topography and presumably also in its physical characteristics (currents, sedimentation, etc.), although the watermasses may be homogeneous. This complexity of the topography may be reflected in heterogeneous habitats within this seamount environment, resulting in patchiness of the benthic fauna. The aim of the present study is to:

A) characterize the benthic fauna (macrofauna and meiofauna) in terms of species composition, biomass and abundance and relate these patterns to geophysical and geological characteristics of the recent sediments and to biological parameters. Also of interest is:

B) the interaction between benthic animals, some of which (foraminifers) are important considering the geological time scale. Recent studies have shown that benthic isopods (Crustacea) actually feed on (and crunch) benthic foraminifers, and may thus have influence on the species composition of the foraminifers and possibly also on the fragmentation of the foraminifers. The impact of this has, however, not yet been quantified.

Samples for studies of the benthos were taken with 0.25 cm^2 boxcorer, supplied with photographic equipment. Altogether, samples were taken at seven stations at depths between 1102 and 1867 meters. The part of the boxcorer planned for biological studies was isolated from the rest of the sample with 20 * 40 cm frame, while still having surface water overlying the sediments. This was, however, not always possible. From each boxcorer subsamples were taken for the study of chloroplastic pigments (2 syringes with 1.25 cm diameter), total carbon (10 cm^2, upper 2 cm layer), meiofauna (three subcorers each 10 cm^2), and the rest was preserved to study the macrofauna. Some of the meiofauna samples were subdivided into 1 cm thick layers to allow study of the vertical distribution of the meiofauna.

A priori one would expect coarse sediments occurring near the central part of the ridge, that are possibly eroded by the seamounts of the area. All samples except for two were, however, taken from bottoms with very fine, soft mud. These were at depths of 1409 to 1777 m. Here the surface sediments are characterized by an abundance of globigerinoid and pteropod mollusc shells together with numerous calcareous sponge spicules. This bottom type could indicate rather slow currents and rapid sedimentation of both planktonic and benthic, resuspended material. Some of the samples seem to have rich benthic fauna.

One of the boxcorer contained "hard bottom", which was actually fine mud, foraminifera shell and calcareous sponge spicules, packed into hard substratum. This hard bottom had a rich epifauna, with ophiuroids, sponges, hydroids and polychaete tubes. It is not evident whether this type of bottom sediments has recently been incorporated into the surface, or whether it is older sediment being eroded. Exact quantities of the benthic animals and the species composition can not be seen until the material has been sorted in the laboratory.

4. Summary

For the first time after the re-unification of Germany a research cruise with RV"Sonne" had has been planned, organized and performed under the leadership of an institute from the former GDR, the Institute of Baltic Sea Research Warnemünde (formerly Institute of Marine Research - Warnemünde). This task was solved with good results in very close cooperation and with the help of the GEOMAR Marine Research Center.

The cruise was divided into two parts. During the first part a short geophysical program was carried out. Two advanced seismoacoustic profiling systems, the Parasound-Paradigma narrow beam echosounder and the SEL90 sediment penetrating echosounder, were installed and tested with good results.

Furthermore, a single Hydrosweep-profile over the Reykjanes Ridge Crest was run. The recorded bathymetric stripe allows a classification into two main segments. The southern segment between the Charles Gibbs Fracture Zone and the Bight Discontinuity is a typical part of the northern Mid Atlantic Ridge with rift mountains bounding a median valley. The Bight Discontinuity seems to be a transition zone between the influenced and non - influenced regions of the Iceland hotspot. From this transition zone the second segment trends 36° northeastward toward Iceland. Oblique spreading and en echelon ridges, striking perpendicularly to the spreading direction, are typical. The overall structure of the Reykjanes Ridge supports a mainly amagmatic-tectonic evolution as typical of episodic spreading models.

During the second part sedimentation processes, including their spatial and temporal variability were investigated in the central part of the Reykjanes Ridge at 59° 30'N. Along 10 lines seismoacoustic profiling and Hydrosweep - mapping were performed. First topographic maps of the working area were created on board. At seven selected stations sediment samples were taken using several sampling devices. The first results suggest that the sedimentation conditions are very complex. They can be traced back to five essential sedimentation processes. Apart from pelagic sedimentation of biogenic carbonate, sedimentation of sponge spicules plays an important role. Volcanic particles are attributed to active submarine volcanism in the central Reykjanes Ridge. Additionally, input of ice-rafted detritus is recorded. However, its percentage plays only a minor role in the sediment. Moreover, the sediments were partly superimposed by strong bottom currents.

Physical properties of the sediments were estimated at 6 sampling stations. They show high water contents, ranging from 120% to 150% with some peaks up to 200%. The average shear strength is about 10 kPa with maximum values up to 20 kPa mainly at horizons where sponge needles are accumulated. No clear increase or decrease in the data with depth was observed, neither in water content nor in shear strength. This

suggests that the sediments are very weakly consolidated.

The benthic fauna (macrofauna and meiofauna) in terms of species composition, biomass and abundance were investigated at the sampling sites. Fine-grained, soft surface sediments are characterized by an abundance of globigerinoid and pteropod mollusc shells together with numerous calcareous sponge spicules. This bottom type could indicate rather slow currents and rapid sedimentation of both planktic and benthic, resuspended material. Hard bottom had rich epifauna, with ophiuroids, sponges, hydroids and polychaete tubes

5. Acknowledgements

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Cruise Report

RV "SONNE" Cruise SO82
1992

SO82A:
Geophysical investigations along the Reykjanes Ridge, North Atlantic
Balboa - Reykjavik, 29.09.-16.10.1992

SO82B:
Sedimentation Pattern of the Reykjanes Ridge, North Atlantic
Reykjavik - Bremerhaven, 17.10.-31.10.1992

Appendix

Contents

A1 Data format of the Paradigma - tapes

(modified SEG-Y format, date: 16.Oct.1991)

definition of the trace header:
(v=variabel):

```
I4(001) = v   Schußpunkt
I4(002) = v   Schußpunkt
I4(003) = v   Schußpunkt
I4(005) = 0   Quelle

I2(015) = 9   Parasound-Seismogramm
I2(016) = 1   Anz. vert. summ. Traces
I2(017) = 1   Anz. hori. summ. Traces
I2(018) = 1   Data use: production

I4(010) = 0   Distance source point to receiver
I4(011) = 0   Receiver group elevations
I4(012) = 0   Surface elevation at source
I4(013) = 0   Source depth below surface
I4(014) = 0   Datum elevation at receiver group
I4(015) = 0   Datum elevation at source
I4(016) = v   Tiefe Parasound in Metern * 10
I4(017) = v   Tiefe Hydrosweep in Metern * 10

I2(035) = -10    Scaler (divisor) for depth
I2(036) = -10    Scaler (divisor) for coordinates

I4(019) = v   Source coordinate - longitude :
               (in Bogensekunden * 10)
I4(020) = v   Source coordinate - latitude :
               (in Bogensekunden * 10)
I4(021) = I4(019)    dto.
I4(022) = I4(020)    dto.

I2(045) = 2   coordinates in seconds of arc * 10

I2(053) = 0   lag time A
I2(054) = 0   lag time B
I2(055) = v   additional delay in ms
I2(058) = v   number of samples
I2(059) = v   sample rate in us
I2(060) = 0   Gain type floating : no
I2(064) = v   Parasound Frequenz in Hz
I2(065) = v   Parasound Frequenz in Hz
I2(066) = v   Signallänge in ms

I2(079) = v   Jahr
I2(080) = v   Julianischer Tag
I2(081) = v   Stunde
I2(082) = v   Minute
```

I2(083)	=	v	Sekunde (siehe auch I2(110))
I2(084)	=	2	Zeit = GMT
I4(046)	=	v	Parasound-Tiefe * 10 in m
I2(093)	=	v	Range in m
I2(094)	=	v	Geschwindigkeit * 10 in Knoten
I2(095)	=	v	Kurs in Grad * 10
I2(096)	=	v	Heading in Grad * 10
I2(097)	=	v	Fensteranfang in Metern
I2(098)	=	v	0/1 - parametrischer Betrieb aus/an *10
I2(099)	=	v	Quellsignalfrequenz in kHz *10
I2(100)	=	v	Anzahl Pulse *10
I2(101)	=	v	Tiefenabhängige Verstärkungsfunktion
I2(102)	=	v	0/1 - NBS-Betrieb aus/an *10
I2(103)	=	v	NBS-Frequenz in kHz (18/33) *10
I2(104)	=	v	NBS-Abstrahl-/Empfangswinkel (2/4/20) *10
I2(105)	=	v	NBS-Pulslänge in ms (bis 25) *10
I2(106)	=	v	NBS-Gain (1-5 für 1,10,100,>,>>)
I2(107)	=	v	0/1 - Pilottonbetrieb aus/an *10
I2(110)	=	v	Hundertstel Sekunden

A2 List of the seismoacoustic profiles

line	date	time(UTC)	positions
P01	07.10.92	12:00	34°39.2'N 057°38.7'W
	13.10.92	09:28	52°19.0'N 035°42.5'W
P02	13.10.92	09:28	52°19.0'N 035°42.5'W
	14.10.92	22:30	58°50.1'N 031°07.3'W
P03	14.10.92	22:30	58°50.1'N 031°07.3'W
	15.10.92	12:06	61°00.1'N 028°04.6'W
P04	18.10.92	12:48	61°21.5'N 027°33.6'W
	19.10.92	03:54	59°12.0'N 030°38.9'W
P05	19.10.92	03:56	59°11.9'N 030°39.8'W
	19.10.92	08:16	59°35.1'N 031°41.9'W
P06	19.10.92	08:34	59°34.1'N 031°44.6'W
	20.10.92	02:20	58°58.2'N 030°08.3'W
P07	20.10.92	02:36	58°57.1'N 030°09.4'W
	20.10.92	08:00	59°20.7'N 031°11.2'W
P08	20.10.92	08:16	59°19.8'N 031°13.1'W
	20.10.92	23:14	58°56.0'N 030°11.2'W
P09	20.10.92	23:34	58°55.1'N 030°13.1'W
	21.10.92	06:14	59°18.6'N 031°14.3'W
P10	21.10.92	06:34	59°17.4'N 031°15.3'W
	21.10.92	21:42	58°53.8'N 030°14.0'W
P11	24.10.92	00:00	59°16.5'N 031°17.1'W
	24.10.92	05:18	58°52.8'N 030°15.7'W
P12A	24.10.92	05:56	58°52.8'N 030°19.9'W

	24.10.92	10:48	59°15.4'N 031°18.7'W
P12B	24.10.92	11:00	59°15.1'N 031°17.5'W
	24.10.92	20:10	58°51.9'N 030°17.6'W
P13	24.10.92	20:12	58°51.9'N 030°17.1'W
	26.10.92	23:46	58°51.3'N 010°58.5'W

A3 List of the sampling stationen

station	date	time(UTC)	position	samplers
SO82-01	19.10.92	10:35	59°30.6'N 31°29.6'W	GKG(0.33 m) KL (0.92 m) SL (4.84 m)
SO82-02	19.10.92	17:04	59°21.4'N 31°05.2'W	GKG(0.40 m) KL (5.75 m) SL (5.56 m)
SO82-03	20.10.92	09:00	59°19.6'N 31°08.4'W	GKG(0.36 m) KL (5.78 m) SL (5.57 m)
SO82-04	20.10.92	17:20	59°05.8'N 30°28.7'W	GKG(0.37 m) KL (5.79 m) SL (5.57 m)
SO82-05	21.10.92	08:30	59°11.2'N 30°54.3'W	GKG(0.47 m) KL (5.90 m) SL (5.90 m)
SO82-06	21.10.92	15:30	59°09.5'N 30°54.9'W	GKG(0.18 m)
SO82-07	24.10.92	16:14	59°00.7'N 30°36.1'W	GKG(0.43 m) KL (5.79 m) SL (5.52 m)
SO82-08	26.10.92	02:00	59°00.1'N 18°59.9'W	SL (1.20 m)

GKG - giant box corer (Großkastengreifer)
KL - giant gravity corer (Kastenlot)
SL - gravity corer (Schwerelot)
(1.20 m) - core recovery

A4 Hydrosweep maps, evaluated on board (copies)

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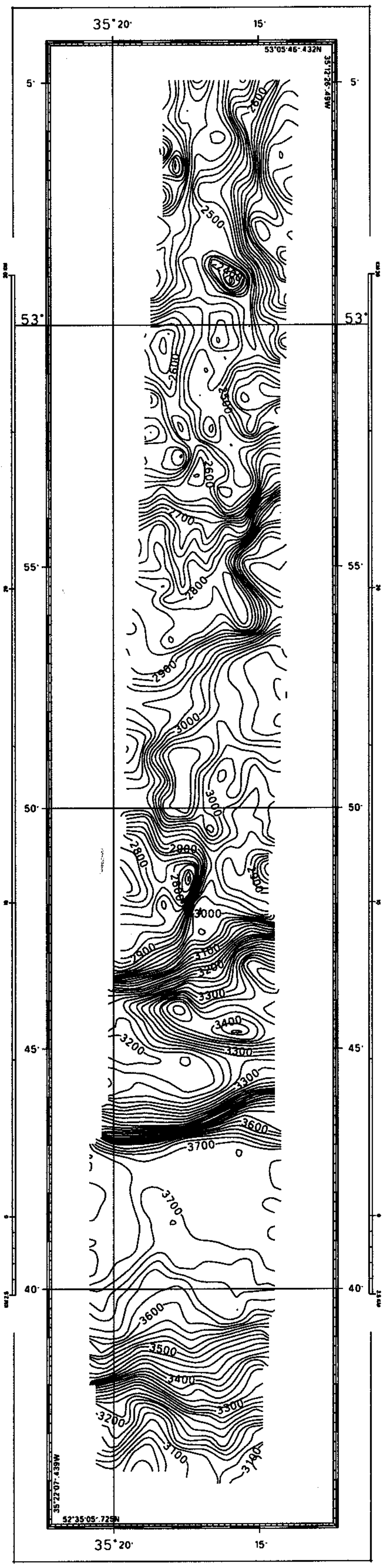

FS SONNE
SO82 A
PROFIL 1
Isolinien 20 m
Masstab: 1 : 100.000
Mercator Projektion
Referenzbreite: 60°N
Datum: 14.10.92

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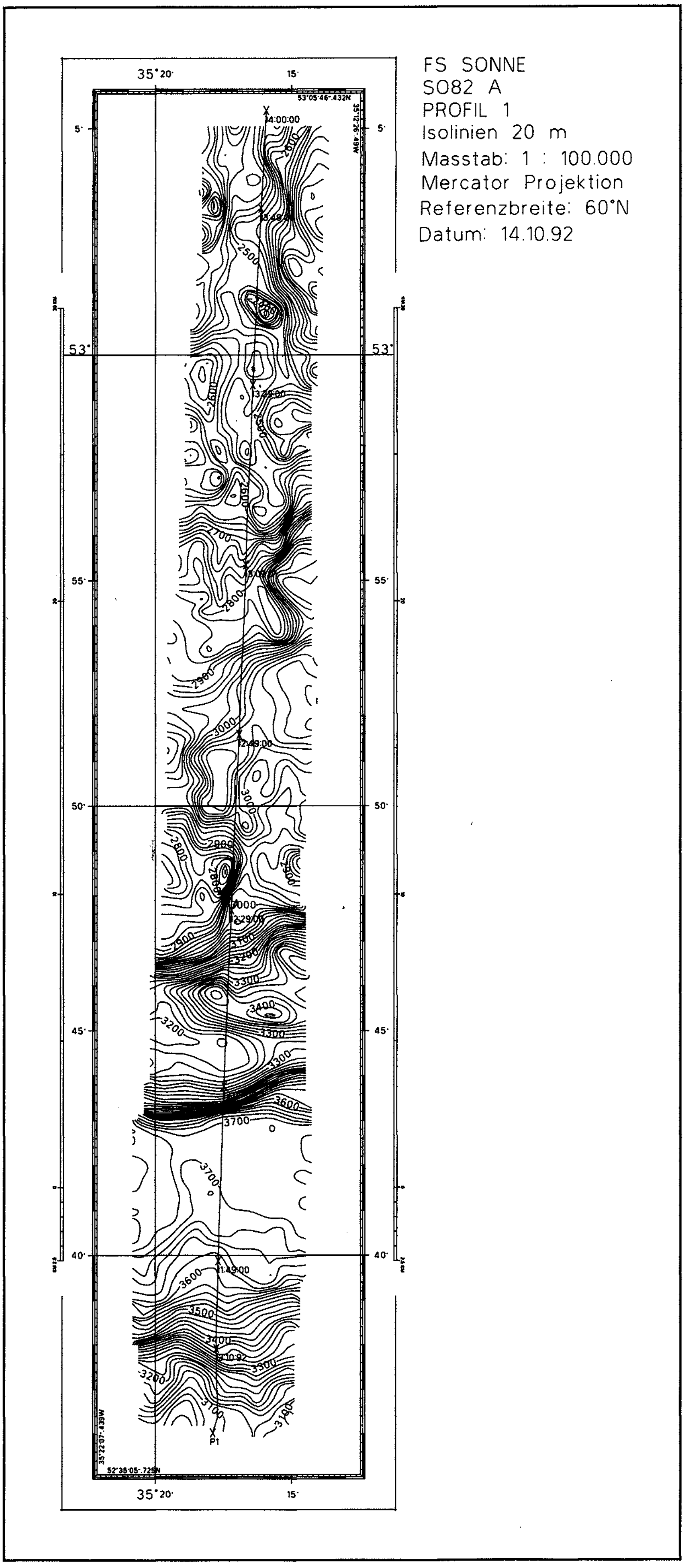

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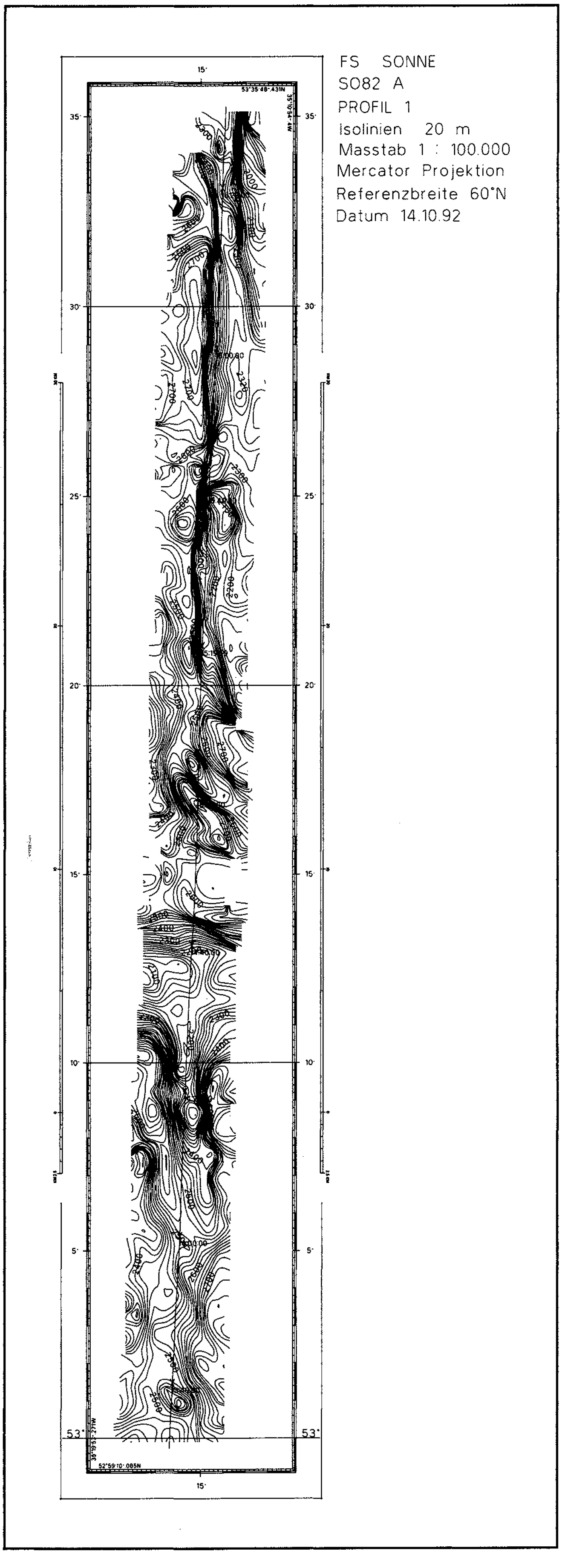

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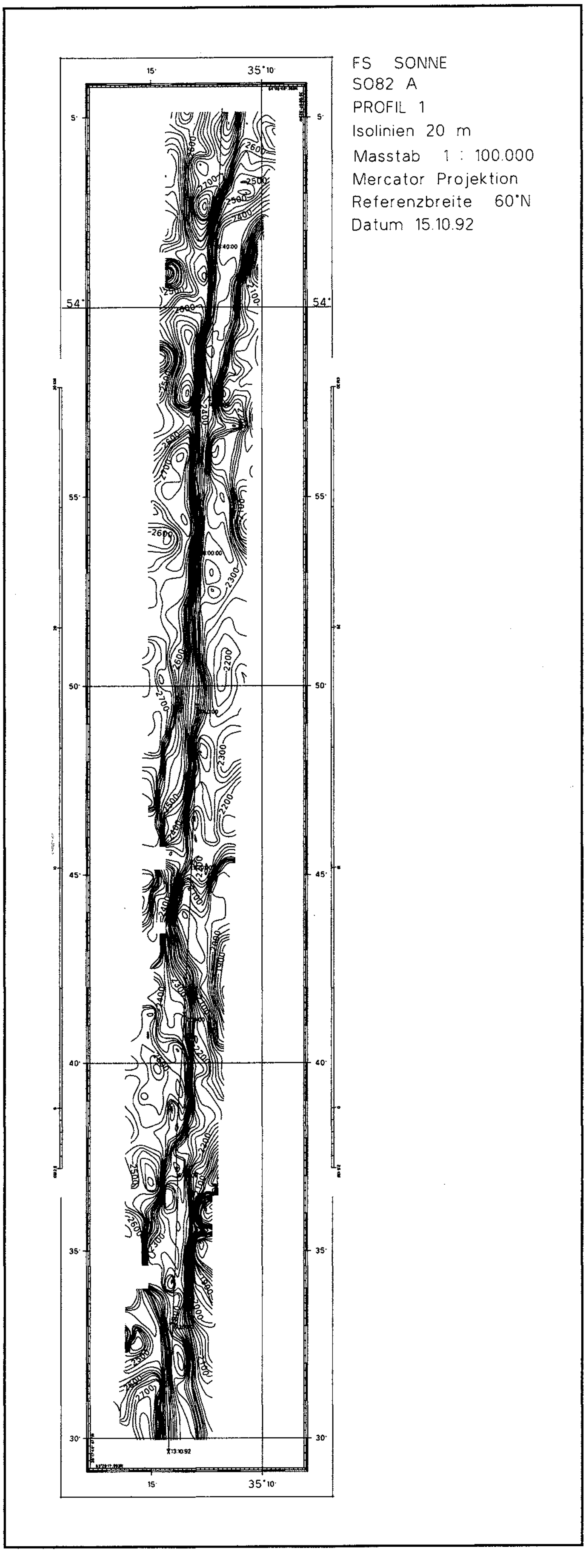

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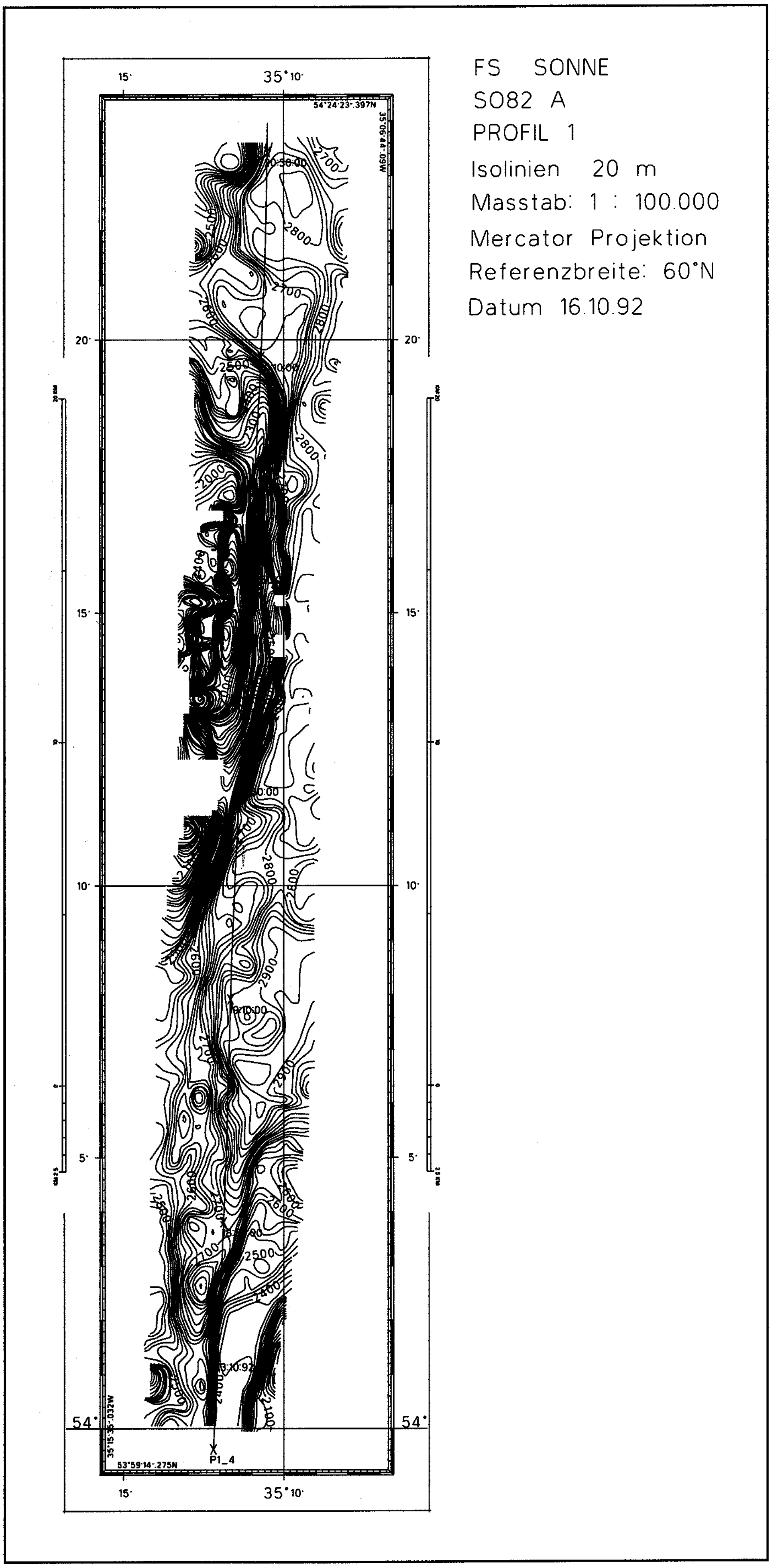

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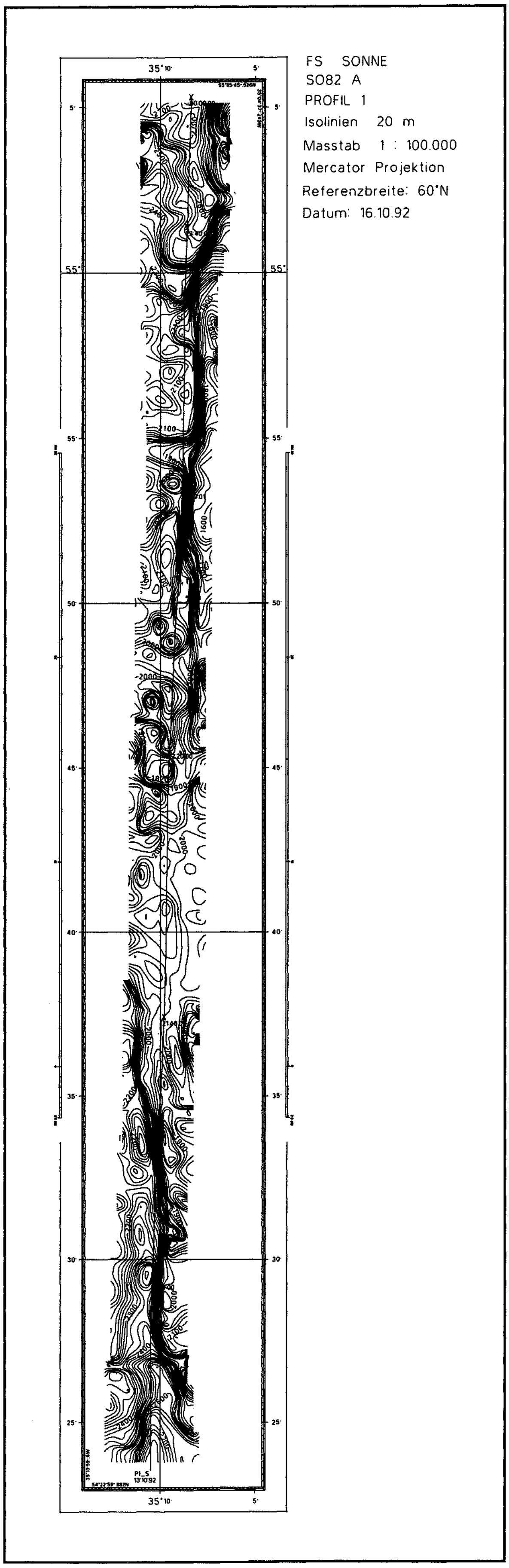

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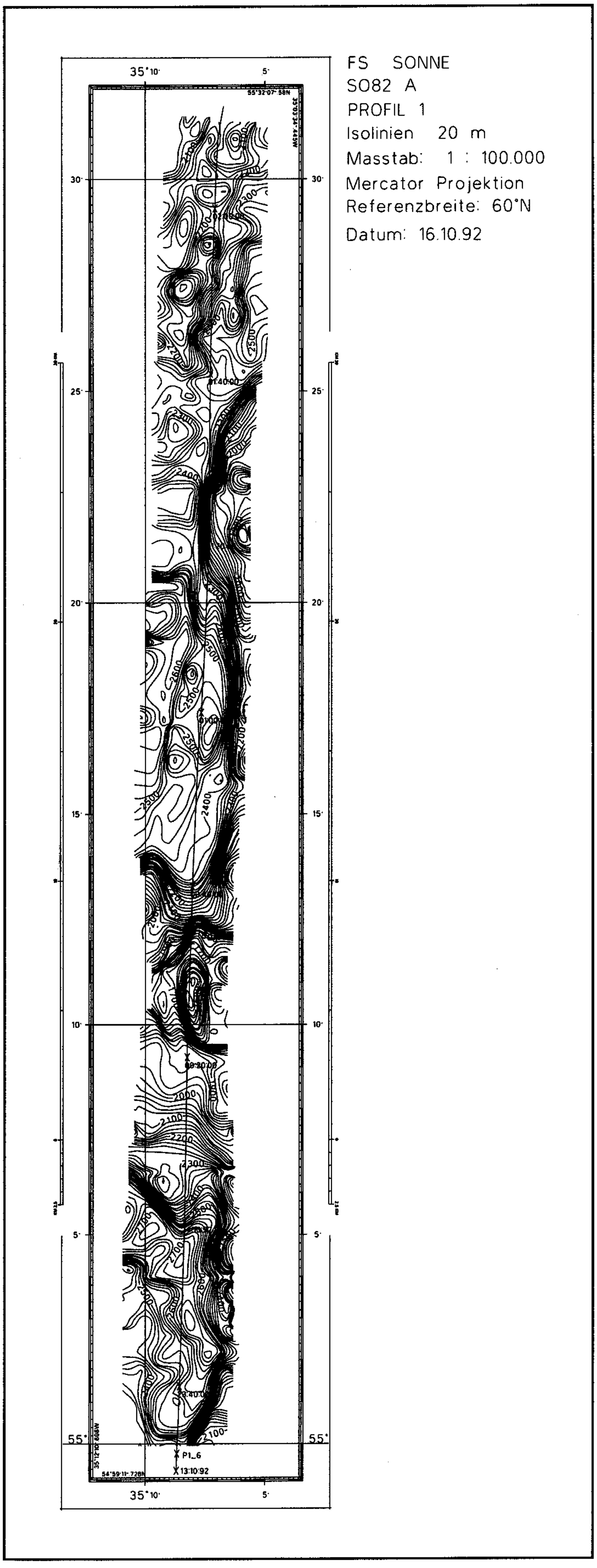

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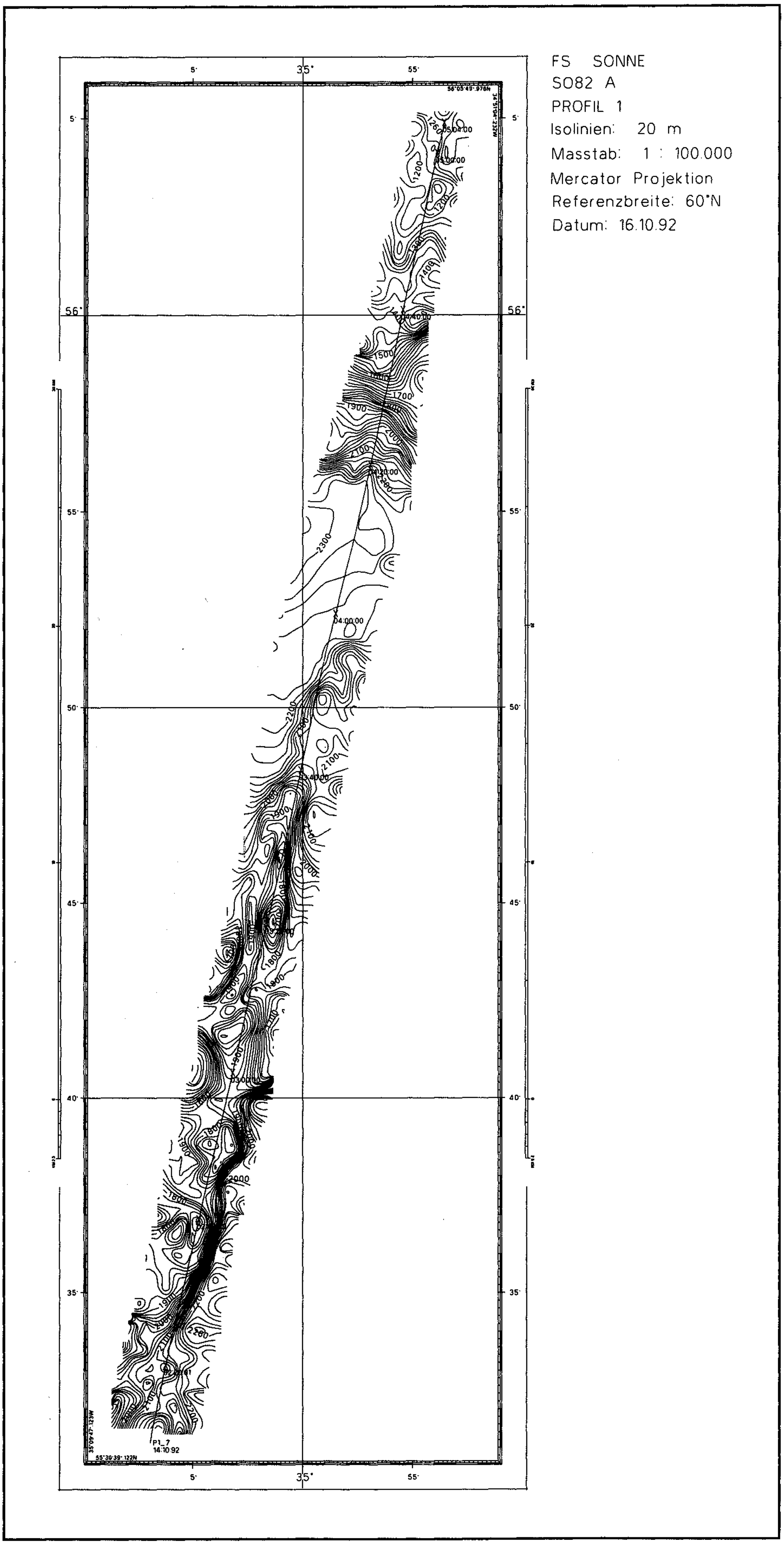

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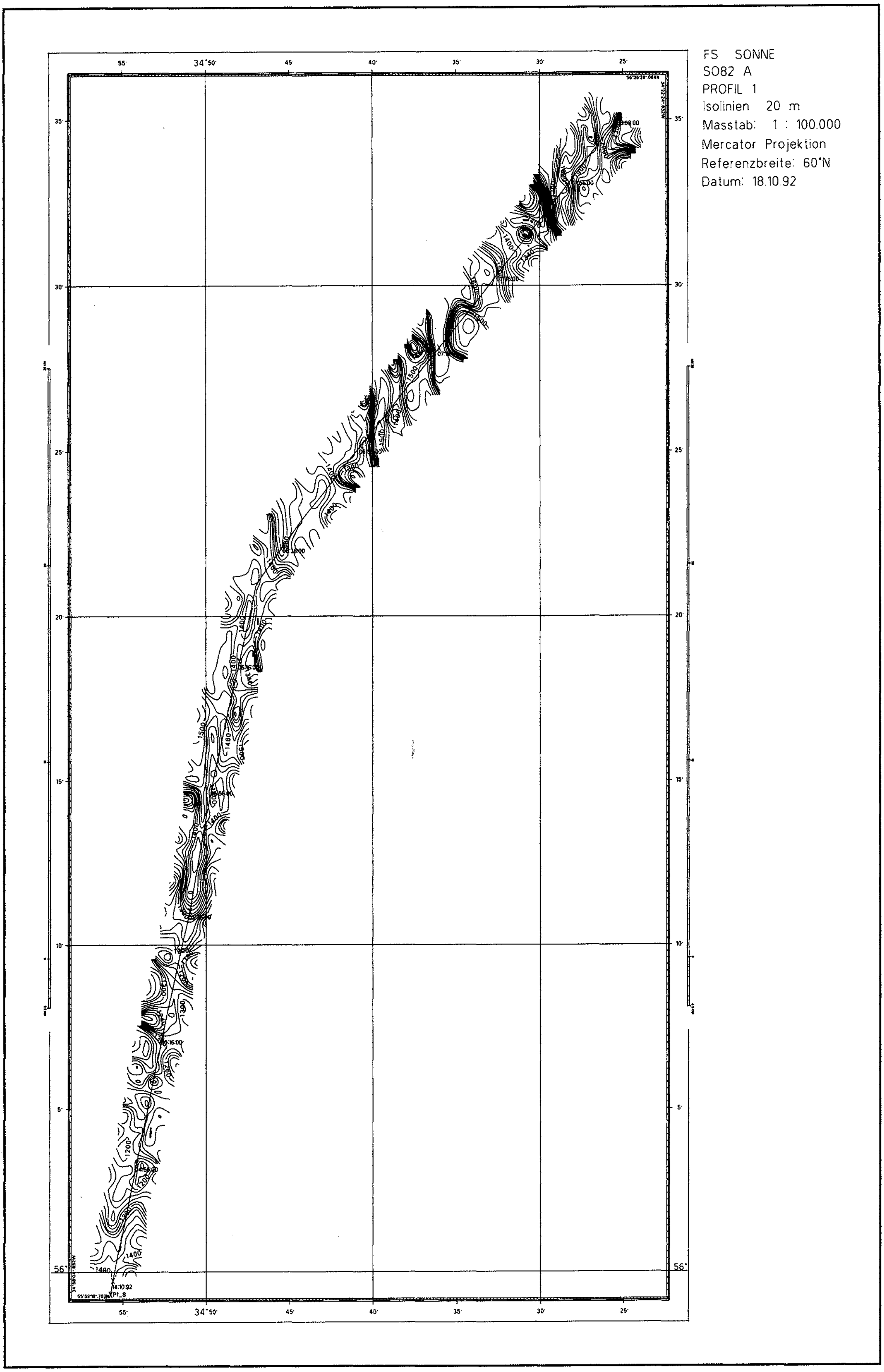

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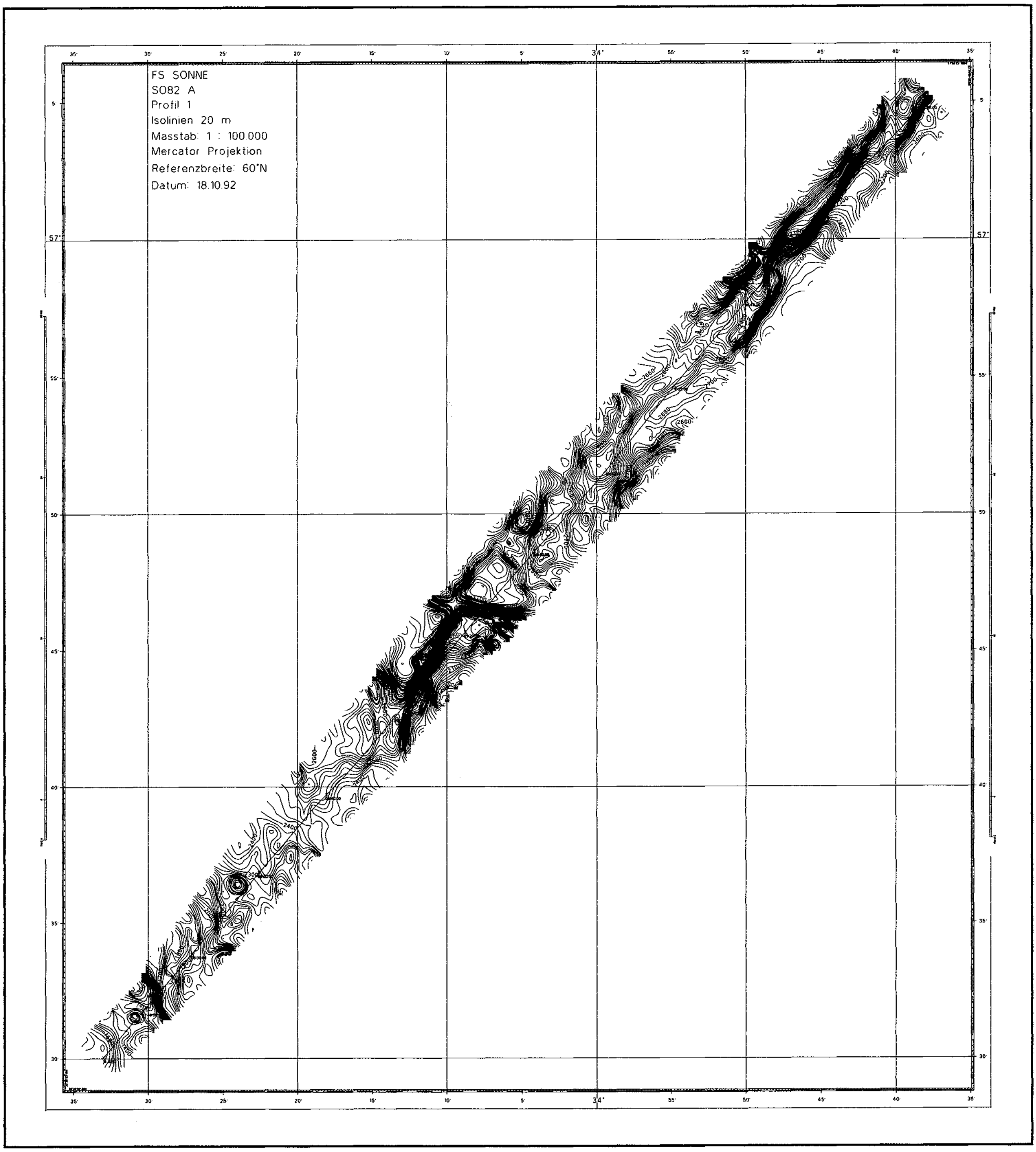

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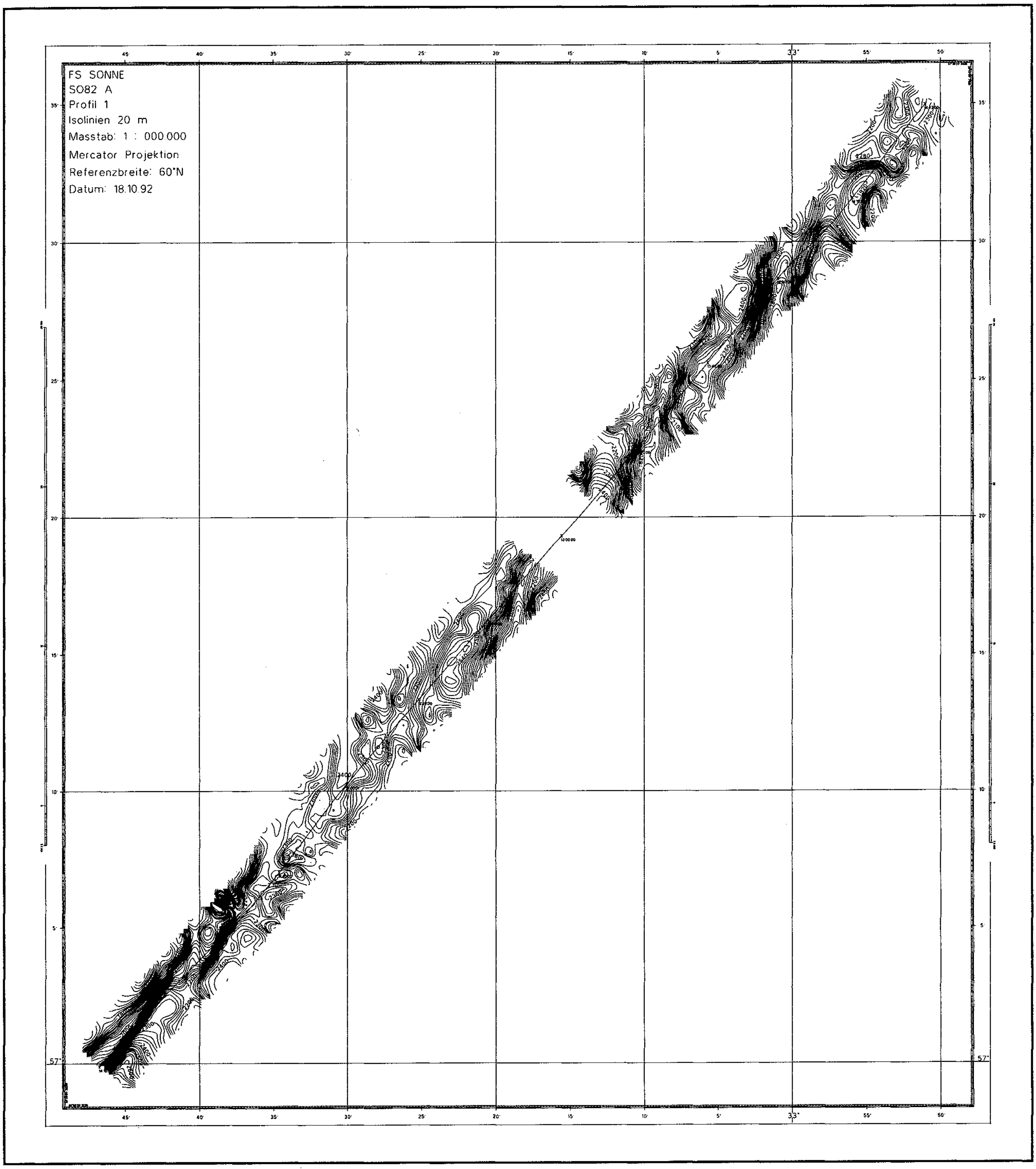

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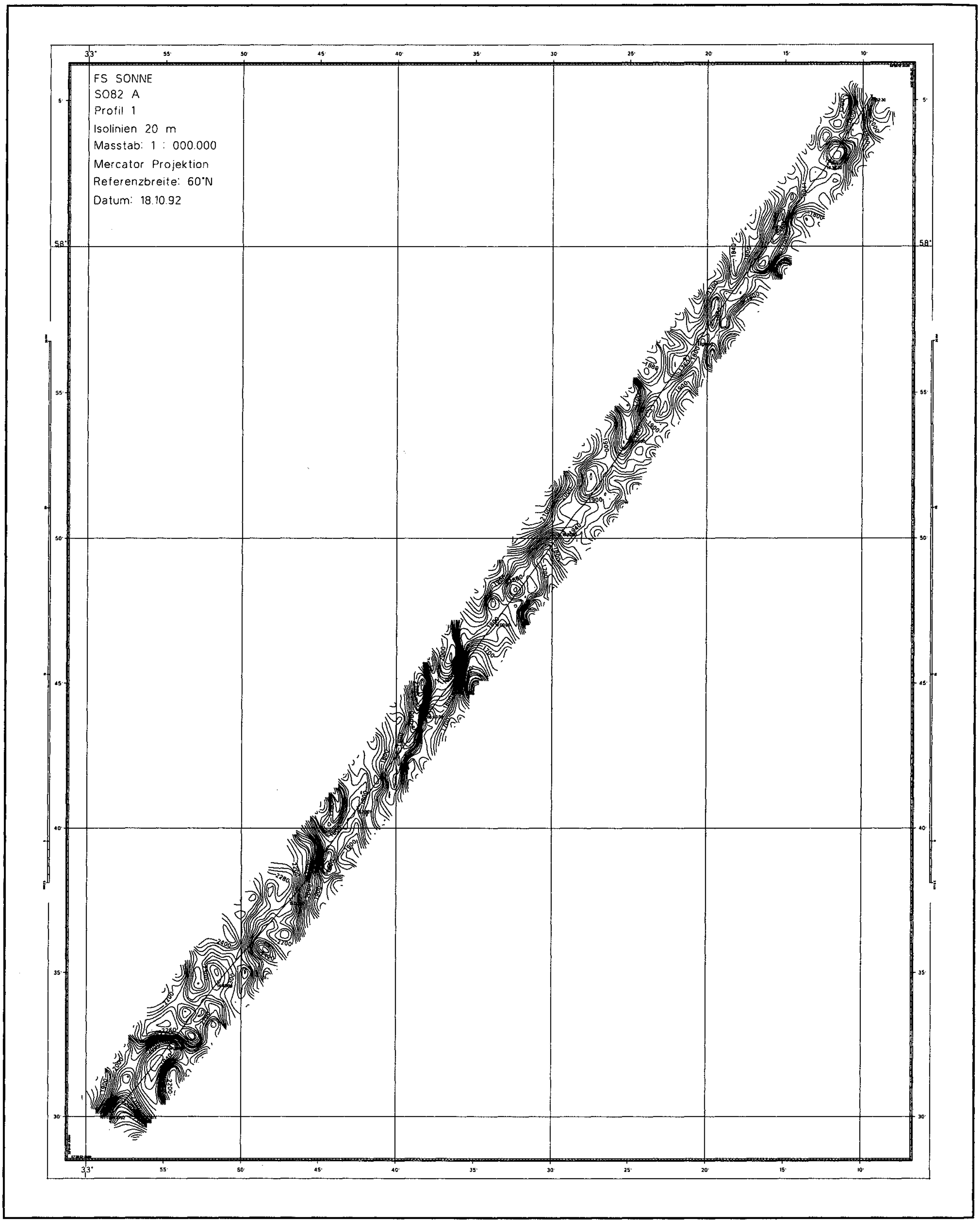

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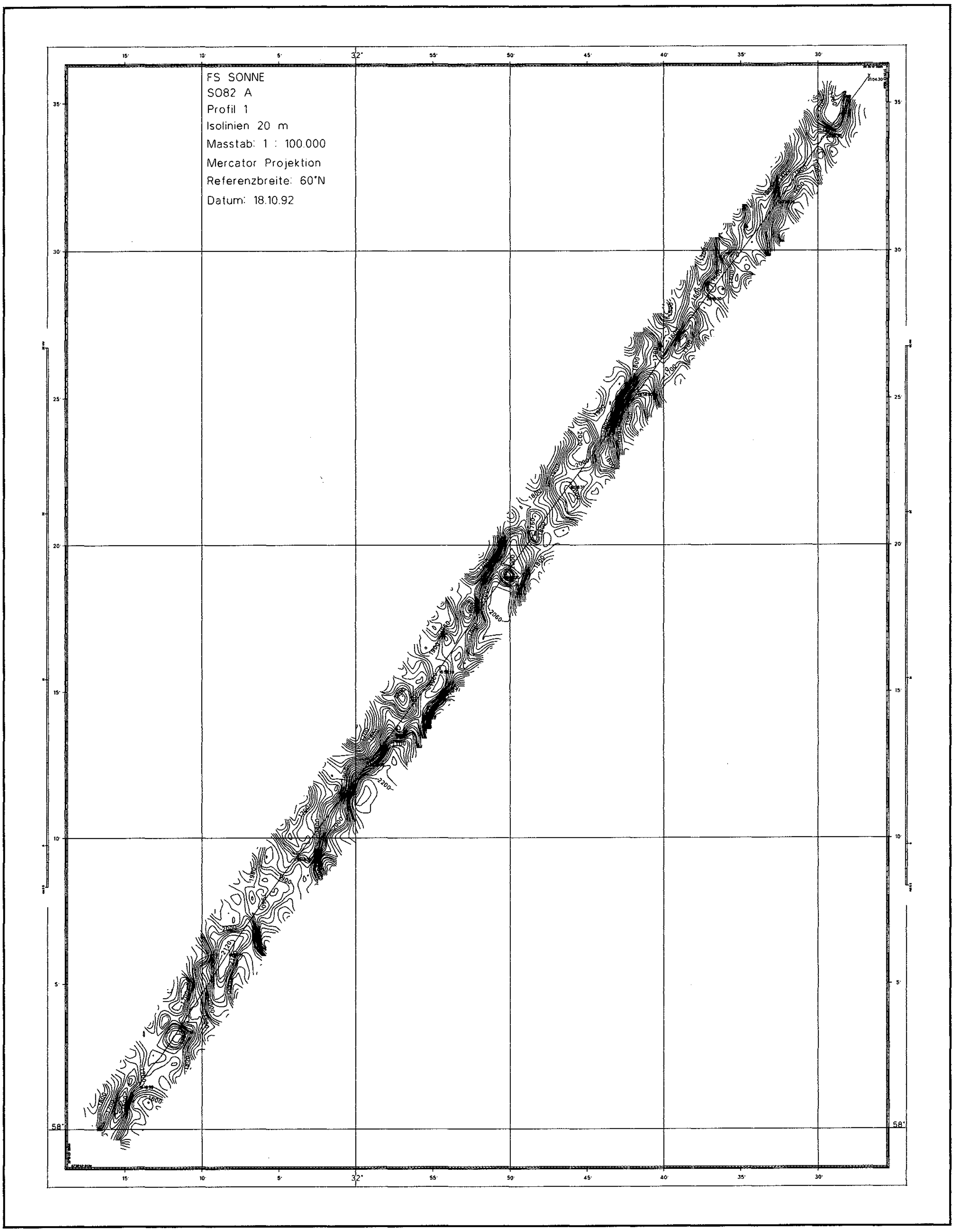

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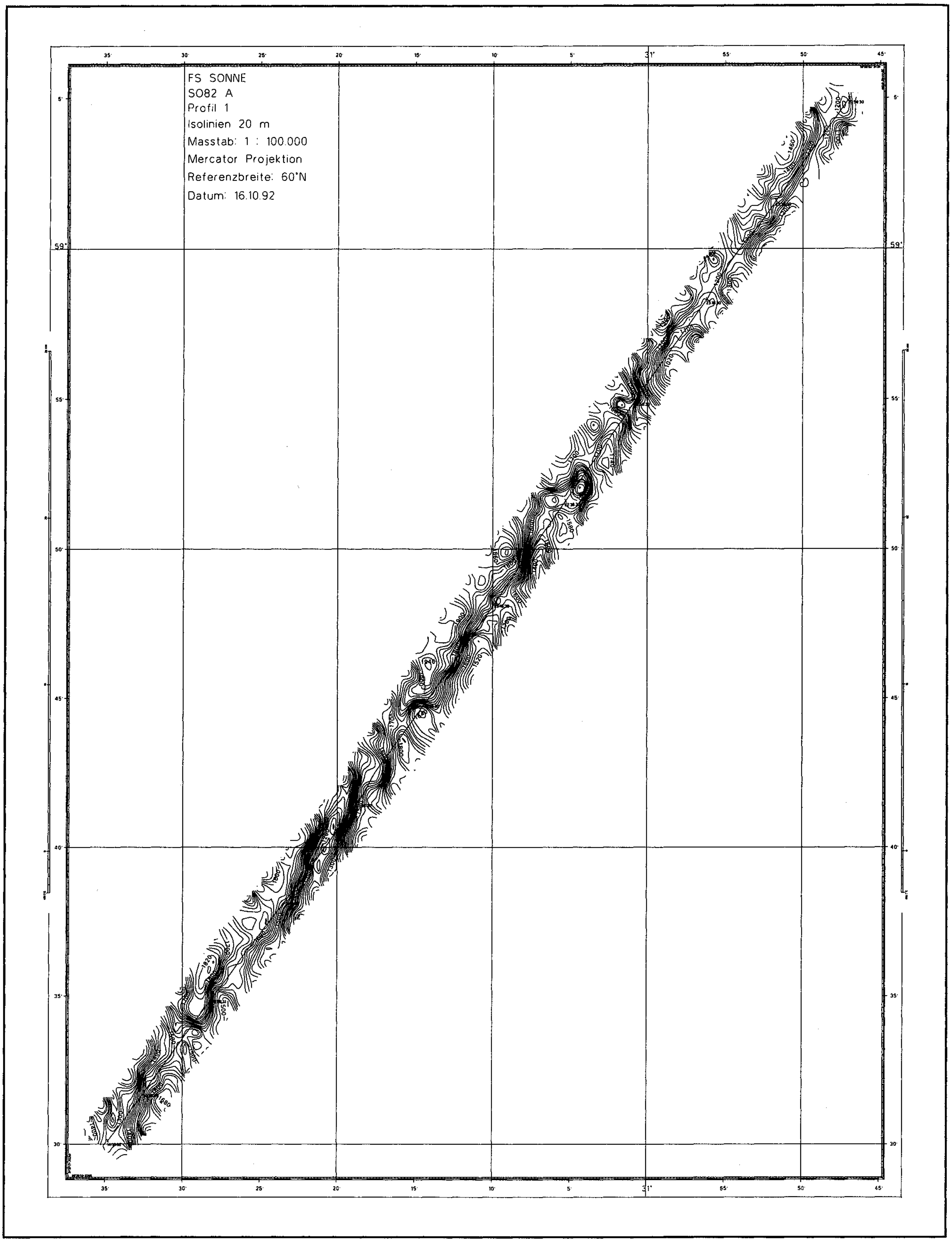

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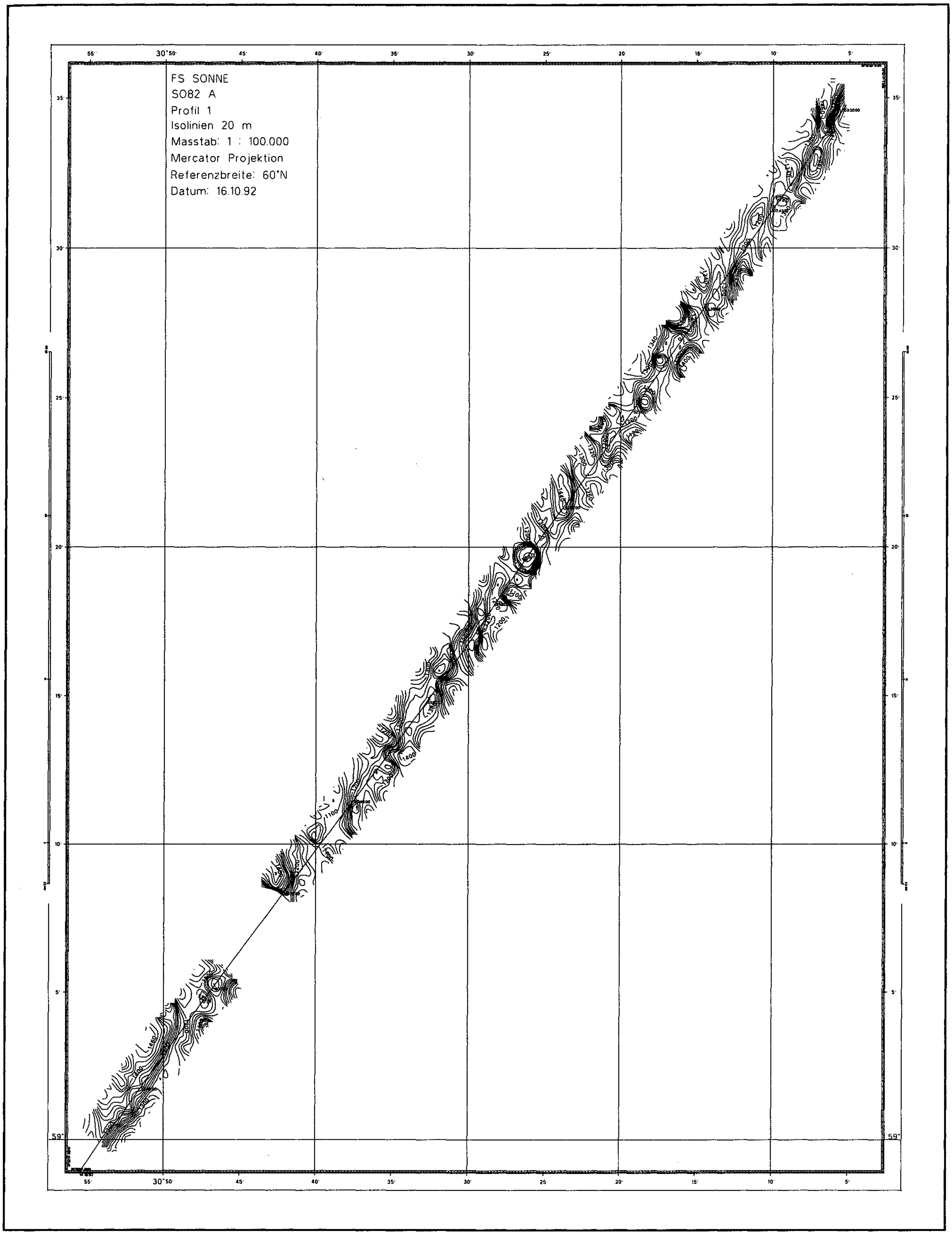

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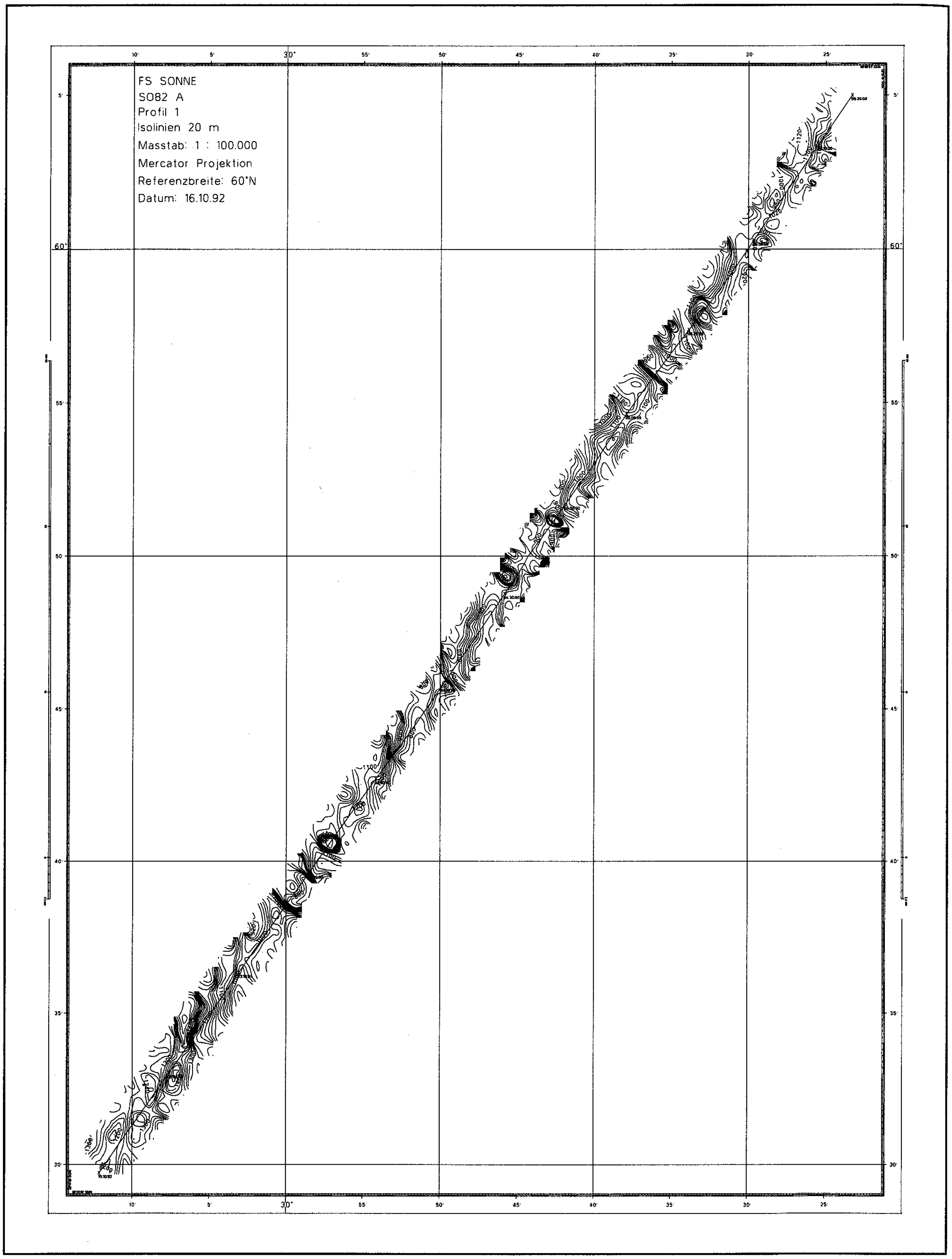

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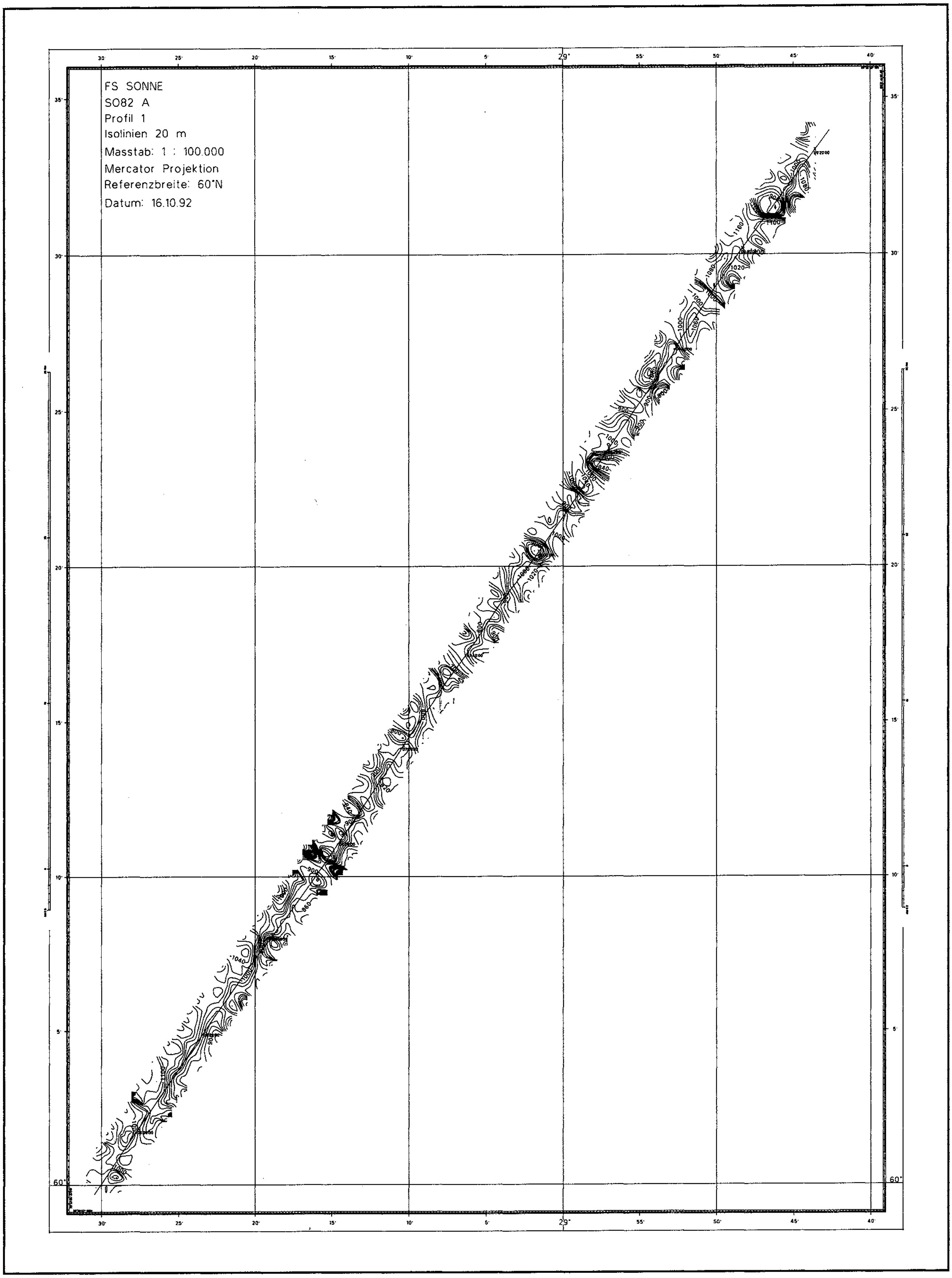

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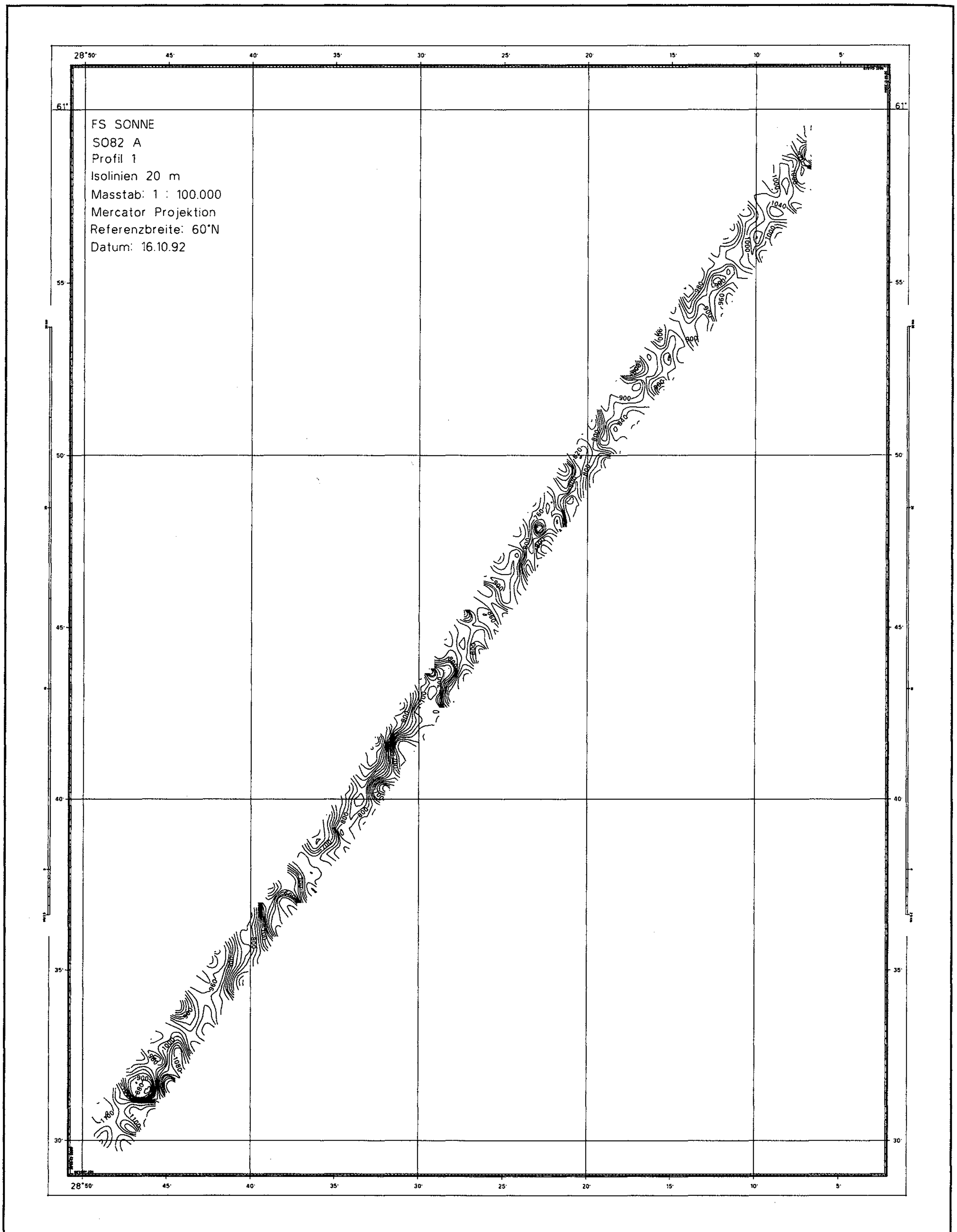

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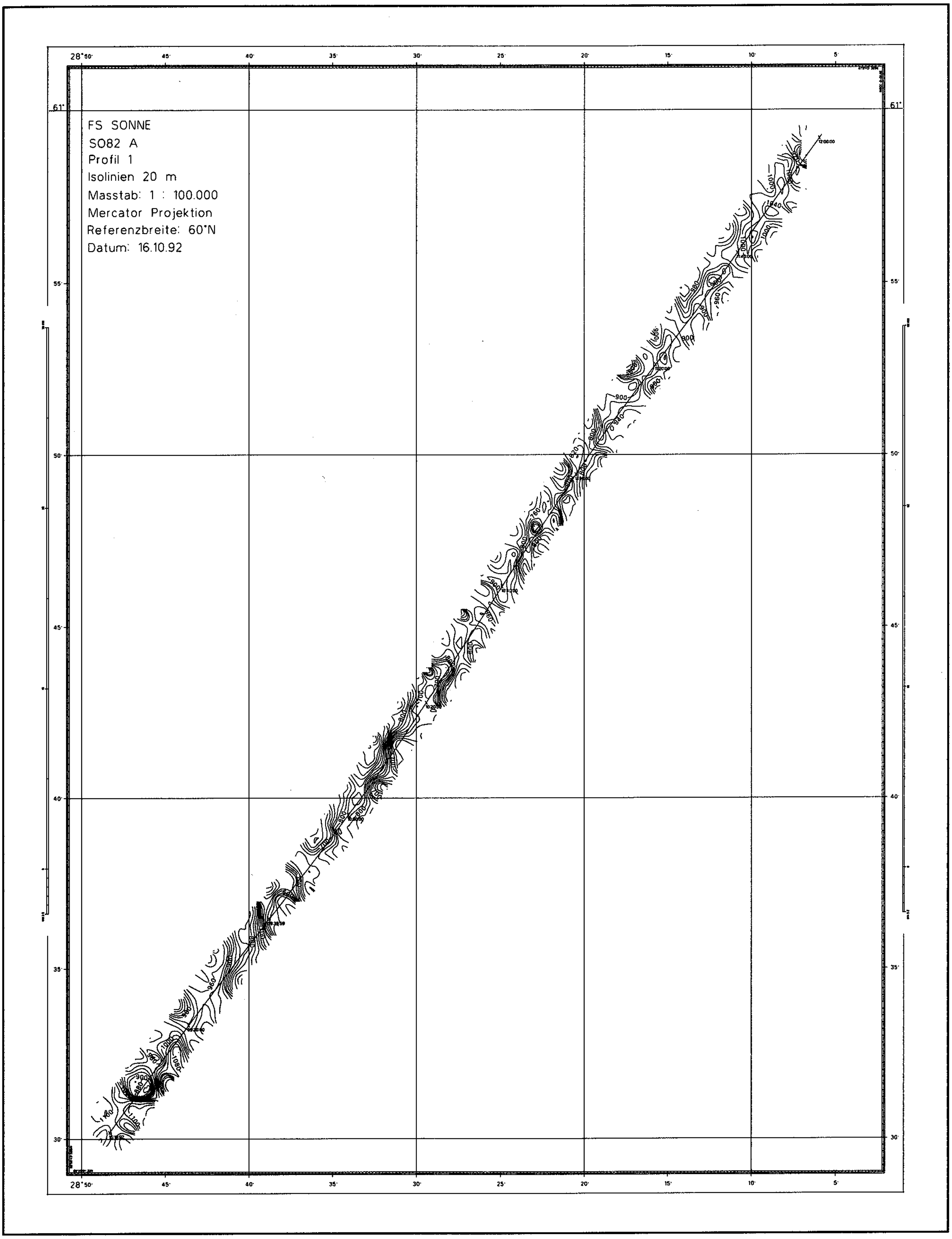

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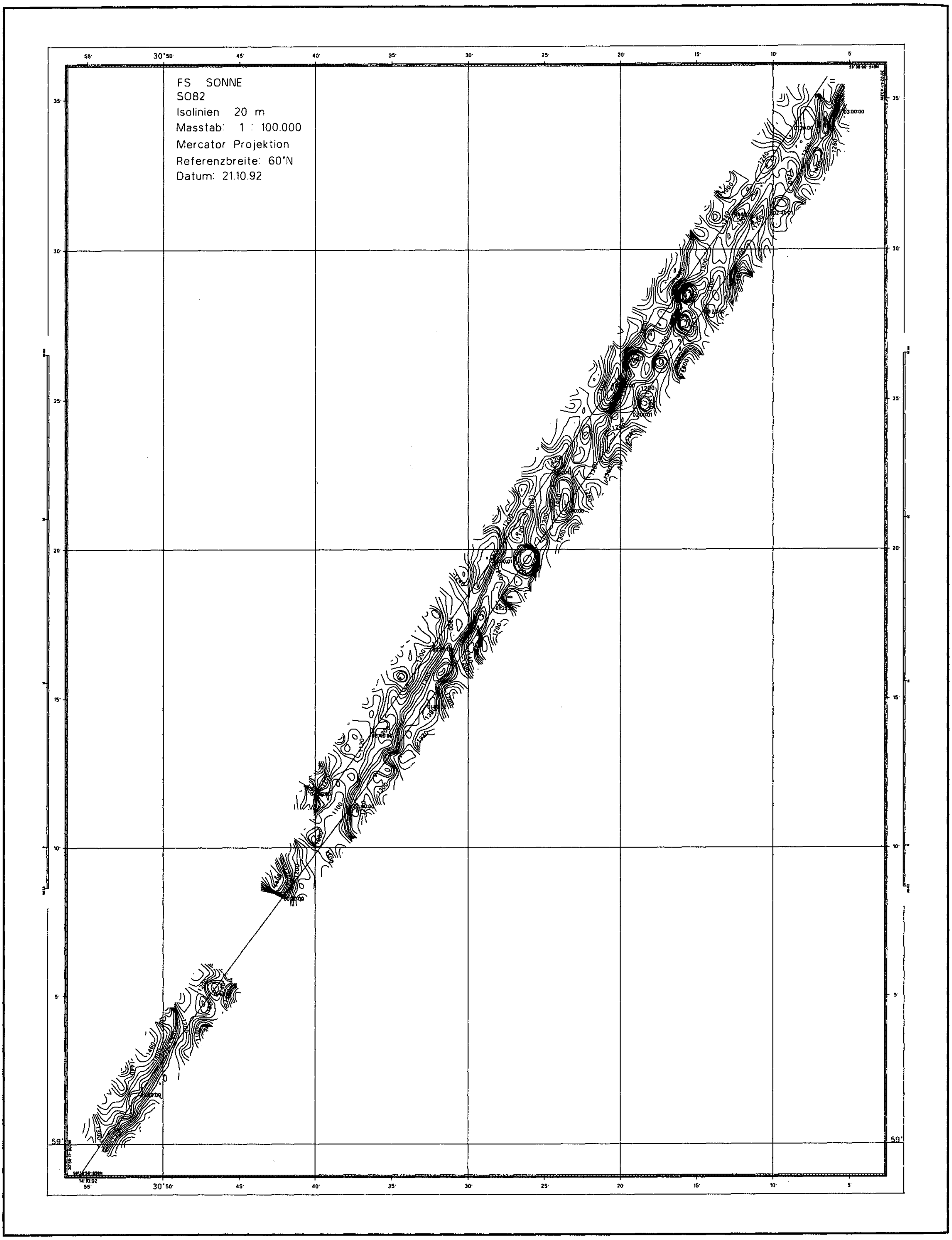

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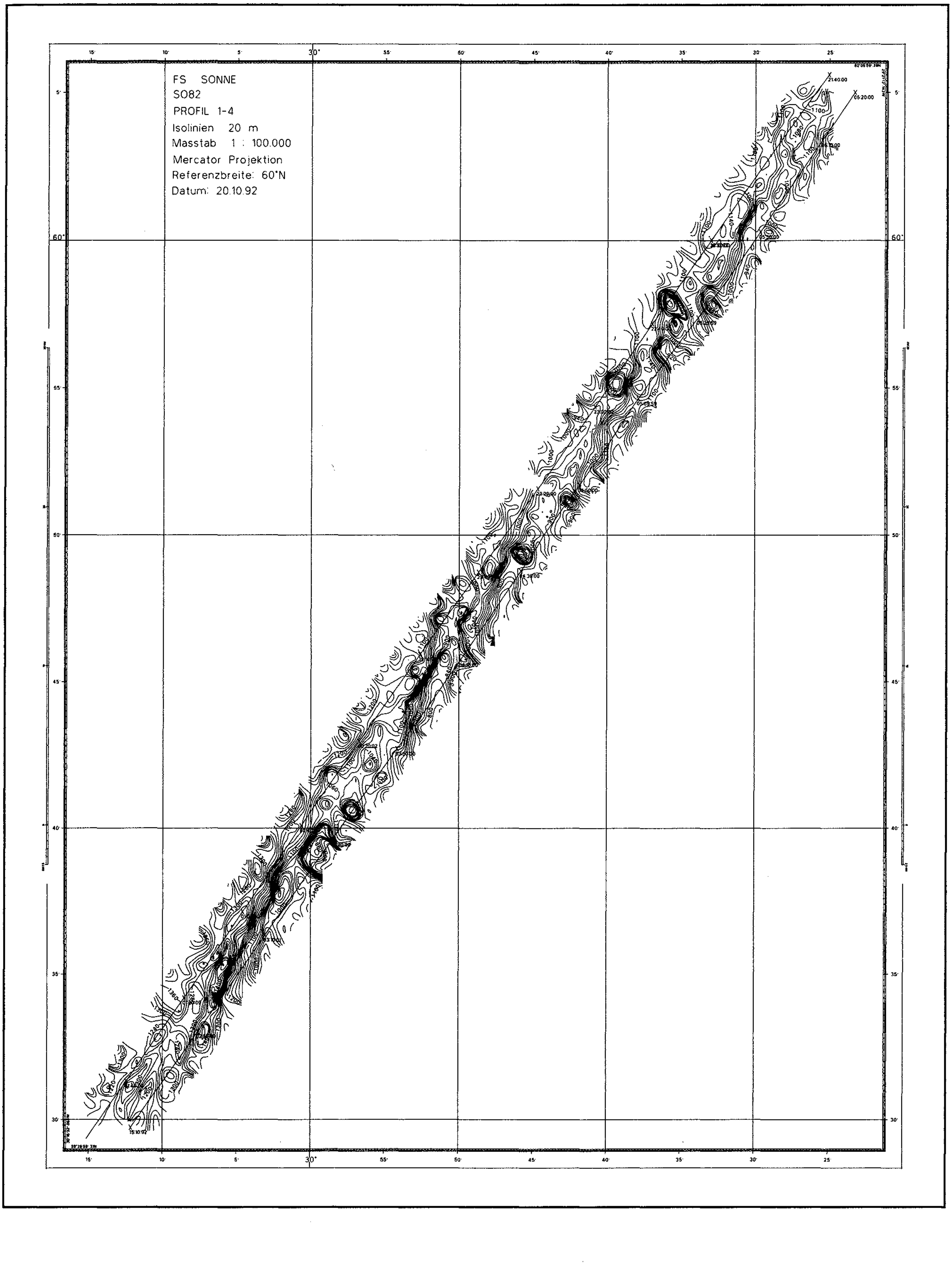

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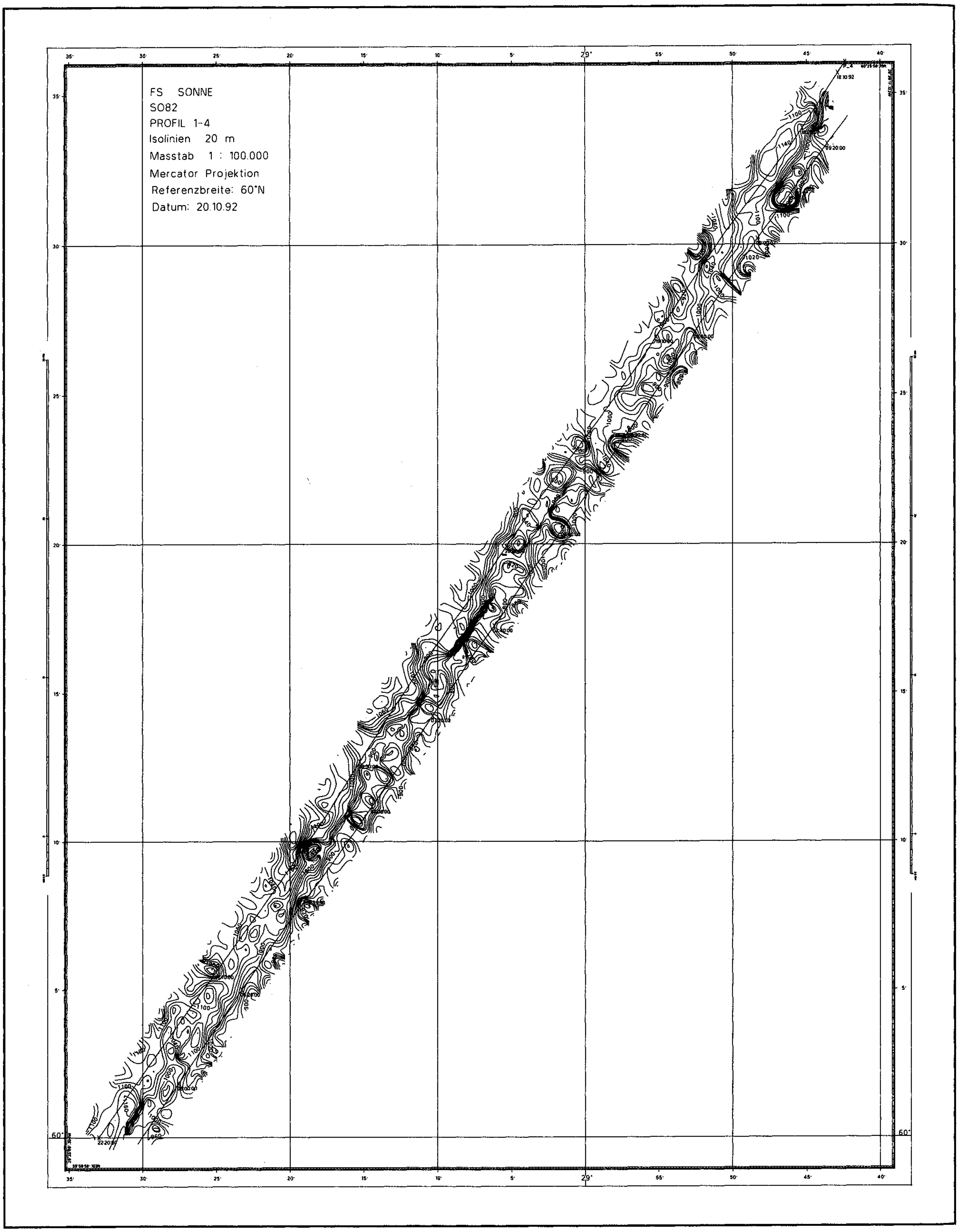

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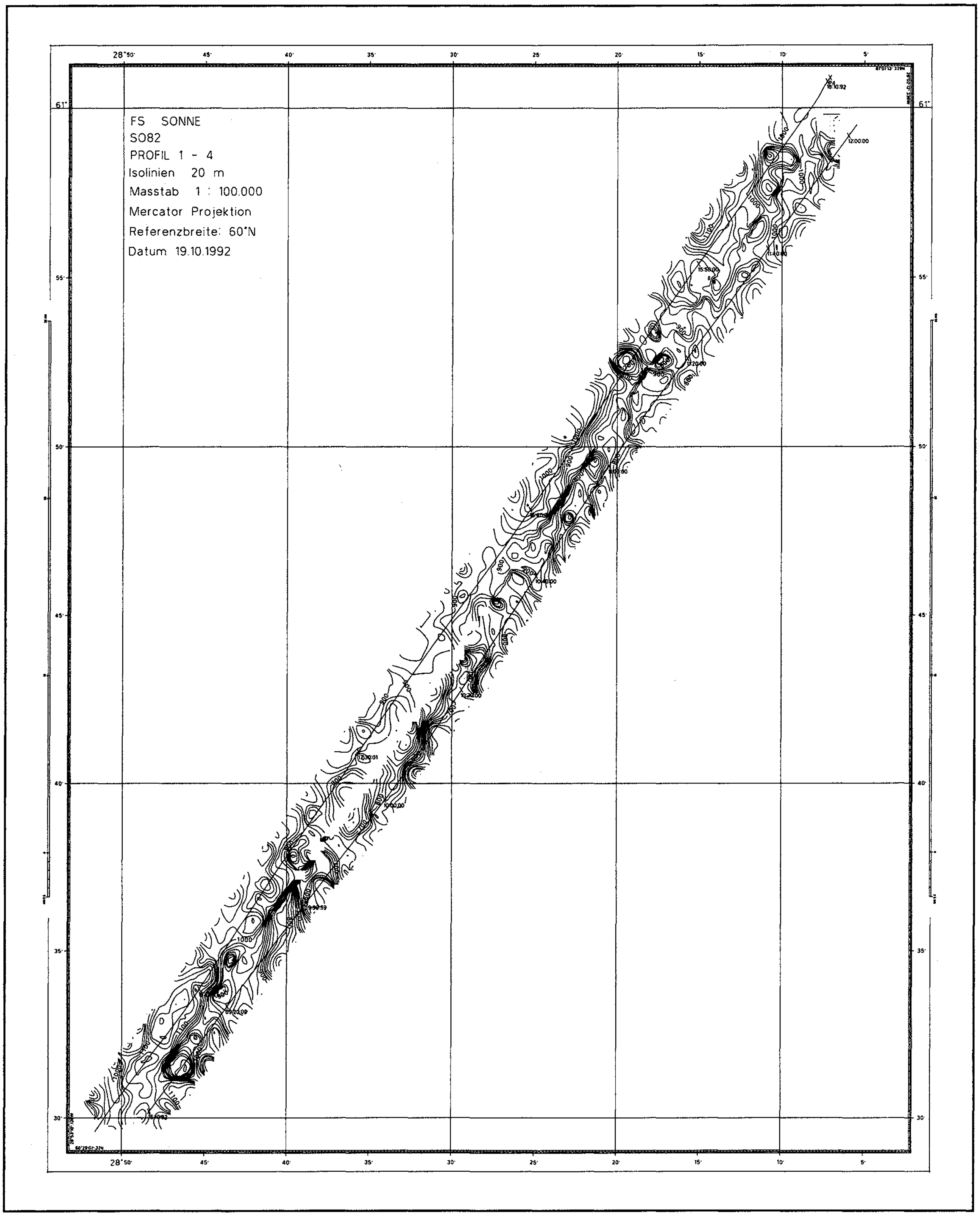

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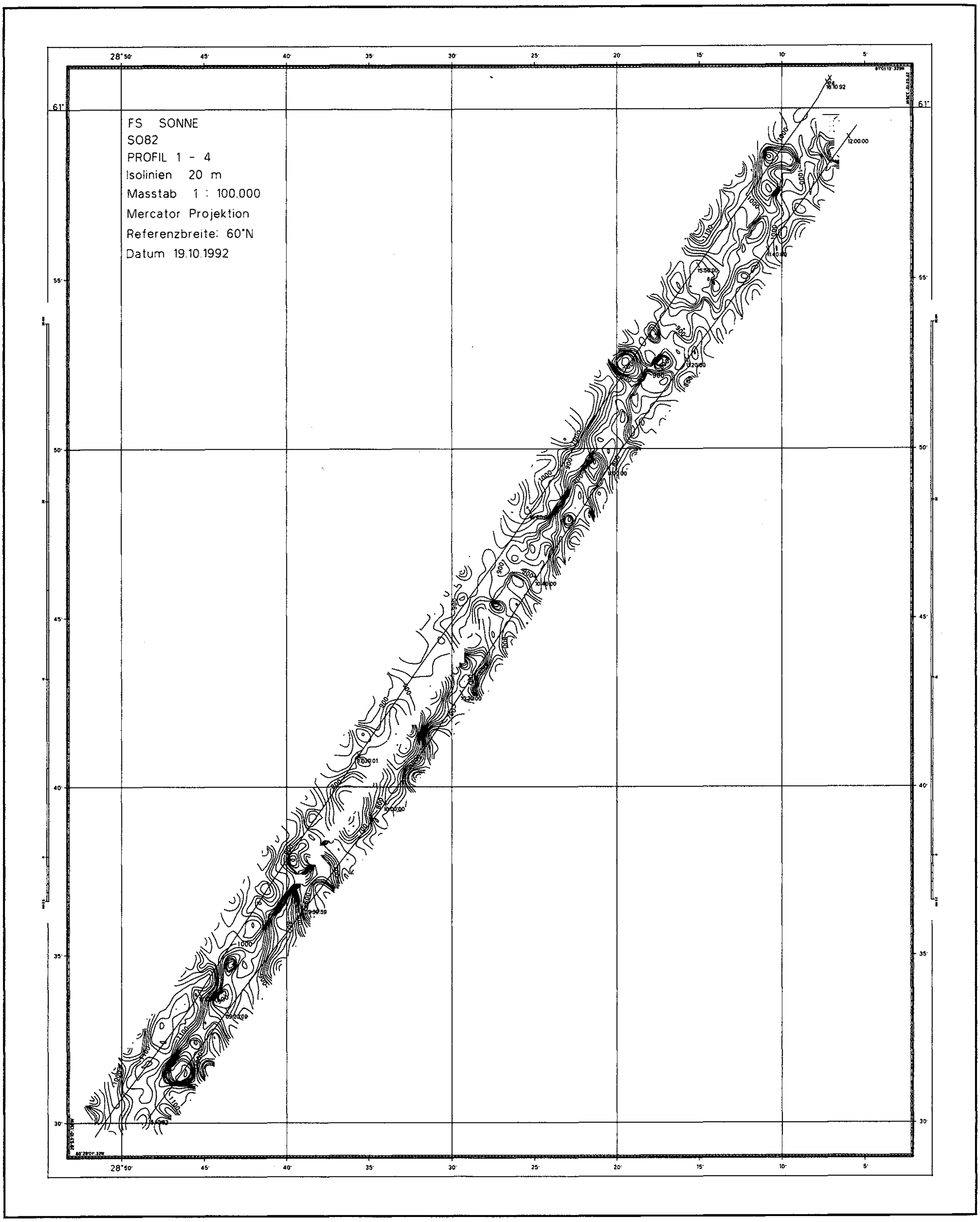

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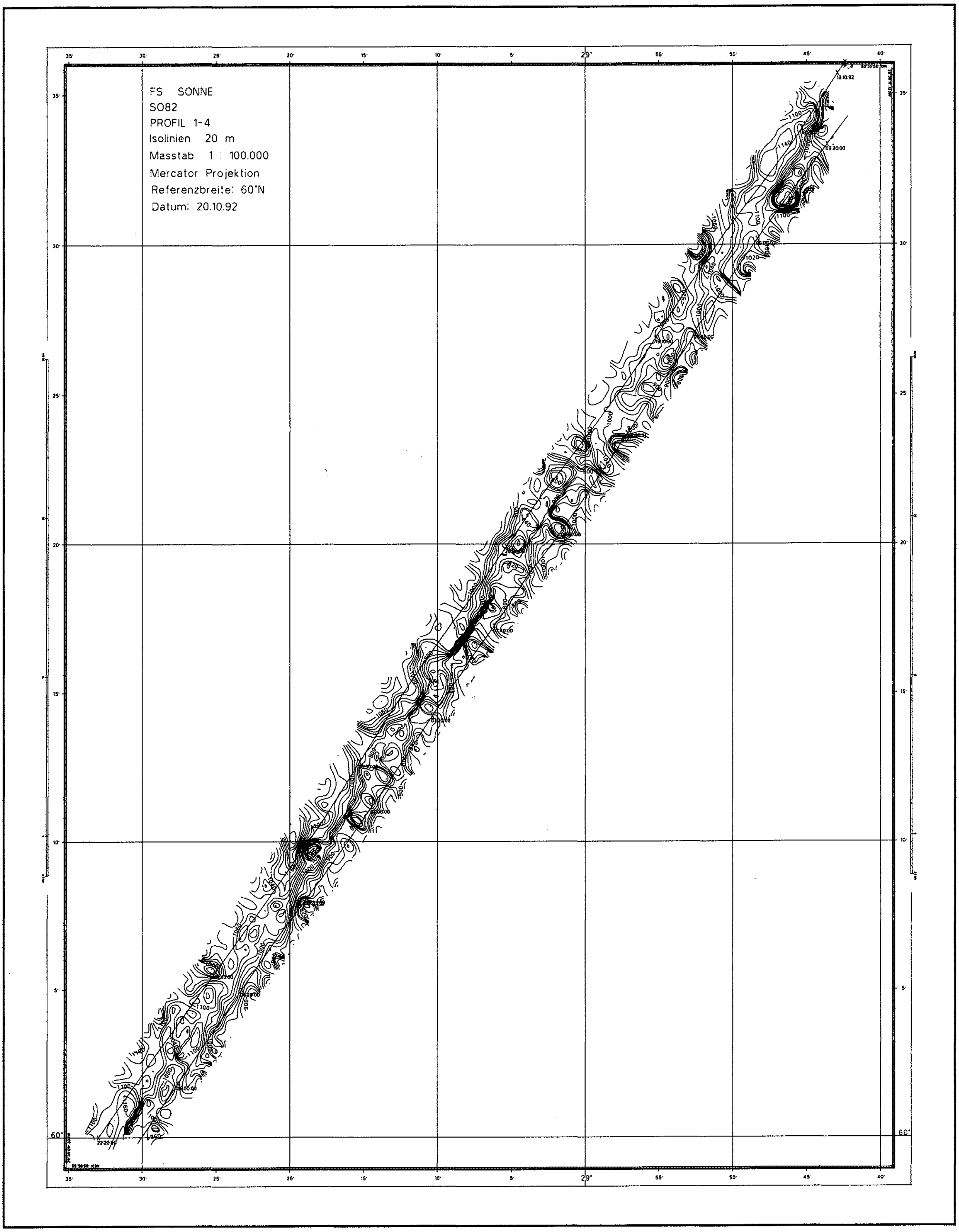

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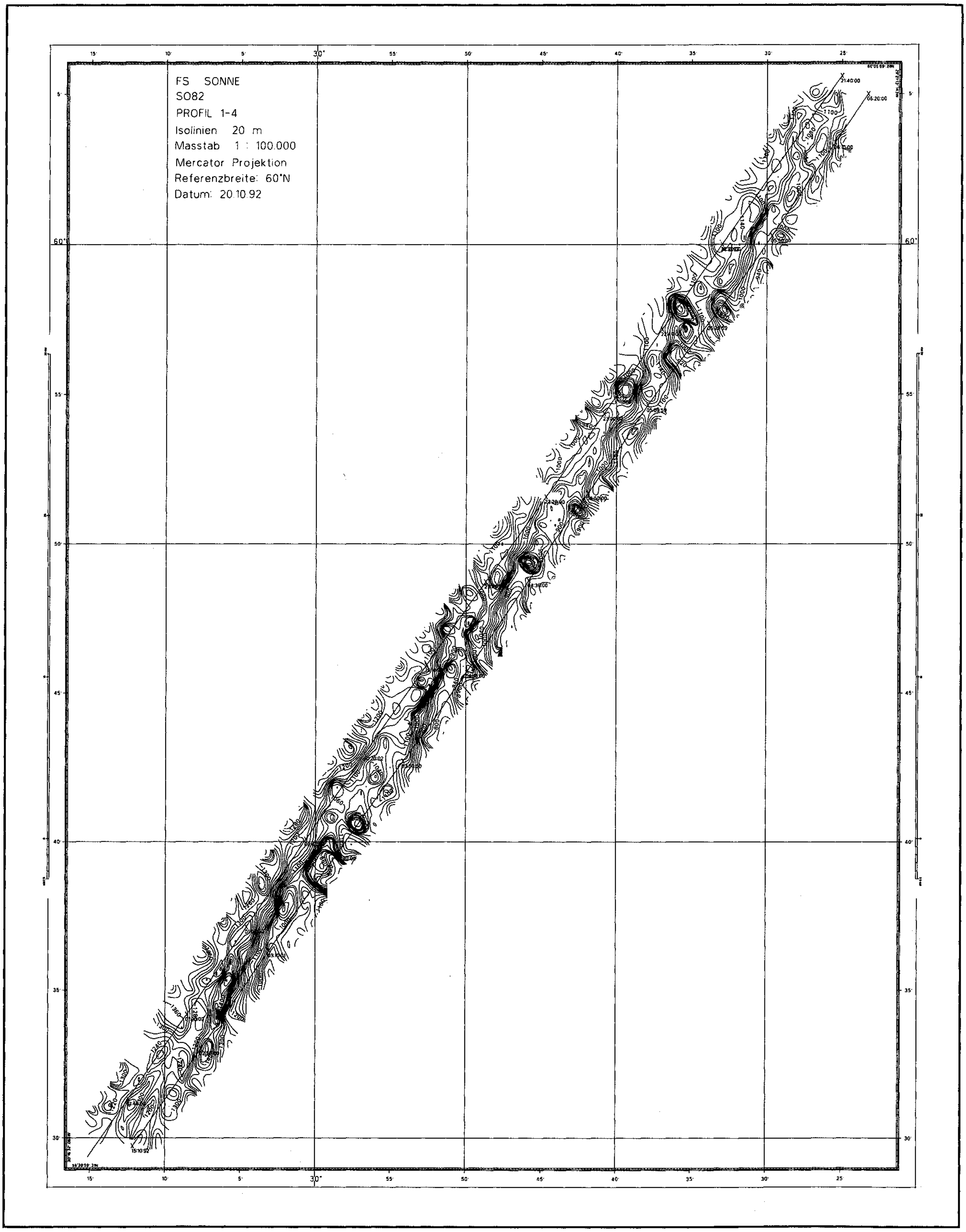

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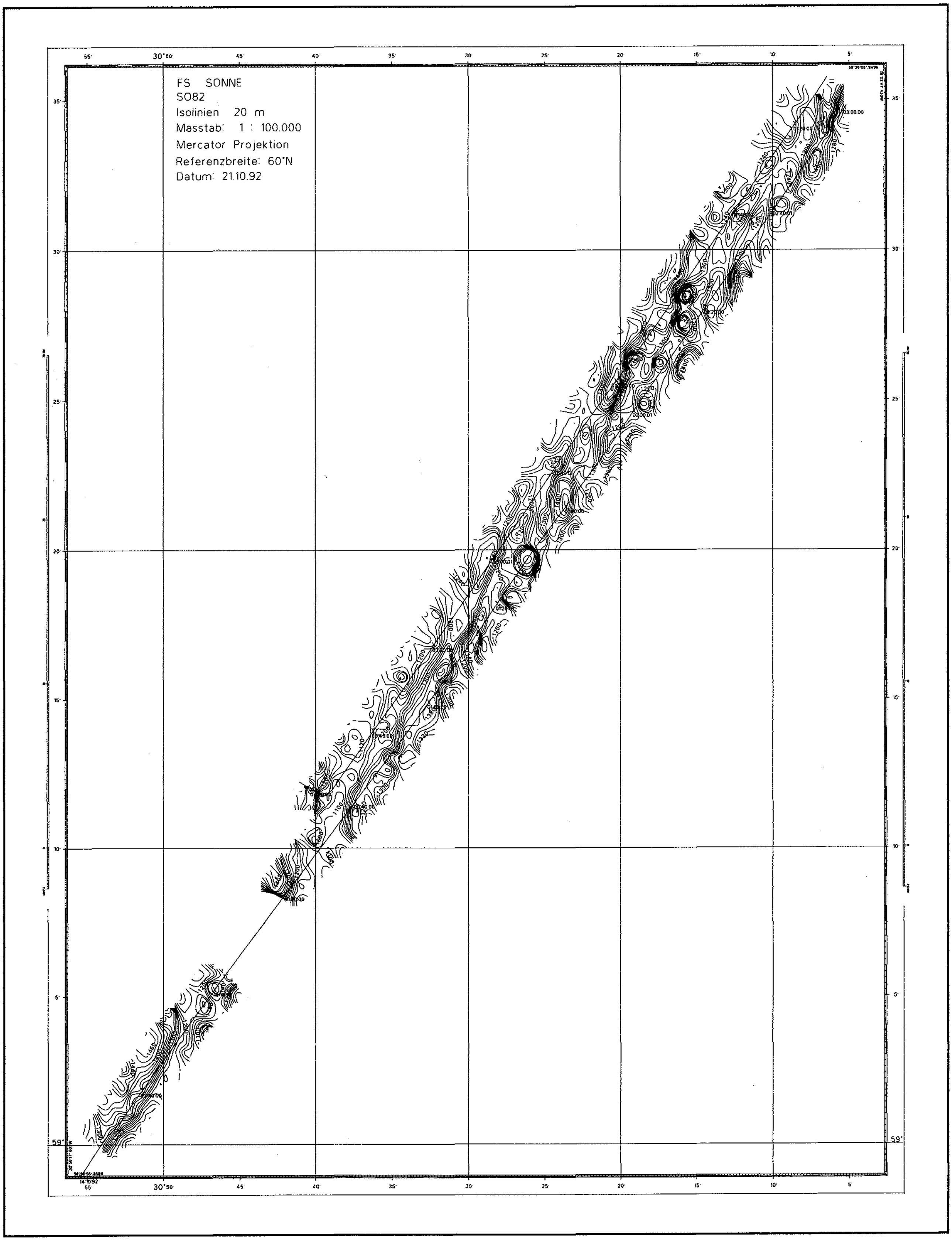

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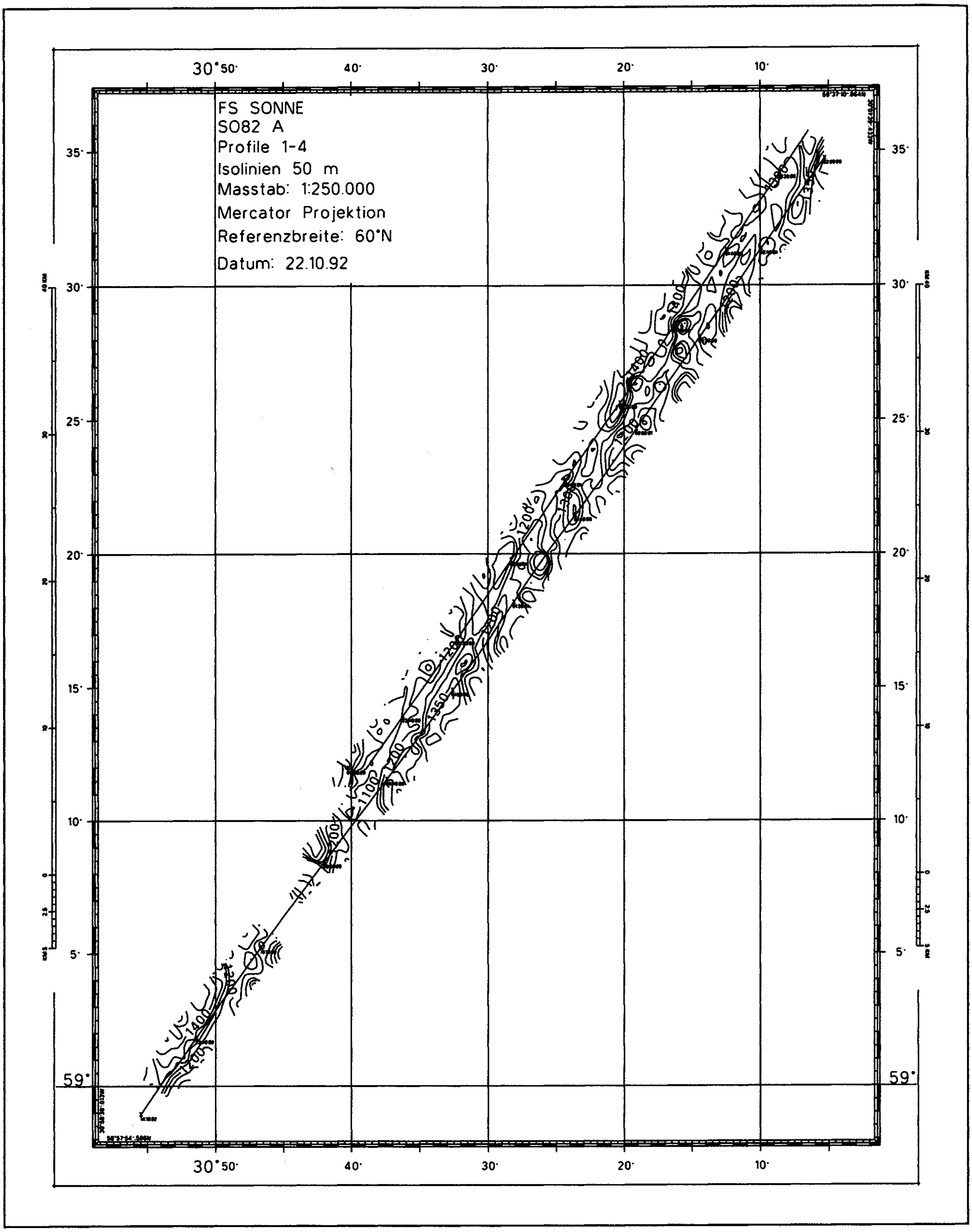

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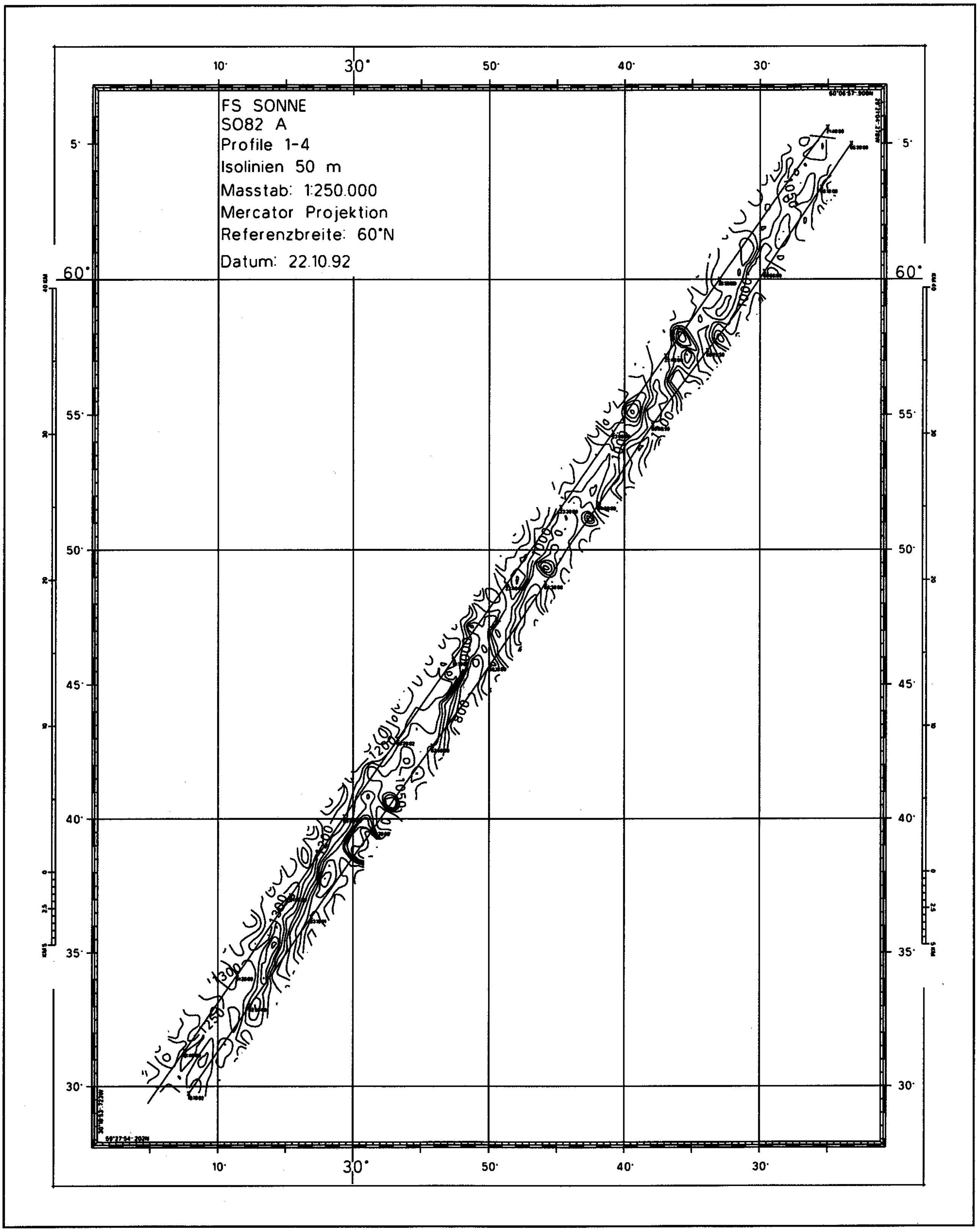

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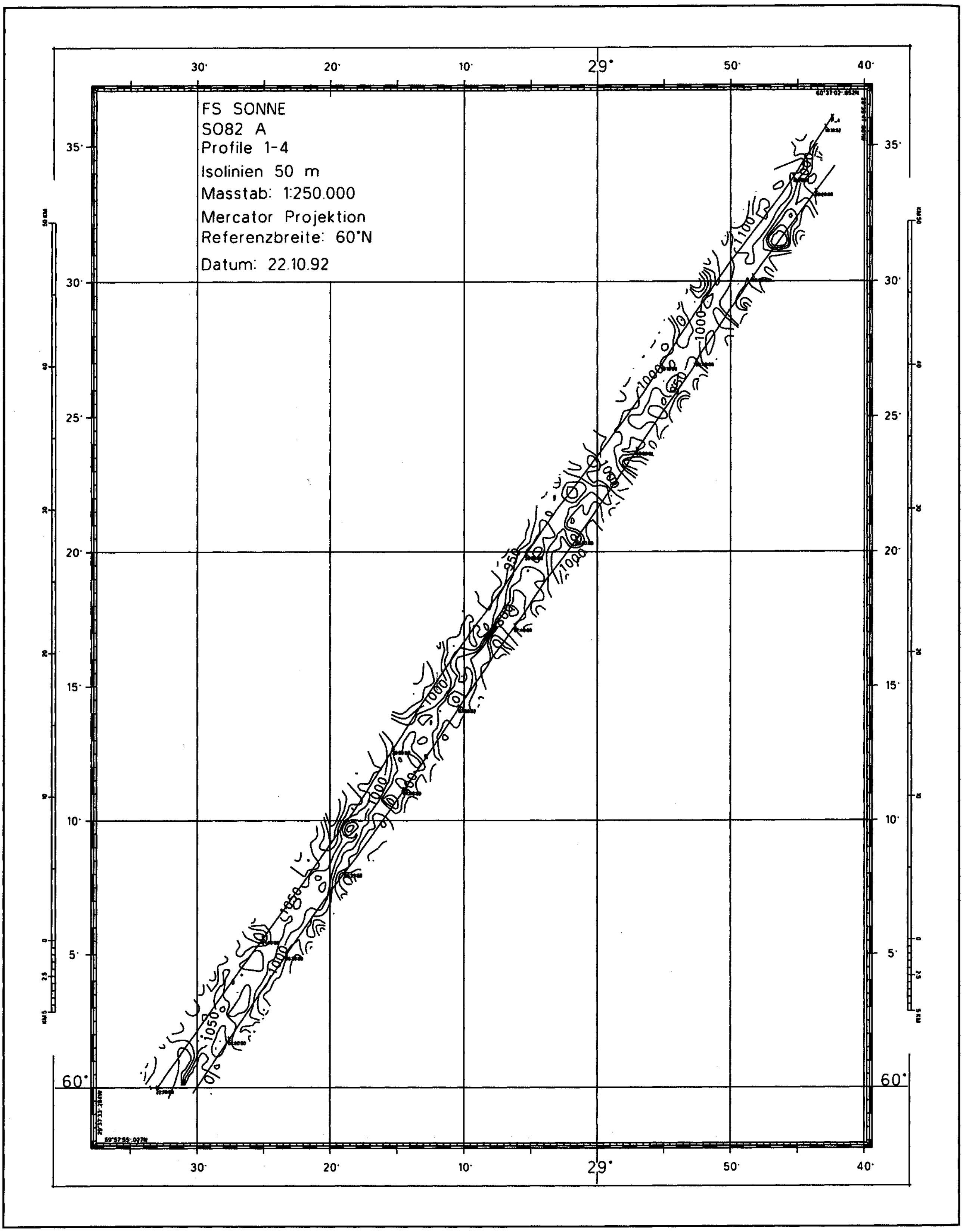

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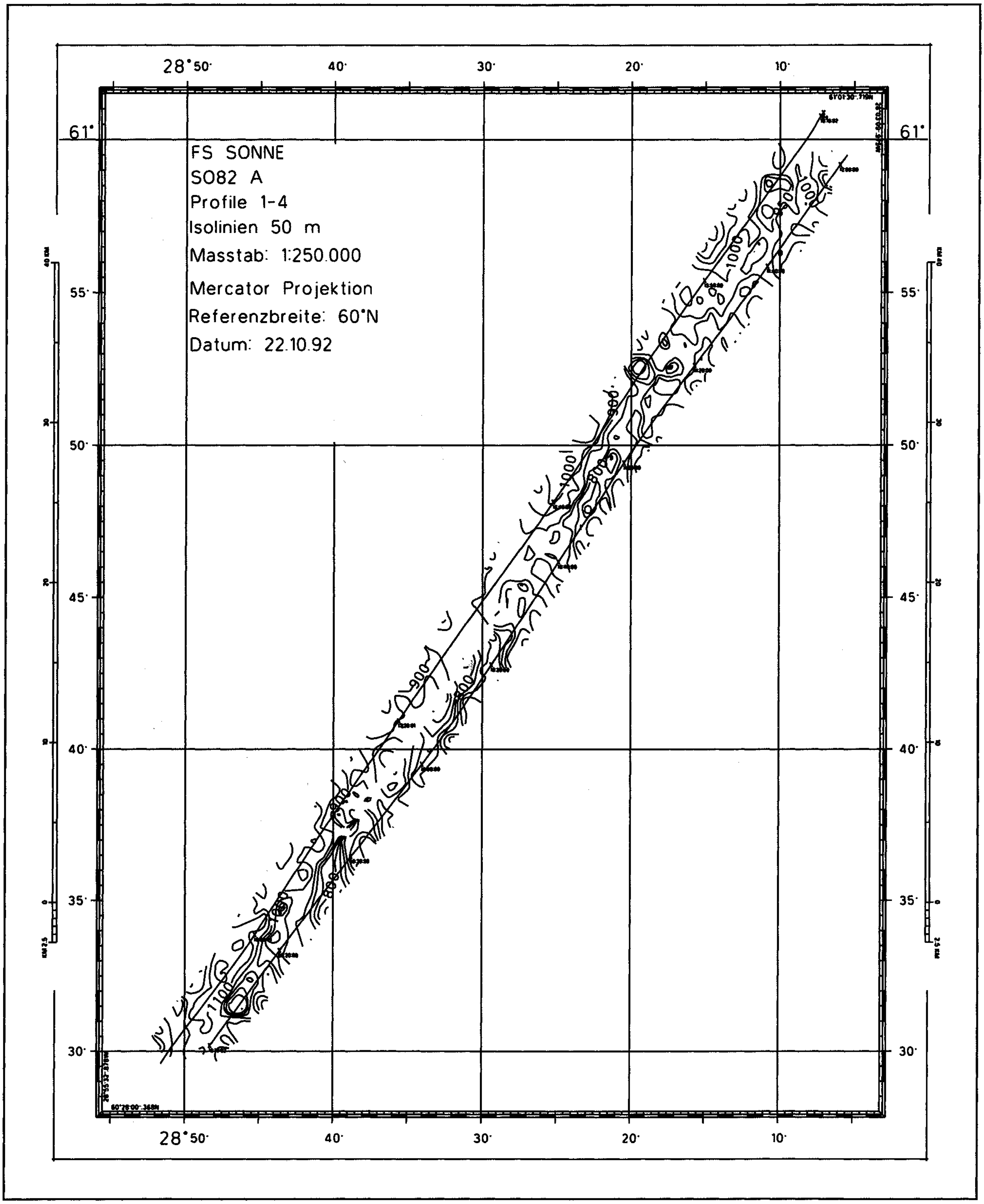

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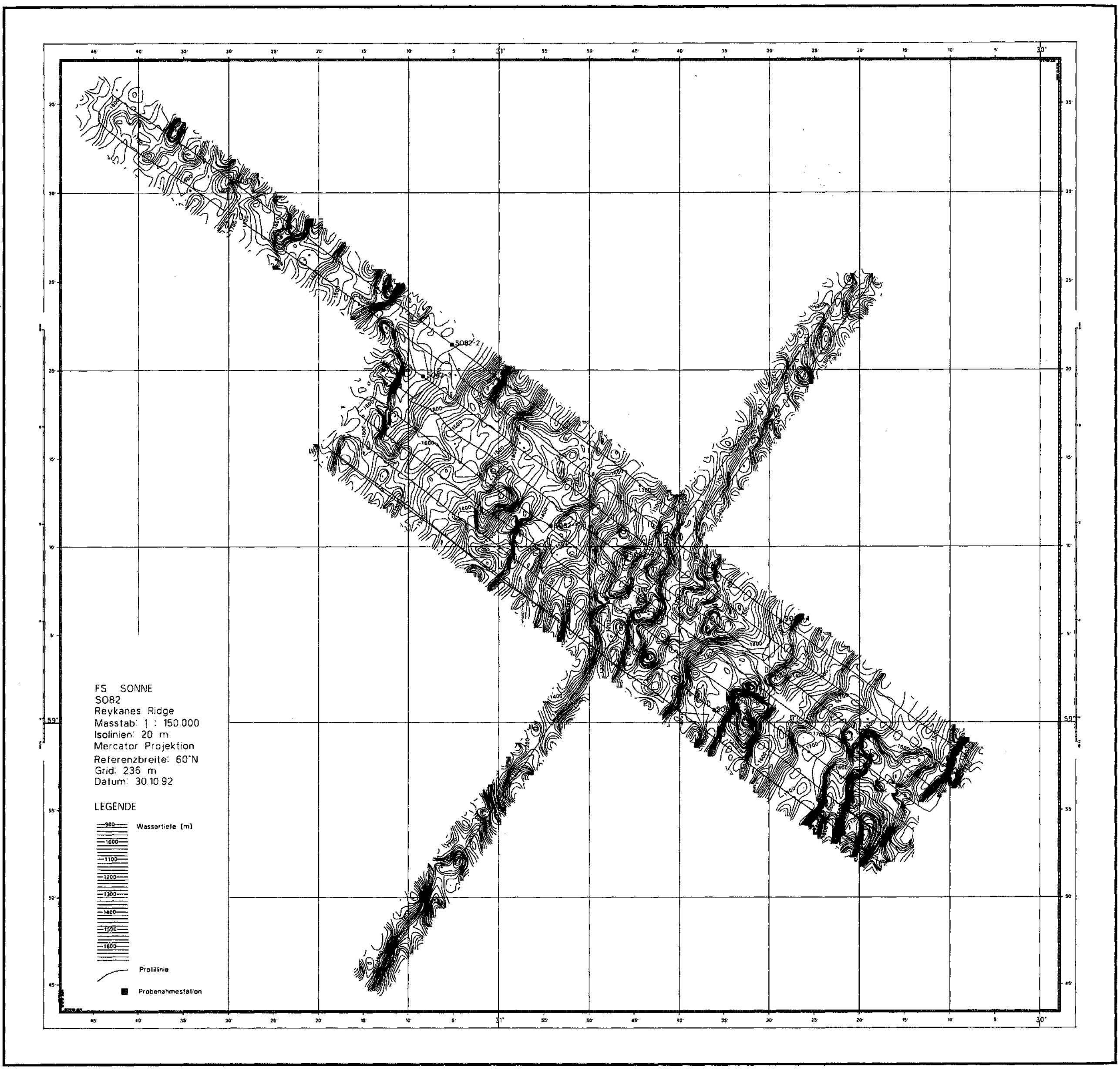

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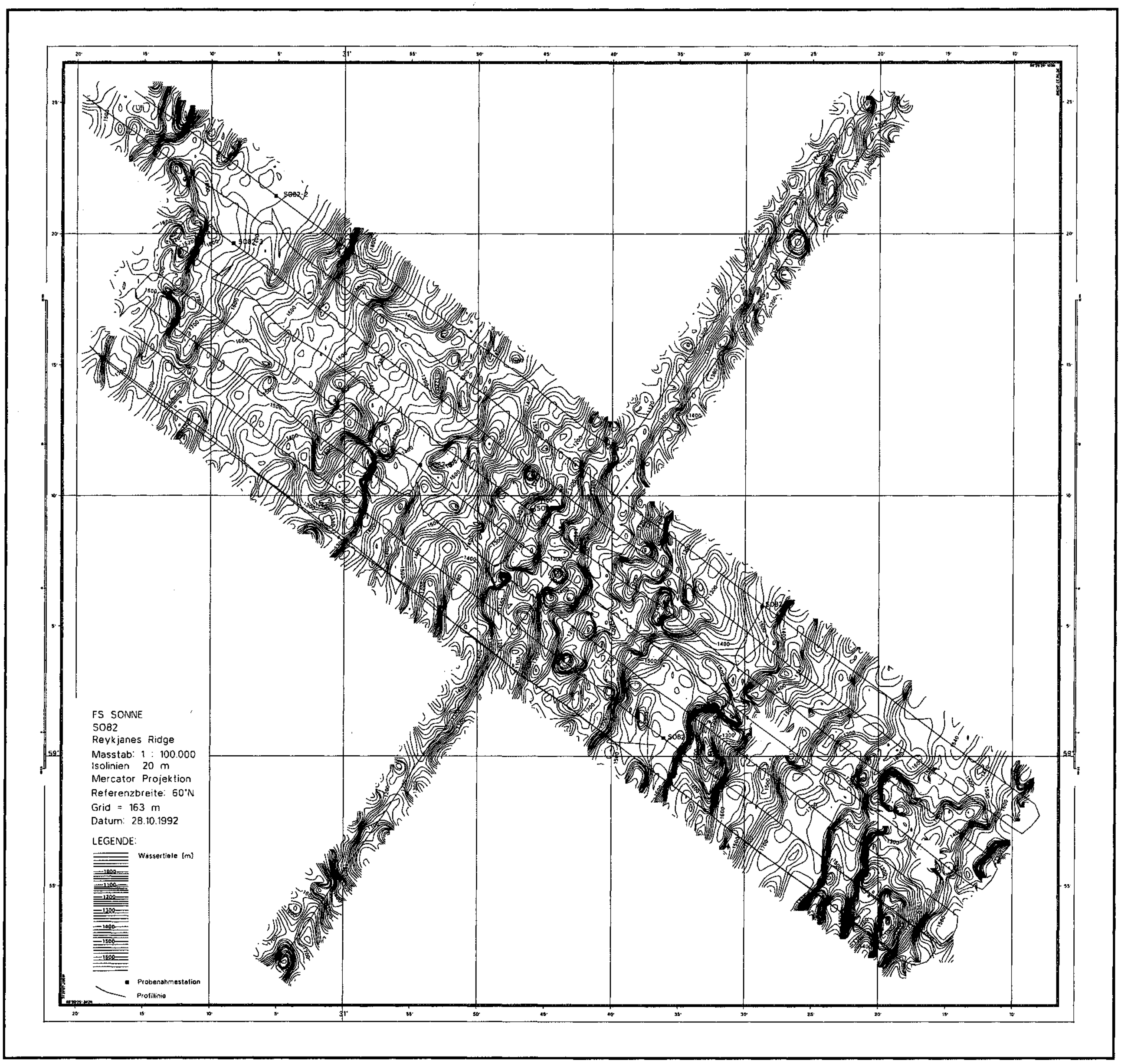

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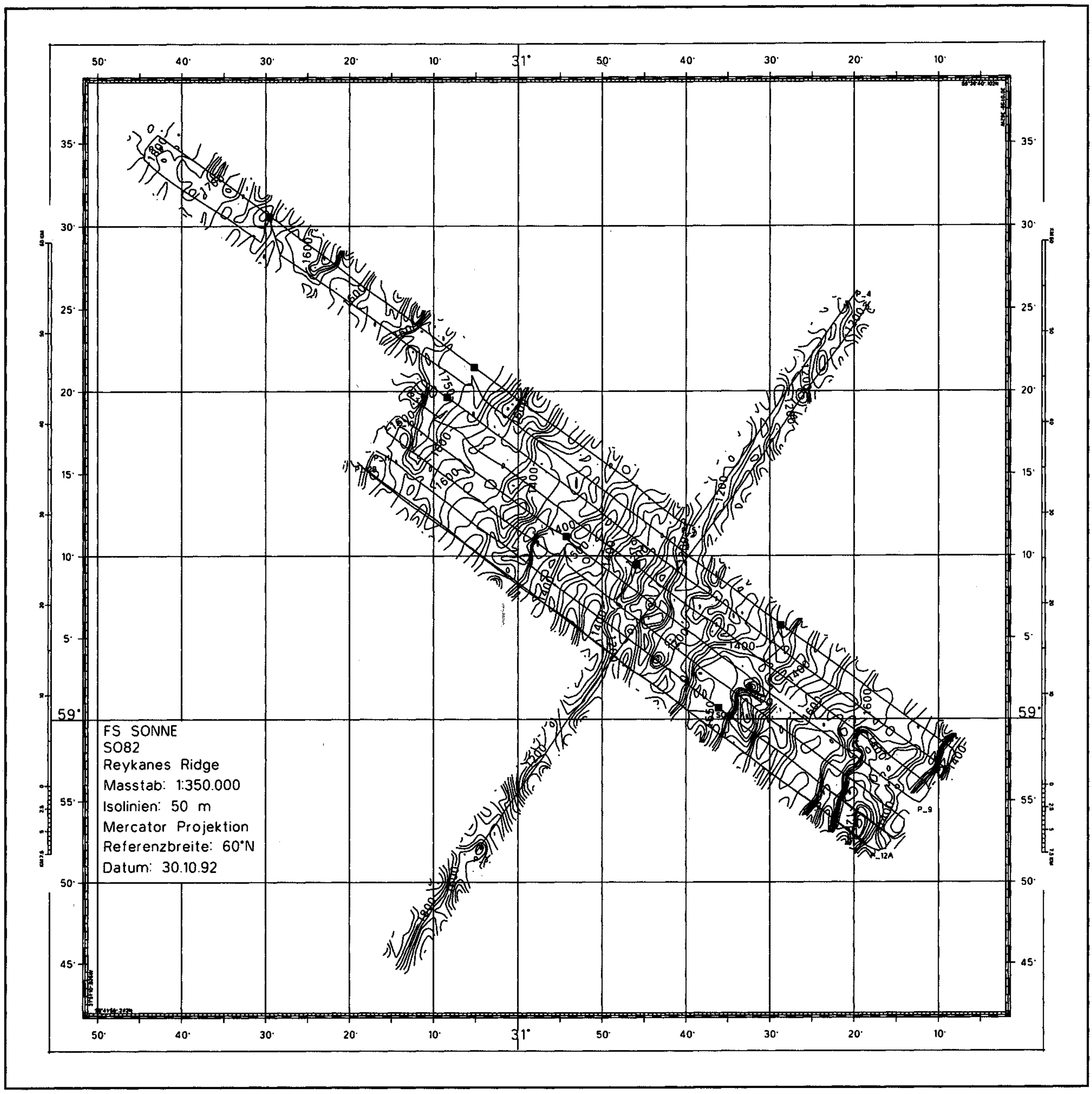
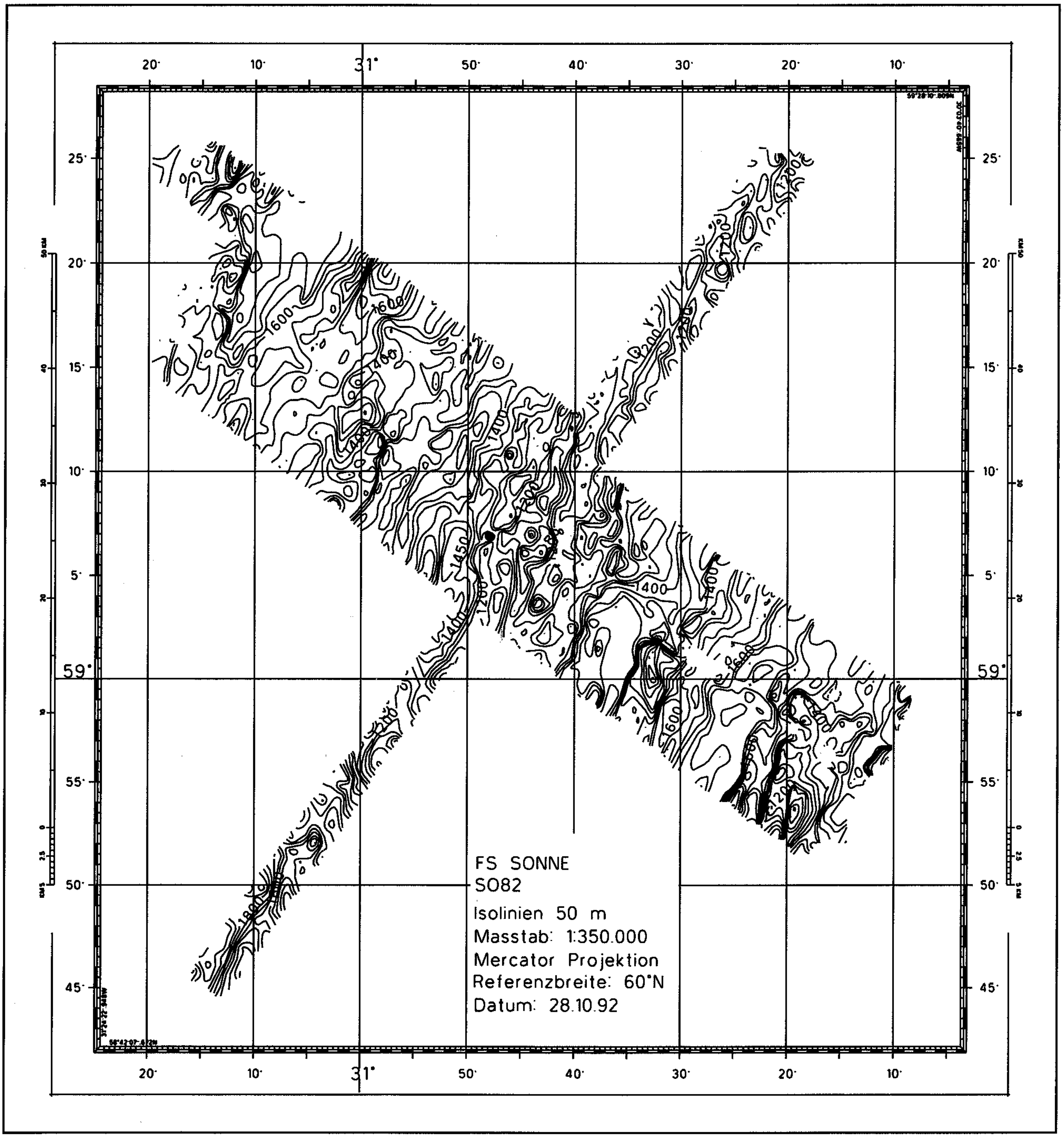
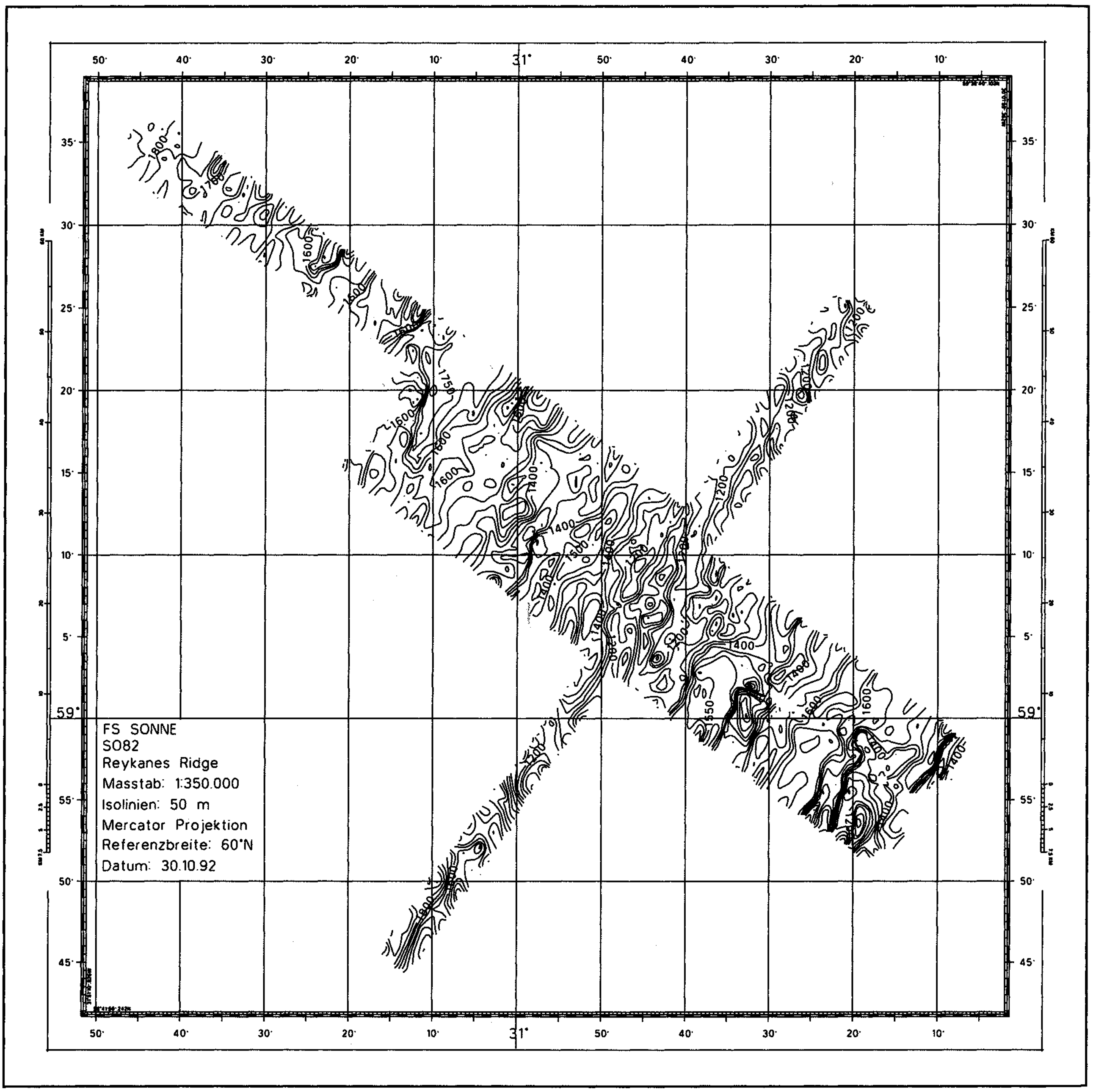


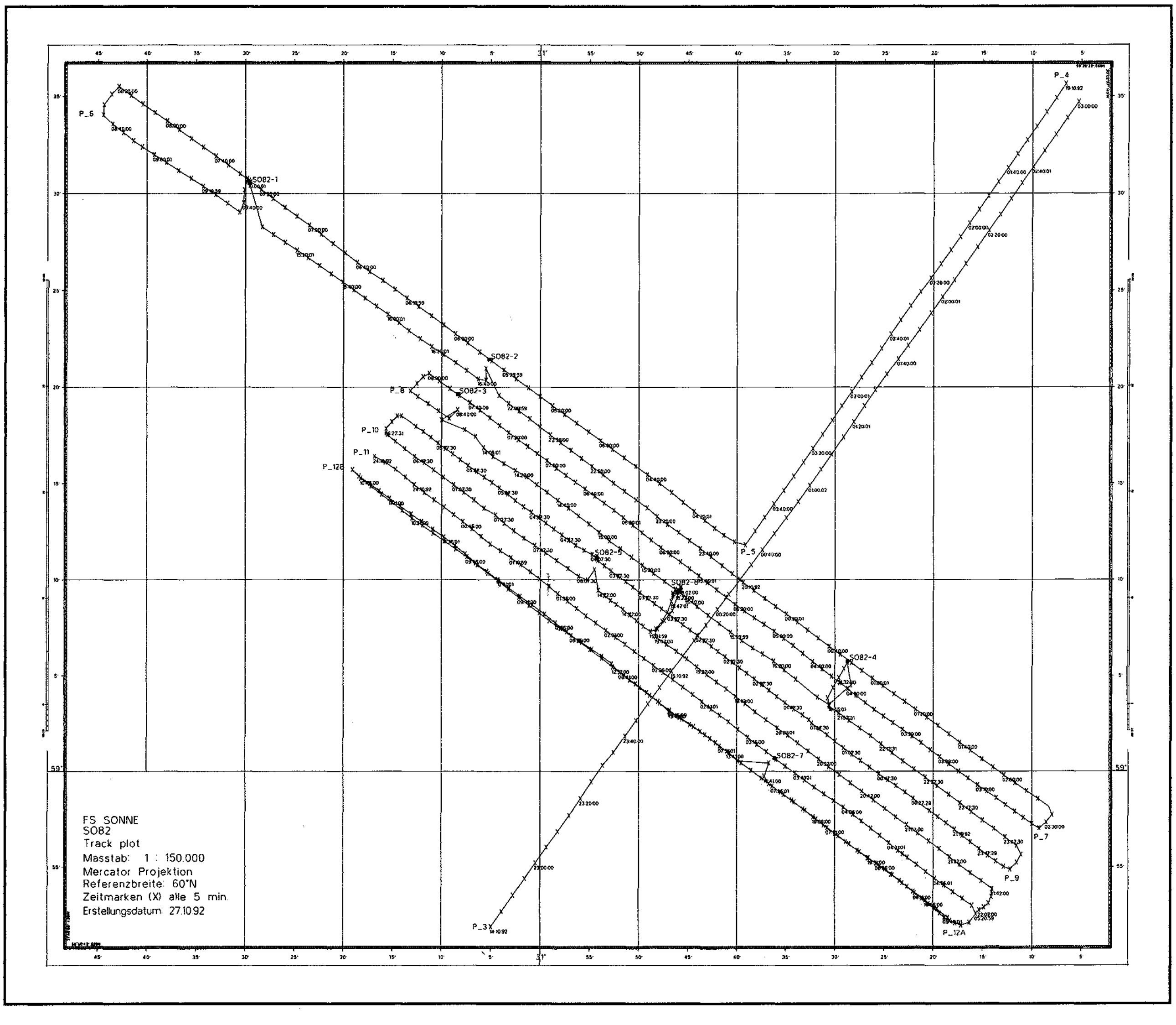
File: rejx350.plt



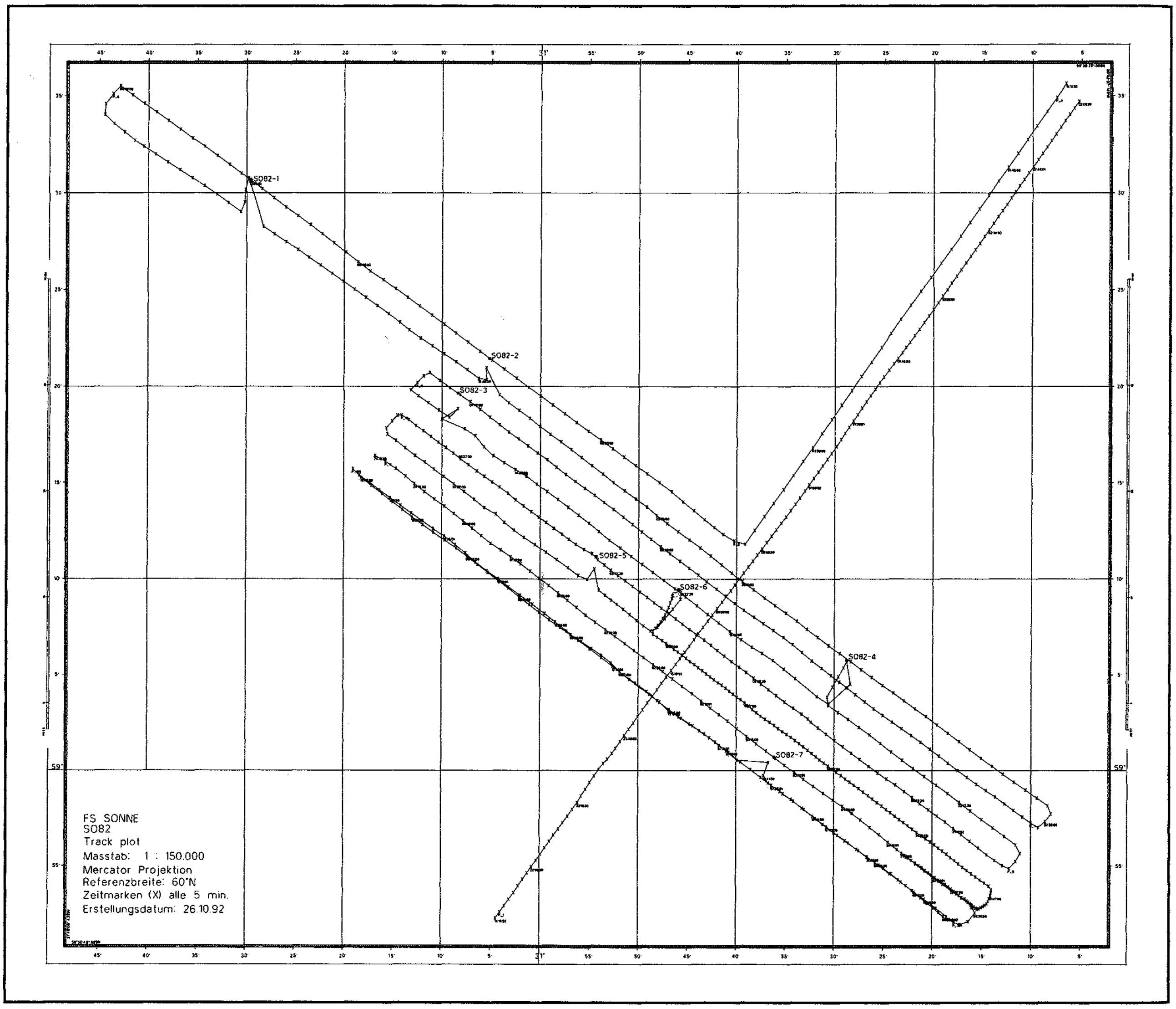
File: reyx350.plt



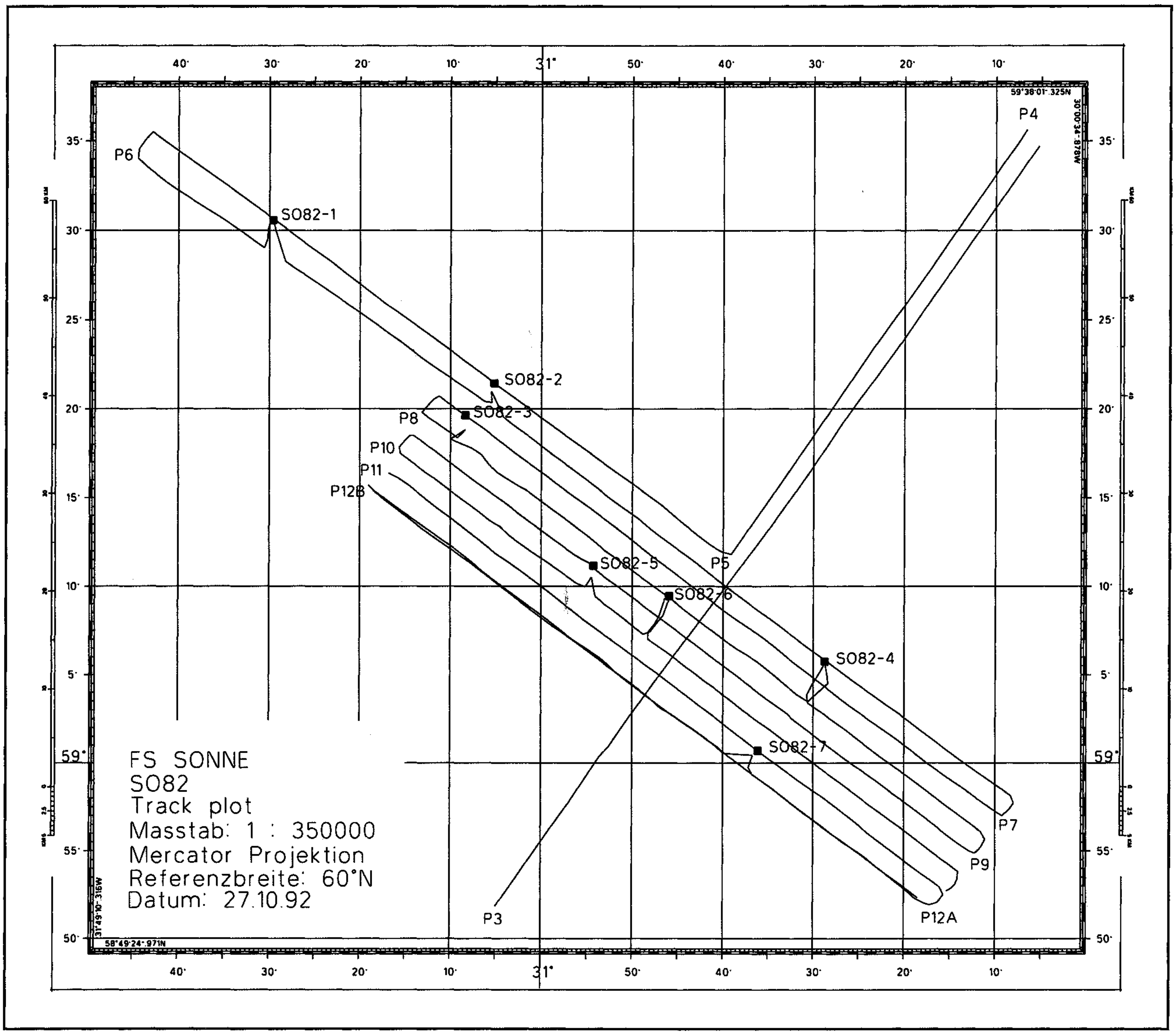
File: tracksx1.plt



File: trackx15.plt

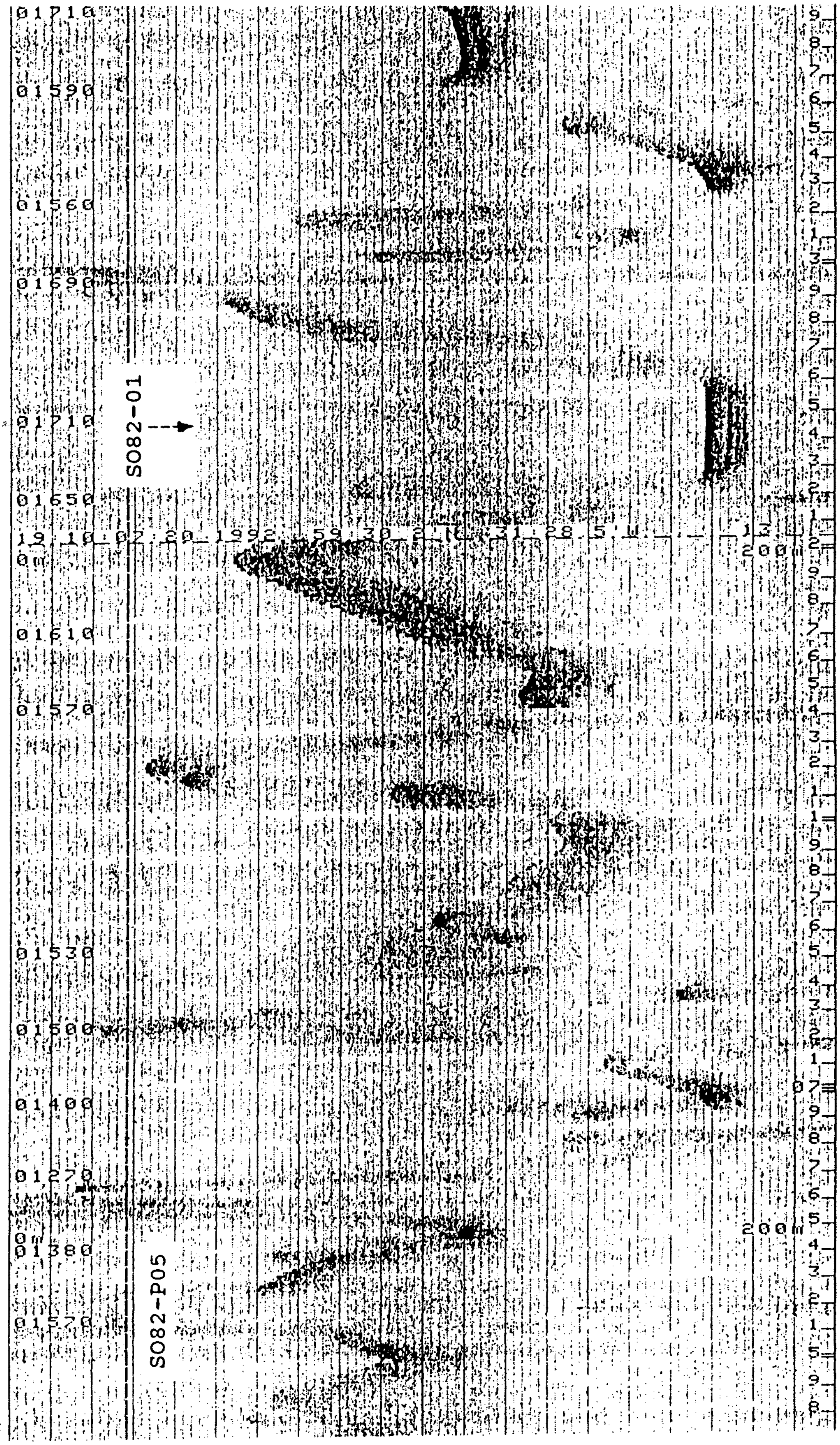


File: tracksx3.plt

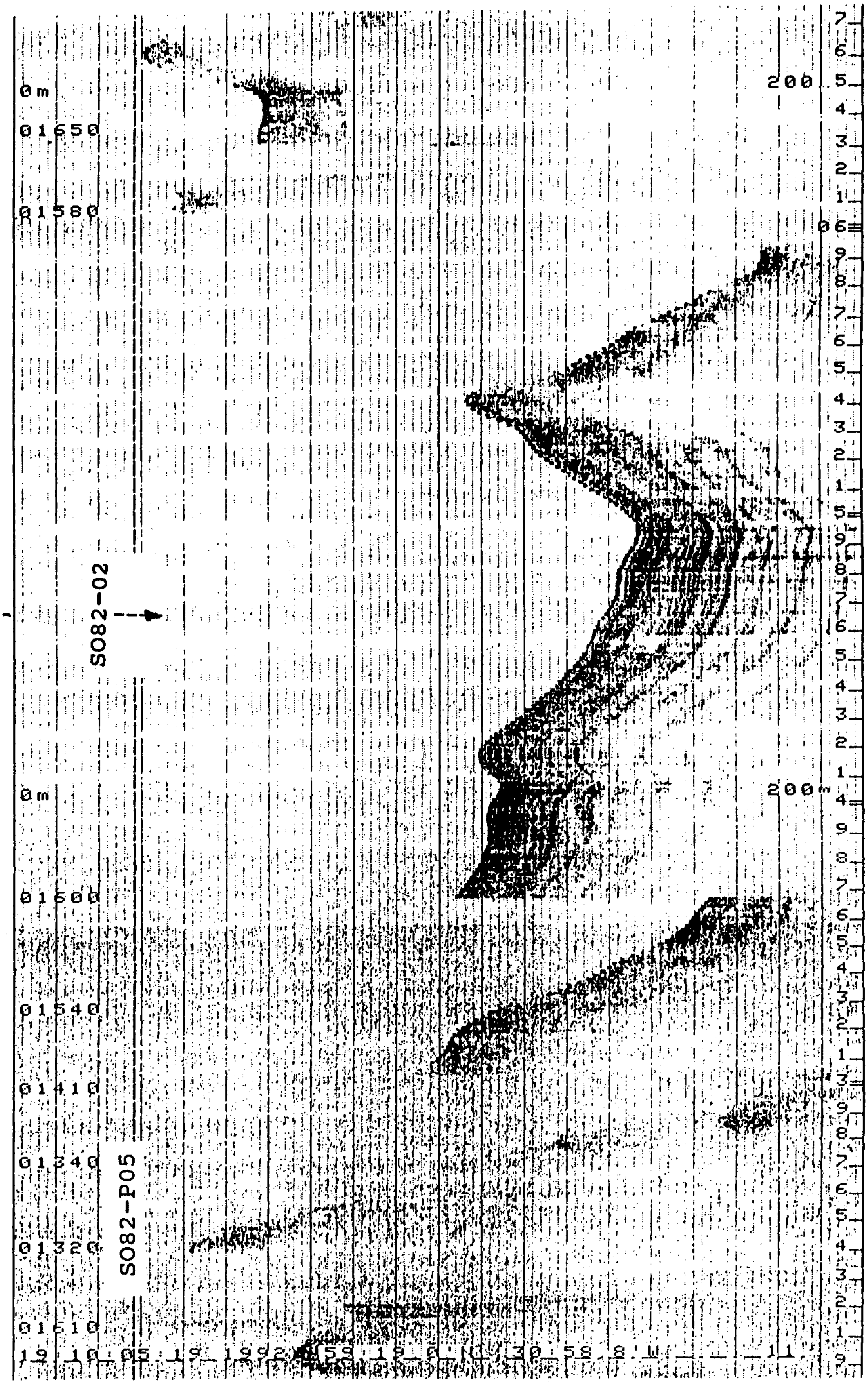


A5 Parasound records at the sampling stations

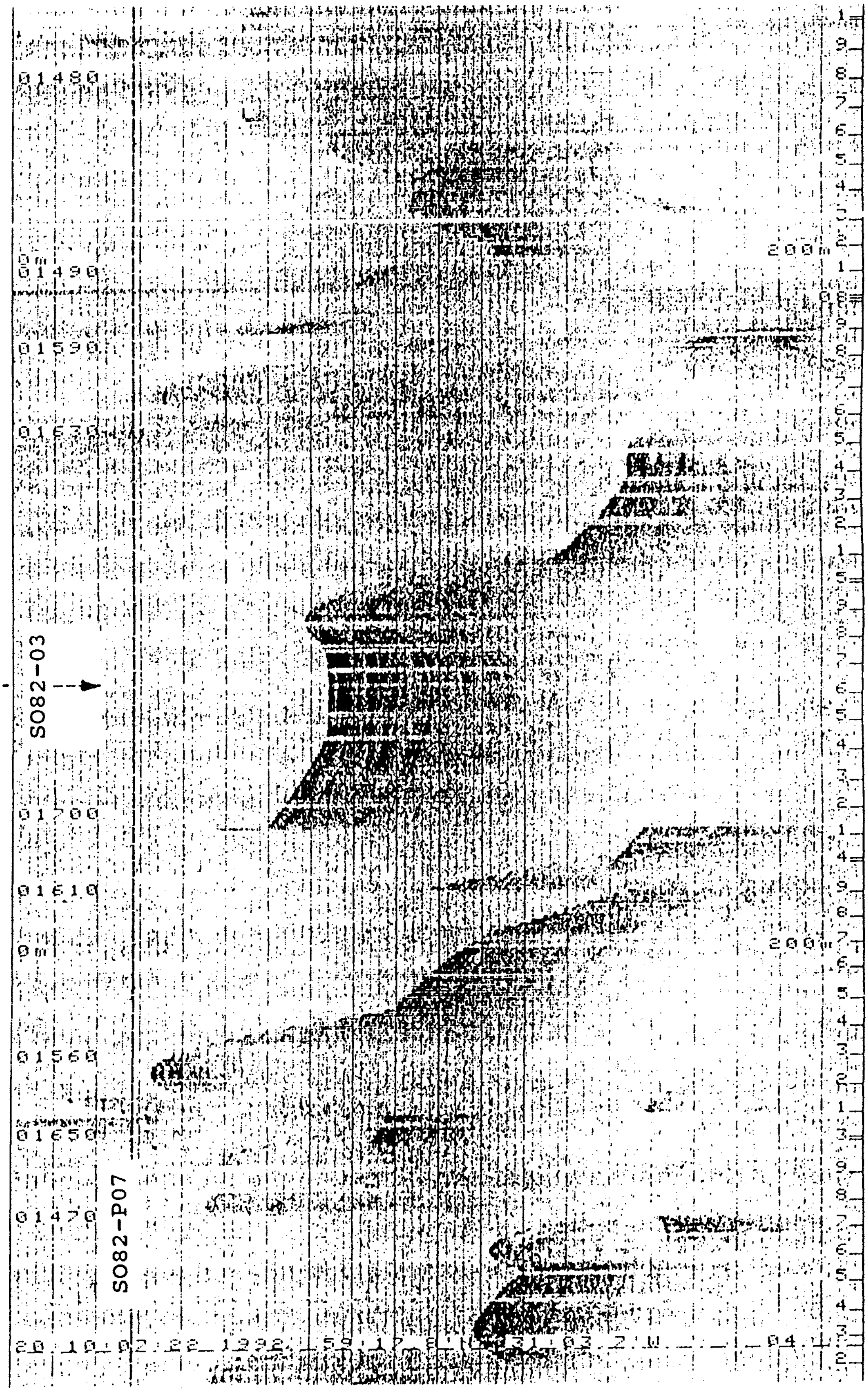
sampling station no: ***SO82-01*** **at line:** ***SO82-P05***



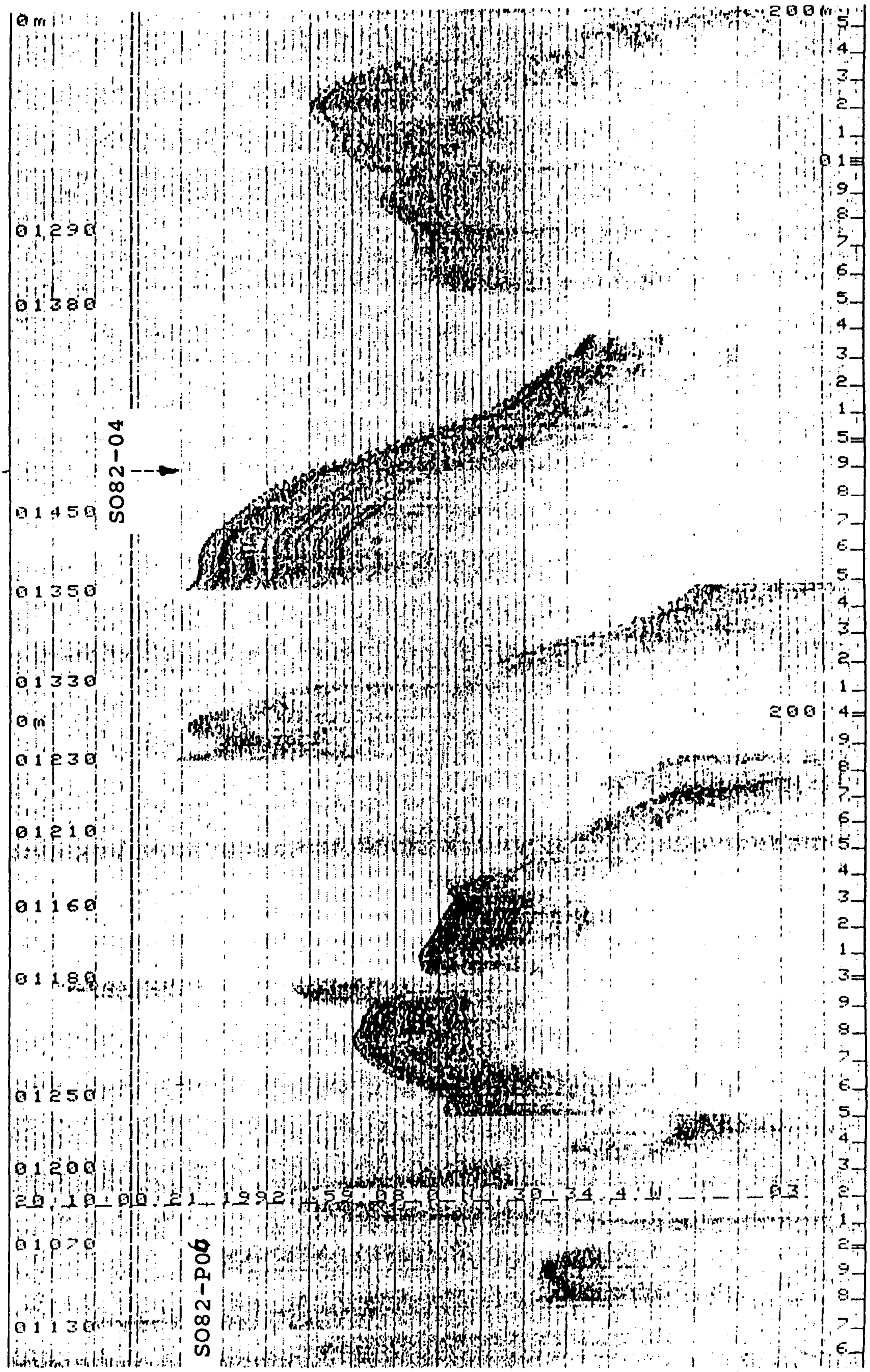
sampling station no: ***SO82-02*** **at line:** ***SO82-P05***



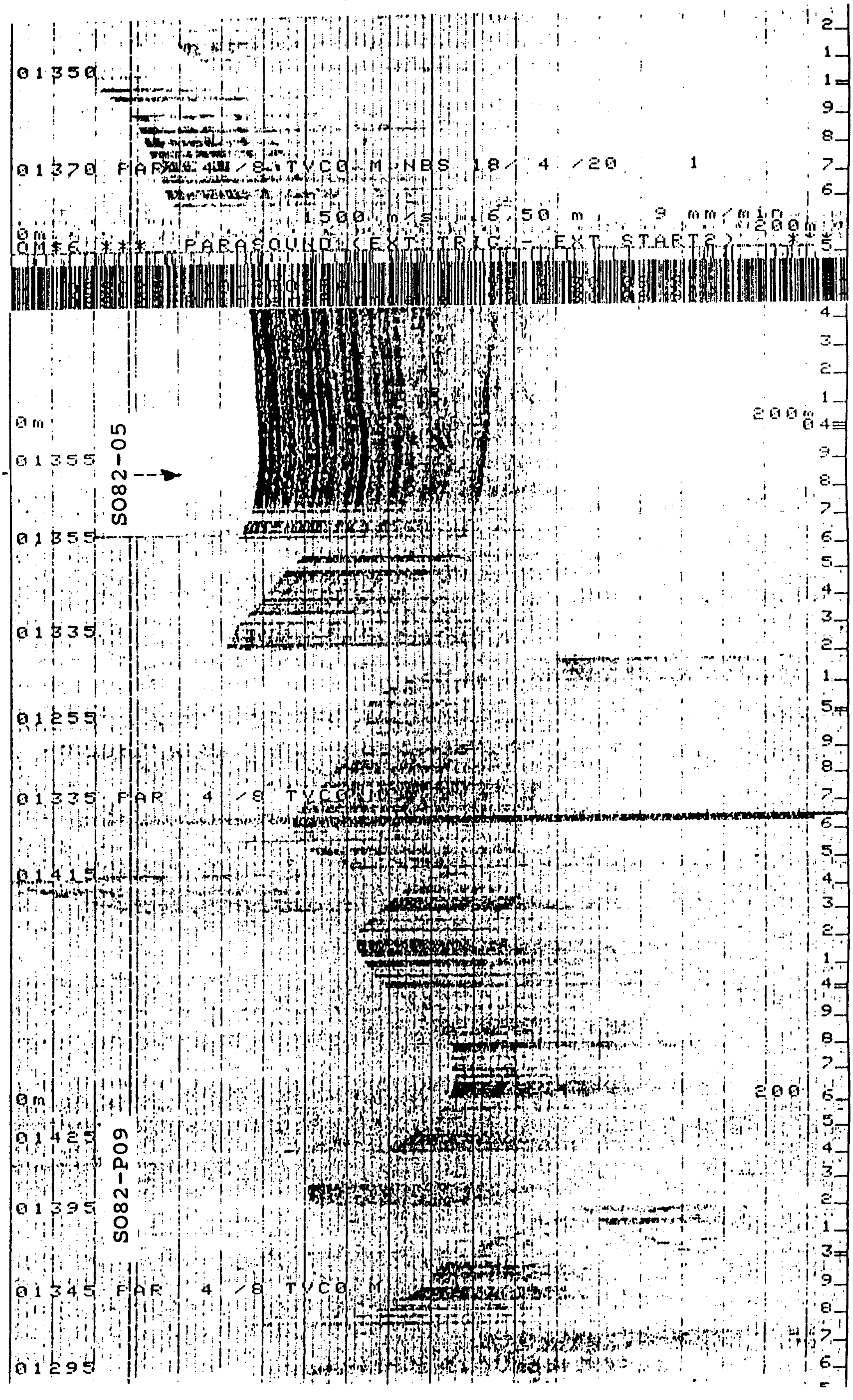
sampling station no: ***SO82-03*** **at line:** ***SO82-P07***



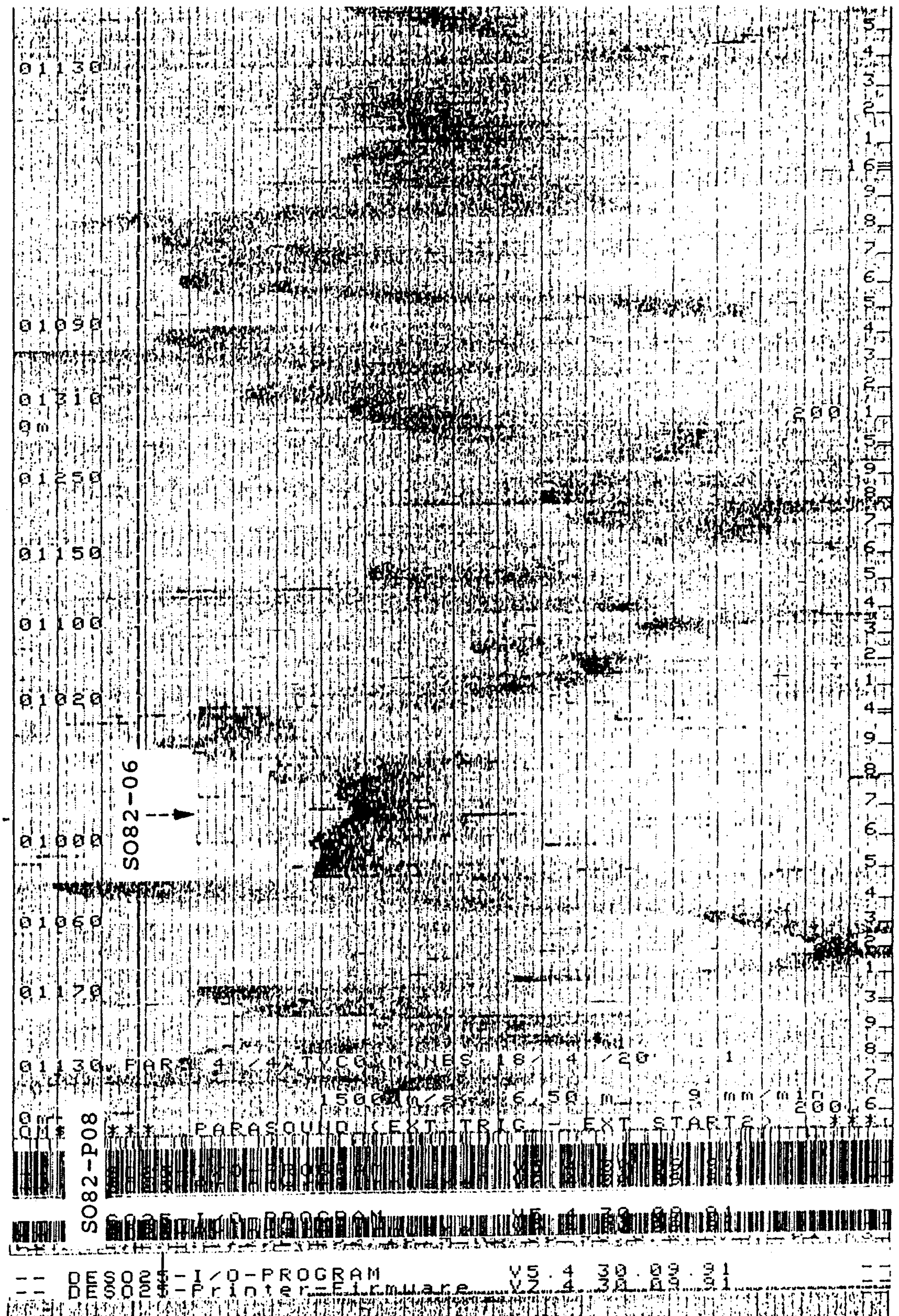
sampling station no: *SO82-04* at line: *SO82-P06*



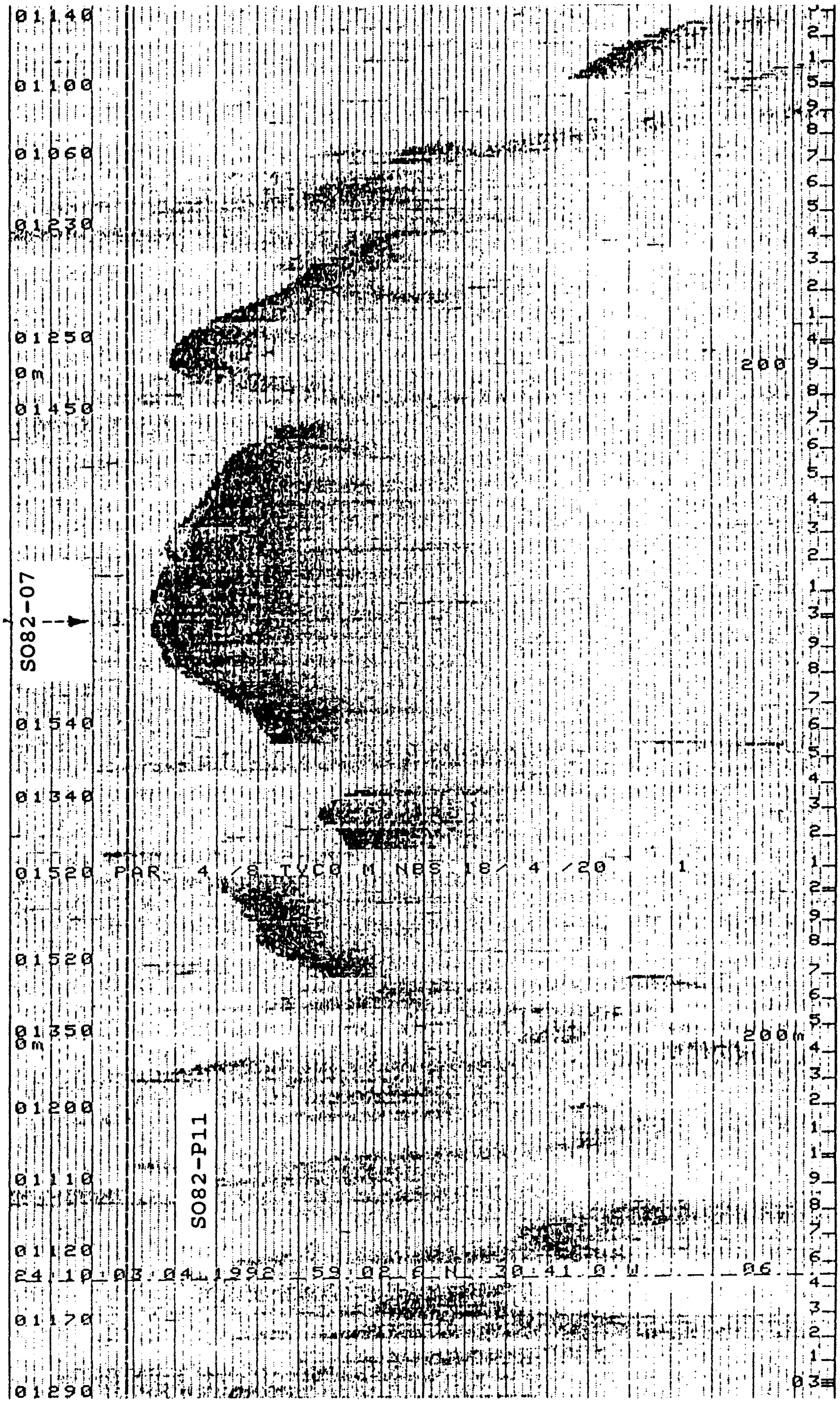
sampling station no: *SO82-05* **at line:** *SO82-P09*



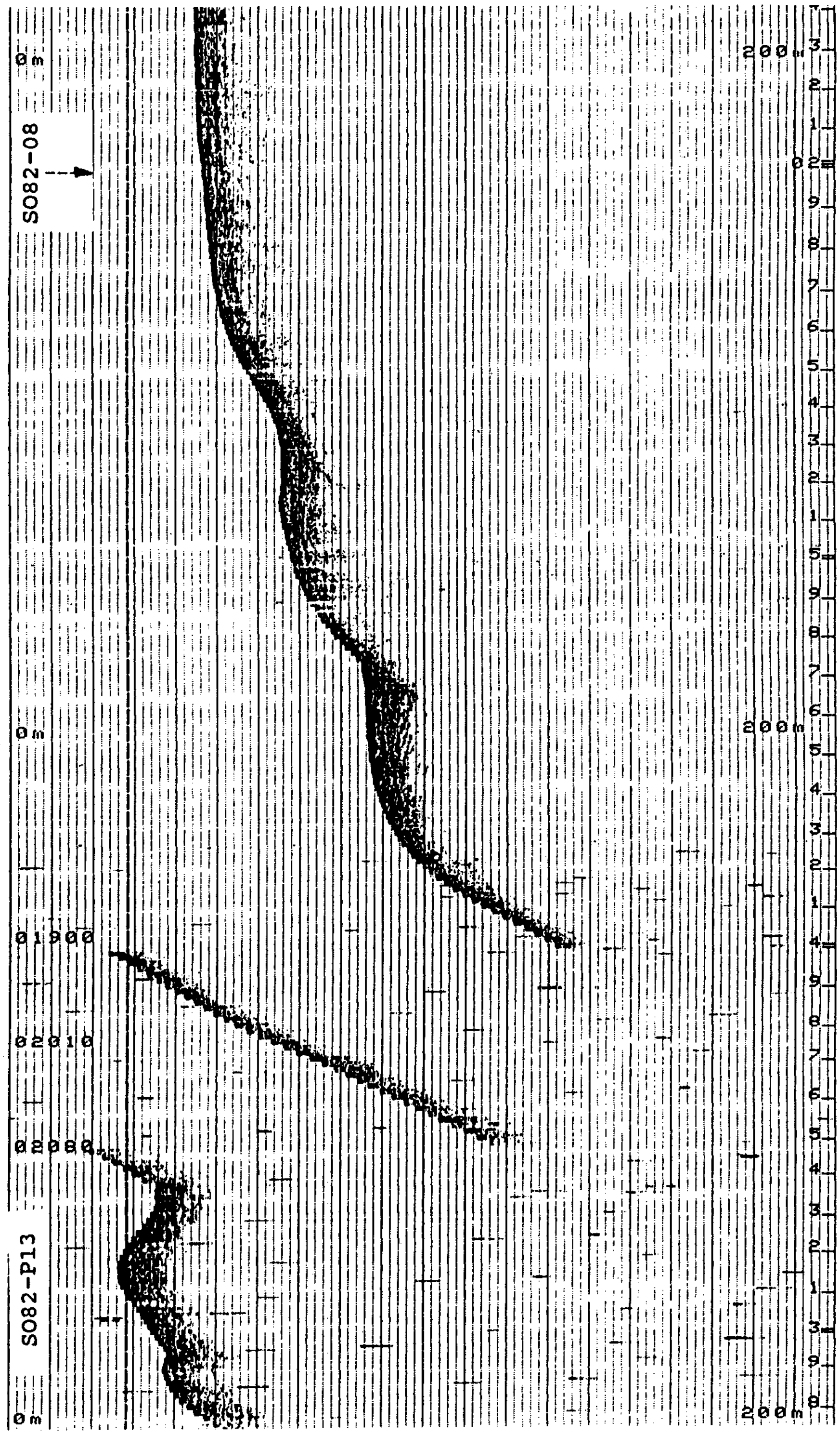
sampling station no: ***SO82-06*** **at line:** ***SO82-P08***



sampling station no: ***SO82-07*** **at line:** ***SO82-P11***

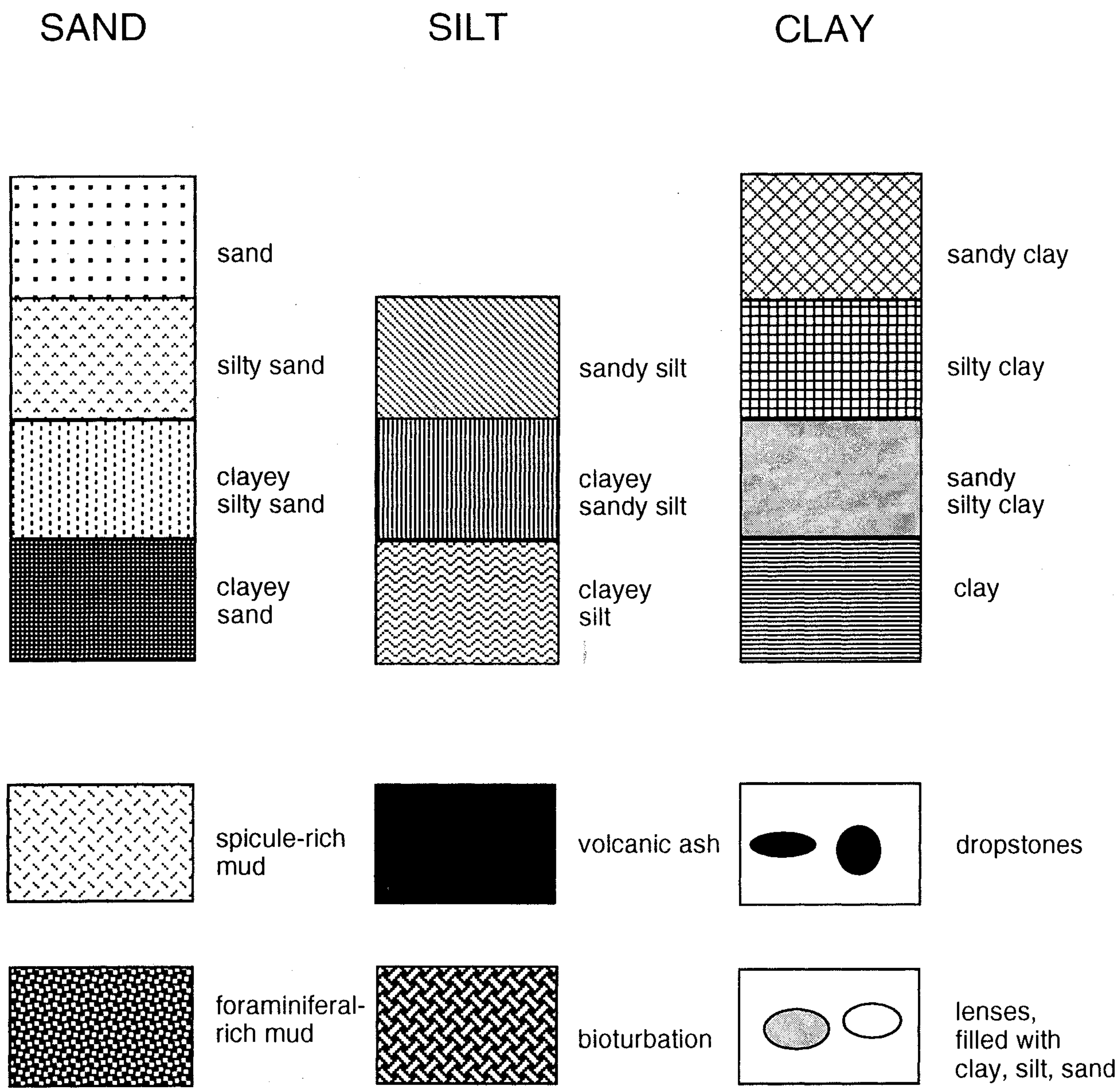


sampling station no: ***SO82-08*** **at line:** ***SO82-P13***



A6 Lithologic descriptions of the cores

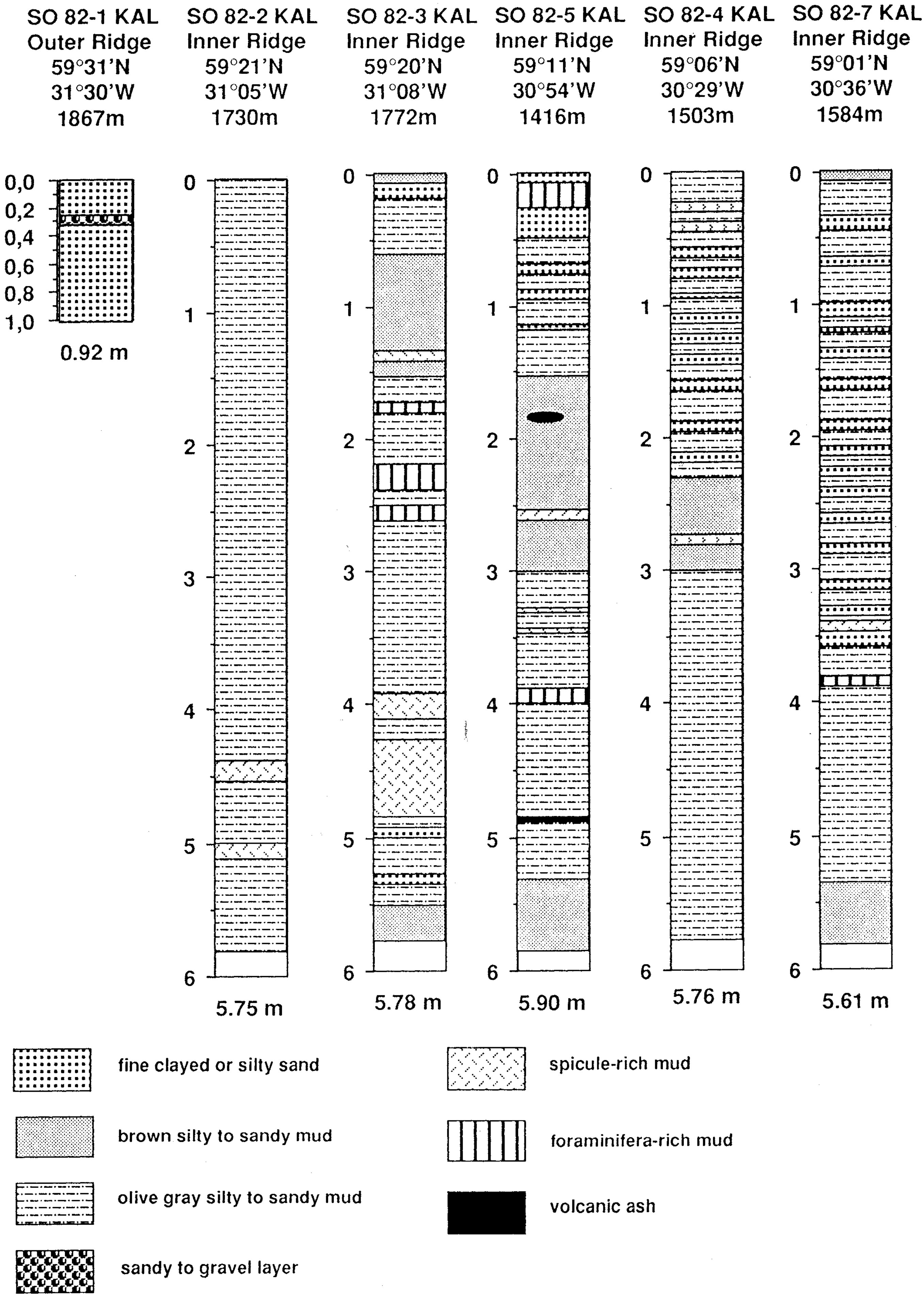
LEGEND



sm = smear slides

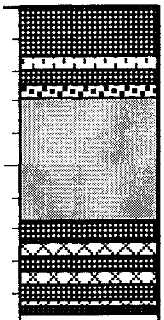
EOC = end of core

D = disturbed structure


SO 82-1 KAL
Outer Ridge
59°31'N
31°30'W
1867m
SO 82-2 KAL
Inner Ridge
59°21'N
31°05'W
1730m
SO 82-3 KAL
Inner Ridge
59°20'N
31°08'W
1772m
SO 82-5 KAL
Inner Ridge
59°11'N
30°54'W
1416m
SO 82-4 KAL
Inner Ridge
59°06'N
30°29'W
1503m
SO 82-7 KAL
Inner Ridge
59°01'N
30°36'W
1584m
0,0
0,2
0,4
0,6
0,8
1,0
0.92 m
0
1
2
3
4
5
6
5.75 m
5.78 m
5.90 m
5.76 m
5.61 m
fine clayed or silty sand
brown silty to sandy mud
olive gray silty to sandy mud
sandy to gravel layer
spicule-rich mud
foraminifera-rich mud
volcanic ash

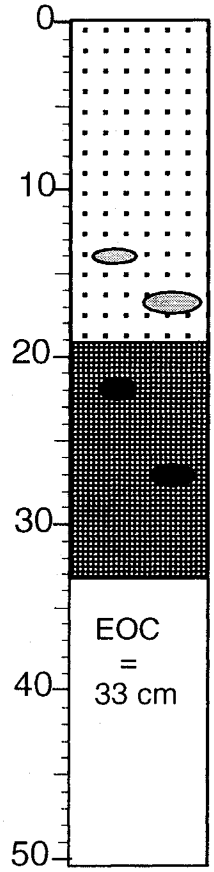
SO82-1-KAL Reykjanes Ridge

Recovery: 0,92 m 59°30'578 N, 31°29'616 W Water depth: 1867 m

Lithology	Struct.	Colour	Description	sm	Age
		10YR 6/6	0,00-0,66 m: dark yellowish orange (10YR 6/6) **0,00-0,16 m: fine to middle sand, clayey**, coarse grains, up to 1 cm diameter (rock fragments, quartz), foraminifers, **0,16-0,20 m: clayey fine silty sand**, **0,20-0,27 m: fine sand, slightly clayey**, foraminfer debris, **0,28 m: sandy layer / gravel**	5cm 12cm 18cm 22cm 30cm 52cm 60cm	Quaternary
		10YR 6/6 to 5YR5/4	**0,27-0,51 m: silty sandy clay**, homogeneous, **0,51-0,66 m: sandy silty clay**, thin sand layers intercalated **0,66-0,92 m: clayey fine sand**, intensely interlayering with **sandy clay**, dark yellowish orange (10YR 6/6) to moderate yellowish brown (5YR 5/4), small foraminifer debris	75cm 80cm	

Depth in core (m): 0, 1, 2, 3, 4, 5

SO82-1-GKG Reykjanes Ridge
Recovery: 0,33 m 59°30'578 N, 31°29'616 W Water depth: 1867 m

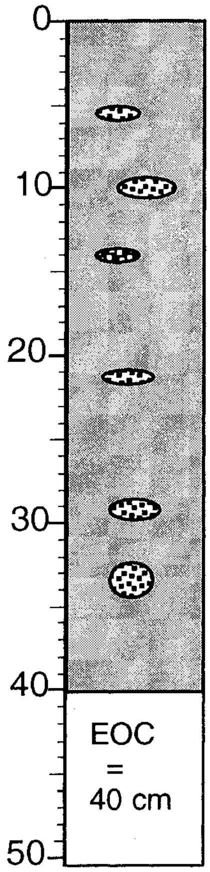


Depth (cm)

Lithology	Struct.	Colour	Description		sm	Age
		10 YR 5/4	**surface:**	fine sand, moderate yellowish brown (10YR 5/4), dropstones upt to 1cm diameter,planktic pteropods and foraminifer, some sponges, fragments of moluscs and corals		
		10 YR 5/4	**0-19 cm:** 0-11 cm:	**middle to fine sand**, moderate yellowish brown (10YR 5/4), many small foraminfers, small carbonate debris	5 cm	Quaternary
		5 YR 4/4	11-19 cm:	moderate brown (5YR 4/4), clayey lenses, some coarser grains and foraminifers	17 cm	
			19-33 cm:	**clayey fine sand**, (5YR 4/4), benthic foraminifers, small dropstones, homogenous sediment	25 cm	

SO82-2-GKG Reykjanes Ridge
Recovery: 0,40 m 59°21'437 N, 31°05'179 W Water depth: 1730 m

Lithology	Struct.	Colour	Description		sm	Age
		10YR 5/4	**surface:**	**clay**, very soft, moderate yellowish brown (10YR 5/4), some foraminifers		
		10YR 5/4	**0-40 cm:**	**silty sandy clay,**	5 cm + 5 cm within sandy lense	Quaternary
			0-15 cm:	moderate yellowish brown (10YR 5/4), sandy lenses, spots of darker, more sandy clay, moderate brown (5Y 4/4),		
			12 cm:	burrow (1 cm diameter), soft, uneven boundary, slightly sharp		
		5GY 6/1	15-40 cm:	greenish gray (5GY 6/1), sandy lenses, soft	20 cm + (s.o.)	

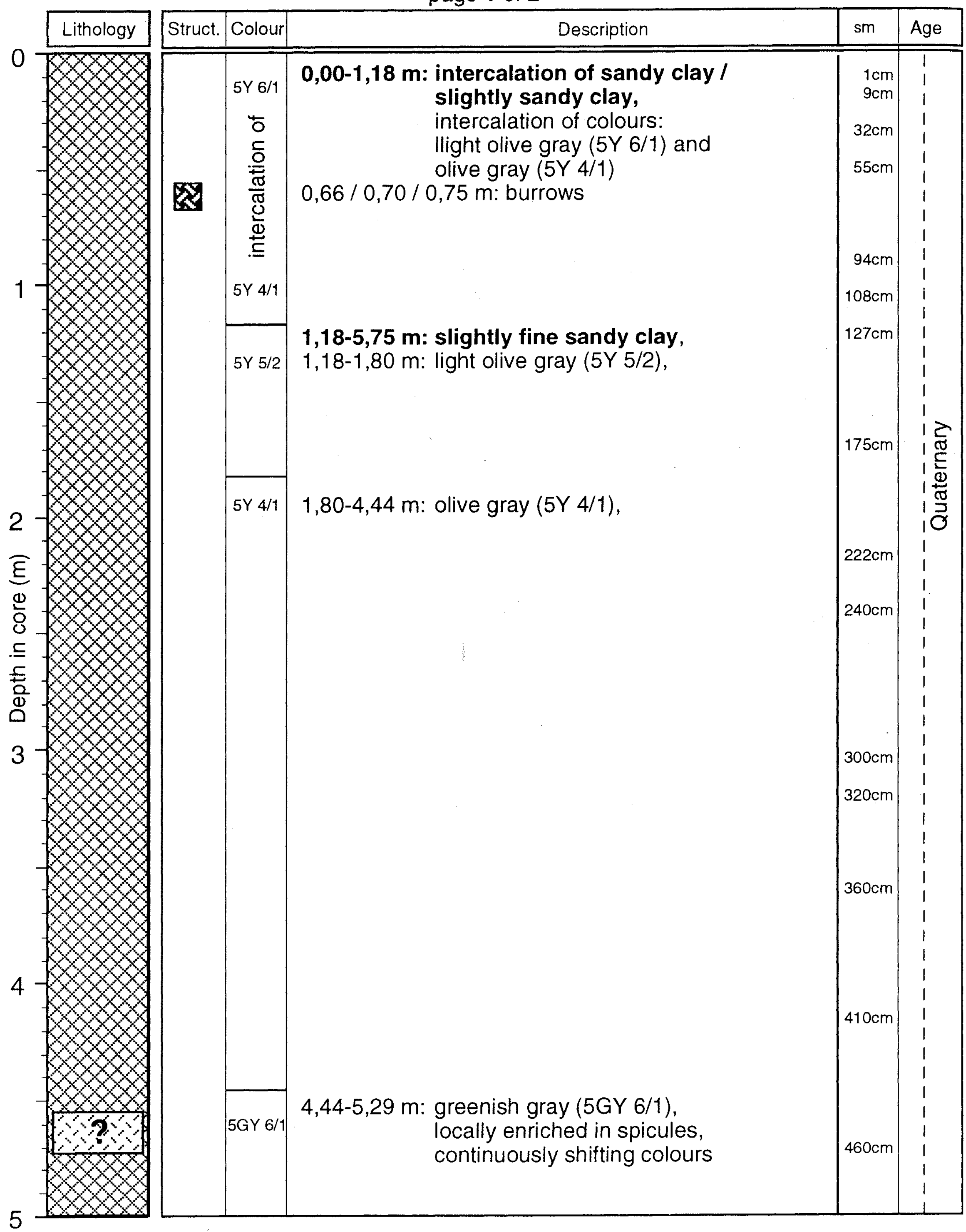


Depth (cm)

SO82-2-KAL Reykjanes Ridge

Recovery: 5,75 m 59°21'437 N, 31°05'179 W Water depth: 1730 m

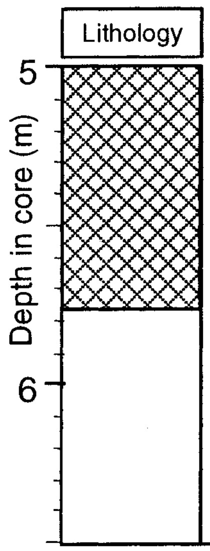
page **1** of 2



SO82-2-KAL Reykjanes Ridge

Recovery: 5,75 m 59°21'437 N, 31°05'179 W Water depth: 1730 m

page **2** of 2



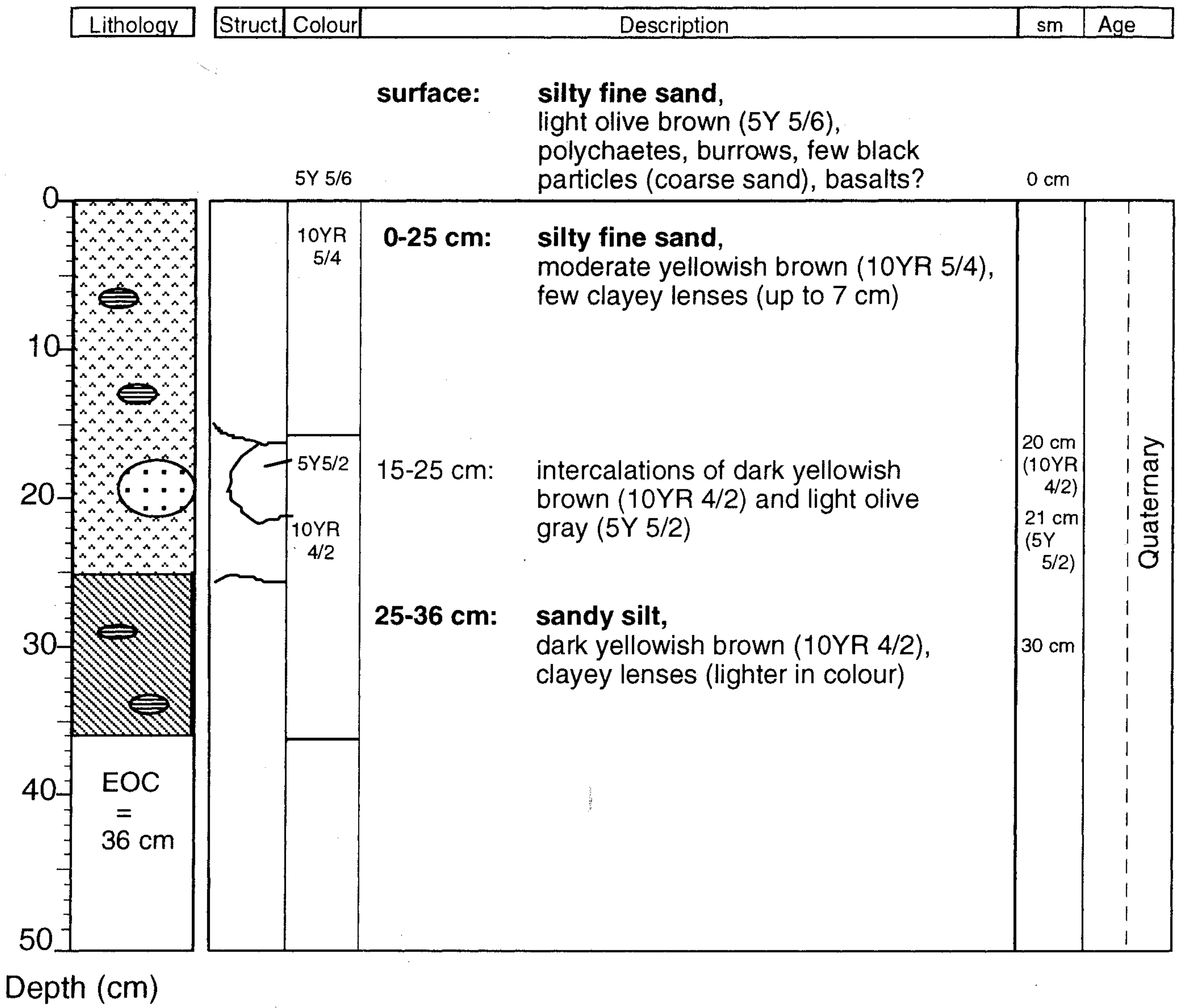
Struct.	Colour	Description	sm	Age
	5GY 6/1	4,44-5,20 m: continued	510cm	
	10Y 4/2	5,29-5,75 m: grayish olive (10Y 4/2),	530cm	
			550cm	
	5GY 6/1	5,63-5,75 m: greenish gray (5GY 6/1)	570cm	

SO82-3-GKG

Recovery: 0,36 m

Reykjanes Ridge
59°19'64 N, 31°08'36 W

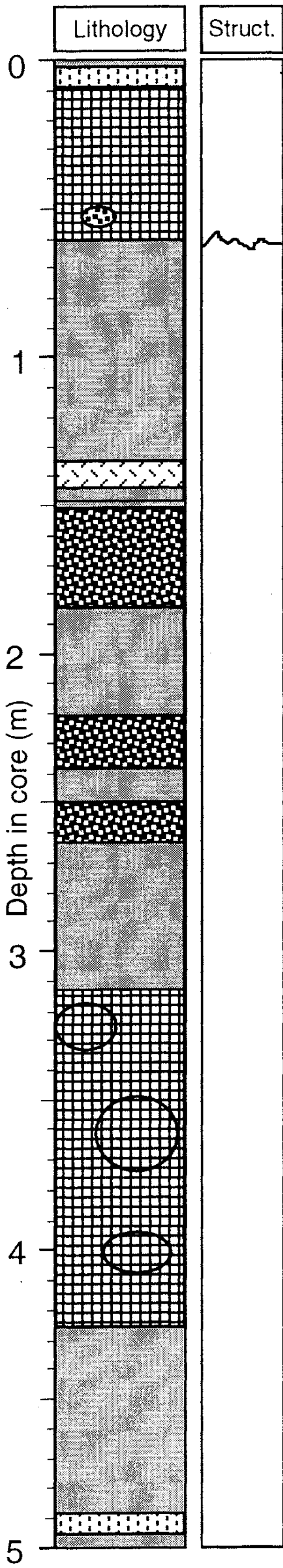
Water depth: 1774 m



SO82-3-KAL Reykjanes Ridge

Recovery: 5,78 m 59°19'64 N, 31°08'36 W Water depth: 1772 m

page **1** of 2



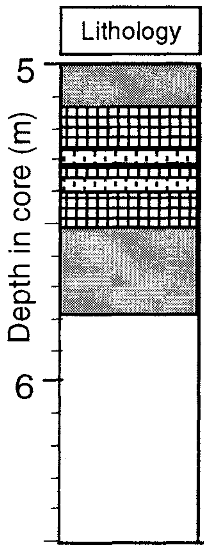
Colour	Description		sm
10YR 5/4	**0,00-0,05 m:**	**sandy silty clay**, mod. yell. br. (10YR5/4),	2cm
5Y 4/1	**0,05-0,09 m:**	**clayey silty sand**,	
	0,09-0,60 m:	**silty clay**,	30cm
		olive gray (5Y 4/1),	
(5Y 6/1)	0,59 m:	sandy streak, light olive gray (5Y 6/1)	
10YR 4/2	**0,60-1,51 m:**	**silty clay, slightly sandy**,	
		dark yellowish brown (10YR 4/2),	
	1,08-1,51 m:	slightly brighter than above,	100cm
	1,38 m:	small pebble, 1 cm diameter,	
		abundant spicules,	
		bottom: some foraminifers	
5Y 4/1	**1,51-3,11 m:**	**sandy silty clay**,	
5Y 5/2	1,51-1,56 m:	olive gray (5Y 4/1), streaky spicules,	
	1,56-3,11 m:	light olive gray (5Y 5/2),	180cm
	1,51-1,82 m:	foraminifers abundant	
	2,20-2,39 m:	foraminifers abundant, spicules	
			260cm
	2,50-2,66 m:	abundant foraminifers	275cm
	2,66-2,77 m:	sediment mottled,	
	2.78-2,88 m:	some foraminfers,	
	2,88-3,11 m:	some benthic foraminifers (> 250 µm)	
	3,11-4,25 m:	**silty clay**,	315cm
		light olive gray (5Y 5/2),	320cm
	3,16-3,27 m/	intercalations with large spots of	
	3,48-3,74 m/	olive gray (5Y 3/2),	
	3,92-4,07 m/		
		abundant spicules and foraminifers	
	4,25-4,86 m:	**sandy silty clay**,	430cm
		olive gray (5Y 3/2),	
		slightly streaky and mottled,	
		abundant spicules and foraminfers	
	4,86-4,90 m:	**sandy silty clay**,	
		medium light gray (N 6),	
	4,90-4,93 m:	**clayey silty sand,**	500cm
N 6	**4,93-5,16 m:**	**sandy silty clay**	

Age: Quaternary

SO82-3-KAL Reykjanes Ridge

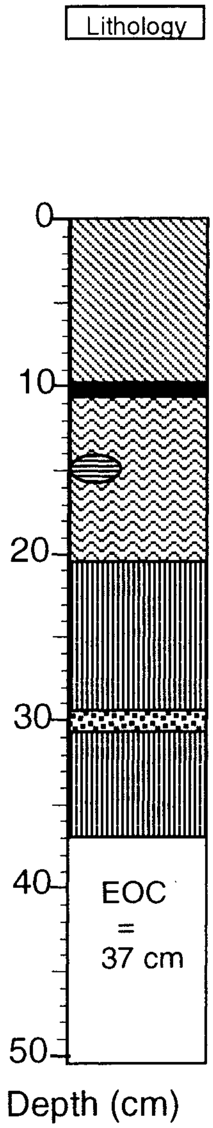
Recovery: 5,78 m 59°19'64 N, 31°08'36 W Water depth: 1772 m

page **2** of 2



Struct.	Colour	Description	sm	Age
	N 6	4,93-5,16 m: continued, sandy silty clay,		
	5Y 4/1	5,10-5,16 m: olive gray (5Y 4/1)		
	5Y 4/1 to 5Y 2/1	**5,16-5,50 m: silty clay,** olive gray (5Y 4/1) to olive blac (5Y 2/1),		
		5,31 m: clayey silty sand		
		5,34-5,35 m: clayey silty sand	570cm	
	10YR 4/2 to 5Y 4/1	**5,50-5,78 m: sandy silty clay,** dark yellowish brown (10YR 4/2) to olive gray (5Y 4/1), some spicules and foraminifers		

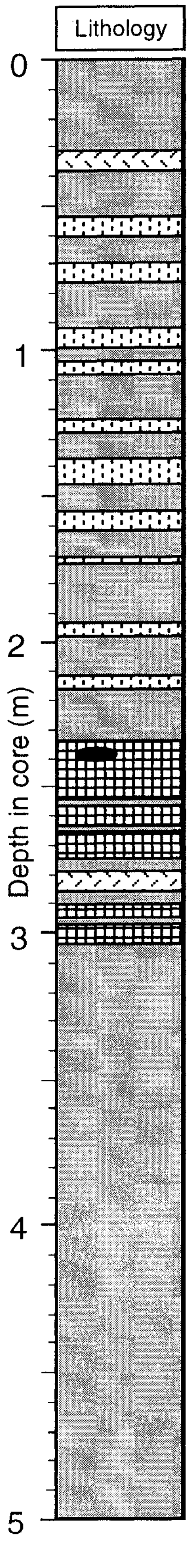
SO82-4-GKG Reykjanes Ridge
Recovery: 0,37 m 59°05'75 N, 30°28'72 W Water depth: 1503 m



Struct.	Colour	Interval	Description	sm	Age
D	5Y 4/4	**surface:**	**sandy silt**, rinsed, moderate olive brown (5Y 4/4), few foraminifers, corals, sponges, polychaeta		
	10YR 5/4	**0-10 cm:**	**sandy silt**, moderate yellowish brown (10YR 5/4), numerous spicules, foraminifers	7 cm	Quaternary
	5YR 3/4	**10 cm:**	**clayey silt**, moderate brown (5YR 3/4), volcanic layer?		
	10Y 4/2	**11-20 cm:**	**clayey silt**, grayish olive (10Y 4/2), numerous spicules,	12 cm	
	N 5	**20-37 cm:**	**clayey silt, slightly sandy**, medium gray (N 5)	21 cm	
		30 cm:	**fine sandy layer**, medium gray (N 5)		

SO82-4-KAL Reykjanes Ridge

Recovery: 5,79 m 59°05'75 N, 30°28'72 W Water depth: 1503 m

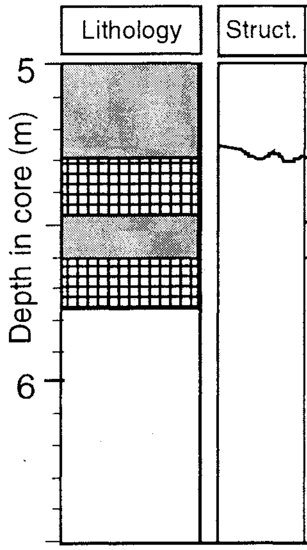


Struct.	Colour	Description	sm	Age
	N 4	**0,00-0,92 m: sandy silty clay,** medium to dark gray (N 4), downward darker coloured 0,25 m: abundant spicules 0,27-0,29 m: layer with greenish streaks, dark greenish gray (5G 4/1), 0,31-0,39 m: spicule ooze, clayey (sandy/silty) matrix, 0,57-0,61 m: clayey silty sand, 0,69-0,71 m: clayey silty sand	5cm 27cm 58cm	Quaternary
	5Y 3/2	**0,92-2.32 m: sandy silty clay** , olive gray (5Y 3/2), intercalations of **clayey silty sand**: 0.92-0.94 m, 1.05-1.07 m, 1.22-1.24 m, 1.36-1.45 m, 1.58-1.62 m, 1.74-1.75 m, 1.92-1.98 m, 2.11-2.14 m	100cm 160cm	
	10YR 4/2	**2,32-2,72 m: silty clay**, spicules, dark yellowish brown (10YR 4/2), 2,36 m: dropstone (?), intercalations of **sandy silty clay**: 2,56-2,58 m, 2,60-2,62 m, 2,65 m	240cm	
	10YR4/2 to 5Y 3/2	**2,72-3,12 m: intercalations of silty clay**, dark yellowish brown (10YR 4/2) to olive gray (5Y 3/2) and **sandy silty clay**, dark yellowish brown(10YR 4/2) 2,80-2,86 m: spicules enriched,	310cm	
	5Y 4/1 to 5Y 5/2	**3,12-5,29 m: (sandy) silty clay,** olive gray (5Y 4/1) and light olive gray (5Y 5/2), different colours intercalating in layers of some cm thickness, darker layers enriched in spicules, slightly motled	350cm 440cm	

SO82-4-KAL Reykjanes Ridge

Recovery: 5,79 m 59°05'75 N, 30°28'72 W Water depth: 1503 m

page **2** of 2



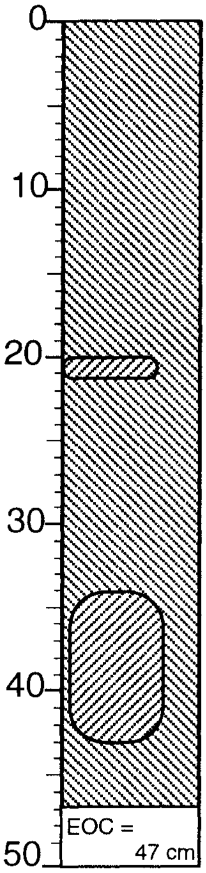
Colour	Description	sm	Age
5Y4/1 to 5Y5/2	3,12-5,29 m: continued (sandy) silty clay,	505cm	
5Y5/2	**5,29-5,46 m: silty clay**, light olive gray (5Y 5/2), few foraminifers	540cm	
5Y 3/2	**5,46-5,60 m: sandy silty clay**, olive gray (5Y 3/2), with more sandy streaks	567cm	
5Y 5/2 to 5Y 3/2	**5,60-5,76 m: silty clay**, light olive gray (5Y 5/2) to olive gray (5Y 3/2), few foraminifers, sediment mottled		

SO82-5-GKG
Recovery: 0,47 m

Reykjanes Ridge
59°11'14 N, 30°54'28 W

Water depth: 1394 m

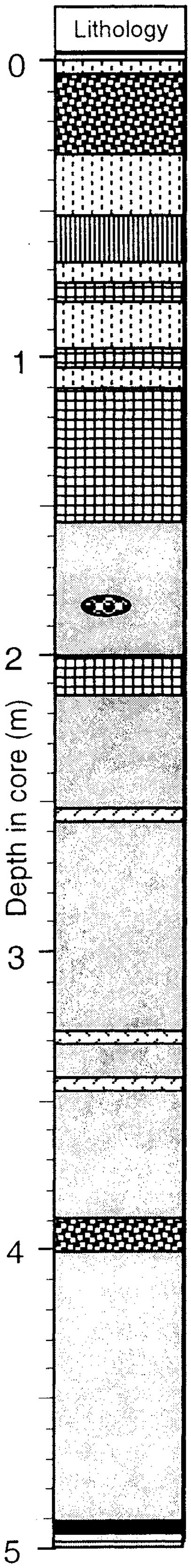
Lithology	Struct.	Colour	Description		sm	Age
	D	5Y 5/6	surface:	**sandy silt**, rinsed, light olive brown (5Y 5/6), gastropoda, numereous pteropods, planktic foraminifers		
		5Y 5/6	**0-47 cm:**	**sandy silt**, llight olive brown (5Y 5/6),	7 cm	Quaternary
		(5Y 4/4)	20 cm:	lense, moderate olive brown (5Y 4/4),		
		(5Y 4/4 - 5Y 5/6)	34-43 cm:	big lense, moderate olive brown (5Y 4/4) to light olive brown (5Y 5/6),	36 cm	
		5Y 5/2	43-47 cm:	olive gray (5Y 5/2)	45 cm	



Depth (cm)

SO82-5-KAL Reykjanes Ridge

Recovery: 5,90 m 59°11'17 N, 30°54'29 W Water depth: 1416 m

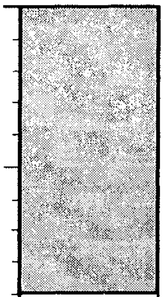


Struct.	Colour	Description	sm	Age
	5Y 4/1 10YR 5/4	**0,00-0,50 m: clayey silty sand,**		Quaternary
		0,00-0,02 m: olive gray (5Y 4/1),		
		0,02-0,50 m: moderate yellowish brown (10YR 5/4),		
		0,00-0,30 m: disturbed, abundant foraminifers, abundant terrigenous material,	43cm	
	5Y 4/1	0,30-0,50 m: spots and streaks of medium dark gray (N 4) and dark yell. brown (10YR 4/2)	60cm	
		0,50-0,69 m: clayey sandy silt, dropstones, olive gray (5Y 4/1), some spicules		
		0,64-0,69 m: spots of sandy silty clay, medium gray (N 5)	110cm	
		0,69-1,54 m: silty clay, olive gray (5Y 4/1), intercalations of clayey silty sand: (0,69-0,72 / 0,82-0,94 / 1,07 m),	150cm	
	10YR 4/2	1,30-1,50 m: burrows of *Zoophycos*		
		1,54-2,00 m: sandy silty clay, dark yellowish brown (10YR 4/2),		
		1,80 m: lense of volcanic sand,		
	10YR 2/2	1,84-2,00 m: some spicules	210cm	
		2,00-2,18 m: silty clay, some spicules, dusky yellowish brown (10YR 2/2)		
	10YR 4/2	**2,18-5,90 m: sandy silty clay**,	240cm	
		2,18-2,67 m: dark yellowish brown (10YR 4/2),		
		2,53-2,56 m: spicule ooze		
	5Y 4/1 / 10YR 4/2 / 10YR 2/2	2,67-3,30 m: intercalation of A) olive gray (5Y 4/1), B) dark yellowish brown (10YR 4/2), C) dusky yellowish brown (10YR 2/2):	294cm	
		B): (2,67-2,73/ 2,83-2,90/3,10-3,15 m), A): (2,73-2,83/2,90-2,96 m), C): (2,96-3,10/3,15-3,30 m),	335cm	
		3,29 m: abundant spicules,		
	5Y 5/2	3,30-4,00 m: light olive gray (5Y 5/2),		
		3,43-3,44 m: spicules enriched,		
		3,90-4,00 m: abundant foraminifers,		
	5Y 2/1	4,00-4,60 m: olive black (5Y 2/1),		
		4,07-4.08 m: more sandy,		
		4,10-4,60 m: some foraminifers,	440cm	
		4,60-5,12 m: medium dark gray (N 4), some darker spots (1 cm diameter) in upper part,		
	N 4	4,91-4,93 m: layer with dark spots - volcanic ash?,		
		4,93-5,00 m: some spicules,	475cm	
		4,96-4,97 m: spots of silty sand		

SO82-5-KAL Reykjanes Ridge

Recovery: 5,90 m 59°11'17 N, 30°54'29 W Water depth: 1416 m

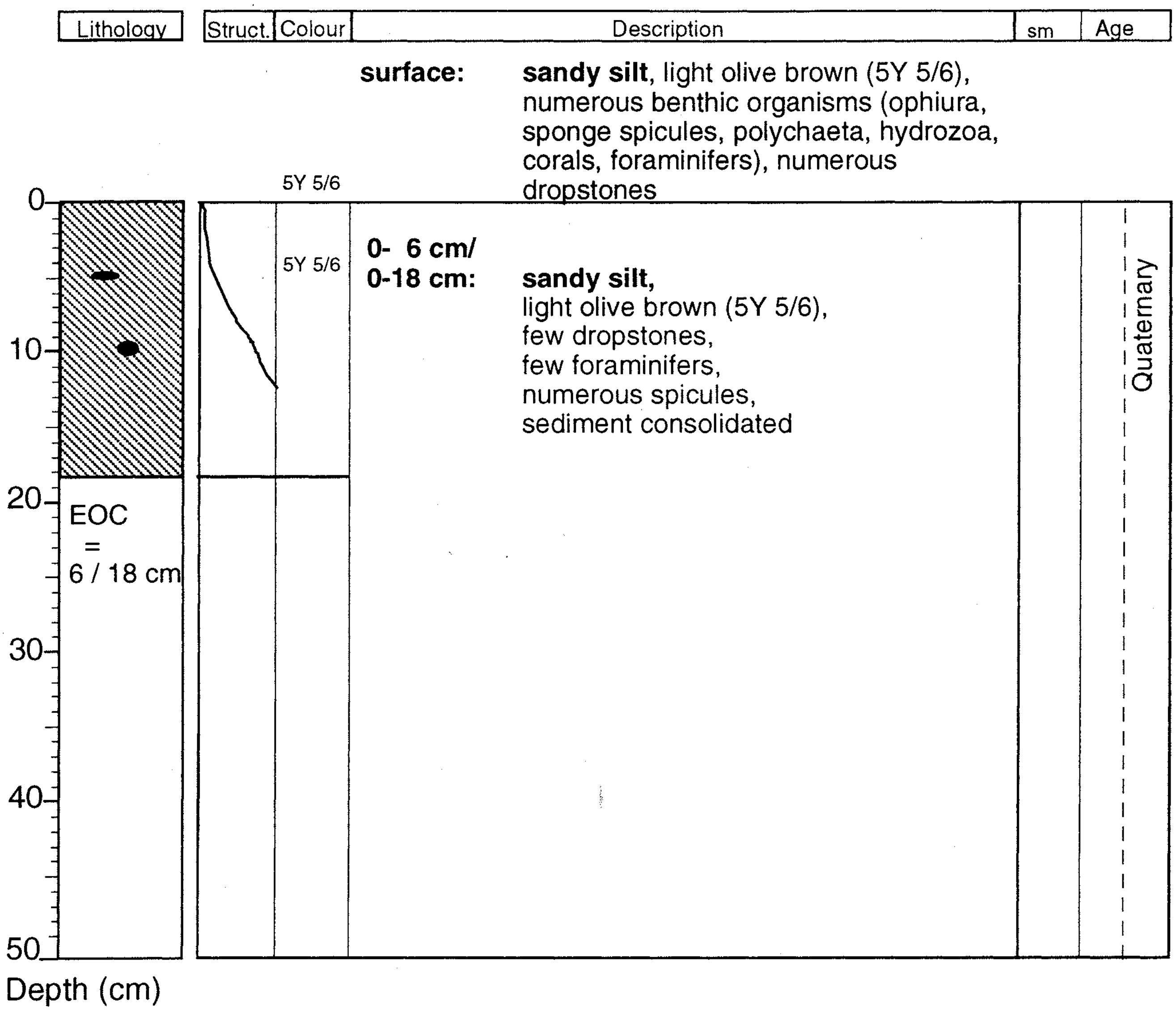
Depth in core (m): 5 – 6



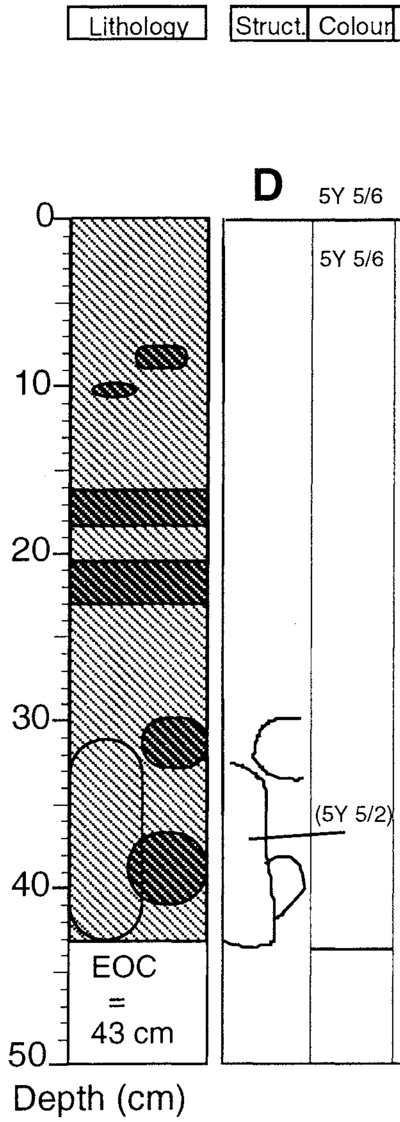
Lithology	Struct.	Colour	Description	sm	Age
		N 4	2,67-5,90 m: continued, sandy silty clay,		
		5Y 4/1	5,12-5,32 m: olive gray (5Y 4/1),		
		10YR 4/2	5,32-5,90 m: dark yellowish brown (10YR 4/2), slightly darker in some parts		

SO82-6-GKG Reykjanes Ridge

Recovery: 0,06 / 0,18 m 59°09'455 N, 30°45'951 W Water depth: 1120 m



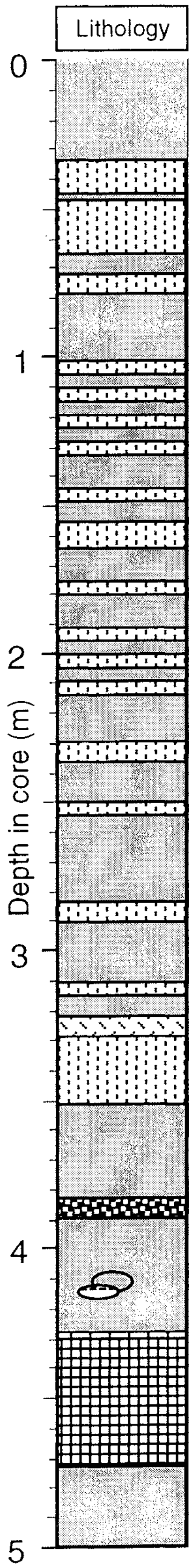
SO82-7-GKG Reykjanes Ridge
Recovery: 0,43 m 59°00'705 N, 30°36'117 W Water depth: 1580 m



Depth	Description	sm	Age
surface:	**sandy silt,** disturbed, light olive brown (5Y 5/6), foraminifers, spicules	surface	
0-32 cm:	**slightly sandy silt,** llight olive brown (5Y 5/6),	5 cm	Quaternary
~10 cm:	darker coloured lenses, grains with diameter up to 3 mm, Fe-oxide-spots?	10 cm Fe-oxide?	
16-18 cm/ 21-23 cm:	darker coloured layers (s.o.)		
32-43 cm:	**clayey sandy silt,** light olive gray (5Y 5/2), 6 cm lateral extension, darker coloured lenses	35 cm (5Y 5/2)	
		40 cm lenses	

SO82-7-KAL Reykjanes Ridge

Recovery: 5,79 m 59°00'705 N, 30°36'117 W Water depth: 1584 m



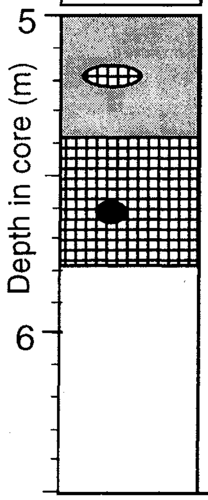
Struct.	Colour	Description	sm	Age
	5Y 4/1	**0,00-0,31 m: sandy silty clay**, olive gray (5Y 4/1), uppermost 4 cm spots of dark yellowish brown (10 YR 4/2)	3cm 22cm	Quarternary
	N 5	**0,31-0,45 m: clayey silty sand**, medium gray (N 5), slightly mottled	44cm	
	5Y 4/1	**0,45-3,25 m: sandy silty clay**, 0,45-1,68 m: olive gray (5Y 4/1), intercalations of **clayey silty sand:** (0,46-0,63 / 0,70-0,74 / 1.02-1,05 / 1.10-1,12 / 1,18-1,21 / 1,27-1,31 / 1,47-1,48 / 1,55-1,61 / 1,67-1,68 m)	100cm	
	5Y 5/2	1,68-2,43 m: light olive gray (5Y 5/2), 1,73 m: small sandy lense, intercalations of **clayey silty sand**: (1,90-1,92 / 2,02-2,04 / 2,12-2,13 / 2,15-2,18 / 2,30-2,33 m)	165cm 210cm	
	5Y 4/1	2,43-4,24 m: olive gray (5Y 4/1), intercalations of **clayey silty sand**: (2,53-2,55 / 2,86-2,90 / 3.10-3,11 / 3,18-3,22 / 3,23-3,25 m) 3,23-3,25 m: abundant spicules **3,25-3,50 m: clayey silty sand** **3,50-4,24 m: sandy silty clay** 3,80-3,90 m: abundant foraminifers 3,91-3,93 m: some spicules 4,14 m: dropstone (?)	280cm 333cm 400cm	
	5Y 3/2	**4,24-4,71 m: silty clay**, olive gray (5Y 3/2), homogeneous	440cm	
	5Y 5/2	**4,71-5,34 m: sandy silty clay**, light olive gray (5Y 5/2)	490cm	

SO82-7-KAL Reykjanes Ridge

Recovery: 5,79 m 59°00'705 N, 30°36'117 W Water depth: 1584 m

page **2** of 2

Lithology



Struct.	Colour	Description	sm	Age
	5Y 5/2	**4,71-5,34 m: sandy silty clay**, light olive gray (5Y 5/2) 5,13-5,15 m: silty clay intraclast,		
	5Y 3/2	5,19-5,34 m: olive gray (5Y 3/2)	530cm	
	10YR 4/2	**5,34-5,79 m: silty clay**, dark yellowish brown (10YR 4/2), 5,40-5,50 m: more olive gray, 5,61 m: dropstone (?)	541cm 572cm	

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