Cruise Report

R/V Maurice Ewing

EW0114

December 7, 2001 – January 25, 2002

Fremantle, Australia – Hobart, Australia

Chief Scientist

James R. Cochran

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Scientific Objectives

The primary goal of the research program undertaken on R/V Maurice Ewing cruise EW0114 was to determine the dependence of melt supply on variations in mantle temperature at constant spreading rate and to investigate the effects of these variations on crustal accretion and the resulting crustal structure and morphology.

The supply of melt to a spreading ridge, the distribution of melt along the axis, melt extraction and emplacement to form the crust and the crust's subsequent tectonic modification are shaped by a matrix of parameters. The most apparent controlling parameter is parameter is spreading rate. However, spreading rate is clearly not the entire story, as demonstrated, for example, by the change from an axial valley to an axial high accompanied by changes in the ridge segmentation, volcanic landforms and crustal thickness which is observed as a slow spreading ridge approaches a hot spot. Other major forcing functions proposed as important controls on the creation of new crust at spreading centers include mantle temperature, mantle source composition, tectonic setting and ridge obliquity.

Analysis of the effects of different parameters that influence crustal accretion requires identification of areas where the individual parameters vary systematically while the spreading rate remains constant. The Southeast Indian Ridge (SEIR) south of Australia is located near the equator of its pole of rotation so the spreading rate varies slowly along the ridge. In particular, spreading rates in the region between 100°E and 116°E vary by only about 1 mm/a, at 75-76 mm/yr. In addition, basalt major element and isotope geochemistry determined from an extensive suite of dredges between 88°E and 118°E suggest a relatively constant mantle source for the basalts.

There is a systematic depth gradient along SEIR to the east of 88°E. Near-axis isochronal ridge flank depths increase slowly from 2800 m at 91°E to 2900 m at 100°E and then more steeply to about 3300 m at 115°E. This portion of the SEIR is located between a shallow section of the ridge axis (78°E to 85°E) influenced by the Amsterdam and Kerguelin hot spots and the very deep Australian-Antarctic Discordance (AAD) (120°E-128°E). A variety of geophysical and geochemical evidence indicates that the AAD is underlain by an unusually cold mantle.

Since the spreading rate and the mantle source both are nearly constant along this portion of the SEIR, the along-axis variation in depth can reasonably be ascribed primarily to the effects of an along-axis variation in mantle temperature between the hot spot-influenced region farther to the west and the AAD farther to the east. In addition, the spreading rate on the SEIR is within the crucial intermediate range (75-80 mm/a) where the crustal accretion process is most sensitive to small variations in melt supply. Therefore, the result of the along-axis temperature gradient is that nearly the entire range of axial morphology and abyssal hills observed at MOR axes and flanks are present within a 1200 km portion of the SEIR between 100°E and 116°E, making the SEIR an ideal laboratory in which to investigate the effects of temperature variations on magma supply and the crustal accretion process.

The field program undertaken on Ewing cruise EW0114 was a seismic experiment utilizing ocean-bottom hydrophone (OBH) seismic refraction lines to determine variations in crustal thickness (taken as a proxy for total melt supply) and upper mantle seismic velocity, and multichannel seismic (MCS) reflection surveys to determine the internal structure of the crust, particularly layer 2A (extrusive) thickness and its relationship both to melt supply and to axial and abyssal hill morphology. The experiments were designed to systematically investigate the relationship between temperature, melt supply, crustal structure and axial and ridge flank morphology to better understand crustal accretion. The stated goals were to:

• *Determine the relationship between mantle temperature and melt production,*
• *Understand the intrasegment distribution of melt as a function of overall melt production and axial morphology,*
• *Understand the pattern of accumulation of Layer 2, both across axis and along-axis*
• *Understand the relationship between crustal structure and ridge morphology*
• *Understand the relationship between crustal structure and abyssal hill formation and morphology*

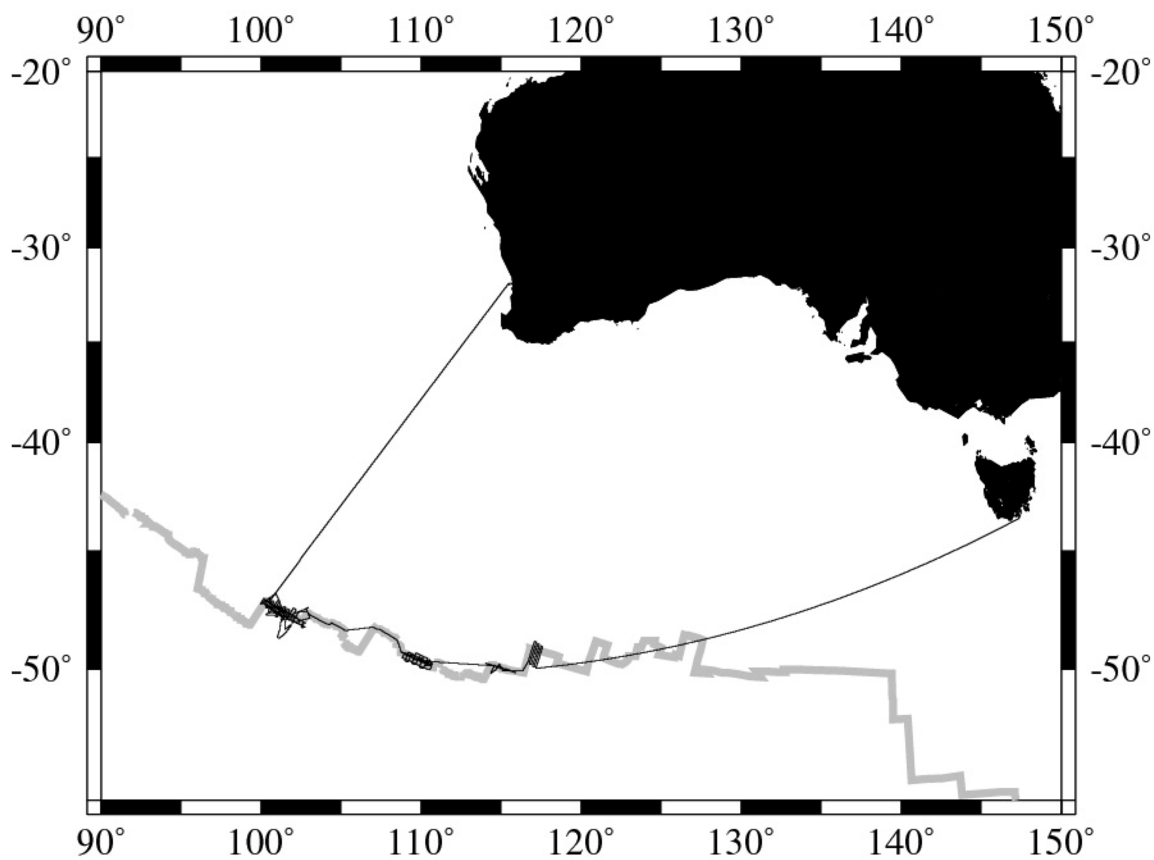


Figure 1. Track chart of R/V Maurice Ewing cruise EW0114 showing the regional setting of the survey in relation to Australia and the Southeast Indian Ridge axis (shown in gray).

Tectonic Setting

The Southeast Indian Ridge forms the plate boundary between the Antarctic and Australian plates from the Indian Ocean Triple Junction located near 25°S, 70°E to the Macquarie Ridge complex south of New Zealand near 63°S, 165°E. Spreading rates for the 1200 km length of ridge axis from 100°E to 116°E are nearly constant at 75-76 mm/yr. The shallowest portion of the SEIR is from about 78°E to 85°E in an area which appears to be influenced by the Amsterdam and Kerguelin hot spots. East of this region, the ridge experiences a long-wavelength increase in depth (Fig. 2) toward the AAD, a region of deep and chaotic topography located between 120°E and 128°E. As mentioned in the previous section, a number or different types of geophysical evidence suggest that the mantle beneath the AAD is unusually cold.

Ridge axis depths increase by 2100 m between 88°E and 116°E. However, much of the change in axial depth is due to the change in the form of the axial morphology (Fig. 3). *Ma and Cochran* [1997] found that ridge flank depth along isochrons increases by 500 m from 88°E to 116°E with about 400 m of the increase between 100°E and 116°E. The increase in ridge flank depth is accompanied by a 50 mGal increase in the level of the mantle Bouguer (MBA) gravity anomalies (Fig. 2)

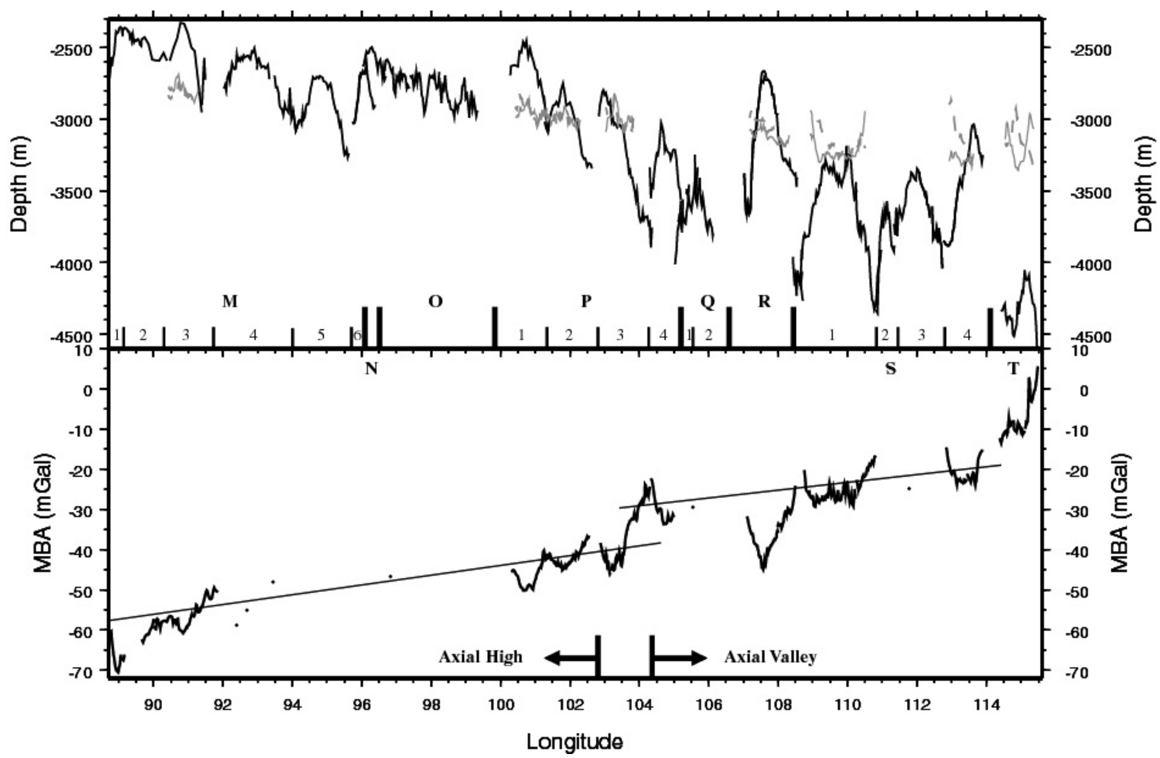


Figure 2 (top) Axial and ridge flank depths as a function of longitude along the SEIR. Axial depths are shown as a heavy line. Ridge flank depths, shown as light lines (solid for the north flank and dashed for the south flank) are from *Ma and Cochran* [1997]. (bottom) Axial mantle Bouguer anomaly as a function of longitude along the SEIR (from *Cochran et al.* [1997]), based on data from the 1994-95 mapping cruise. Between the detailed survey boxes, spot values (dots) were obtained where the ship track crossed the axis. Thin lines show regional tremds. First- and second-order ridge segmentation is shown between the two plots. The segments studied during EW0114 were P1, P2, S1 and T.

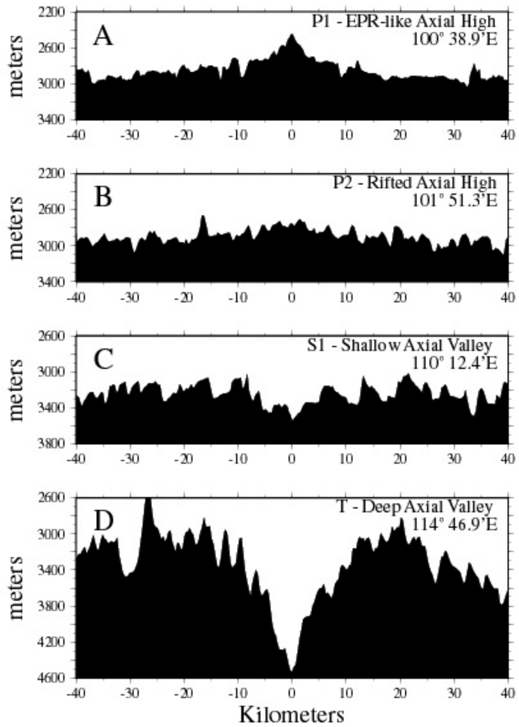


Figure 3. Bathymetric profiles across the ridge axis from near the center of each of the segments studied during EW0114. These four segments span the range of mid-ocean ridge axial morphology.

The along-axis variation in depth and MBA gravity results from a combination of crustal thickness variations and changes in mantle temperature. If the depth change is assumed to result only from a change in crustal thickness, *Cochran et al* [1997] calculated that change at 1.7-2.4 km, depending on the crustal density. On the other hand, if the depth change results only from a change in mantle density arising from an along-axis temperature gradient, then the temperature change is 55°C-100°C, depending on the depth to which it is assumed to extend [*Cochran et al.*, 1997].

The form of the axial morphology varies systematically along the SEIR axis. The ridge axis for almost 2000 km to the west of 103°E is characterized by an axial high while the axis east of 104°30'E to 129°E at the eastern boundaryof the AAD is generally characterized by an axial valley. The axial morphology of the SEIR consists primarily of rifted axial highs and shallow axial valleys rather than the well-developed end-member morphologies characteristic of the EPR and MAR. Rifted axial highs on the SEIR are generally lower and less well developed than those found on the EPR and are characterized by faults with throws of 50-100 m very near the axis, often within 1 km. Segment P2, investigated during EW0114 is a typical example of this morphology (Fig 3B, 4). Similarly, axial valleys on the SEIR are less distinct than the axial valleys observed at slow spreading ridges and are generally less than about 500-700 m deep except near segment ends where they may deepen to about 1 km. Segment S1, also studied during EW0114 exhibits this morphology (Fig. 3C, 4). These two morphologies appear to form a distinctive intermediate spreading rate morphology which is prevalent on the SEIR and on other intermediate spreading rate ridges away from the influence of hot spots.

Well developed "EPR-like" axial highs are found at a few vigorous segments along the SEIR, most notably for our purposes at segment P1 east of the 100°E transform (Figs. 3A, 4). A deep well-developed axial valley characterizes segment T near 115°E (Figs. 3D, 4) at the extreme eastern end of the surveyed area. Thus the entire range of axial morphology observed at mid-ocean ridge axes can be observed at a constant spreading rate in a 1200 km length of the SEIR between 100°E and 116°E.

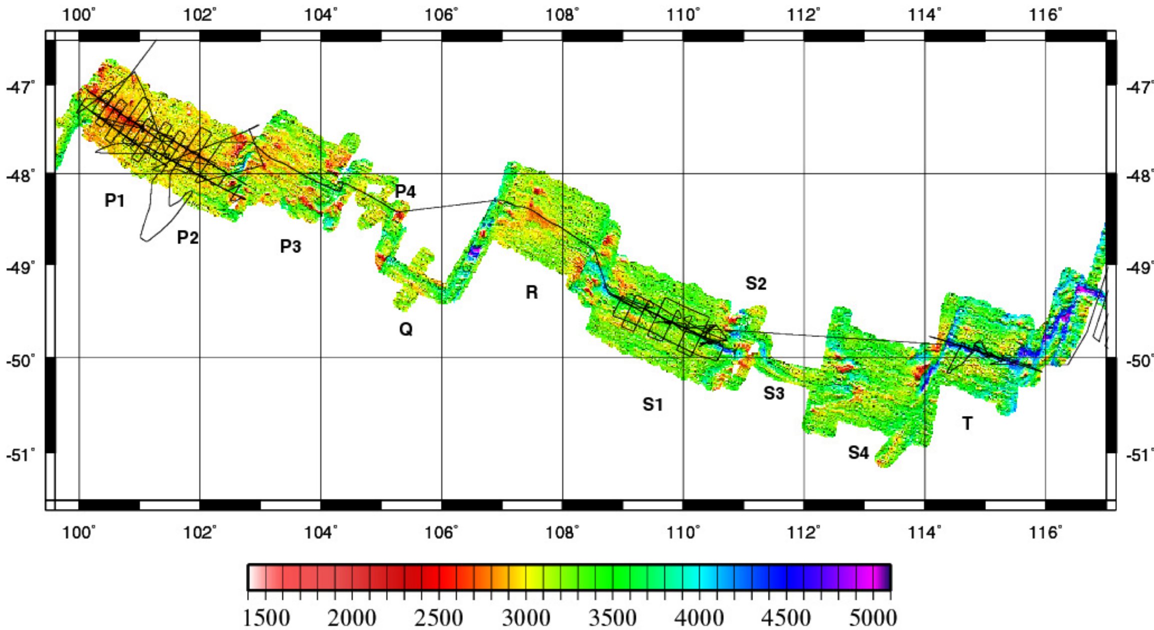


Figure 4. EW0114 track chart of operations within the survey area superimposed on a shaded relief SeaBeam bathymetry map based on data from the 1994-95 Melville Westward 9 cruise. Second order ridge segments P1 through T are identified.

Operational Objectives

The primary operational objective of R/V Maurice Ewing cruise EW0114 consisted of carrying out seismic surveys in four segments of the Southeast Indian Ridge which, at the same spreading rate of ~76 mm/a, exhibit the entire range of axial morphologies normally observed at mid-ocean ridges. These four segments are :

- Segment P1centered near 100° 45’E which is characterized by a well developed 400-m “EPR-like” axial high.
- Segment P2 centered near 102°E which is characterized by a rifted axial high.
- Segment S1 centered near 109°45’E which is characterized by a shallow axial valley
- Segment T centered near 115°E which is characterized by a 1000-1300 m deep axial valley.

Within each of those four segments, the operational objectives were:

• Collection of two OBH refraction lines located at the axis and along an isochron approximately 20 km (~525 ka) south of the axis.

For each refraction line, four OBHs were deployed 15-20 km apart along the length of the segment. The Ewing’s entire 20-gun 8480 in^3 array was used for the refraction lines with a 120-second (~300 m) shot interval. The guns were deployed at a depth of 8 m. The refraction lines were run east-to-west (into the wind) to avoid gun tangling beginning 30 km east of the first OBH and continuing 30 km past the final OBH. Prior to OBH retrieval a short (~3.5 km) cross line over each OBH was shot with a single gun to aid in relocation of the OBH. See the section on OBH operations for a more complete discussion.

• Collection of a grid of MCS data.
The MCS surveys were carried out with a 10-gun 3050 in^3 array shooting to the Ewing's 6-km 480-channel streamer. An 8-m gun depth was also used for the reflection studies. The MCS survey of the two western axial high segments (P1 and P2) consisted of isochron lines coincident with the refraction lines and a series of across-axis lines at 10 km spacings designed to determine along axis variations in magma chamber geometry and Layer 2A thickness. A 50-m (~20 sec) shot interval was used. The MCS survey in Segment S1 also had fewer across-axis lines and relied more on isochron lines, again including lines coincident with the refraction lines. The reason for the change in strategy was the higher-relief topography in the axial valley segments. For the same reason, the shot interval was changed to 37.5 m (~15 sec) in order to facilitate application of DMO techniques to suppress scattered energy resulting from the rougher topography. A similar strategy was planned for Segment T with a deep axial valley, although the consistently miserable weather during the last two weeks in the field area prevented that survey from being conducted.

An additional objective during transits between the primary surveys was to obtain an MCS profile along the axis of as many of the intervening segments as possible in order to allow us to examine in detail changes in magma chamber depth and on-axis Layer 2A thickness accompanying the changes in axial morphology observed along the SEIR axis.

The details of the MCS program and on-board processing are discussed in the MCS Operations section of this report.

We successfully carried out all planned operations in Segments P1 and P2, acquired along-axis MCS lines in Segments P3, P4 and R during the transit to Segment S1 and carried out the entire planned MCS program in Segment S1. However the continuous bad weather during the final two weeks in the field area resulted in only being only to obtain a single on-axis refraction line in each of Segments S1 and T. We were not able to collect any MCS data in Segment T. In all, 11 days were lost to weather during the cruise.

Operations in Segment T were made more difficult when rough seas damaged the starboard boom making it inoperative. As a result, about half of OBH line 6, along the axis in Segment T was run with a reduced gun array which varied between 2255 in^3 and 4835 in^3 as a result of gun tangles (another byproduct of the heavy seas), but was 3105 in^3 during most of that period. However we were still able to obtain data to distances of ~30 km, including PmP arrivals, so we have confidence that we will be able to determine the crustal thickness in Segment T. A record section from Segment T is shown in Figure 13.

Shipboard Operations

The WHOI OBH operation ran very smoothly and efficiently. The OBHs, although old, functioned very well and good quality data was recorded on 23 of the 24 deployments. The one exception was OBH 27 during refraction Line SEIR05 in Segment S1, which had extremely low signal amplitude. The hydrophone on that frame was replaced prior to the next refraction line.

Similarly the Ewing data acquisition effort was relatively smooth. The gunners kept the guns in good working order and were generally very efficient in deploying and recovering them. The crew is industrious and helpful. In particular, the mates did a very

good job of putting us over waypoints and accurately on station, and were always careful to be sure how we wanted them to make turns.
There were however difficulties in some areas.

A major rebalancing of the streamer was required at the beginning of operations due to the much colder water than in the previous operational areas. The central part of the streamer initially ended up too heavy even after the removal of a significant amount of lead and tended to sink (to as deep as 20-30 m). This became a problem when three of the SRDs (streamer recovery devices) deployed bringing the streamer to the surface. The problem was corrected when the streamer was brought aboard during a period of bad weather.

The seismic data logging system showed an alarming tendency to freeze up during the first few days of seismic operations. It had to be rebooted to resume recording, generally resulting in the loss of about 20 minutes of data. Joe Stennett finally located the problem as a badly seated controller bus.

Two data logging problems developed after we changed the shot interval from 50 m to 37.5 m. The first problem was that the interval between shots not infrequently fell below the time necessary to record each shot (approximately 13-14 sec.). This problem arose from the fact that the mates, still worried about the necessity to keep the steamer from sinking (even though it had been rebalanced), had increased the speed to well over 5 knots. The problem was solved by simply asking them to slow down.

The second problem is that duplicate FFID numbers were assigned to successive shots. This occurred every 256 shots. The origin was never determined, but it appears to be software related and did not occur when shooting was at 50 m intervals.

Onboard seismic processing faced a number of difficulties. Our greatest problem was with the Promax licenses. We were operating on a series of 10-day "demo" licenses. These were not delivered on a timely basis, resulting in putting our processing out of business for 7-10 days at a time. In addition, when the permanent license arrived, it was formatted differently than the temporary licenses and could not be installed. Quite apart from that problem, the whole issue of support for on-board processing needs to be carefully thought through. There were times when simple tasks such as copying tapes became inexplicably difficult. Additional disk space and an additional server are badly needed.

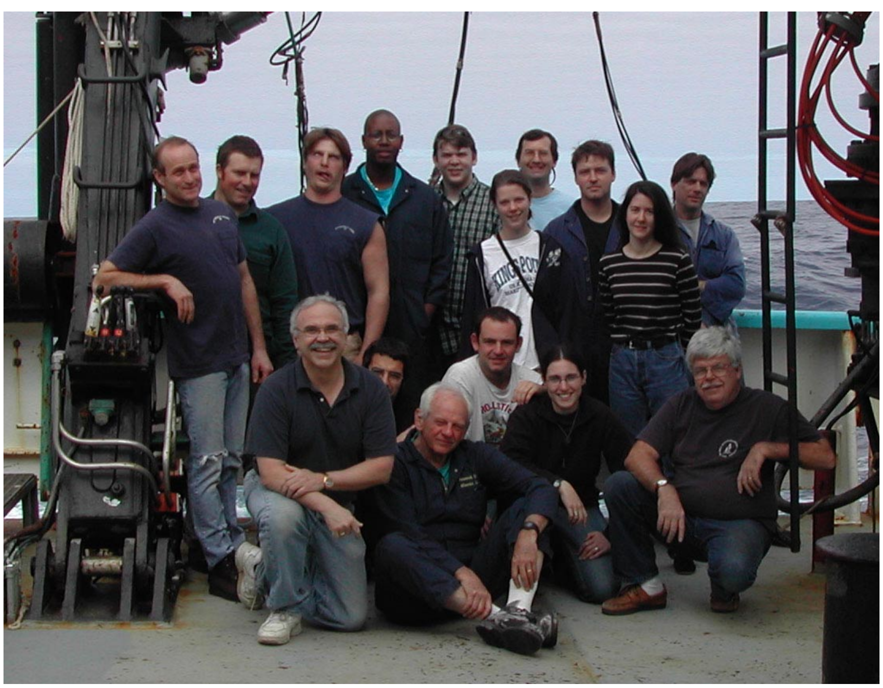
Personnel

Science Party

Name	Position	Affiliation
Cochran, James	Chief Scientist	Lamont Doherty Earth Observatory
Floyd, Jacqueline	Co-Chief Scientist	Lamont Doherty Earth Observatory
Rubio, Eduardo	Scientist	Inst. of Earth Sciences, Barcelona
Baran, Janet	Scientist	Lamont Doherty Earth Observatory
Medvedev, Benjamin	Scientist	Geophysical Institute of Israel
Cochran, Ian	Scientist	Colby College
DuBois, David	Scientist	Woods Hole Oceanographic Institute
Fraioli, Ann	Scientist	Lamont Doherty Earth Observatory
Handy, Robert	Scientist	Woods Hole Oceanographic Institute

Ewing Science Technicians

Name	Position
Stennett, Joe	Science Officer
DiBernardo, John	Chief Gunner
Gordon, Hamish	Airgun Technician
Hagel, Karl	E/T - Technician
Nicholson, Glenn	Airgun Technician
Oliver-Goodwin, Richard	System Manager
Walsh, Justin	Airgun Technician



R/V Maurice Ewing Crew

	Name	Position
1	Landow, Mark	Master
2	Thurston, Gilbert	Chief Mate
3	Beauregard, Robert	2nd Mate
4	Thomas, Richard	3rd Mate
5	Ewing, Robert	Boatswain
6	Noonan, Megan	A/B
7	Branniff, Marcella	A/B
8	Miller, Warren	A/B
9	Sypongco, Arnold	O/S
10	Doughty, Daniel	O/S
11	Karlyn, Albert	Chief Engineer
12	Tucke, Matthew	1st Engineer
13	Flores, Miguel	2nd Engineer
14	Rooney, Christopher	3rd Engineer
15	Matos, Francisco	Technician
16	Hathorne, Robert	Oiler
17	Strickland, L. Gordon	Oiler
18	Lee, Daniel	Oiler
19	Smith, John	Steward
20	Taylor, Kelly	Cook
21	Moqu, Luke	Utility

Cruise Narrative

12/7 JD341 (Friday) – The R/V Maurice Ewing left the dock at Fremantle, Australia at ~1330 local time (0530 GMT). We steamed northwest along the channel through the offshore islands and then headed south at 11 knots for the first OBH refraction site which will be the axial line in segment P1 (~ 47°S, 100°E).

12/8 JD342 (Saturday) – Lab watches began at 0000 GMT (0800 local). Continuing southwest at 10.5 knots into fairly constant 20 knot winds. First fire and boat drill at 1020 local. About 0415 GMT, we went off the southern edge of the Naturaliste Plateau with depths dropping rapidly to > 5500 m in the Diamentina Zone with very rough bathymetry.

12/9 JD343 (Sunday) – Continuing transit to the P1 refraction sites. Conducted release tests on 16 releases from 0100Z to 0440Z. All operated satisfactorily. However there was initially a problem getting the transceiver to operate. The transceiver will be left turned on. Magnetometer was deployed on leaving the test site.

12/10 JD344 (Monday) – Continuing transit to the P1 refraction sites. Very gray skies but low winds (5-20 knots) and high barometer (1030 mbar). We passed out of the Diamentina Zone into an area of more typical MOR relief, The magnetometer is picking up a good set on seafloor spreading magnetic anomalies.

12/11 JD345 (Tuesday) – Continuing transit to the P1 refraction sites. The barometer dropped slowly but steadily all day and the winds came up to 25 knots. The ship has also started to move around a bit. Chairs and other movable items were bungie corded in preparation for the roaring 40s.

12/12 JD346 (Wednesday) – We reached the first OBH deployment site at ~ 0500 local (2200 on JD345 GMT). First OBH (#20) was deployed at 2208Z (JD345), the final OBH (#27) was launched at 0225Z. We sailed to the end of the line and gun deployment began about 0530Z. About 0700Z gun deployment has halted with 12 guns in the water due to failure of two valves in the cooling system for the compressor. Repairs were made and deployment resumed at 0746Z. After several test firings of the guns, the first recorded shot (shot #5) of the cruise was fired at 0807Z. The OBH lines are being shot with the Ewing's full 20 gun, 8445 cu. in. array. A 120 second repetition rate was used for the refraction lines. We completed shooting the 112 km line at 2045Z and the guns were aboard and booms secured by 2202Z (0602 on Thursday, local).

12/13 JD347 (Thursday) – We began the day by retrieving the OBHs. Prior to each retrieval, we ran a short 2 mile cross line across each OBH firing a single small gun. This was done to allow more accurate determination of the OBH position. For the first OBH, the cross line was shot at a 120 sec rep rate. Subsequent cross lines used a 60 sec firing rate. The first OBH was on board at 0212Z and the final one at 1255Z. We then got underway for OBH line2, the off-axis segment P1 line. The first OBH for Line 2 was in the water at 1640Z and the final one at 2128Z.

12/14 JD348 (Friday) – We arrived at a point 10 miles downwind the end of the line right at 0000Z, turned into the wind and began to deploy the guns. The first shot was at 0352Z. The 102 km long line was completed at 1644Z. The guns were in by 1800Z and we returned to pick up the OBHs. The cross line over the first OBH was delayed for about 30 minutes because the Spectra program which controls the guns crashed. The first OBH was recovered at 2144Z.

12/15 JD349 (Saturday) – We continued to recover OBHs through the morning in slowly deteriorating weather. The winds were steady at 30-35 knots. The final OBH was on board at 0839Z (1239 local). As we steamed to the third OBH refraction line (the on-axis line in segment P2), the wind decreased, and the seas moderated as we deployed the OBHs. The first deployment was at 1132 and they were all in the water by 1632. We steamed to a spot 10 miles from the beginning of the line and began gun deployment. The guns went in very fast and we began shooting at 2108Z, well before we reached the planned beginning of the line. However these additional shots may not be useful since we were across the transform at the eastern end of segment P2.

12/16 JD350 (Sunday) – We continued to run OBH line 3, completing it at 1208Z. There were intermittent problems with gun tangles during the line and several times when one to three guns were out of service. The guns were aboard by 1300Z and we spent the rest of the day in shooting the short ranging lines and recovering the OBHs in slowly deteriorating weather.

12/17 JD351 (Monday) – The final OBH was recovered at 0429Z. We transited to the beginning of OBH line 4 (the off-axis line in segment P2) and began deploying at 0854. The weather continued to deteriorate and the seas became rougher, giving Dave and Rob a number of good soakings. By the time the final OBH was deployed at 1421Z, the wind was blowing 40 knots and it was too rough to deploy the guns, so we turned into the wind to wait for better conditions.

12/18 JD352 (Tuesday) – The weather improved somewhat overnight (winds down to 25-30 knots, barometer up to 1002 mbar) and through the morning the seas dropped a little, so we got underway toward the gun deployment site at 0500Z and began deploying guns at 0656Z. First shot was at 1007Z. At 1148Z (shot 58), the Captain said that he was turning into the wind, so the gunners could get out on the boom to deal with a bad tangle of guns 1 and 2. We turned about 20° off the line. The guns were back in the water at 1216Z (shot 65). We turned back toward the line. We did not do a loop for fear of worse tangling as the wind came behind us. We were back on the track at 1249Z (shot 82), 5.3 km from where we left it. At 1941Z (shot 288), the Spectra program crashed, bringing shooting to a halt. Richard rebooted it and shooting resumed at 2025Z again with a 5.3 km gap in shots. The program also restarted the recorded shot numbers at 1. The line was finished without further incident.

12/19 JD353 (Wednesday) – OBH line 4 was completed at 0035Z. Because of rough weather bringing in the guns took six hours. We then suspended operation and sailed slowly into the wind waiting for conditions to improve. We got underway toward the first OBH site at 1430Z. Because of worry about OBH battery life, we decided to shoot all of the ranging lines across the OBHs first and then pick them up from east to west heading back toward the start of the MCS survey. The rest of the day was spent in moving down the line of OBHs shooting the ranging cross lines.

12/20 JD354 (Thursday) – The shooting was completed and the first OBH (#27) was released at 070Z It was on deck at 0810Z. We proceeded back up the line of OBHs and the final OBH (#20) was on deck at1524Z. We then transited to the beginning of the MCS line. We also received word that while we had the OBHs down for line 3, a large (7.0) earthquake occurred to the east of us in the AAD. We checked the OBH records and found that we did record it. We began deploying the streamer at ~2200Z in improving but cold weather. The streamer deployment became quite a social event with over a third of the people on board out on the fantail.

12/21 JD355 (Friday) – Streamer deployment continued through the morning. It was a long process since we needed to swap out five bad sections and to reballast the streamer for the colder water. Streamer deployment finished at ~1000Z and the guns were out by 1140Z. First shot on MCS line 1 (along the axis in segment P1) was at 1353Z. The MCS lines are being run with a 10-gun, 3050 cu. in array. The shooting is being done on a 50 m (nominal 20 sec.) schedule. Between tapes 20 and 21 (shot 1188) the logging system froze and about 100 shots were lost before it could rebooted. The plan is to reshoot that portion of the line during one of the cross lines. Line 1 was completed at 2351Z (shot 1771).

12/22 JD356 (Saturday) – The first shot (#24) on Line 2 along the axis in segment P2 was at 0040Z. We continued to shoot the line though the morning in steadily improving weather. The center part of the streamer, where less weight was removed, showed a definite tendency to sink. Last shot of Line 2 was at 1029Z. We ran the short axis-perpendicular Line 3 from 1042Z to 1259Z and first recorded shot on Line 4 (shot 19) was at 1324Z. Line 4 is an isochron line over the P2 off-axis OBH line. Last shot of Line 4 was at 2332Z.

12/23 JD357 (Sunday) – The first shot of Line 5 (the off axis isochron line in Segment P1) was at 0024Z. However the logging system froze again and 92 shots (4.5 km of line) were lost before it was rebooted. Last shot on Line 5 was at 0954Z. First shot on Line 6, the westernmost cross line was at 1009Z. During tape 130 (shot 436 – 1226Z) the data logging system froze up again. Since this is a recurring problem and Line 6 is partially in the transform and of marginal value, an effort was made to find the problem instead of just rebooting. The problem was located in a badly seated controller bus and recording was resumed at 1305 (shot 554). Line 6 was completed at 1334Z (shot 628). We continued with axis perpendicular lines 7 and 8 completed during the day.

<u>12/24 JD358 (Monday)</u> – We continued to run the axis-perpendicular lines at a 10 km spacing in reasonably good weather. Completed lines 9, 10 and 11 across the axis in segment P1. Preliminary onboard processing of the axial Lines 1 and 2 shows a well developed Layer 2a and in places a very convincing AMC

<u>12/25 JD359 (Tuesday)</u> – Continued to run the axis-perpendicular lines as the weather held. Completed lines 12, 13 and 14. This completes the axis-perpendicular lines in segment P1 Line 12 was divided into parts 12a, 12b and 12c with 12b (0646Z-0803Z) filling in the data gap on Line 1. After dinner the science party had our Christmas grab bag and celebration followed by lessons and carols in the lounge.

<u>12/26 JD360 (Wednesday)</u> – Continued to run axis-perpendicular lines in segment P2 as the barometer dropped 20 mbar and the weather deteriorated. Completed Lines 15, 16, 17. At the end of Line 17 conditions were too rough to continue. We broke off work, turned into the wind and brought the guns aboard. Conditions were too rough to retrieve the streamer, so we continued to steam into the wind for the remainder of the day

<u>12/27 JD361 (Thursday)</u> – We began the day steaming into the wind in bad weather - the winds were steadily over 40 knots with seas to match. Life on board was extremely uncomfortable. Conditions gradually improved in the early afternoon and at ~0700 we began a slow turn back to the north. By 0900, we were headed back toward the ridge. However we were now over 40 miles south of the work area, so it was a long steam back. At ~2100, we turned back to the south into the wind to deploy the guns.

12/28 JD362 (Friday) - Gun deployment was finished at ~0030 and we turned back north toward the ridge. The first shot of Line 18 was at 0519Z. Completed Line18 at 1237Z and began Line 19 at 1432Z. During Line 19, the center portion of the streamer, which had been riding deep, became very difficult to get below the surface. At 2018, Line 19 was broken off 13 km south of the ridge axis because of the worsening weather. We began to bring in the guns and the streamer.

12/29 JD363 (Saturday) – The streamer was on board at ~0445Z. It was discovered that Bird 14 was gone and that three of the SRDs (streamer recovery devices) had deployed giving an explanation of why the central part of the streamer was riding at the surface. Following recovery of the streamer, we turned and ran with the wind to the general area where we would redeploy for Line 20 and then hove-to.

12/30 JD364 (Sunday) – Streamer redeployment began at ~2330 (JD363). It was slow because two sections needed replacing and the ballasting problem was corrected. The streamer was out at ~0700Z and the guns joined it by ~1015Z. First shot on Line 20 was at 1051Z and the line was completed at 1713Z. This completed the work in segment P2.
We turned east and transited to western end of segment P3. First shot on Line 21 along the axis of P3 was at 2236.

12/31 JD365 (Monday) – We continued Line 21 along the axis of P3. P3 is a transitional segment between an area of primarily axial highs to the west and primarily axial valleys to the east. We finished the ~120 km line at1053Z and began a line along the axis of P4, our first axial valley segment, at 12:38Z. That 65 km line was completed at 1853Z. Line 23 was begun at 1948Z. Line 23 cuts across the ridge flank of segment Q on 2-3 ma crust to the western end of the segment R axis. Segment Q is offset considerably south of both P4 and R by transforms and it was not feasible from a time point of view to transit south to its axis.

01/01 JD001 (Tuesday) – Line 23 was completed at 0801Z and first shot on Line 24 along the segment R axis was at 0843Z. Last shot (#2520) on this 125 km-long line was at 2239Z. We then turned south to transit to our next intensive study area in segment S1. The weather improved considerably and everyone was grateful for a calm, low activity New Year's Day.

01/02 JD002 (Wednesday) – The first shot on Line 25 along the axis of segment S1 was at 0535Z The shooting interval was changed from 50 m (nominal 20 sec.) to 37.5 m (nominal 15 sec.) to facilitate planned application of DMO processing to data from the two rougher eastern segments. The last shot (#3975) on this ~150 km-long line was at 2140Z). First shot on short axis-perpendicular line 26 was at 2158Z with last shot at 2347Z.

01/03 JD003 (Thursday) – We continued with the MCS program in segment S1. It was rainy and the barometer dropped from 1027 mbar to 1011 mbar over the course of the day, but the wind and seas remained reasonable. Line 27, an isochron line designed to coincide with the planned off-axis OBH refraction line was begun at 2358Z (JD002) and completed at 1523Z. We also completed Line 28 across the axis and Line 29, just axisward of the major rift valley fault were also completed during the day.

01/04 JD004 (Friday) – Continued the MCS program in segment S1. Completed across-axis lines 30, 31 and 33 (along with the short, connecting axis-parallel Line 30a) and Line 32 along the top of the main rift-bounding fault to the north of the axis.

01/05 JD005 (Saturday) – Continued the MCS program in segment S1 as the weather continued to hold. Completed across-axis lines 34, 36 and 37 (with short connecting Lines 33a and 36a) and axis-parallel line 35 located about 20 km from the axis on the north flank.

01/06 JD006 (Sunday) – We finished up the MCS program with Line 38 which continues Line 32 along the top of the rift-bounding fault through the rest of the segment. Line 38 was finished at 0758Z and we began to pull in the guns and streamer. The guns were aboard by ~0930 and the streamer by ~1300Z. We then transited to the first on-axis OBH site and began deployment of the first OBH (#20). It was in the water at 1539Z and deployment of the rest of the OBHs continued through the rest of the day as the barometer fell steadily from 1015 to 982 mbar. The last OBH was in the water at 2009.We then transited to the beginning of the line.

01/07 JD007 (Monday) – Gun deployment for OBH line 5 began at ~0100Z and shooting began at 0408Z. Shooting continued in steadily deteriorating weather and sea conditions until 0640Z, when it was necessary to suspend operations. All guns were in by 0748, we then turned into the wind at ~ 1 knot. We remained in that mode for the rest of the day as the barometer continued to drop, reaching 972 mbar by the end of the day.

01/08 JD008 (Tuesday) – We remained hunkered down steaming slowly into the wind waiting for conditions to improve.

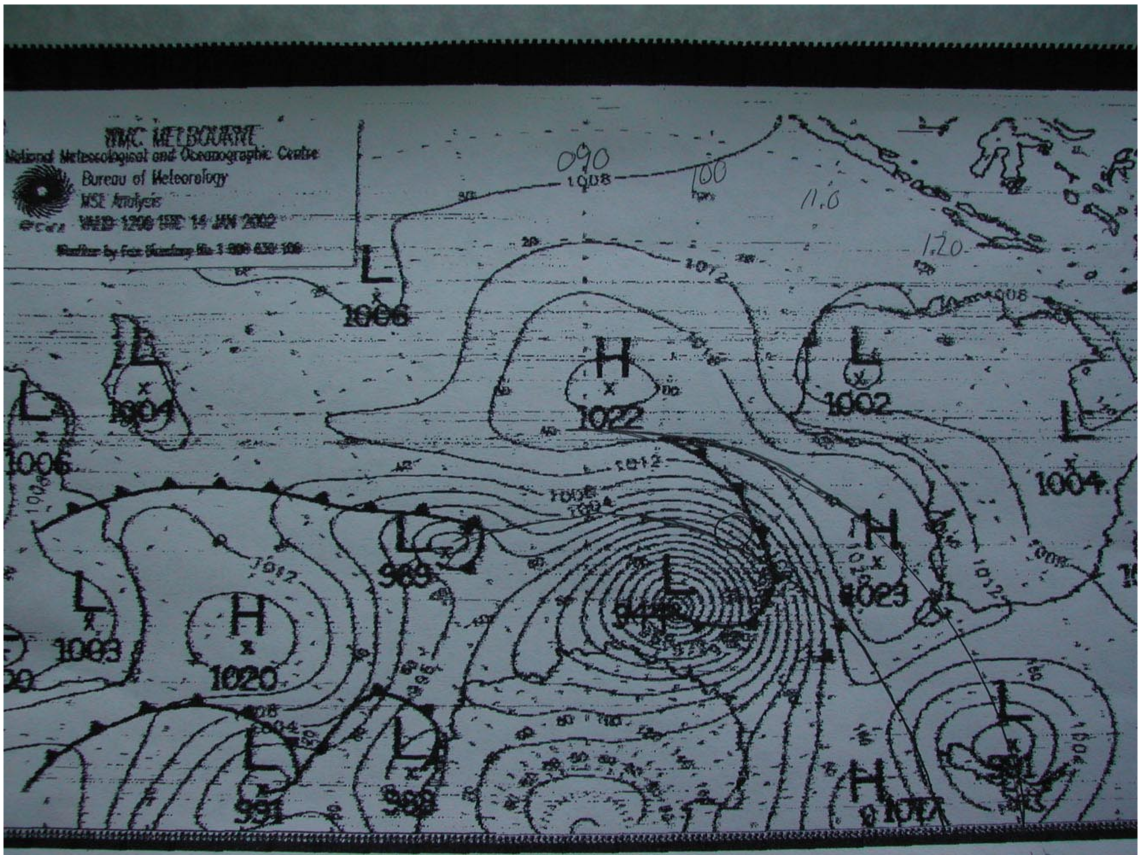
01/09 JD009 (Wednesday) – Yesterday's summary continued to apply for most of the day. By 2100Z conditions had improved to the extent that we proceeded to a point 10 miles downwind from where we broke off the OBH line and began to deploy the guns.

01/10 JD010 (Thursday) – Gun deployment was complete at about 0110Z. We got onto the OBH line and first shot for OBH line 5a was at 0212Z. We continued shooting the refraction line through the day with last shot at 1412Z. The guns were aboard at ~1700. We then proceed back down the line of OBHs, shooting the short ranging lines and recovering the OBHs. OBH20 was on board at 2222Z.

01/11 JD011 (Friday) – We continued recover the OBHs in deteriorating weather. OBH16 was aboard at 00201. However after shooting the crossing line on OBH25 at about 0400Z, it was decided that conditions were too dangerous to attempt to recover it We did go to the site of OBH 20 and shot the ranging line across it in order to be sure it was done before the batteries gave out. We then turned into the wind to wait out the weather. Adding to the frustration was the fact that this was not even a real storm. The sky was clear and the sun was shining; it is simply that the winds were blowing at 30-40 knots. There were a pod of whales around the ship though.

01/12 JD012 (Saturday) – By about 1100Z (1500 local), conditions had improved to the point where we could recover the two OBHs. OBH25 was on board at 1314 and OBH20 at 1527. As a result of the time lost during OBH line 5, a decision was made to forego planned OBH6, the off-axis line in segment S1, and to proceed directly to segment T, our deep axial valley end member segment. The 180 mile transit was begun immediately after OBH20 was secured. Reading of the data from OBH 27 showed a problem with the hydrophone leading to a greatly reduced signal strength. The other three OBHs gave good quality data

01/13 JD013 (Sunday) – We continued the transit to segment T, arriving at the first OBH site for the axial line at ~0730Z. We deployed OBH 20 at 0746Z and proceeded down the rift valley axis deploying the other OBHs in deteriorating weather. The final OBH (#27) was deployed at 1154Z. By this time the wind was at 40-50 knots and we had to suspend work.



01/14 JD014 (Monday) – We remained hunkered down steaming slowly into the wind waiting for conditions to improve.

01/15 JD015 (Tuesday) – We continued to wait out the weather for practically the entire day. The winds began to drop during the night and at ~2230Z (0630 on 1/16 local) we got underway to shoot the crossing lines (which only use 1 gun) while waiting for the seas to drop sufficiently to put out the entire gun array.

01/16 JD016 (Wednesday) – We worked our way from west to east down the line of OBHs shooting the crossing lines. The last ranging line was completed at 0804Z. We then proceeded to a point 10 miles beyond the eastern end of the line and turned back to the west to deploy the guns. The guns were in the water at ~1230Z and the first shot was at 1237Z. We proceeded down the line passing over OBH27 at 1507 (shot 76) and OBH 16 at 1959 (shot 222). The wind then picked very quickly to near 40 knots and the line was abandoned at 2051 (shot 248). During the gun retrieval, an unusually large wave hit the starboard boom while it was being swung in and the teeth on the gear to swing it were sheared off. The boom was then brought in by hand and secured. It was however quite out of service. The guns were all aboard by 2230Z.

01/17 JD017 (Thursday) – By the time the guns were aboard, the wind speed had dropped back to the upper 20s. We circled back to above where we had suspended the line, waited for a few hours to gauge what the weather was doing and began to deploy the remaining 12 available guns at about 0600Z. The remaining array provided 4790 cu. in. of air. The first shot on OBH line 6a was at 0759Z. We passed over OBH25 at 1040Z (shot 82). At about that time, a massive six gun tangle developed on the port boom. Gun 13, a large 850 cu. in. gun was returned to service at 1212Z, but the others were gone for the duration as the gunners struggled to untangle them. That left us with only 3265 cu. in. for the rest of the line. We passed over OBH20 at 1240Z (shot 141) and last shot on the line (shot 258) was at 1632Z. The guns were aboard at 1830 and we returned to retrieve the OBHs.

01/18 JD018 (Friday) – Collecting the OBHs was a relatively quick procedure since we did not need to run the ranging lines. The first OBH (OBH 20) was aboard at 2211Z (JD017), and the final OBH (OBH27) was on board at 0519Z. We then started toward the first off-axis OBH deployment site. However, Joe expressed concern about the sea state and the beating that the guns had taken and said that he was unwilling to put the guns back into the water unless conditions improved markedly. That decision combined with a worry about coming too close to the departure time with OBHs still in the water signaled the end of our seismic program. A decision was made to spend the remaining time in a Hydrosweep, gravity and magnetics survey of unmapped Segment U. We laid out a track to run lines at 8 km spacings extending 50 km from the axis on both flanks. We changed course at 0730Z and started east toward the beginning of the first line. Line 1 was begun at 1330Z. Completed Line 1 at 2006 and started line 2 at2035.

01/19 JD019 (Saturday) – We continued running the Segment U Hydrosweep survey completing lines 2 ,3, 4 and most of line 5.

01/20 JD020 (Sunday) – We continued running the Segment U Hydrosweep survey completing lines 5 and 6. At 0800, we ended the survey and headed for Hobart.

OBH Operations

Six seismic refraction experiments were completed, using four instruments on each deployment. For each refraction line, the four OBHs were deployed 15-20 km apart along the length of the segment. The Ewing's 20-gun 8480 in^3 array was used for the refraction lines with a 120-second (~300 m) shot interval. The guns were deployed at a depth of 8 m. The gun array is shown on the setback and offset diagram (Fig. 5). The refraction lines were run east-to-west (into the wind) to lessen gun tangling. The lines began 30 km east of the first OBH and continued 30 km past the final OBH.

Prior to OBH retrieval a short (~3.5 km) cross line over each OBH was shot with a single 385 in^3 gun to aid in relocation of the OBH. The cross lines were shot with a 60 sec shot interval with the exception of the first line (OBH 20 on OBH line 1) which had a 120 sec shot interval.

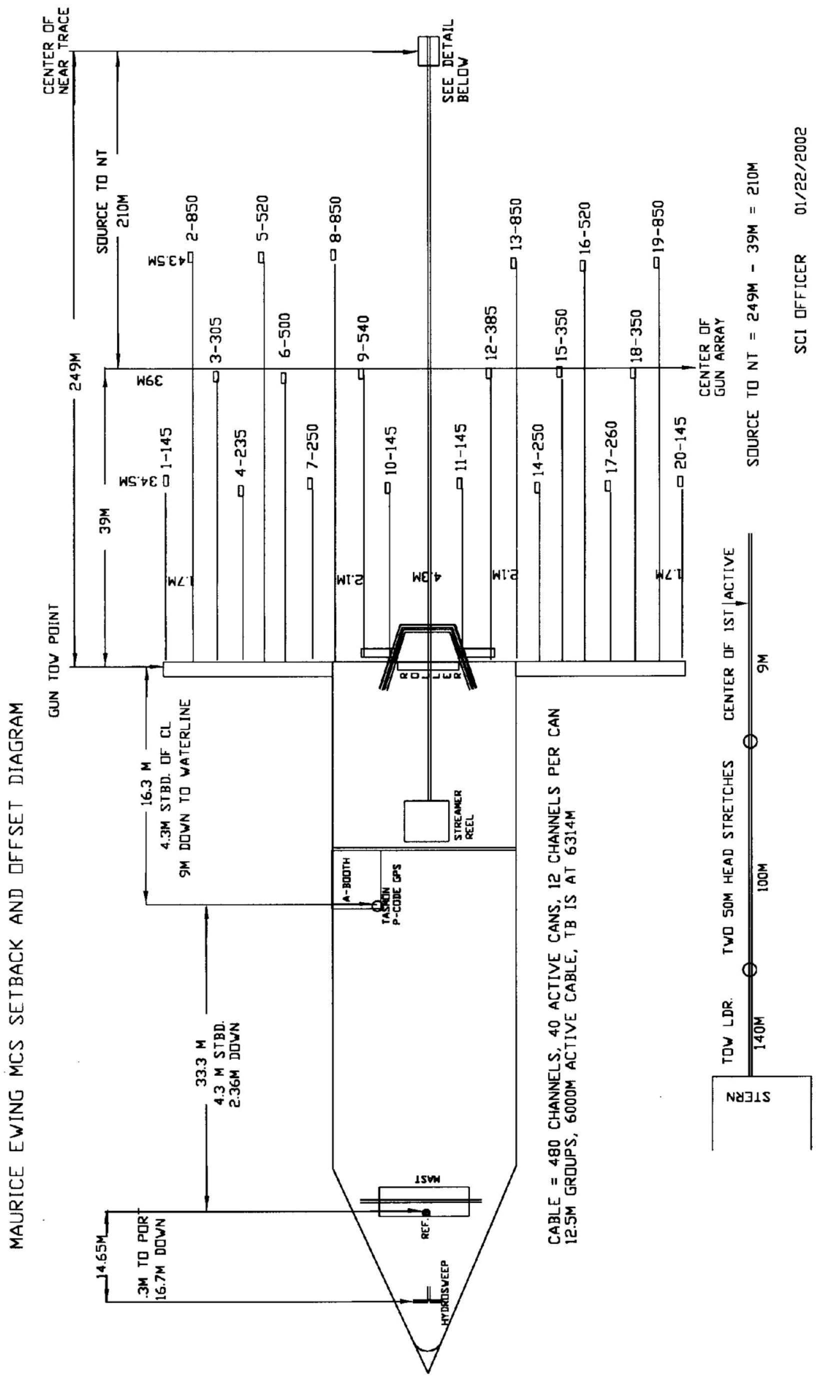
Deployments 1 and 2 were carried out in Segment P1, characterized by an "EPR-like" axial high. The first seismic refraction line (SEIR01) was shot along the ridge axis and the second line (SEIR02) was shot along an isochron 20 km (~525 ka) south of the axis. The same strategy was applied in Segment P2, characterized by a low, rifted axial high. Refraction line SEIR03 was run along the axis and SEIR04 along the 525 ka isochron 20 km south of the axis. In Segments S1 and T, weather prohibited the off-axis lines from being run and only the on-axis lines (SEIR05 in Segment S1 and SEIR06 in Segment T) were obtained.

Tables 1-6 give the give the details for each of the six OBH lines and Figures 6-9 give shot-point maps for each of the four segments in which refraction experiments were carried out. The color scale used in Figs. 6-9 is the same as in Fig. 4. The OBH frame and electronics configuration and clock corrections are documented in Tables 7-9.

There are two occurrences that need to be kept in mind during interpretation of seismic line SEIR04. The first is that at Shot 58 we needed to turn into wind (about 20° from the line) so the gunners could go out on the boom to deal with a bad tangle of guns 1 and 2. The two guns were back in the water for shot 65. We then turned back toward the line. We did not do a loop to pick up the line where we turned off of it for fear of worse tangling as the wind came behind us. We were back on the track for shot 82, 5.3 km from where we left it. At 1941Z (shot 288), the Spectra program crashed, bringing shooting to a halt. Richard rebooted it and shooting resumed at 2025Z with a 5.3 km gap in shots. The program also restarted the recorded shot numbers at 1. Again we did not do a loop for fear of massive gun tangling. The line was finished without further incident

Lines SEIR05 and SEIR06 were each shot in two parts because weather forced a suspension of operations during shooting. During gun retrieval when line SEIR06 was broken off, an exceptionally large wave hit the starboard boom while it was being swung in shearing off gear teeth, effectively putting the boom out of commission. The boom was then brought in by hand and secured. When the line was resumed it was with a partial gun array. In addition there was considerable trouble with gun tangling due to the heavy seas during the remainder of the line, so different combinations of guns were available throughout the line. The total volume varied from 2210 in^3 to 4540 in^3 during the second half of the line. Details are given in the experiment summary (Table 6).

Representative on- and off-axis record sections constructed on-board are shown in Figures 10 -13. Figure 10 shows a record section from line SEIR01 along the axis in Segment P1 The sudden decrease in the amplitude of the arrivals at a distance of 12-15 km reflects the presence of an axial magma chamber beneath this inflated "EPR-like" segment. High-amplitude arrivals are found out to a much greater distance on line SEIR05 (Figure 11), run along the axis in Segment S1, which is characterized by a shallow 500-800 m deep axial valley. Figure 12 shows a record section from the off-axis line, SEIR02, in Segment P1. PmP arrivals can be observed on the western limb (negative distances) with a triplication at a distance of over thirty km, reflecting reasonably thick crust. Figure 13 shows a record section from Segment T. Because of the miserable weather and reduced gun array, high amplitude arrivals can not be observed for as great a distance as at other lines. Even so, PmP arrivals can be seen in Figure 13. The fact that the PmP phase occurs much sooner at Segment T than at Segment P1 (Figure 11) implies a much thinner crust in Segment T, which is the segment nearest the AAD and is characterized by a deep (>1200 m) axial rift valley.



MAURICE EWING MCS SETBACK AND OFFSET DIAGRAM
GUN TOW POINT
CENTER OF NEAR TRACE
SEE DETAIL BELOW
SOURCE TO NT 210M
249M
39M
CENTER OF GUN ARRAY
16.3 M
4.3M STBD. OF CL
9M DOWN TO WATERLINE
33.3 M
4.3 M STBD.
2.36M DOWN
14.65M
.3M TO POR
16.7M DOWN
A-BOOTH
TASMAN P-CODE GPS
STREAMER REEL
MAST
REF.
HYDROSWEEP
CABLE = 480 CHANNELS, 40 ACTIVE CANS, 12 CHANNELS PER CAN
12.5M GROUPS, 6000M ACTIVE CABLE, TB IS AT 6314M
STERN
TOW LDR.
TWO 50M HEAD STRETCHES
CENTER OF 1ST ACTIVE
140M
100M
9M
SOURCE TO NT = 249M - 39M = 210M
SCI OFFICER 01/22/2002

Figure 5

Table 1: SEIR01 Refraction Experiment Summary

(12/11/2001z (345) - 12/13/2001z (347))

OBH	EID	Drop Location	Water/OBH Depth(m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Date/Time	# of Tracks
First Shot					0001	12/12 08:07:34.609	
27	27	47° 30.596′S 101° 03.296′E	2639.9/2635	12/12 0225z / 12/13 1251z	0109	12/12 11:35:34.609	50
16	16	47° 24.612′S 100° 50.337′E	2480.8/2476	12/12 0058z / 12/13 0926z	0181	12/12 13:59:34.609	40
25	25	47° 20.002′S 100° 40.263′E	2480.7/2476	12/11 2343z / 12/13 0554z	0238	12/12 15:53:34.609	35
20	20	47° 13.996′S 100° 28.180′E	2699.9/2695	12/11 2208z / 12/13 0212z	0308	12/12 18:13:34.609	30
Last Shot					0384	12/12 20:45:34.609	
OBH 20 Ranging, first shot					0388=0001	12/12 23:48:21.130	
last shot					0468=0081	12/13 02:28:21.130	
OBH 25 Ranging, first shot					0001	12/13 03:27:19.153	
					0002	12/13 03:36:17.154	
last shot					0025	12/13 04:22:17.154	
OBH 16 Ranging, first shot					0001	12/13 07:13:59.176	
last shot					0018	12/13 07:47:59.176	
OBH 27 Ranging, first shot					0001	12/13 10:43:54.195	
last shot					0022	12/13 11:25:54.195	

Fixes are from Tasmon GPS receiver which is located 55.3m forward of the center of the gun array.

The OBH depth is the water depth rounded to the nearest meter minus 5m for the approximate height of the hydrophone above the seafloor.

The OBHs were programmed to turn on at 0700z on 12/12/2001.

Source: 20-gun, 8445 cu. in. airgun array, 120s. firing rate. For ranging shots, single gun #12 at 385 cu. in. was used. The guns were towed at ~8m depth.

Table 2: SEIR02 Refraction Experiment Summary

(12/13/2001z (347) - 12/15/2001z (349))

OBH	EID	Drop Location	Water/OBH Depth(m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Date/Time	# of Tracks
First Shot					0001	12/14 03:51:47.290	
					0004	12/14 03:52:17.290	
27	20	47° 40.321′S 100° 54.747′E	2888.3/2883	12/13 2128z / 12/15 0839z	0130	12/14 08:04:17.290	44
16	23	47° 32.977′S 100° 40.456′E	2870.4/2865	12/13 1950z / 12/15 0448z	0209	12/14 10:42:17.290	39
25	25	47° 27.961′S 100° 30.033′E	2812.9/2808	12/13 1821z / 12/15 0100z	0263	12/14 12:30:17.290	33
20	19	47° 22.538′S 100° 19.170′E	2905.5/2901	12/13 1640z / 12/14 2144z	0322	12/14 14:28:17.290	29
Last Shot					0390	12/14 16:44:17.290	
OBH 20 Ranging, first shot					0001	12/14 19:30:15.000	
last shot					0041	12/14 20:10:15.000	
OBH 25 Ranging, first shot					0001	12/14 22:53:09.399	
last shot					0036	12/14 23:28:09.399	
OBH 16 Ranging, first shot					0001	12/15 02:31:26.420	
last shot					0046	12/15 03:16:26.420	
OBH 27 Ranging, first shot					0001	12/15 06:28:04.443	
last shot					0037	12/15 07:04:04.443	

Fixes are from Tasmon GPS receiver which is located 55.3m forward of the center of the gun array.

The OBH depth is the water depth rounded to the nearest meter minus 5m for the approximate height of the hydrophone above the seafloor.

The OBHs were programmed to turn on at 0400z on 12/14/2001.

Source: 20-gun, 8445 cu. in. airgun array, 120s. firing rate. Guns were towed at ~8m depth. For ranging shots, single gun #12 at 385 cu. in. was used. The firing rate was 60s.

Table 3: SEIR03 Refraction Experiment Summary

(12/15/2001z (349) - 12/17/2001z (351))

OBH	EID	Drop Location	Water/OBH Depth(m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Date/Time	# of Tracks
First Shot					0001	12/15 21:08:01.000	
27	27	47° 54.971′S 102° 13.479′E	3006.5/3002	12/15 1634z / 12/17 0429z	0134	12/16 01:34:01.000	51
16	19	47° 48.700′S 101° 58.487′E	2832.3/2827	12/15 1449z / 12/17 0050z	0212	12/16 04:10:01.000	45
25	25	47° 44.001′S 101° 46.490′E	2732.4/2727	12/15 1317z / 12/16 2135z	0276	12/16 06:18:01.000	41
20	23	47° 38.144′S 101° 32.488′E	2821.6/2817	12/15 1132z / 12/16 1803z	0346	12/16 08:38:01.000	37
Last Shot					0450	12/16 12:06:01.000	
OBH 20 Ranging, first shot					0001	12/16 15:30:59.000	
last shot					0046	12/16 16:15:59.000	
OBH 25 Ranging, first shot					0001	12/16 19:33:25.000	
last shot					0045	12/16 20:17:25.000	
OBH 16 Ranging, first shot					0002	12/16 22:56:17.675	
last shot					0036	12/16 23:30:17.675	
OBH 27 Ranging, first shot					0001	12/17 02:11:39.693	
					0002	12/17 02:11:49.693	
					0003	12/17 02:11:59.693	
					0001=0004	12/17 02:12:53.000	
last shot					0049=0052	12/17 03:00:53.000	

Fixes are from Tasmon GPS receiver which is located 55.3m forward of the center of the gun array.

The OBH depth is the water depth rounded to the nearest meter minus 5m for the approximate height of the hydrophone above the seafloor.

The OBHs were programmed to turn on at 1800z on 12/15/2001.

Source: 20-gun, 8445 cu. in. airgun array, 120s. firing rate. Guns were towed at ~8m depth.
For ranging shots, single gun #12 at 385 cu. in. was used. The firing rate was 60s.

Table 4: SEIR04 Refraction Experiment Summary

(12/17/2001z (351) - 12/20/2001z (354))

OBH	EID	Drop Location	Water/OBH Depth(m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Date/Time	# of Tracks
First Shot					0001	12/18 10:07:29.883	
27	23	48° 03.695′S 102° 04.499′E	2920.2/2915	12/17 1421z / 12/20 0811z	0109	12/18 13:43:29.883	96
16	19	47° 58.655′S 101° 50.578′E	2940.3/2935	12/17 1232z / 12/20 1043z	0181	12/18 16:07:29.883	101
25	25	47° 53.675′S 101° 36.973′E	2905.3/2900	12/17 1045z / 12/20 1306z	0255	12/18 18:35:29.883	104
					0288	12/18 19:41:29.883	
					0001=0289	12/18 20:25:08.945	
20	20	47° 49.985′S 101° 26.947′E	2981.4/2976	12/17 0903z / 12/20 1519z	4=292	12/18 20:31:08.945	106
Last Shot					0414	12/19 00:35:08.945	
OBH 20 Ranging, first shot					0001	12/19 22:54:52.100	
					0001=0006	12/19 22:59:52.100	
last shot					0102=0107	12/20 00:40:52.100	
OBH 25 Ranging, first shot					0001	12/20 01:29:30.115	
last shot					0052	12/20 02:20:30.115	
OBH 16 Ranging, first shot					0001	12/20 03:45:42.128	
last shot					0048	12/20 04:32:42.128	
OBH 27 Ranging, first shot					0001	12/20 05:55:55.140	
last shot					0049	12/20 06:43:55.140	

Fixes are from Tasmon GPS receiver which is located 55.3m forward of the center of the gun array.

The OBH depth is the water depth rounded to the nearest meter minus 5m for the approximate height of the hydrophone above the seafloor.

The OBHs were programmed to turn on at 1400z on 12/17/2001.

Source: 20-gun, 8445 cu. in. airgun array, 120s. firing rate. Guns were towed at ~8m depth.
For ranging shots, single gun #12 at 385 cu. in. was used. The firing rate was 60s.

Table 5: SEIR05 Refraction Experiment Summary

(1/6/2002z (006) - 1/12/2002z (012))

OBH	EID	Drop Location	Water/OBH Depth(m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Date/Time	# of Tracks
First Shot, Line 5					0001	01/07 04:08:02.105	
Last Shot, Line 5					0077	01/07 06:40:02.236	
First Shot, Line 5A					0001=0078	01/10 02:12:13.358	
27	27	49° 28.988′S 109° 19.993′E	3232.1/3227	01/06 2010z / 01/10 2219z	066=143	01/10 04:22:13.358	135
16	19	49° 32.986′S 109° 32.677′E	3273.2/3268	01/06 1848z / 01/11 0158z	129=206	01/10 06:28:13.358	139
25	25	49° 37.495′S 109° 47.031′E	3437.3/3432	01/06 1711z / 01/12 1300z	197=274	01/10 08:44:13.358	189
20	20	49° 41.418′S 110° 00.192′E	3271.0/3266	01/06 1539z / 01/12 1527z	256=333	01/10 10:42:13.358	192
Last Shot, Line 5A					0361=0438	01/10 14:12:13.358	
OBH 27 Ranging, first shot					0001	01/10 19:46:29.010	
last shot					0034	01/10 20:19:29.010	
OBH 16 Ranging, first shot					0001	01/10 23:51:31.489	
last shot					0034	01/11 00:24:31.487	
OBH 25 Ranging, first shot					0001	01/11 03:30:39.010	
last shot					0028	01/11 03:57:39.010	
OBH 20 Ranging, first shot					0001	01/11 07:49:01.533	
last shot					0023	01/11 08:11:01.537	

Fixes are from Tasmon GPS receiver which is located 55.3m forward of the center of the gun array.

The OBH depth is the water depth rounded to the nearest meter minus 5m for the approximate height of the hydrophone above the seafloor.

The OBHs were programmed to turn on at 0100z on 01/07/2002.

Source: 20-gun, 8445 cu. in. airgun array, 120s. firing rate. Guns were towed at ~8m depth.
For ranging shots, single gun #12 at 385 cu. in. was used. The firing rate was 60s.

Table 6: SEIR06 Refraction Experiment Summary

(1/13/2002z (013) - 1/18/2002z (018))

OBH	EID	Drop Location	Water/OBH Depth(m)	Deployment/Recovery Time	Nearest Approach Shot #	Nearest Approach Date/Time	# of Tracks
OBH 20 Ranging, first shot					0001	01/16 01:56:35.235	
last shot					0041	01/16 02:36:35.235	
OBH 25 Ranging, first shot					0001	01/16 03:54:47.829	
last shot					0037	01/16 04:30:47.829	
OBH 16 Ranging, first shot					0001	01/16 05:51:06.841	
last shot					0039	01/16 06:29:06.841	
OBH 27 Ranging, first shot					0001	01/16 07:33:41.851	
last shot					0032	01/16 08:04:41.851	
First Shot, Line 6					0001	01/16 12:36:51.881	
27	27	50° 01.297′S 115° 15.257′E	4167.9/4163	01/13 1154z / 01/18 0517z	0157	01/16 17:48:51.881	158
16	19	49° 58.802′S 115° 02.975′E	4120.1/4115	01/13 1039z / 01/18 0258z	0222	01/16 19:58:51.881	156
Last Shot, Line 6					0248	01/16 20:50:51.881	
First Shot, Line 6A					0001=0249	01/17 07:58:43.996	
25	23	49° 55.274′S 114° 45.563′E	4273.6/4269	01/13 0909z / 01/18 0026z	082=330	01/17 10:40:43.996	154
20	20	49° 52.697′S 114° 33.668′E	4308.0/4303	01/13 0746z / 01/17 2210z	141=389	01/17 12:38:43.996	150
Last Shot, Line 6A					0258=0506	01/17 16:32:43.996	

Fixes are from Tasmon GPS receiver which is located 55.3m forward of the center of the gun array.

The OBH depth is the water depth rounded to the nearest meter minus 5m for the approximate height of the hydrophone above the seafloor.

The OBHs were programmed to turn on at 1500z on 01/13/2002.

Source: For ranging shots, single gun #12 at 385 cu. in. was used. The firing rate was 60s.

Line 7: 20-gun, 8445 cu. in. airgun array, 120s. firing rate. Guns were towed at ~8m depth.

Line 7A: Same firing rate and gun depth, however only stern guns and port boom was used at start (Guns #9-20, 4790 cu. in.).

Shots 249-329, 07:58z-10:38z, guns 9-20, 4790 cu. in.; shot 330, 10:40z,dropped gun #14, less than or equal to 4540 cu. in.; shots 341-346, 11:02z-11:12z, guns 9-13 and 19-20, 3060 cu. in.; shots 347-376, 11:14z-12:12z, guns 9-12 and 19-20, 2210 cu. in.; shots 377-506, 12:14z-16:32z, guns 9-13 and 19-20, 3060 cu. in.

Table 7: EW0114 OBH FRAME CONFIGURATION

Frame	9 kHz Release	11 kHz Release	Flasher #1	Flasher #2	Radio	Frequency	Hydrophone	Leads
16	14143	14156	18089	F03012	18051	160.725 (C)	GF-1 (M)	19BB
20	13653	22839	F03009	F03013	G04-001	159.480 (B)	GF-3 (B)	5MM
25	14734	14125	18110	F03008	18060	160.785 (D)	1135 (B)	22BB
27	14744	14159	18111	F03011	18046	160.725 (C)	001 (M)	37BM

For hydrophone leads:

BB is Burton to OBH, Burton to hydrophone.
BM is Burton to OBH, Mecca to hydrophone.
MM is Mecca to OBH, Mecca to hydrophone.

Notes:

1. 11 kHz release S/N 22839, on Frame #20 was replaced by S/N 14152 after SEIR01.
2. For Frame #27 on SEIR06, the hydrophone S/N 001 and leads 37BM were replaced by hydrophone GF-15 (M) and leads 33MB. The signal recorded on SEIR05 was very low.
3. For Frame #20 on SEIR06, the leads 5MM were replaced by 36BM. The replaced leads were too short to be comfortably routed on this frame.

Table 8: EW0114 OBH ELECTRONICS CONFIGURATION

EID	Track Count	Filter	HG GRA	LG GRA	P.S.I.	Tattle-tale	Disk	Kato	Piggy-back	Vectron Oscillator	WET
16	809	5	2	8	5	145	26841636G MK1926FCV	81620	14	143129 317Y1322	176
19	2132	4	13	9	6	82	38513629P MK2104MAV	116	07	1218029 317Y1322	238
20	809	15	26	5	4	168	56021926P MK1926FCV	76394	15	1431330 317Y1322	225
23	809	8	24	14	12	138	56021924P MK1926FCV	76395	10	1167160 318Y0467	177
25	2132	17	12	11	8	165	28R37378P MK2104MAV	118	12	1167161 318Y0467	203
27	809	2	21	28	10	167	26841613G MK1926FCV	81618	04	1167158 318Y0467	174

Notes:

EID is Electronics ID.
P.S.I. is Power Supply Interface.
Pre-amp gain is +20dB.
Filter cutoff freq./type is 80Hz DEK 6 Pole LP with a gain selection of 0.
High Gain GRA 0 (Channel 1) gain is 35dB, attenuation is 7dB, type DEK.
Low Gain GRA 1 (Channel 2) gain is 9dB, attenuation is 7dB, type DEK.
Power Supply Interface type is KRP May 1991 with jumper positions W1 and W2 both set to 'A'.
Piggyback Board type is KRP May 1991.
Program Version is 28 (1 Feb 2000).
Threshold A/D # is 16300, 0.122 volts, 49%.
Sample Rate is 200 samples/s.

Table 9: EW0114 OBH CLOCK CORRECTIONS

SEIR01

OBH	EID	Clock	Clock Check	Correction	Clock Check	Correction	Drift Rate
16	16	1431329	345:12:53:25	+0.058457	347:11:22:50	+0.077185	+1.118991E-07
20	20	1431330	345:10:15:36	-0.033051	347:03:57:59	-0.051112	-1.202920E-07
25	25	1167161	345:11:41:58	-0.004105	347:07:28:06	-0.008823	-2.994263E-08
27	27	1167158	345:13:47:50	-0.005948	347:18:38:02	-0.016273	-5.428154E-08

SEIR02

OBH	EID	Clock	Clock Check	Correction	Clock Check	Correction	Drift Rate
20	19	1218029	347:10:41:23	+0.005047	349:00:35:19	+0.005947	+6.596499E-09
27	20	1431330	347:15:16:23	-0.055944	349:11:14:14	-0.076210	-1.280462E-07
16	23	1167160	347:14:28:23	-0.027784	349:07:17:26	-0.038284	-7.145628E-08
25	25	1167161	347:16:12:15	-0.009800	349:03:38:48	-0.013580	-2.962545E-08

SEIR03

OBH	EID	Clock	Clock Check	Correction	Clock Check	Correction	Drift Rate
16	19	1218029	349:06:36:14	+0.005793	351:02:35:51	+0.007128	+8.429254E-09
20	23	1167160	349:09:36:17	-0.038902	350:20:08:38	-0.047929	-7.259874E-08
25	25	1167161	349:10:27:32	-0.014353	350:23:19:33	-0.018330	-2.996511E-08
27	27	1167158	348:22:22:40	-0.020330	351:07:46:18	-0.031635	-5.471450E-08

SEIR04

OBH	EID	Clock	Clock Check	Correction	Clock Check	Correction	Drift Rate
16	19	1218029	351:05:13:42	+0.007070	354:13:38:13	+0.008160	+3.765489E-09
20	20	1431330	350:19:11:01	-0.089534	354:17:35:02	-0.133782	-1.302021E-07
27	23	1167160	350:22:26:13	-0.048535	354:10:10:13	-0.070365	-7.241906E-08
25	25	1167161	351:01:43:33	-0.018597	354:16:07:33	-0.028127	-3.063915E-08

SEIR05

OBH	EID	Clock	Clock Check	Correction	Clock Check	Correction	Drift Rate
16	19	1218029	006:08:11:15	-0.000316	011:03:55:53	+0.000357	+1.615156E-09
20	20	1431330	006:07:43:07	-0.293771	013:00:33:15	-0.370339	-1.322400E-07
25	25	1167161	006:07:58:29	-0.072948	012:14:46:39	-0.088229	-2.814751E-08
27	27	1167158	006:08:27:12	-0.102922	011:00:17:17	-0.125988	-5.729189E-08

SEIR06

OBH	EID	Clock	Clock Check	Correction	Clock Check	Correction	Drift Rate
16	19	1218029	013:06:23:07	-0.001517	018:08:37:32	-0.002280	-1.733835E-09
20	20	1431330	013:04:34:18	-0.372178	018:01:15:00	-0.427364	-1.313821E-07
25	23	1167160	013:05:42:31	-0.209737	018:06:52:00	-0.240049	-6.949600E-08
27	27	1167158	013:06:04:06	-0.134462	018:10:43:32	-0.160827	-5.874999E-08

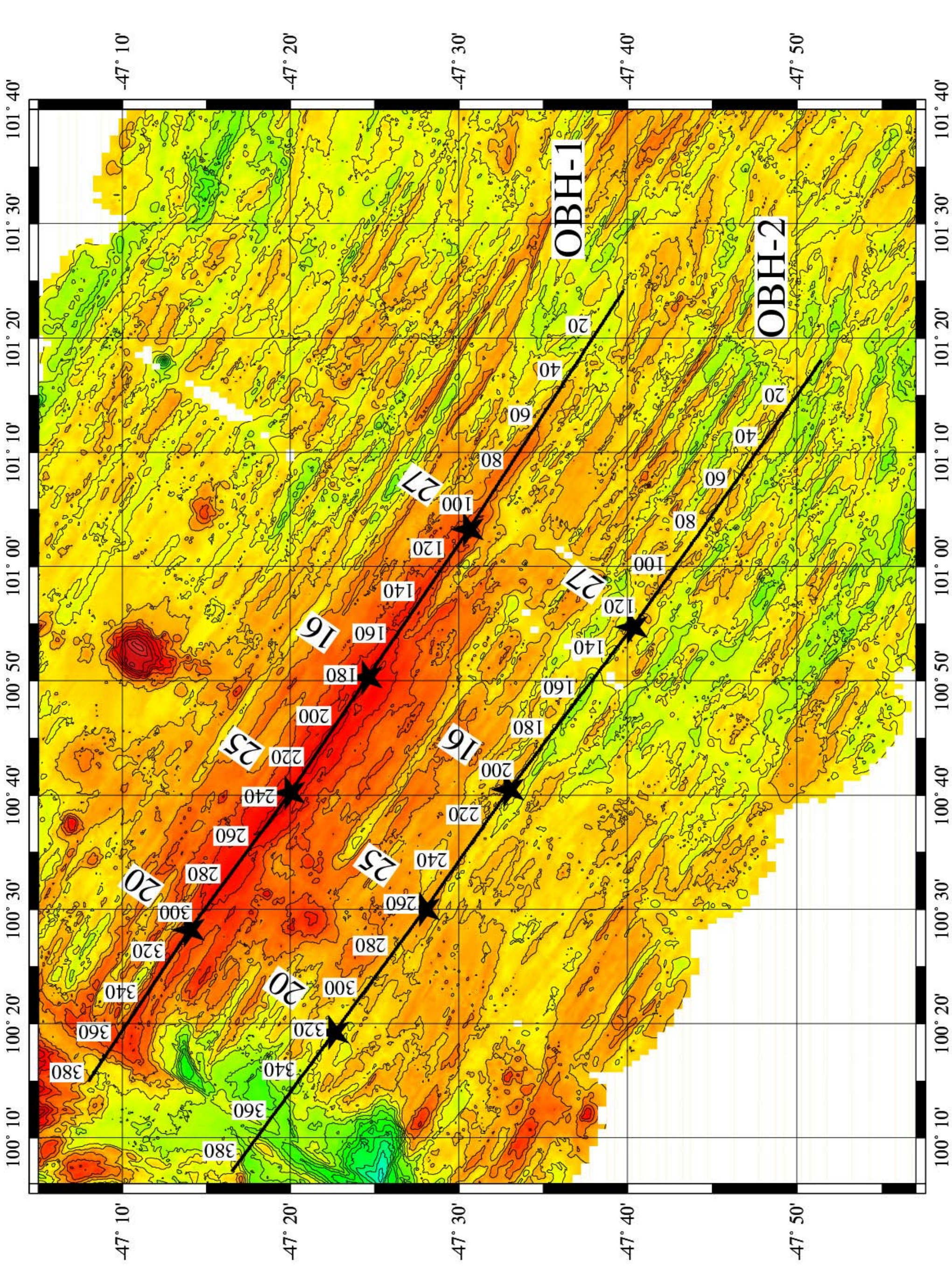

OBH-1
OBH-2
-47° 10'
-47° 20'
-47° 30'
-47° 40'
-47° 50'
100° 10'
100° 20'
100° 30'
100° 40'
100° 50'
101° 00'
101° 10'
101° 20'
101° 30'
101° 40'
27
16
25
20

Figure6

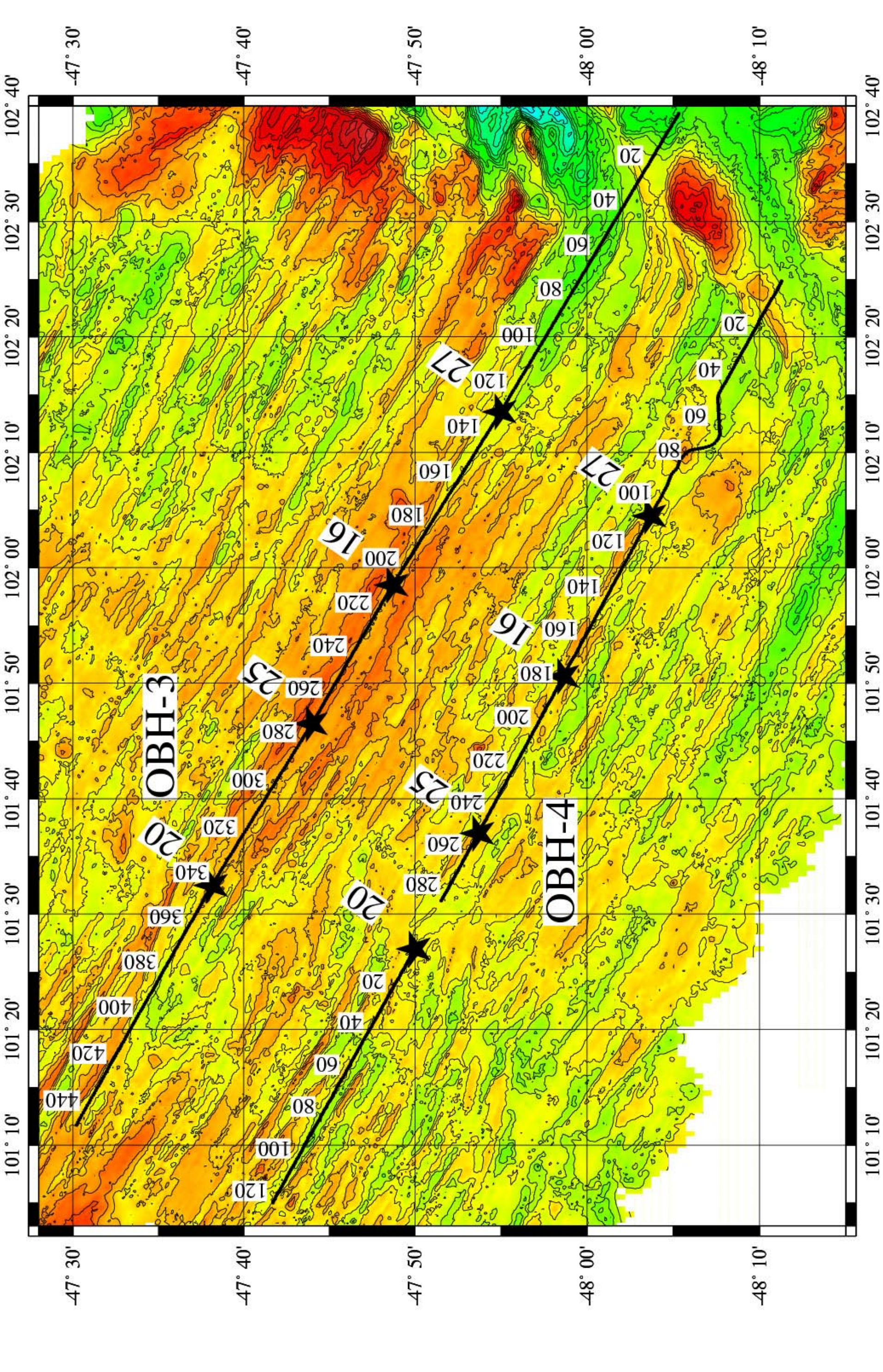

-47° 30'
-47° 40'
-47° 50'
-48° 00'
-48° 10'
101° 10'
101° 20'
101° 30'
101° 40'
101° 50'
102° 00'
102° 10'
102° 20'
102° 30'
102° 40'
OBH-3
OBH-4

Figure 7

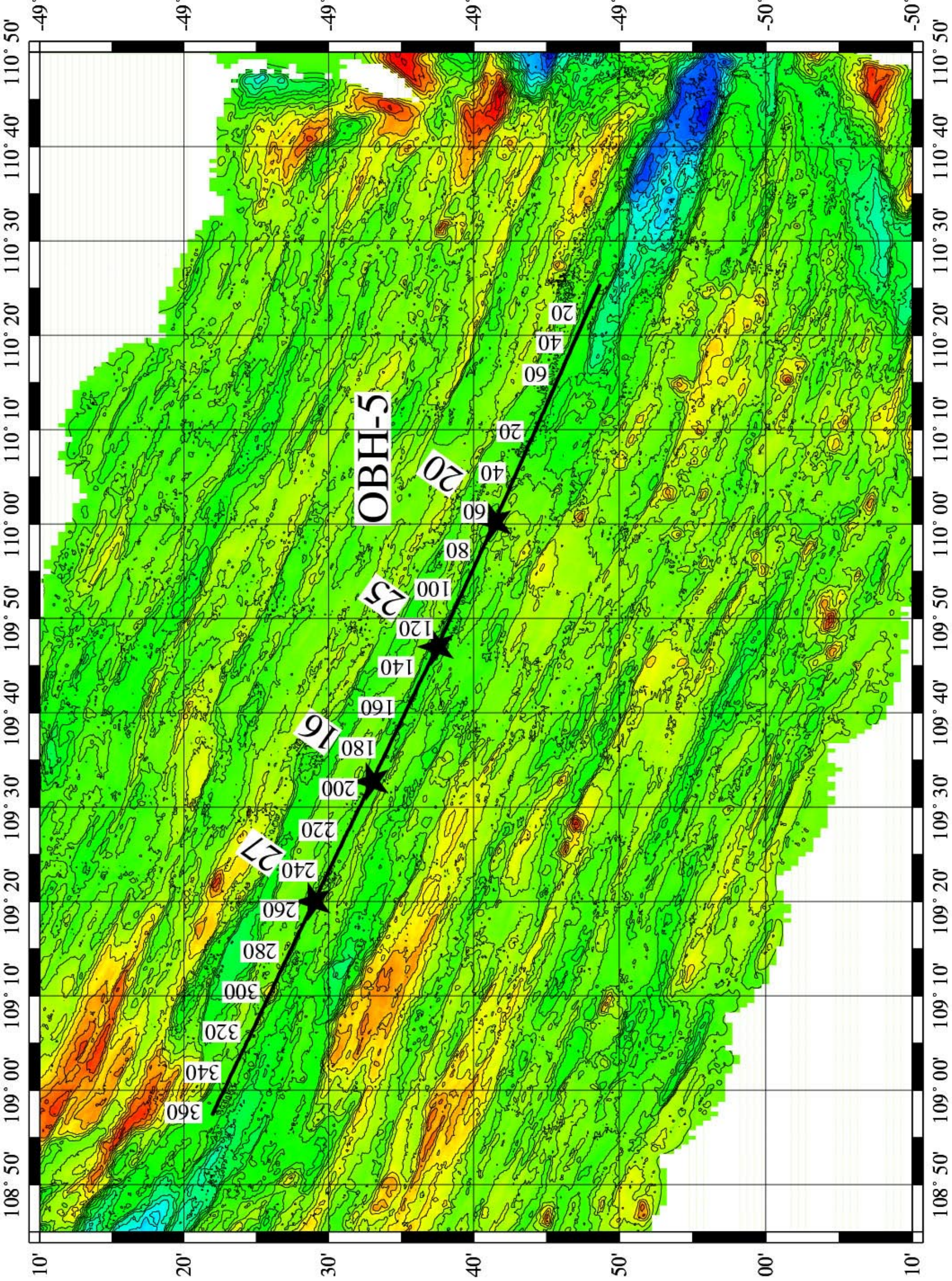

OBH-5
20
25
16
27
-49° 10'
-49° 20'
-49° 30'
-49° 40'
-49° 50'
-50° 00'
-50° 10'
108° 50'
109° 00'
109° 10'
109° 20'
109° 30'
109° 40'
109° 50'
110° 00'
110° 10'
110° 20'
110° 30'
110° 40'
110° 50'

Figure 8

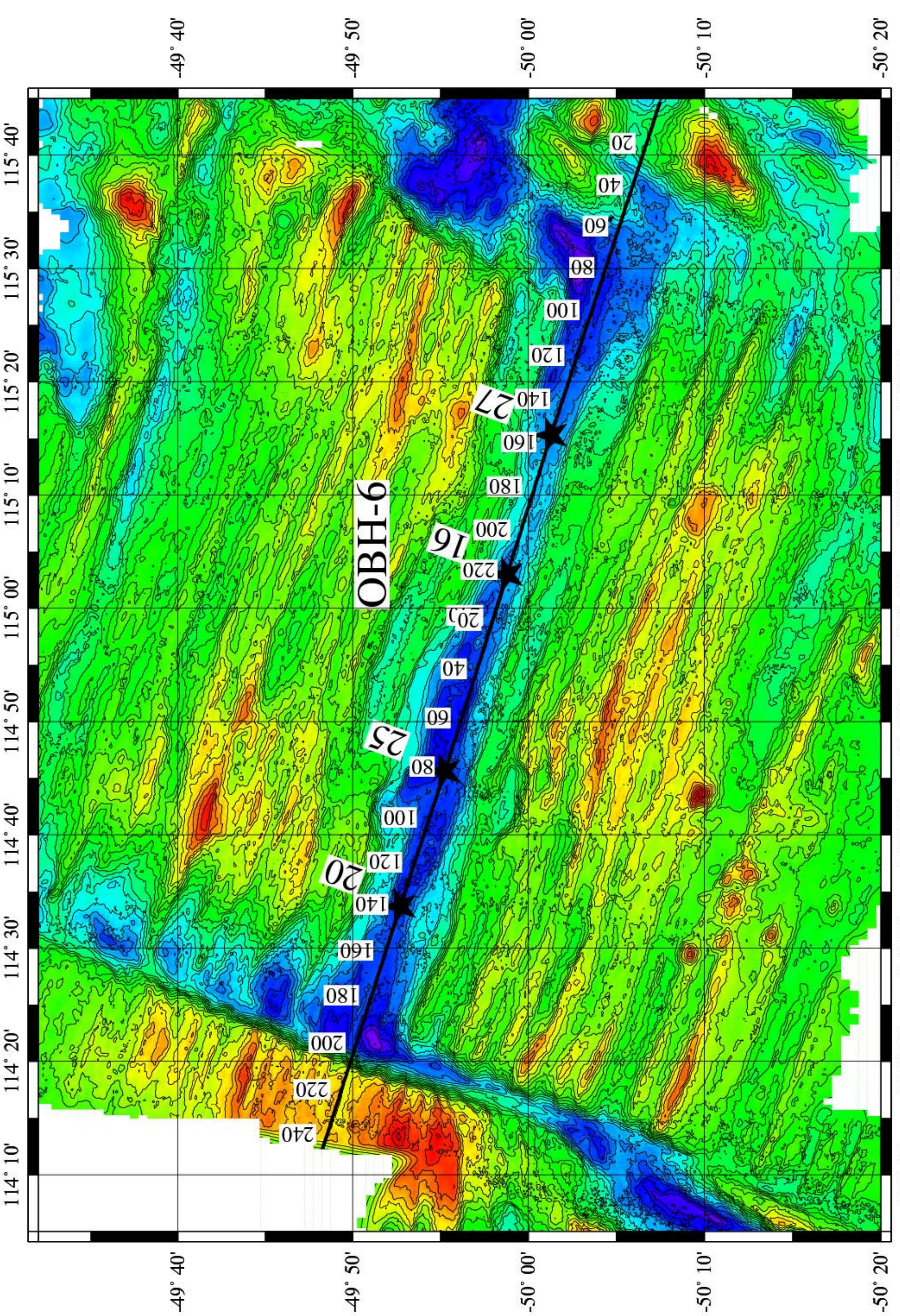

OBH-6
27
16
25
20
-49° 40'
-49° 50'
-50° 00'
-50° 10'
-50° 20'
114° 10'
114° 20'
114° 30'
114° 40'
114° 50'
115° 00'
115° 10'
115° 20'
115° 30'
115° 40'

Figure 9

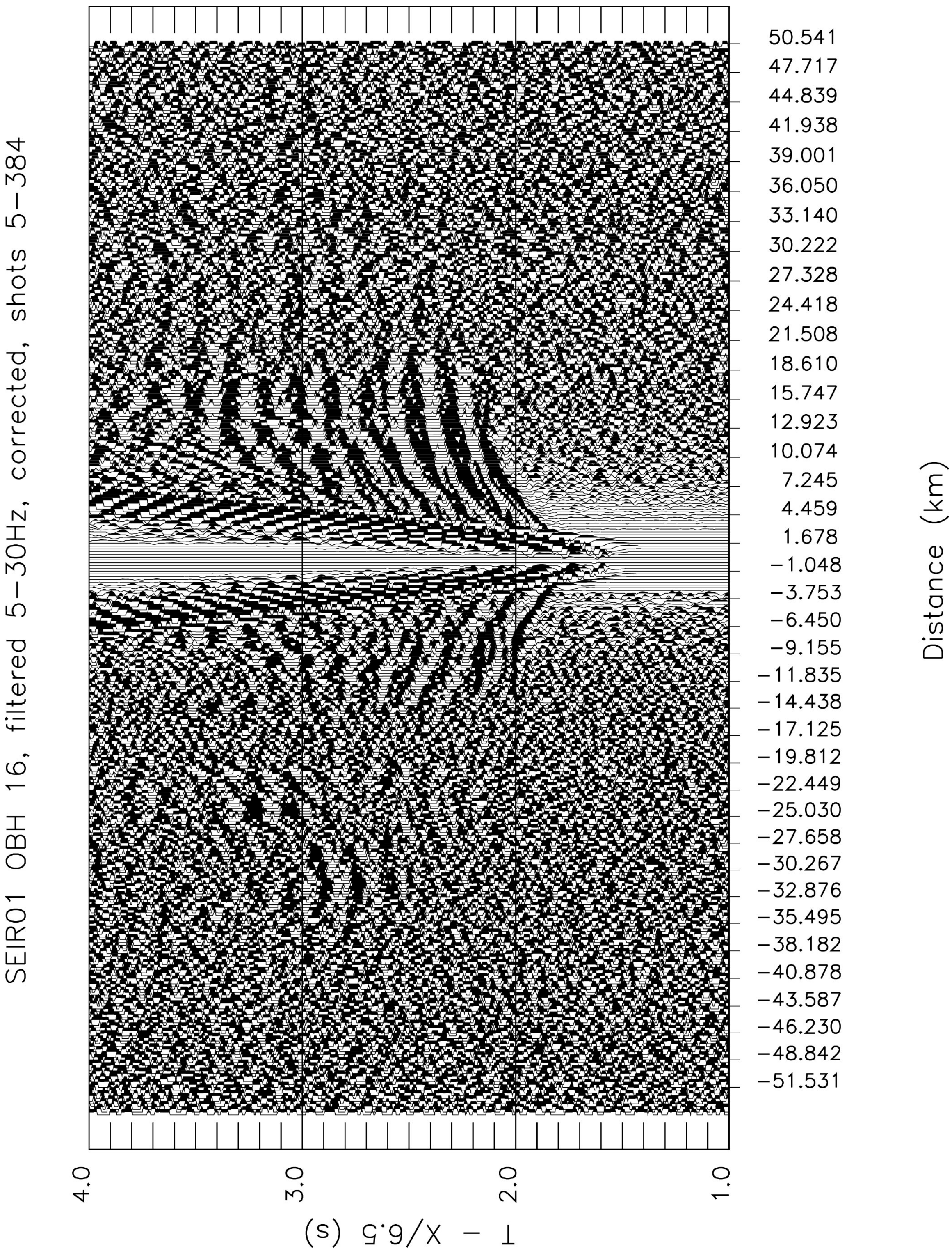

SEIR01 OBH 16, filtered 5−30Hz, corrected, shots 5−384
Distance (km)
50.541
47.717
44.839
41.938
39.001
36.050
33.140
30.222
27.328
24.418
21.508
18.610
15.747
12.923
10.074
7.245
4.459
1.678
−1.048
−3.753
−6.450
−9.155
−11.835
−14.438
−17.125
−19.812
−22.449
−25.030
−27.658
−30.267
−32.876
−35.495
−38.182
−40.878
−43.587
−46.230
−48.842
−51.531
T − X/6.5 (s)
4.0
3.0
2.0
1.0

Figure 10

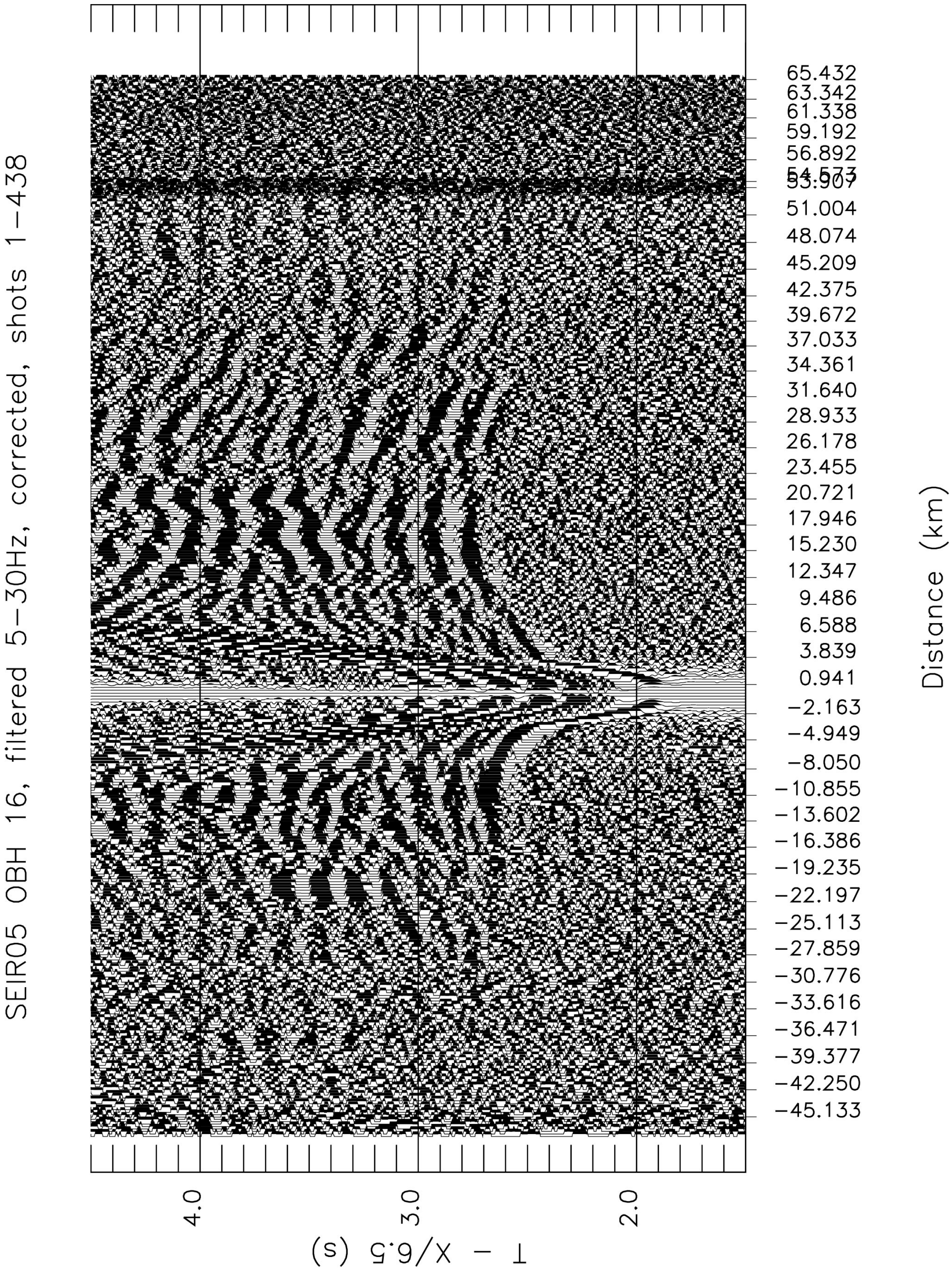
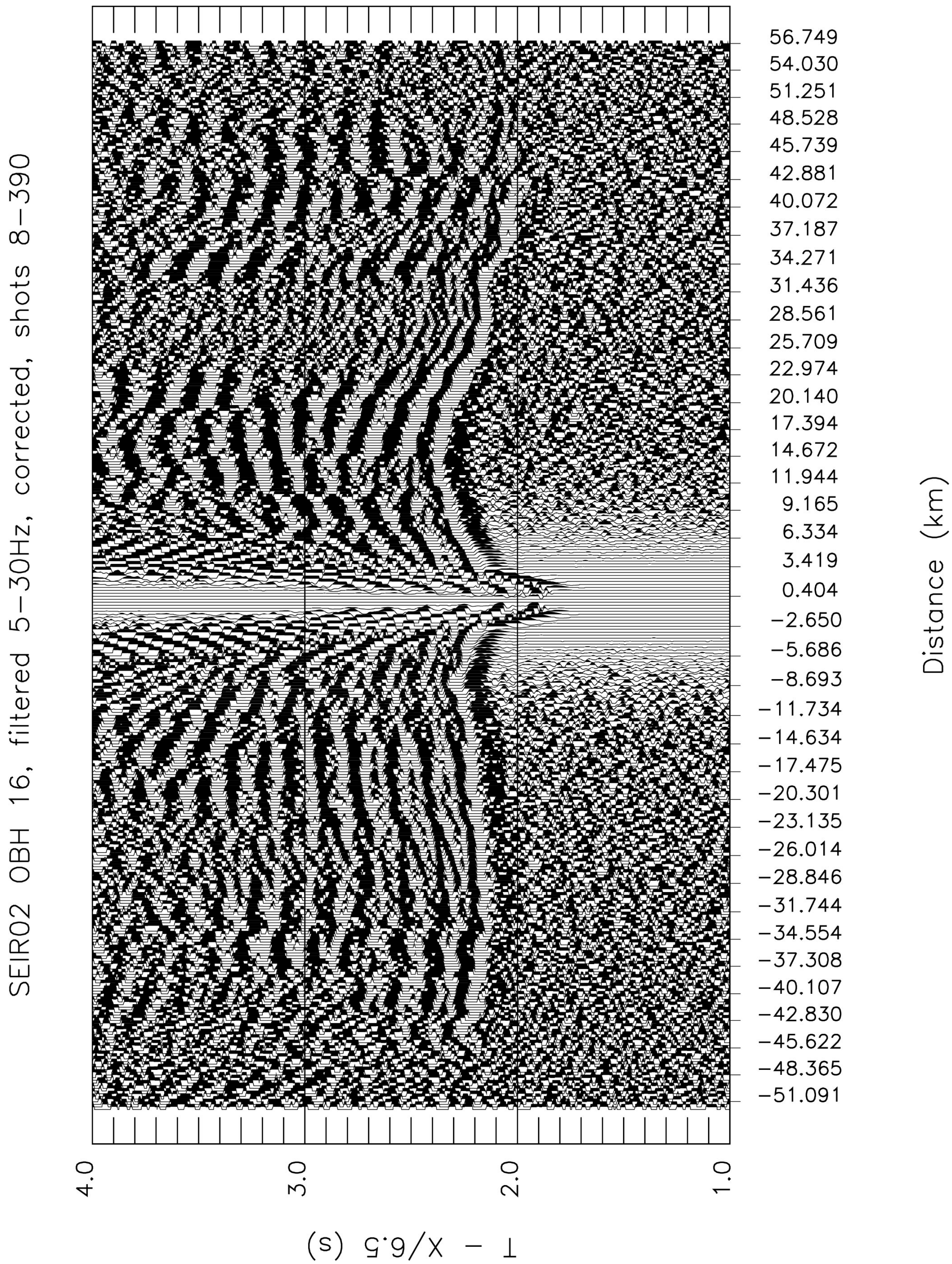
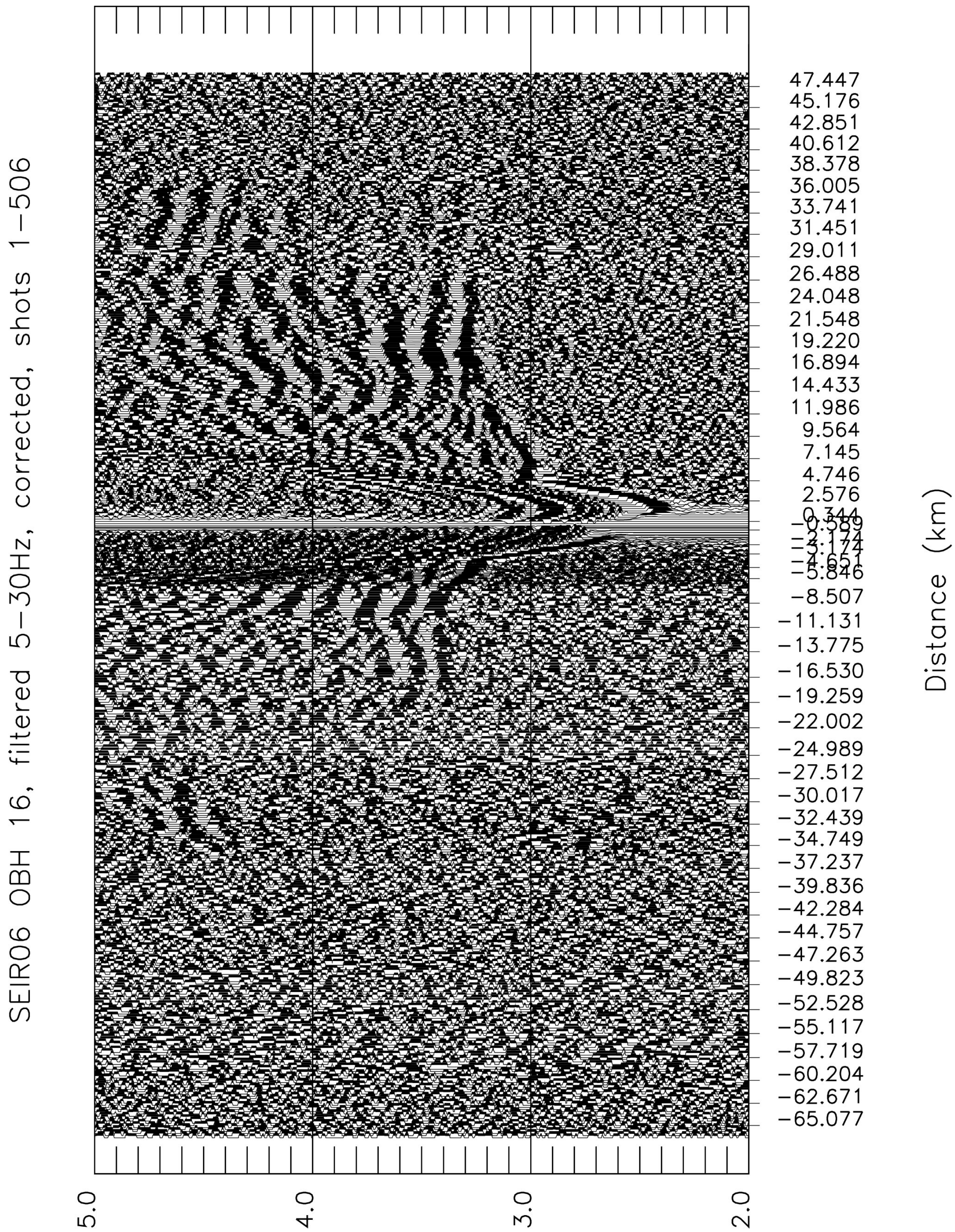

SEIR05 OBH 16, filtered 5–30Hz, corrected, shots 1–438
Distance (km)
65.432
63.342
61.338
59.192
56.892
54.573
53.907
51.004
48.074
45.209
42.375
39.672
37.033
34.361
31.640
28.933
26.178
23.455
20.721
17.946
15.230
12.347
9.486
6.588
3.839
0.941
−2.163
−4.949
−8.050
−10.855
−13.602
−16.386
−19.235
−22.197
−25.113
−27.859
−30.776
−33.616
−36.471
−39.377
−42.250
−45.133
4.0
3.0
2.0
T − X/6.5 (s)

Figure 11



SEIR02 OBH 16, filtered 5−30Hz, corrected, shots 8−390
56.749
54.030
51.251
48.528
45.739
42.881
40.072
37.187
34.271
31.436
28.561
25.709
22.974
20.140
17.394
14.672
11.944
9.165
6.334
3.419
0.404
−2.650
−5.686
−8.693
−11.734
−14.634
−17.475
−20.301
−23.135
−26.014
−28.846
−31.744
−34.554
−37.308
−40.107
−42.830
−45.622
−48.365
−51.091
Distance (km)
4.0
3.0
2.0
1.0
T − X/6.5 (s)

Figure 12



SEIR06 OBH 16, filtered 5−30Hz, corrected, shots 1−506
47.447
45.176
42.851
40.612
38.378
36.005
33.741
31.451
29.011
26.488
24.048
21.548
19.220
16.894
14.433
11.986
9.564
7.145
4.746
2.576
0.344
−5.846
−8.507
−11.131
−13.775
−16.530
−19.259
−22.002
−24.989
−27.512
−30.017
−32.439
−34.749
−37.237
−39.836
−42.284
−44.757
−47.263
−49.823
−52.528
−55.117
−57.719
−60.204
−62.671
−65.077
Distance (km)
5.0
4.0
3.0
2.0
T − X/6.5 (s)

Figure 13

MCS Operations

A total of 13 days (~2400 km) of multichannel seismic reflection (MCS) data were collected on EW0114 using a Digicon 6 km, 480 channel, hydrophone streamer with a channel group spacing of 12.5 m. Shooting was done with a 10-gun, 3050 in^3 array (Fig. 14). Guns and streamer were towed at a depth of 8 m. Streamer depth was maintained by 26 Syntron depth controllers ("birds'). Birds were deployed at 150 m intervals in the front 1500 m of the streamer and at 300 m intervals (every second can) throughout the remaining 4500 m. Even-number birds were both compass and depth, while odd-number birds were depth only. The MCS data were recorded at a 2 ms sampling interval for 12 sec records interval using the Spectra recording system. Data were written to Imation 3490 cartridge tapes in SEGD format.

Shooting during lines 1 – 21 was on distance at 50 m intervals. For a nominal ship speed of 9 km/hr (4.86 kts), this results in shooting at 20-sec time intervals. This shot interval was chosen to reduce sampling of energy from previous shots reverberating in the water column. For lines 22-38, located in the eastern part of the study area, where the axis is marked by a valley and the ridge flank topography is much rougher, the shooting interval was reduced to 37.5 m (nominal 15 sec). This change was made to facilitate the application of DMO (dip move out) techniques to suppress seafloor scattered energy.

It was necessary to replace five streamer sections when the streamer was first deployed on JD355. These sections had apparently been damaged during the previous cruise. We also had to replace an additional two sections when the streamer was retrieved and redeployed between lines 19 and 20 on JD363. One of these was damaged during retrieval when it became lodged between the A-frame and one of the vertical roller guides. The second section was apparently damaged while being towed along the surface following the unanticipated deployment of 3 SRDs (streamer recovery device) during line 19. As a result, there were no spare streamer sections left at the end of the cruise.

A major rebalancing of the streamer was required at the beginning of operations due to the much colder water than encountered in the previous operational areas. The central part of the streamer was initially still too heavy even after the removal of a significant amount of lead and tended to sink to as deep as 20-30 m. This became a problem when the streamer sank deep enough during rough weather on line 19 that three of the SRDs deployed bringing that portion of the streamer to the surface. As a result Bird 14 was ripped off and a streamer section appears to have been damaged. The streamer was brought aboard at the end of line 19 (which had to be cut short due to the bad weather). When the streamer was redeployed prior to line 20, Bird 1 was moved to replace Bird 14, the bad section was replaced and additional lead was removed from the middle portion of the streamer. No further problems in maintaining streamer depth were encountered.

The GPS receiver on the tailbuoy was damaged during heavy weather encountered between lines 17 and 18 and ceased operating. Subsequent to this, tailbuoy position, range and bearing were eliminated from Spectra's Kalman filtering. In addition, incorrect magnetic declinations were initially input to the compass data, leading to incomplete P1/90 files. This was corrected by Line 17.

The MCS work consisted of detailed surveys of three segments; P1 characterized by an inflated "EPR-like" axial high, P2 with a more typical intermediate spreading rate low "rifted" axial high and S1 with a shallow 500-800 m deep axial valley, again typical of

Figure 14: R/V EWING 10-AIRGUN ARRAY USED ON LEG 0114

(Guns were arranged to match working depth transducers)
(not to scale)

```
      total array  3050 cu in., 50 liters                    Distance from Center line

STARBOARD
|---GUN 1-------------------|145(2.4L)                                  |+17.8m
|
|---GUN 2-----------------------------              |850(13.9L)         |+16.3m
|
|---GUN 3------------------------         |305(5.0L)                    |+14.8m
|
|
|
|---GUN 7--------------------|80(1.3L)                                  |+8.8m
|
|
|---GUN 9------------------------         |585(8.9L)                    |+3.5m

|-----------------center line-------------------------------------------

|---GUN 12-----------------------         |385(6.3L)                    |-3.5m
|
|
|---GUN 14------------------|120(2.0L)                                  |-8.8m
|
|
|
|---GUN 17------------------|200(3.3L)                                  |-13.3m
|
|---GUN 18-----------------------         |235(3.9L)                    |-14.8m
|
|
|---GUN 20------------------|145(2.4L)                                  |-17.8m
PORT


             Gunline length
|<------  104 ft (32m)----->|
|<------- 121 ft (37m---------------------   |
|<------- 135 ft (41m)--------------------------------->  |
```

Guns 1-8 are towed from the starboard boom.
Guns 9-12 are towed from the stern A-frame.
Guns 13-20 are towed from the port boom.
Gun volumes given in cubic inches and liters.
Gunline lengths are measured from the stern.

many intermediate spreading rate ridge segments. We also planned a survey in segment T, in which the axis is within a 1200 m deep axial valley. However, continual miserable weather over the last 10 days in the field area prevented that work from being carried out.

An MCS line log with the details of each line is given in Table 10 and shot point maps for each of the 6 segments in which data were collected are shown in Figures 17-22. The color scale used in Figs.17-22 is the same as in Fig. 4. The MCS survey of the two western axial high segments, P1 and P2 (Figs. 17, 18), consisted of isochron lines coincident with the on- and off-axis refraction lines and a series of across-axis lines at 10 km spacings designed to determine along axis variations in magma chamber geometry and Layer 2A thickness. The MCS survey in Segment S1 (Fig. 22) had fewer across-axis lines and relied more on isochron lines, again including lines coincident with the refraction lines. The reason for the change in strategy was the higher-relief topography in this axial valley segment.

An additional objective during transits between the primary surveys was to obtain an MCS profile along the axis of as many of the intervening segments as possible in order to allow us to examine in detail changes in magma chamber depth and on-axis Layer 2A thickness accompanying the changes in axial morphology observed along the SEIR axis. Profiles were obtained along the axis of segments P3, P4 and R (Figs. 19-21).

Preliminary on-board MCS processing on R/V Maurice Ewing was carried out using ProMAX 2D on a Sun Sparc Ultra server (grampus). One of the first steps in the processing sequence is to define the shot-receiver-midpoint geometry of the seismic line. Figure 15 shows the distance between shots derived from the Spectra P1 files as part of an analysis by E. Rubio and B. Medvedev. The nominal shooting interval for Line 1 along the axis in segment P1 was 50 meters while it was 37.5 m for Line 25 along the

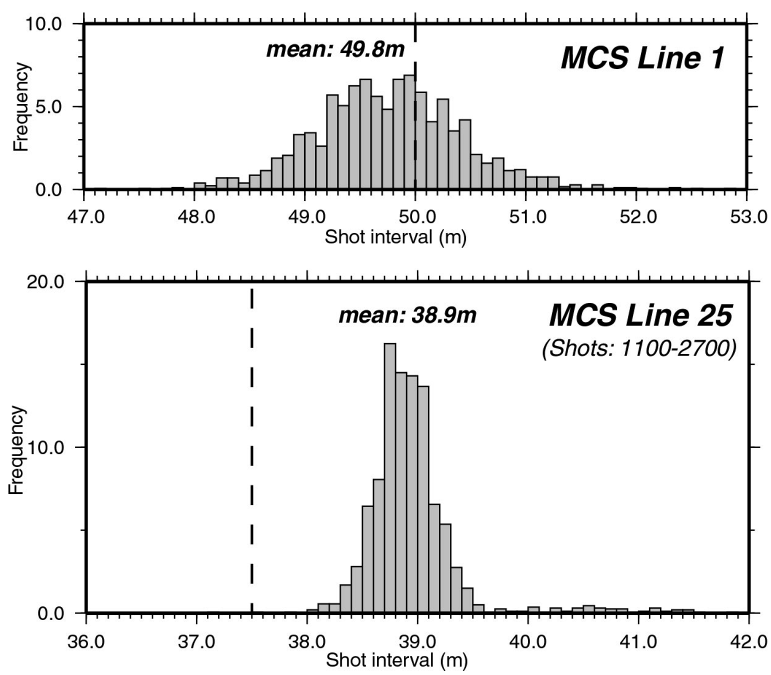


Figure 15.- Frequency of the different values in the shooting interval for the studied profiles derived from the P1 source position logs generated by Spectra. Dashed lines mark nominal values used.

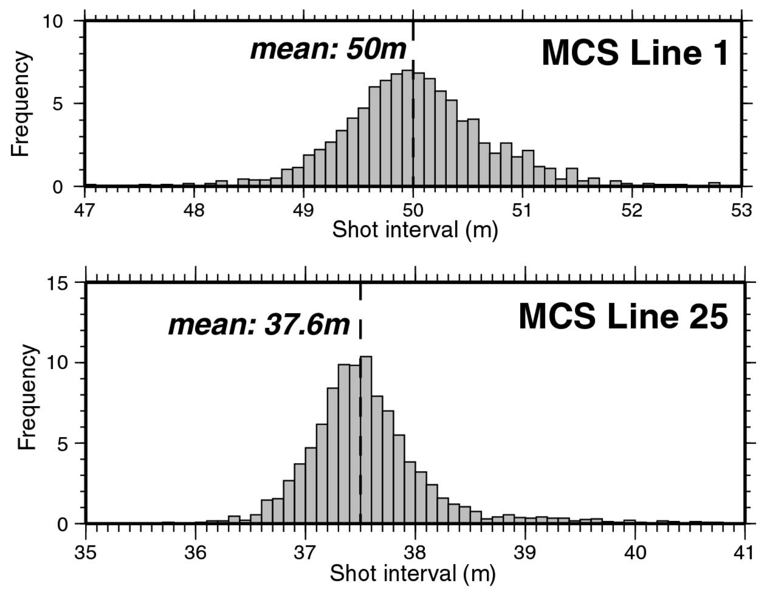


Figure 16.- Frequency of the different values in the shooting interval for the studied profiles obtained after sampling the navigation at each shooting time. Dashed lines mark nominal values used.

axis in segment S1. It is apparent that although the mean distance is close to the desired shot spacing for Line 1, it is significantly less for Line 25. Figure 16 shows the shooting interval determined from the ts.n and ts.n.status files (shot time records merged with smoothed navigation. This determination of the shot interval is much closer to the prescribed shooting distance. The reason for the difference is that the ts.n files sample the navigation at the time of the shot to a msec, while the shot times in the P1 files is only to a sec. Our conclusion is that the ts.n and not the P1 files should be used in determining the geometry.

Two separate on-board processing efforts were undertaken. The first was designed to be fairly straight-forward near real time processing for quality control and to assist in most effectively placing cross lines. In practice, this effort was severely limited by a series of software and hardware related problems in copying the field tapes onto disk and by the only intermittent availability of ProMAX as a result of license problems. As a result, processing was basically limited to the on-axis lines. Common depth point bins were set at 25 m for this processing. Processing steps utilized in this processing included anti-alias filtering and resampling from 2 to 4 ms, bandpass filtering (5-35 Hz) and constant velocity stacking at various intervals from 1500-4000 m/s. Other processing steps included deconvolution and F-K filtering. Two constant velocity stacks for Line 1 along the axis in Segment P1 are shown in Figs. 23 and 24. Figure 23 shows a constant velocity stack at 1538 m/s. Layer 2A can be easily identified at about 200 ms below the seafloor and is fairly continuous along the length of the segment. A well developed layer 2A arrival can also be seen along the length of Line 2 along the Segment P2 axis, although it does become somewhat less distinct toward the eastern end of the segment where the axis is located within a valley which deepens to the east toward the 102°45’E transform. It is more difficult to identify on the CVS profiles in Segment S1, where the axis is located within a valley. Figure 24 shows a CVS with a stacking velocity of 2430 m/s, designed to image axial magma chamber reflections. Reflections from the top of the

AMC are visible at 4.0-4.25 s at CDPs 1700-2000 and at 3.8-4.0 s at CDPs 2200-2600. Reflected energy between 4.0-4.5 s at CDPs 3000-3800 may also contain AMC reflections. As mentioned in the OBH discussion above, the sudden attenuation of amplitude of the OBH arrivals at a shot distance of 12-15 km (Fig. 10) reflects the presence of an axial magma chamber under much of this segment, Further processing and analysis of the axis-perpendicular lines is needed to define its geometry.

The second processing effort used the data from lines 1 (along the axis in Segment P1) and 25 (along the axis in Segment S1) to examine the effectiveness of DMO (dip move out) techniques in imaging events in the lower crust, including Moho that are obscured by seafloor scattered energy. Line 1 was shot with a nominal 50 m interval, while the shorter 37.5 m shooting interval was used for Line 25, allowing the effect of the change to be evaluated. The data was sorted into 6.25 m CDP bins rather than the 25 m bins used in the previous processing in order to have a better lateral resolution, and therefore less spatial aliasing, during the possible poststack processes to be performed. Another criteria in the choice was the fact that with the nominal bin size of 6.25 m the traces within a CDP gather are more likely even spaced than in the 25 m bin case which improves the results of the FK filtering in the CDP gathers. In order to save CPU time and disk space, and since we were more interested in the DMO technique effects on structures deeper than layer 2A, we decided to resample the datasets to 8 ms after applying an antialiasing highcut filter. The maximum frequency derived from this new sampling rate is above the mean frequencies of the AMC and Moho events.

The effect of the DMO processing is shown in Figures 25-28. Figures 25 and 26 show a portion of line 1 along the axis in Segment P1 (Fig. 17) with and without DMO. The application of DMO has dramatically reduced the amount of seafloor scattered energy in the lower crustal section and brought out probable Moho reflections between CDPs 8500 and 9400 at about 5.7 s. Figures 27 and 28 show a portion of of line 25 along the axis in Segment S1 (Fig. 22). Again the DMO processing has reduced the scattered energy in the lower crust allowing observation of possible Moho reflections (CDPs 10400-11599 at 6.3 s).

This analysis determined that using a 37.5 m shooting interval increased lateral resolution without a huge increase in processing time. It also determined that multiples from the previous shot were attenuated sufficiently that they do not pose a problem. Our conclusion is then that the shorter shooting distance is worthwhile in rough terrain where seafloor scattering can be a problem. A detailed report on the DMO processing prepared by E. Rubio and B. Medvedev can be obtained on request from the project PIs.

Table 10: MCS Line Log

	Line	Latitude	Longitude	Jday	Time	File #	Shot #
Start	1	47º 10'.58	100 18 99	355	1352	1	2
End		47 37 18	101 17 36	355	2351	1683	1771
Start	2	47 34 98	101 21 97	356	0040	1684	24
End		47 59 48	102 24 98	356	1028	3502	1841
Start	3	48 00 38	102 25 71	356	1042	3503	19
End		48 08 09	102 18 21	356	1259	3843	360
Start	4	48 08 17	102 26 34	356	1317	3844	1
End		47 44 97	101 11 49	356	2331	5672	1845
Start	5	47 45 97	101 06 53	357	0024	673	99
End		47 19 85	100 13 56	357	0954	7224	1743
Start	6	47 18 65	100 13 00	357	1008	7225	30
End		47 05 11	100 25 87	357	1334	7624	628
Start	7	47 07 75	100 33 15	357	1454	7625	1
End		47 25 48	100 16 32	357	1926	8305	762
Start	8	47 27 07	100 23 70	357	2047	8306	34
End		47 11 51	100 39 47	358	0032	9035	765
Start	9	47 14 78	100 46 22	358	0206	9036	1
End		47 36 19	100 25 50	358	0744	9984	950
Start	10	47 39 31	100 32 21	358	0855	9985	3
End		47 09 61	101 02 66	358	1615	11309	1344
Start	11	47 12 89	101 09 83	358	1752	11310	1
End		47 38 19	101 43 22	359	0020	12461	1153
Start	12a	47 41 33	100 50 02	359	0139	12462	1
End		47 27 11	101 03 93	359	0459	13088	633
Start	12b	47 26 80	100 56 45	359	0646	13090	48
End		47 30 90	101 03 80	359	0803	13282	240
Start	12c	47 27 03	101 03 99	359	1001	13283	140
End		47 24 40	101 06 57	359	1041	13400	257
Start	13	47 27 62	101 13 50	359	1158	13401	1
End		47 48 97	100 52 51	359	1715	14350	951
Start	14	47 52 21	100 59 28	359	1837	14351	1
End		47 26 40	101 23 98	360	0050	15490	1140
Start	15	47 30 06	101 30 47	360	0227	15491	31
End		47 48 64	101 12 90	360	0653	16312	848
Start	16	47 51 02	101 19 99	360	0803	16372	1
End		47 32 41	101 37 95	360	1243	17136	824
Start	17	47 37 34	101 43 10	360	1446	17137	88
End		47 56 51	101 24 35	360	1918	17988	939
Start	18	47 59 63	101 31 01	362	0519	17989	2
End		47 30 30	101 59 97	362	1237	19296	1308
Start	19	47 34 27	102 10 69	362	1432	19297	2
End		47 56 03	101 50 16	362	2018	20254	958
Start	20	48 05 10	101 55 05	364	1051	20255	2
End		47 40 00	102 20 48	364	1713	21377	1128

Start	21	47 42 59	102 56 42	364	2235	21378	59
End		48 12 00	104 16 46	365	1053	23648	2330
Start	22	48 07 34	104 25 19	365	1238	23649	95
End		48 25 00	105 12 49	365	1853	24893	1436
Start	23	48 25 50	105 19 76	365	1948	24169	120
End		48 17 99	106 54 96	001	0801	26536	2488
Start	24	48 18 33	106 59 94	001	0843	30001	1
End		48 50 69	108 29 99	001	2238	32519	2519
Start	25	49 19 46	108 44 99	002	0535	32520	1
End		49 53 17	110 37 29	002	2140	36483	3975
Start	26	49 54 31	110 38 29	002	2158	36484	48
End		50 02 06	110 32 37	002	2346	36904	475
Start	27	50 02 30	110 31 19	002	2357	36905	27
End		49 33 93	108 50 01	003	1523	40433	3565
Start	28	49 32 66	108 49 06	003	1542	40434	54
End		49 21 54	108 57 68	003	1808	41039	670
Start	29	49 21 01	108 59 03	003	1821	41040	31
End		49 28 18	109 26 26	003	2213	41987	978
Start	30	49 24 20	109 23 92	003	2340	41988	1
End		49 42 88	109 10 02	004	0426	43013	1027
Start	30a	49 43 39	109 08 33	004	0441	43014	34
End		49 40 46	108 58 11	004	0603	43327	392
Start	31	49 39 39	108 57 82	004	0616	43328	1
End		49 20 65	109 11 80	004	1033	44353	1031
Start	32	49 21 00	109 15 47	004	1103	44354	21
End		49 35 09	109 54 46	004	1655	45780	1557
Start	33	49 30 78	109 52 01	004	1829	45781	1
End		49 49 20	109 38 02	004	2263	46799	1020
Start	33a	49 49 63	109 36 23	004	2251	46800	49
End		49 46 39	109 23 76	005	0041	47230	479
Start	34	49 45 29	109 23 54	005	0055	47231	57
End		49 22 08	109 40 68	005	0613	48503	1330
Start	35	49 22 55	109 44 11	005	0642	48504	115
End		49 34 56	110 24 19	005	1246	49925	1536
Start	36	39 35 37	110 24 44	005	1257	49926	44
End		49 59 14	110 06 52	005	1829	51231	1350
Start	36a	49 59 32	110 05 04	005	1845	51232	46
End		49 55 89	109 53 26	005	2032	51639	458
Start	37	49 54 62	109 52 71	005	2051	51640	55
End		49 35 15	110 06 79	006	0120	52703	1118
Start	38	49 36 60	100 00 46	006	0249	52704	1
End		49 47 68	110 34 99	006	0758	53938	1236

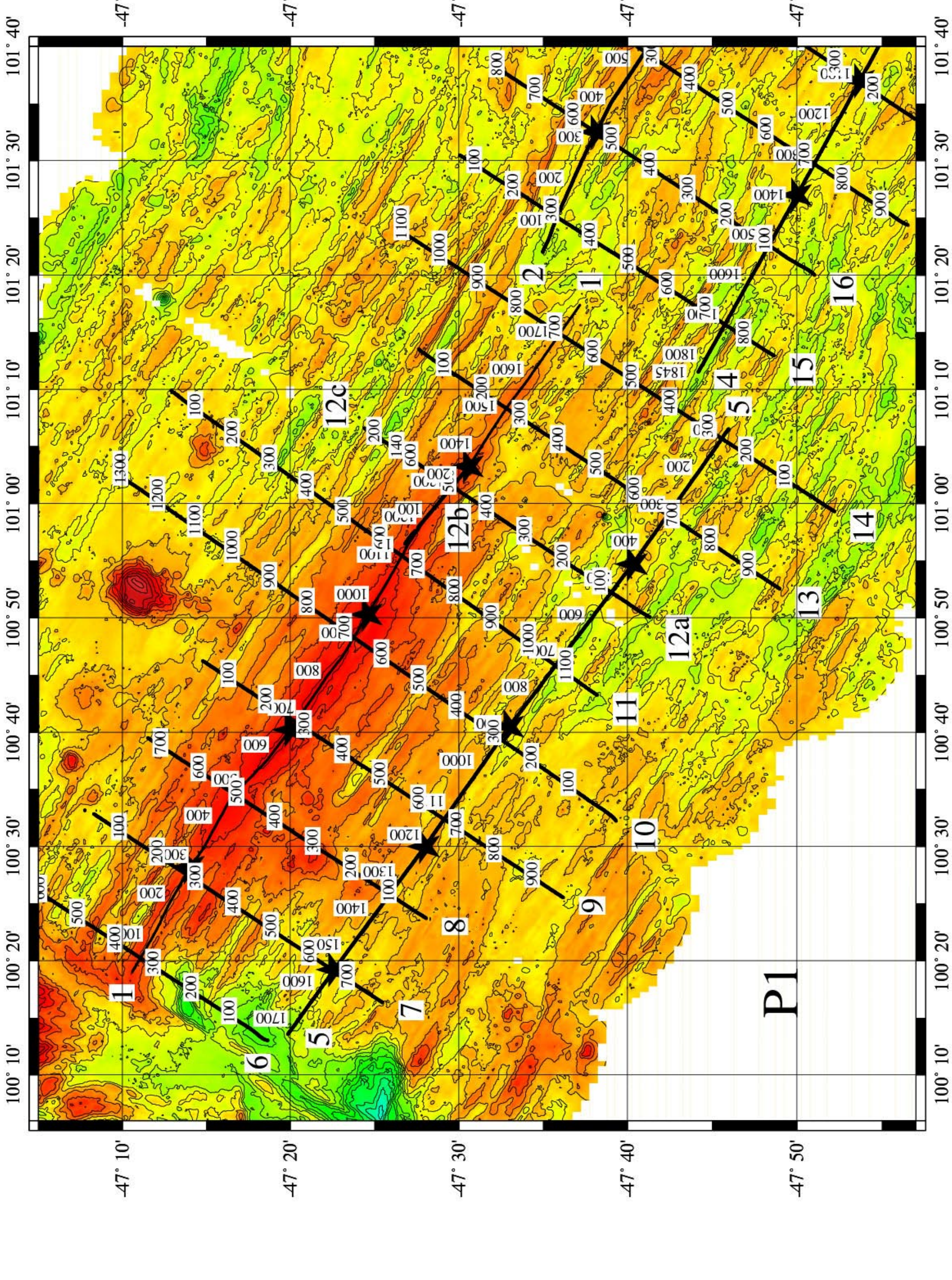


Figure 17

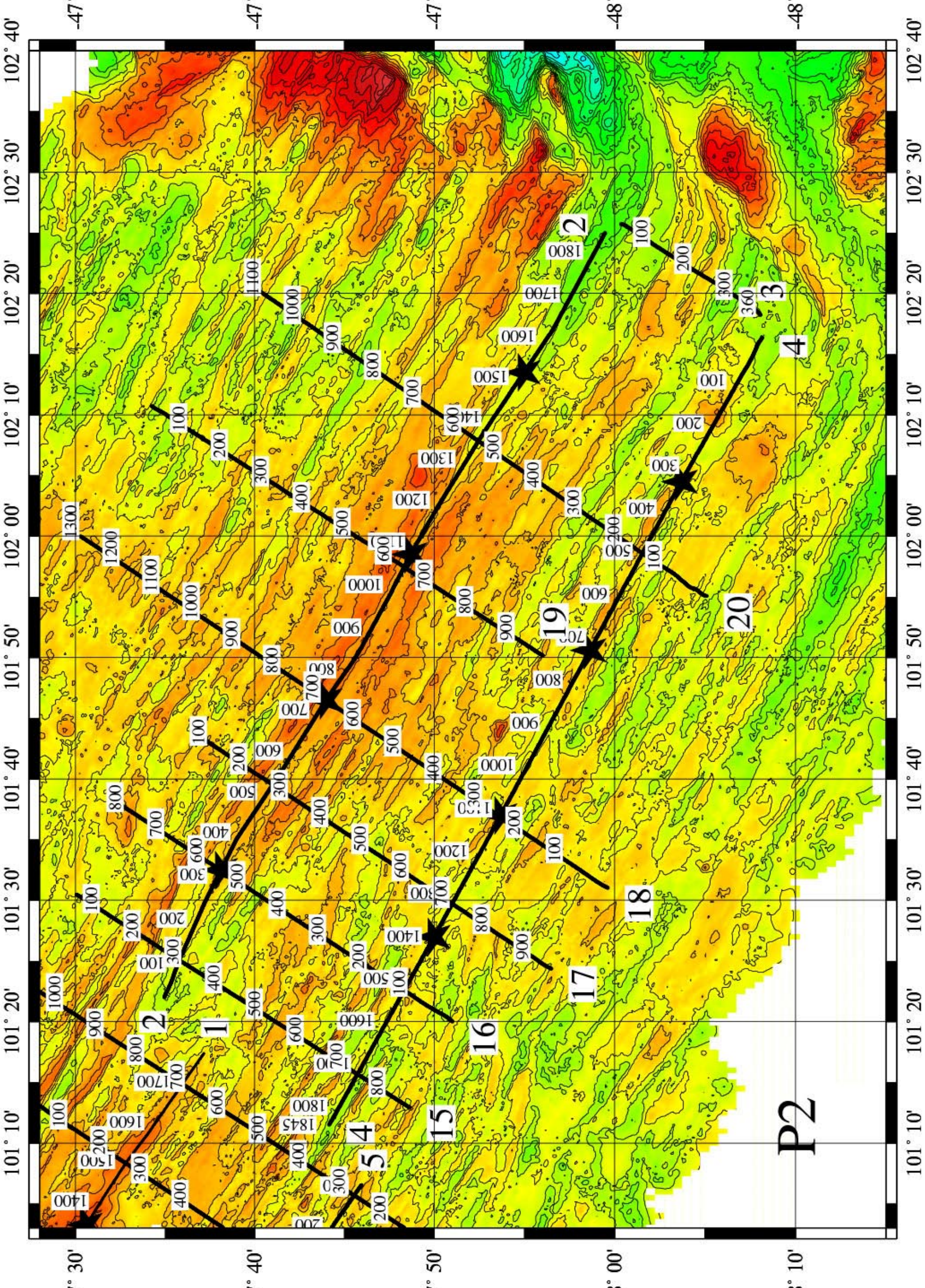

-47° 30'
-47° 40'
-47° 50'
-48° 00'
-48° 10'
101° 10'
101° 20'
101° 30'
101° 40'
101° 50'
102° 00'
102° 10'
102° 20'
102° 30'
102° 40'
P2

Figure 18

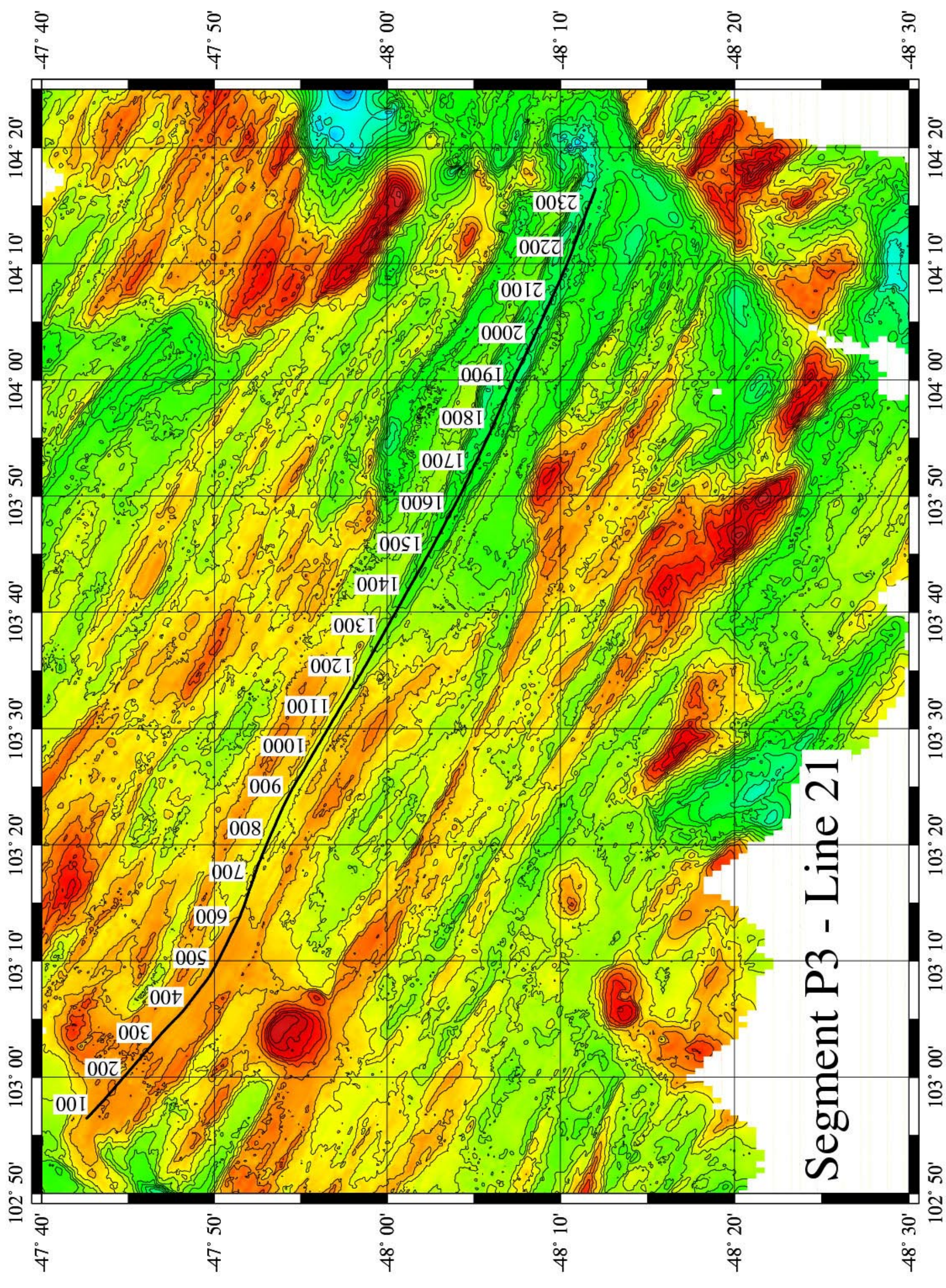

Segment P3 - Line 21
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
-47° 40'
-47° 50'
-48° 00'
-48° 10'
-48° 20'
-48° 30'
102° 50'
103° 00'
103° 10'
103° 20'
103° 30'
103° 40'
103° 50'
104° 00'
104° 10'
104° 20'

Figure 19

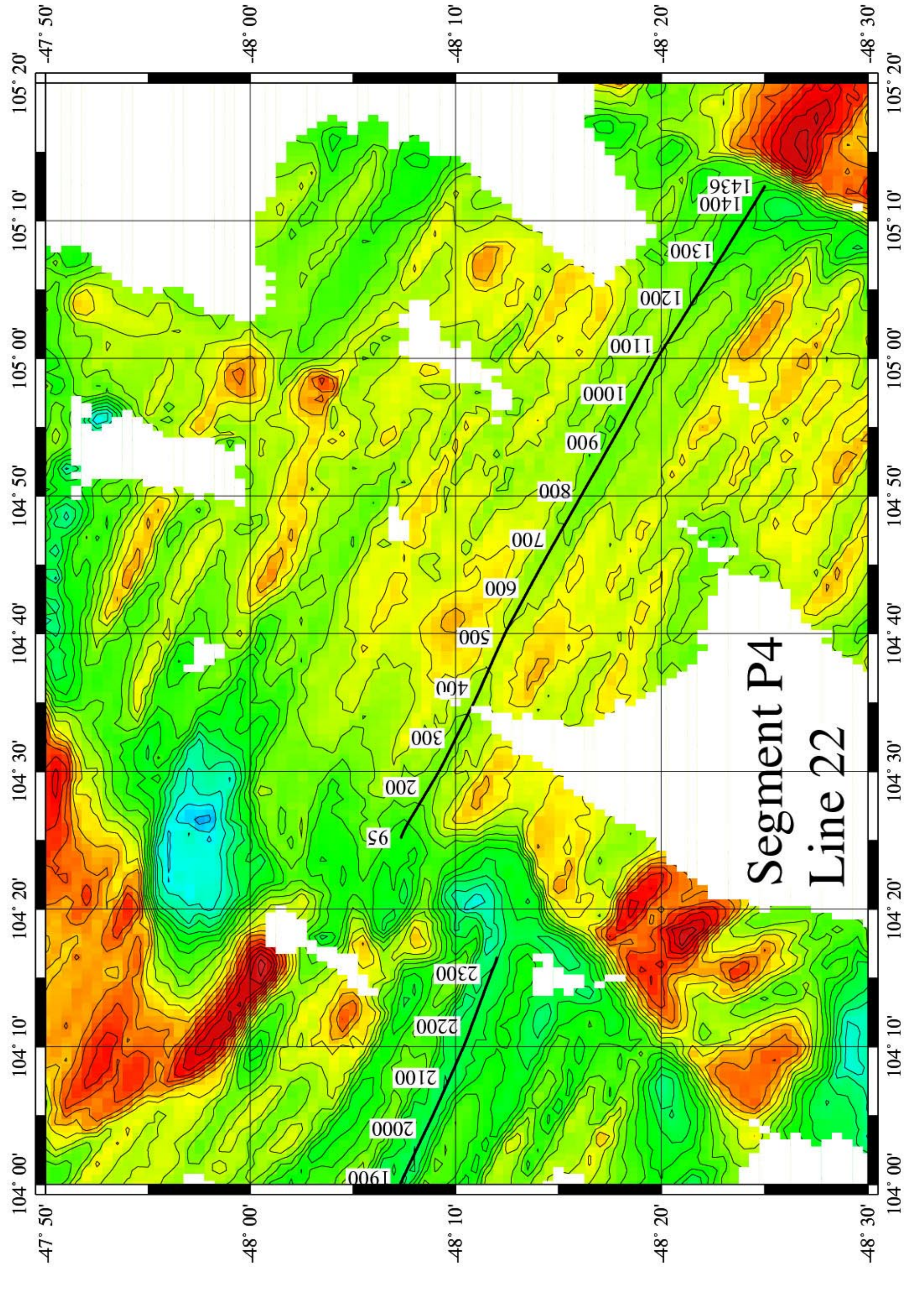

Segment P4
Line 22
-47° 50'
-48° 00'
-48° 10'
-48° 20'
-48° 30'
104° 00'
104° 10'
104° 20'
104° 30'
104° 40'
104° 50'
105° 00'
105° 10'
105° 20'

Figure 20

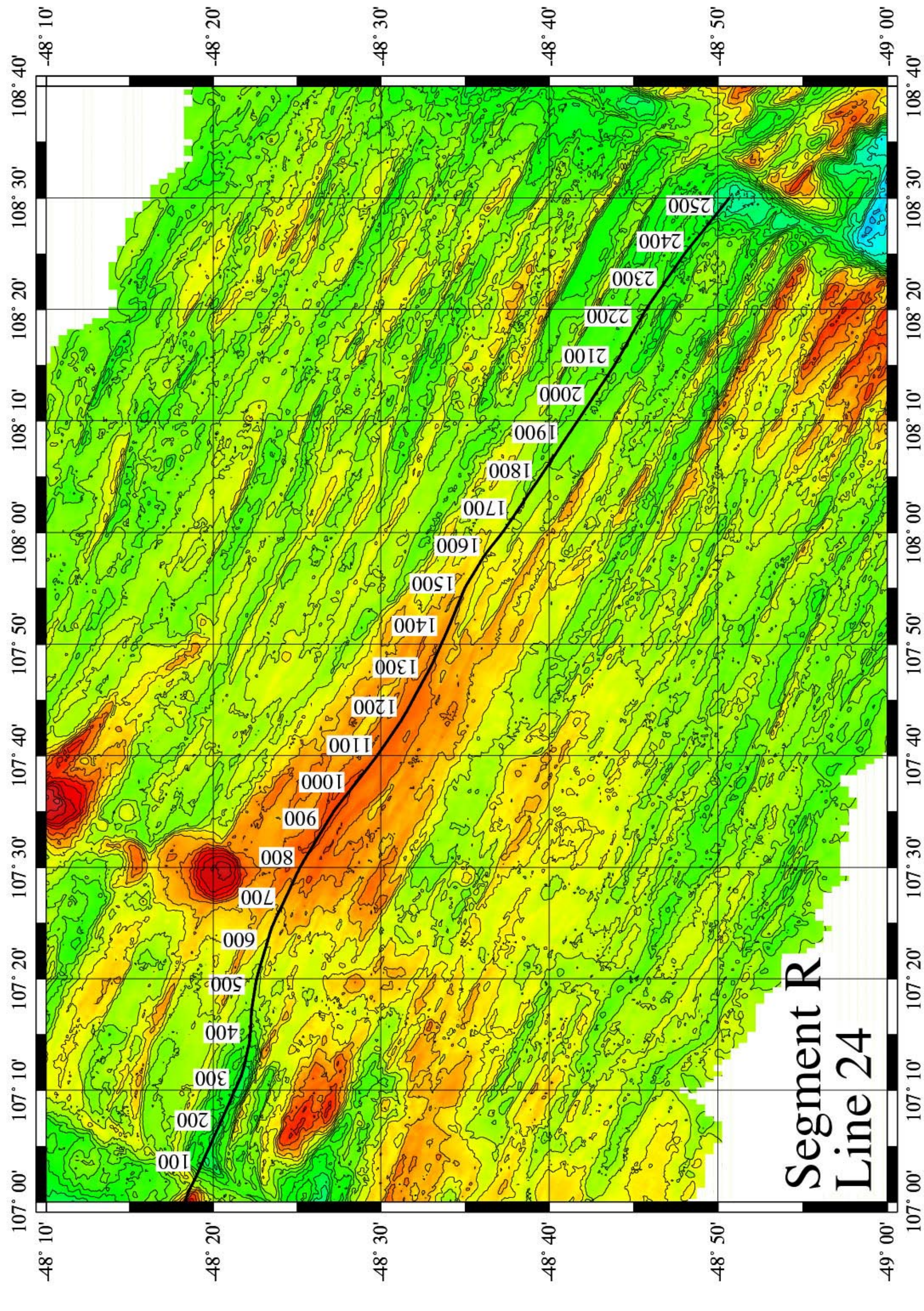

Segment R
Line 24
-48° 10'
-48° 20'
-48° 30'
-48° 40'
-48° 50'
-49° 00'
107° 00'
107° 10'
107° 20'
107° 30'
107° 40'
107° 50'
108° 00'
108° 10'
108° 20'
108° 30'
108° 40'
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500

Figure 21

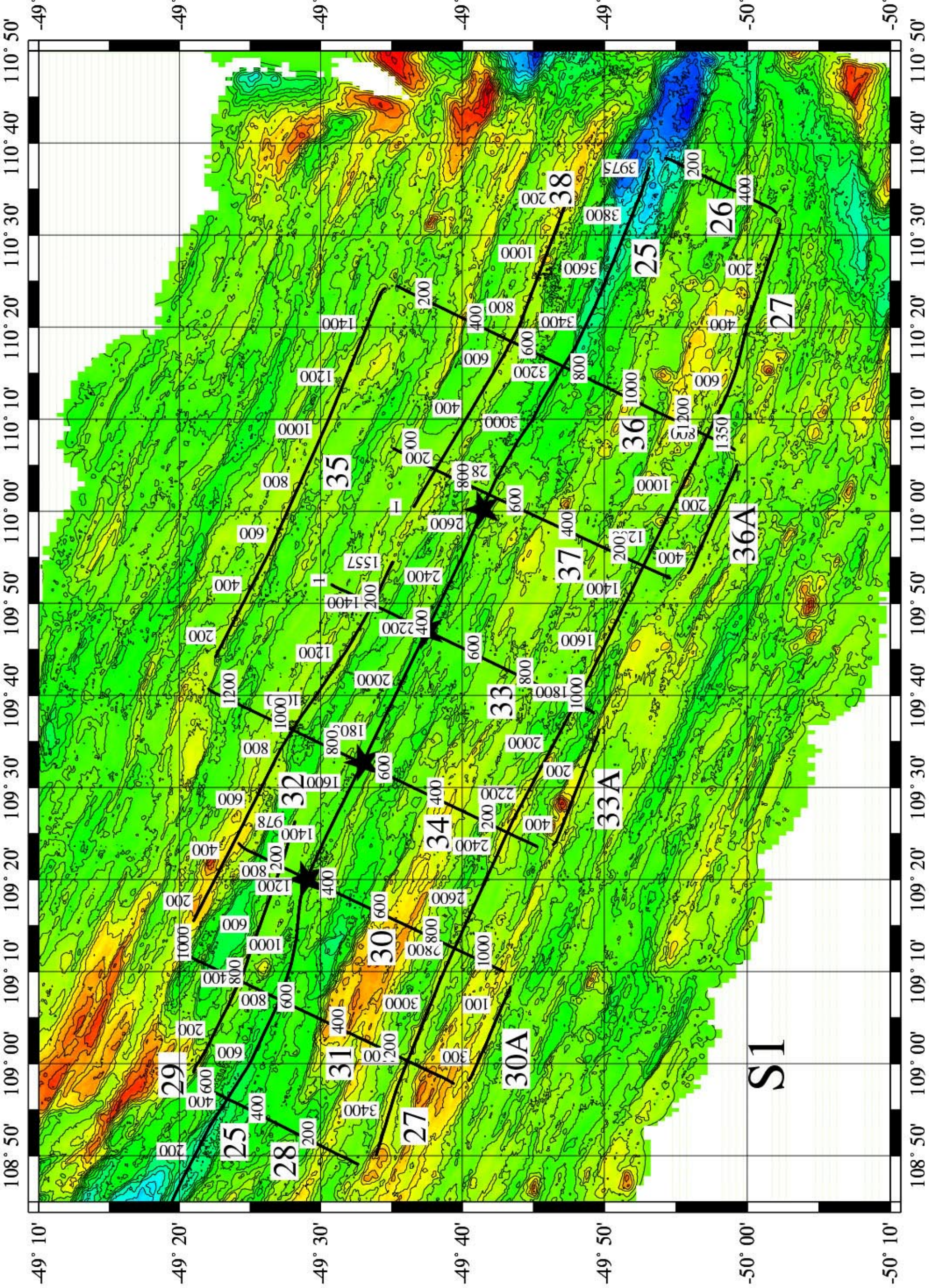


Figure 22

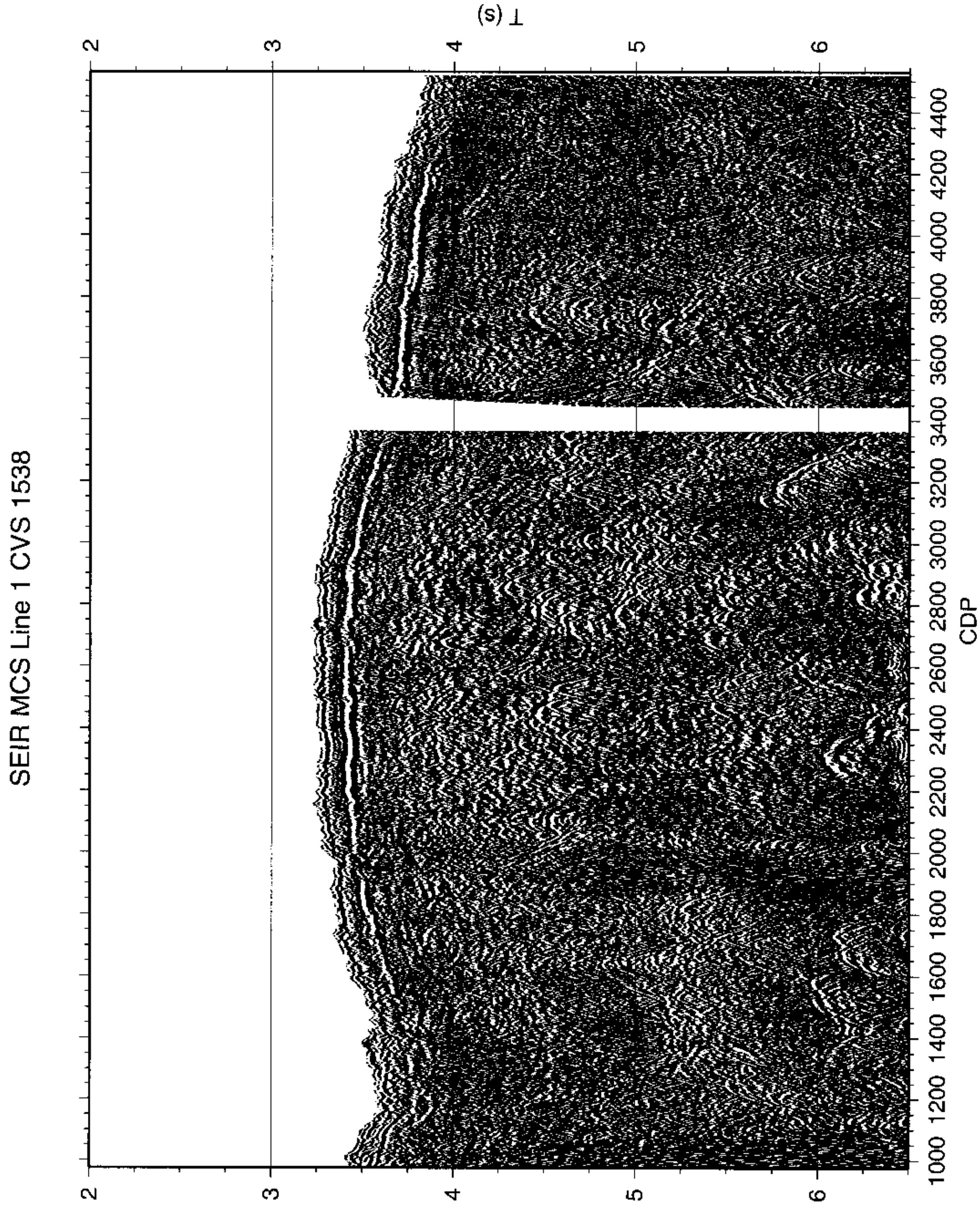

SEIR MCS Line 1 CVS 1538
T (s)
CDP
1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000 4200 4400
2
3
4
5
6

Figure 23

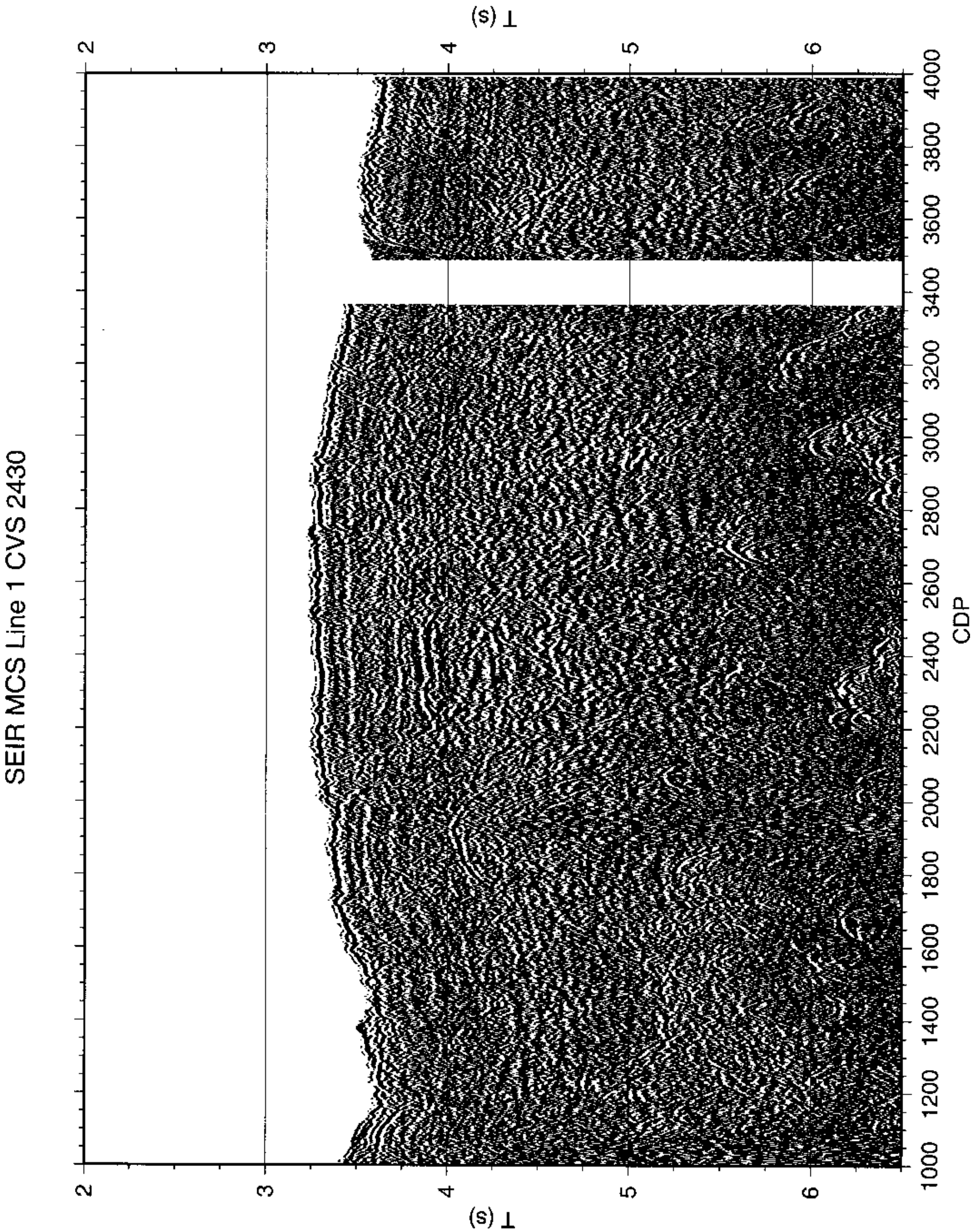

SEIR MCS Line 1 CVS 2430
T (s)
CDP
2
3
4
5
6
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000

Figure 24

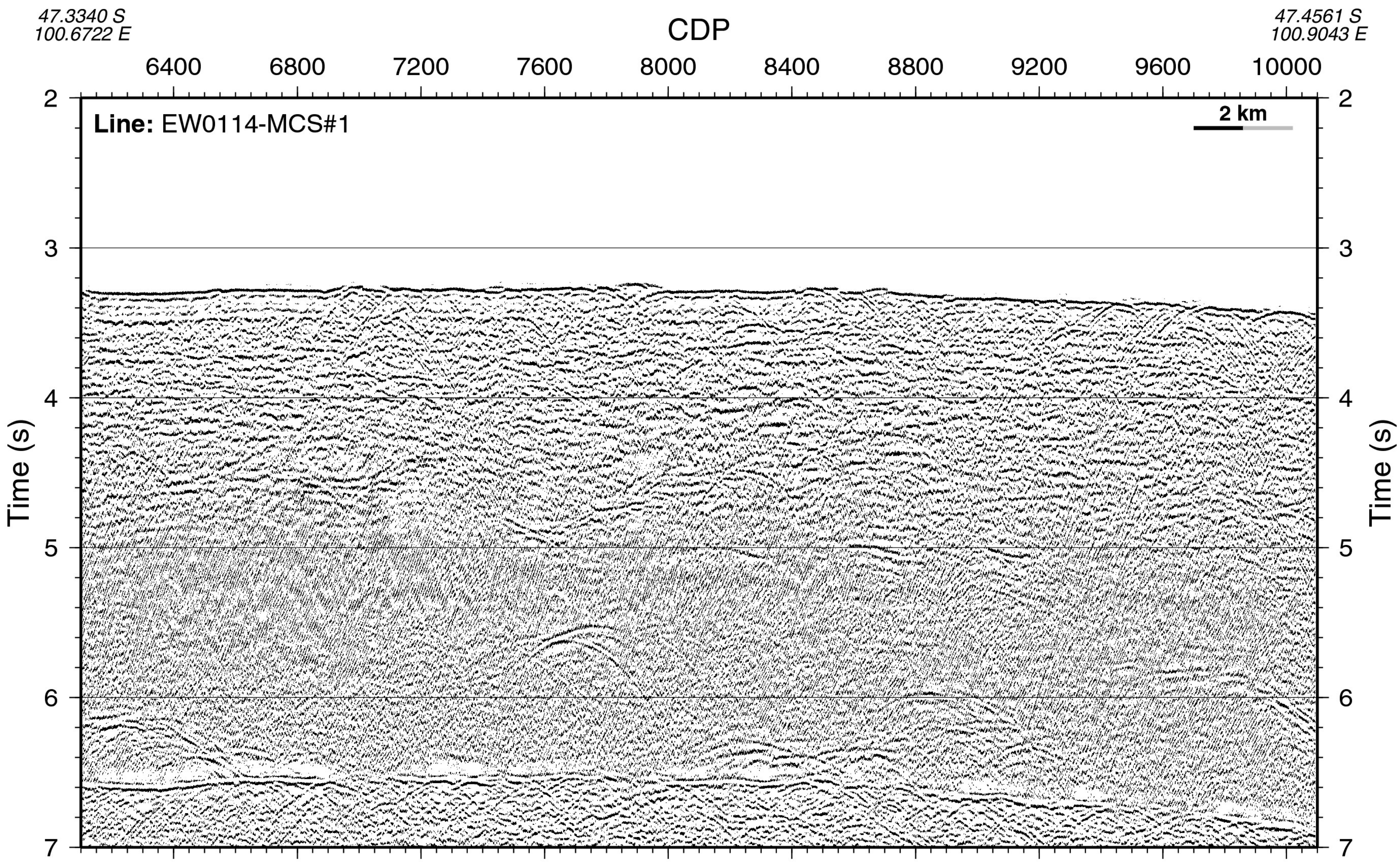


Figure 25.- Stack section of line EW0114-MCS#1 between CDPs 6100 and 10100 obtained after the following processing sequence: geometry, trace editing, trace mute, bandpass filter, NMO (vfhm), stack and agc (200 ms).

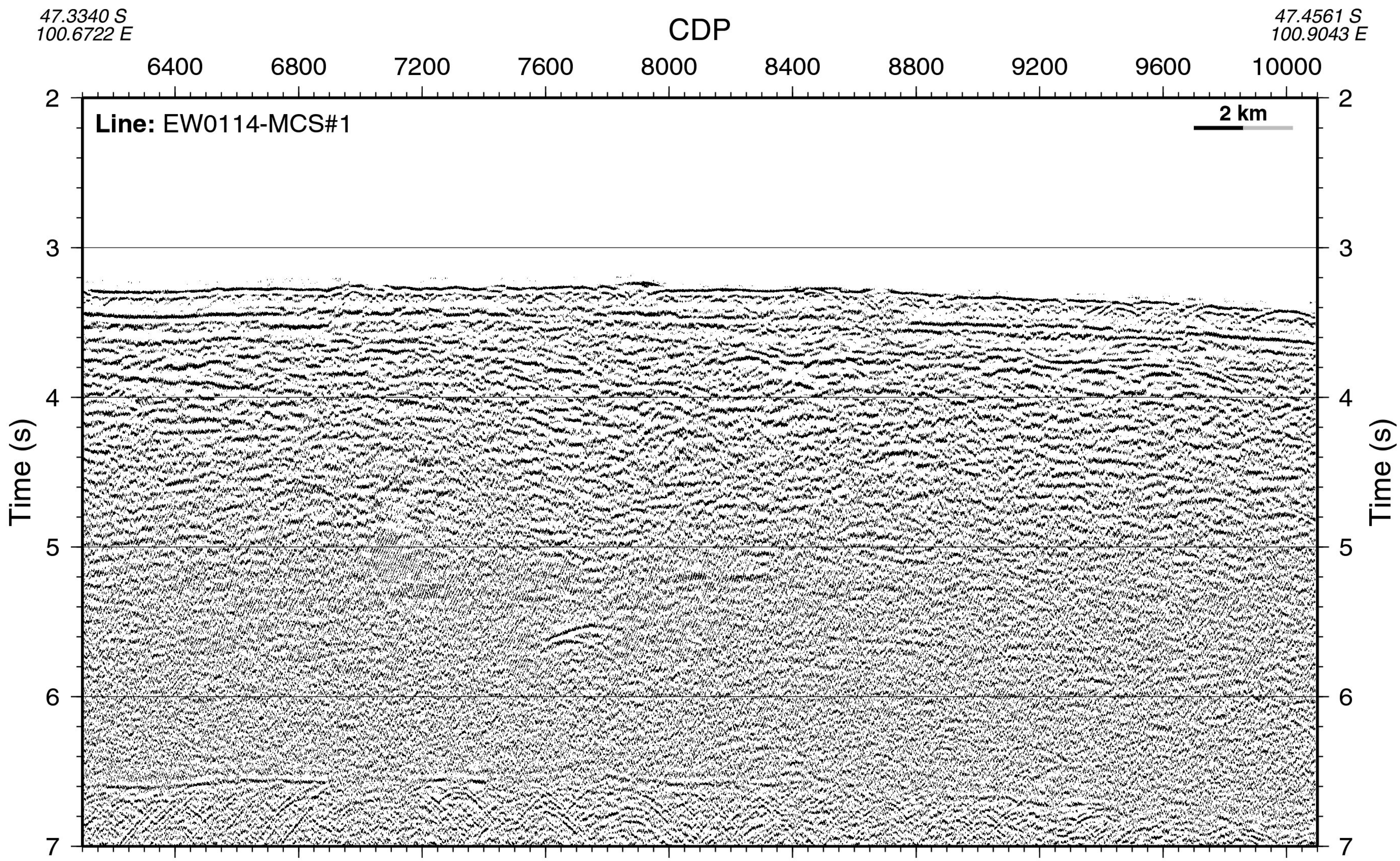


Figure 26.- Stack section of line EW0114-MCS#1 between CDPs 6100 and 10100 obtained after the following processing sequence: geometry, trace editing, trace mute, bandpass filter, NMO (1465 m/s), DMO (offset binning for DMO), NMO inverse (1465 m/s), FK filter (velocity fan), NMO (vfhm), stack and agc (200 ms).

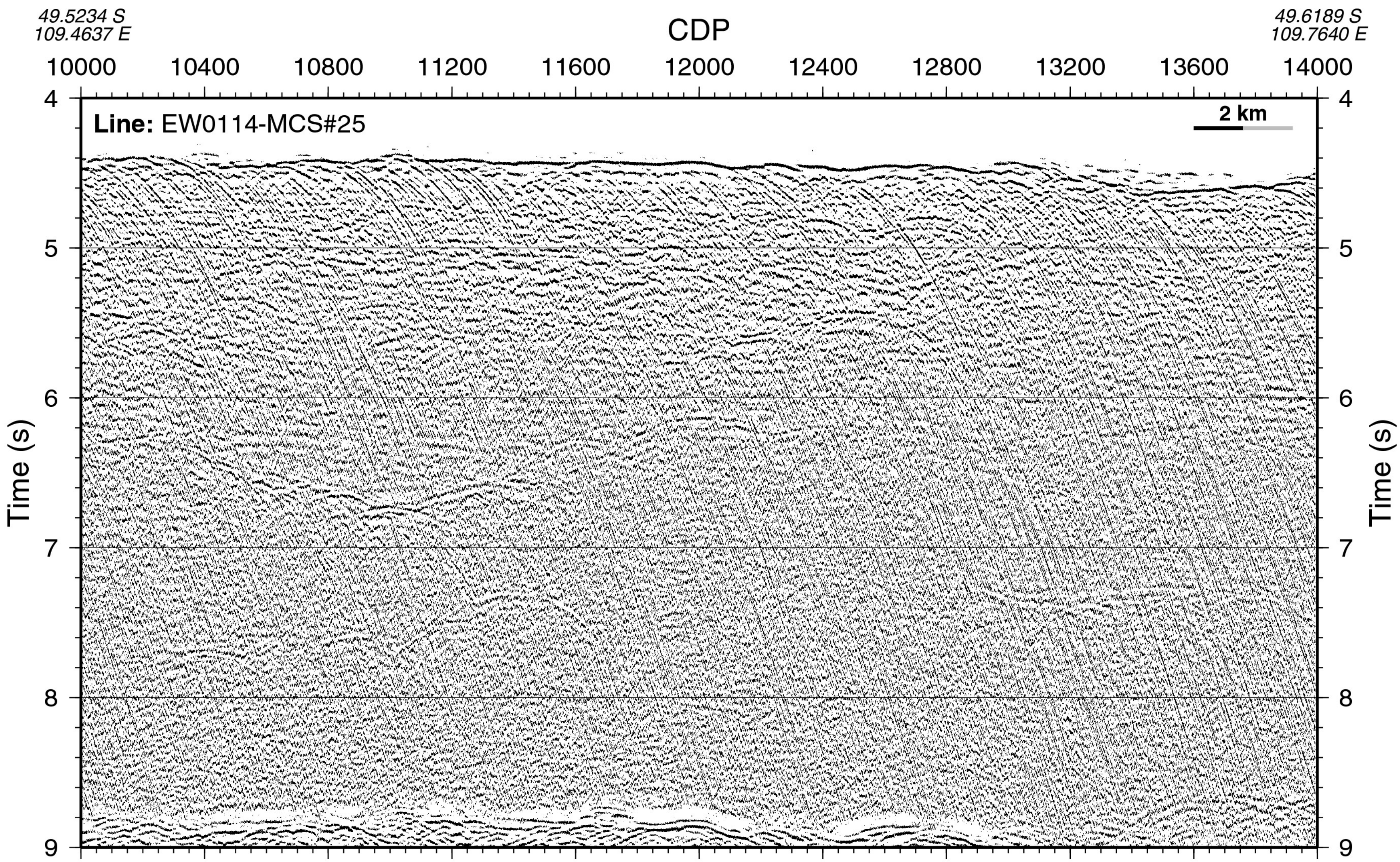


Figure 27.- Stack section of line EW0114-MCS#25 between CDPs 10000 and 14000 obtained after the following processing sequence: geometry, trace editing, trace mute, bandpass filter, NMO (vfhhm), stack and agc (200 ms).

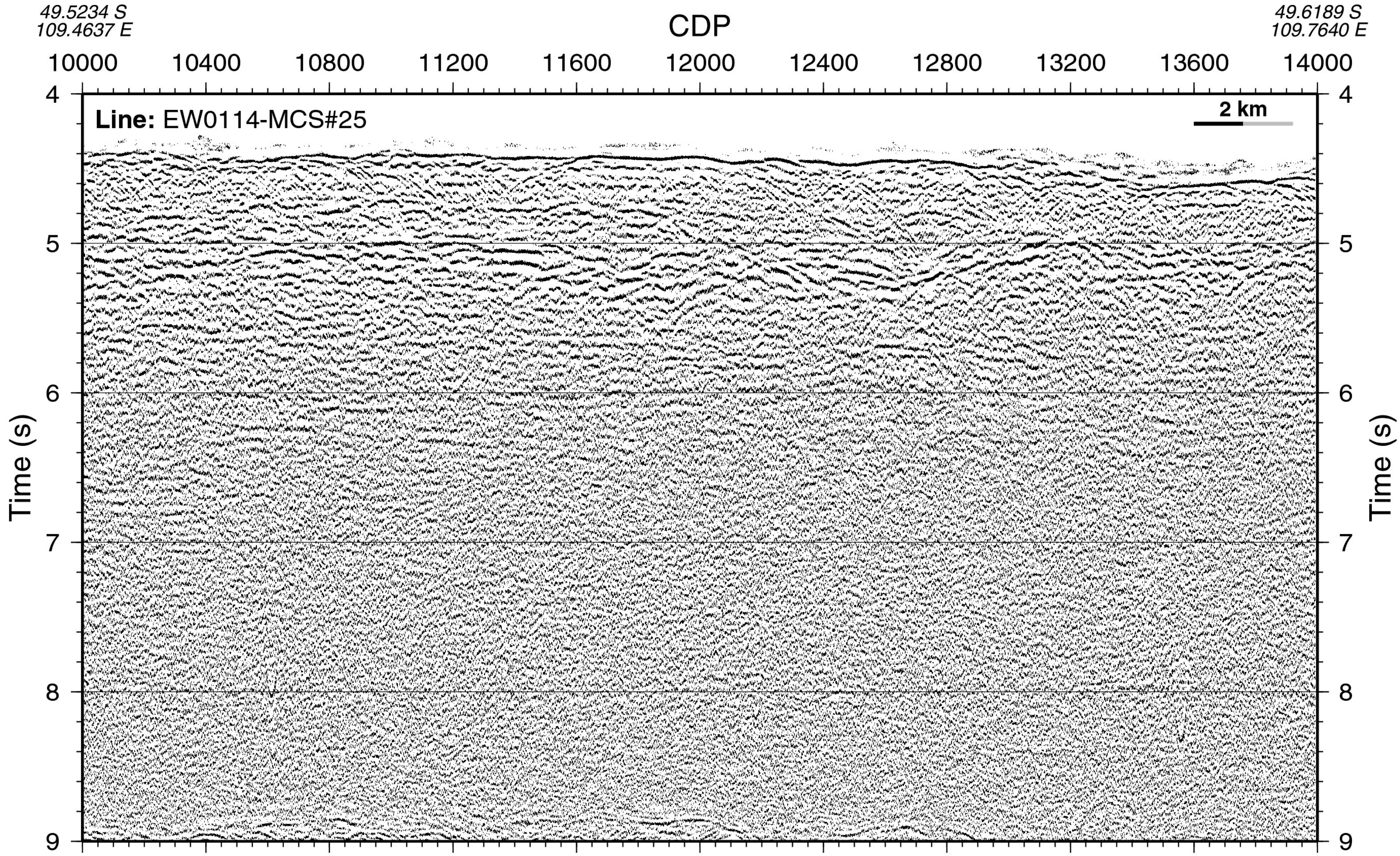


Figure 28.- Stack section of line EW0114-MCS#25 between CDPs 10000 and 14000 obtained after the following processing sequence: geometry, trace editing, trace mute, bandpass filter, NMO (1465 m/s), DMO (offset binning for DMO), NMO inverse (1465 m/s), FK filter (velocity fan), NMO (vfhhm), stack and agc (200 ms).