CRUISE REPORT

SeaMARC, SeaBeam and Photographic Surveys on the Mediterranean Ridge

R/V Conrad, Cruise 25-06
April/May 1984

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INTRODUCTION

egional Setting:

The Mediterranean Ridge is an arcuate ridge of complexly deformed sediment which parallels the convergent plate margin between Africa and the Aegean. Although our view is not universally shared, we and an increasing number of other scientists view the Mediterranean Ridge as an accretionary prism of offscraped sediments analogous to the Barbados Ridge. The outcrop of the subduction zone is thus a deformation front on the convex (southern) side of the Mediterranean Ridge.

An additional tectonically active zone is found on the northern (concave) side of the Mediterranean Ridge in the Hellenic Trench System. The role of this northern tectonic zone does not fit easily into the classic model of a convergent plate margin. One possible scenario is to view the Hellenic trench system as a the site of northward verging convergent motion, where the Mediterranean Ridge is being bodily overthrust onto the continental margin of Crete and the Peloponesus. Such an unusual sense of motion might result from·the increased difficulty of convergent motion at the southern perimeter of the Mediterranean Ridge as the African continent collides with the accretionary complex.

An additional complication is introduced by the relatively small radius of curvature of the Hellenic convergent plate margin. This geometry makes it difficult to envision orthogonal convergence across all portions of the plate margin within a rigid plate framework. At least two different resolutions of this paradox are possible. LePichon nd co-workers have suggested that the eastern part of the Hellenic Arc s experiencing strike-slip motion, while the western part of the Arc experiences convergent motion. In contrast, Stride and co-workers have suggested that the Aegean is expanding radially outward and the entire Hellenic Arc is undergoing orthogonal compression.

Equipment:

The goal of this program was to use remote sonar and video mapping systems to map in three dimensions the structure and morphology of the deformation along the tectonically active margins of the Mediterranean Ridge. The specific tools used were Lamont's SeaMARC I system, the Lamont Olympus camera system, and the Conrad's SeaBeam multi-narrow beam echo sounder. In addition a 3.5kHz echosounder was run during transits and SeaBeam surveys whenever it did not interfere with SeaBeam. The SeaBeam system produces bathymetric contour maps at 10m intervals along a swath of the seafloor whose width is equal to two-thirds of the water depth. On each lowering, the camera system produces approximately a thousand 35mm color transparencies of an area of the seafloor from .5m to 5m across, spaced 10 to 20m apart. The SeaMARC system is a nearbottom-towed swathmapping system which routinely produces a 1,2 or 5km wide side scan sonar image and a 4.5kHz subbottom profile of the seafloor. Almost all of the SeaMARC data on this cruise were collected at 5km swath width. For portions of the survey we used the experimental CHIRP subbottom profiling system instead of SeaMARC's usual 4.5kHz profiler. The CHIRP system uses a swept-frequency sound pulse rather han a tone burst at a single frequency; after appropriate processing he CHIRP returns should yield a higher resolution, deeper penetration rofile as well as quantitative data on frequency dependent attentuation. Navigation was by Loran-C and transit satellite. In most areas there was a consistent offset of up to a mile between satellites and loran; the maps illustrated here are in Loran coordinates, computed by a Northstar 6000 loran receiver using time delays from the slave stations in Lampedusa and Kargabaun (slaves X and Y).

Survey Plan:

Detailed surveys were conducted at four sites. These were chosen to contrast the allegedly strike slip eastern half of the Ridge versus the alledgedly orthogonally converging western half of the Ridge; and the concave (northern) side of the Ridge versus the convex (southern) side. These sites were:

(1) Sirte site:
  - orthogonal convergence, convex side.
  - SeaMARC, SeaBeam

(2) Herodotus site:
  - strike slip or oblique convergence, convex site.
  - SeaMARC, SeaBeam

(3) Pliny/Strabo site:
  - strike slip or oblique convergence, concave side.
  - SeaMARC, SeaBeam and camera

(4) Matapan site:
  - orthogonal convergence, concave side.
  - SeaMARC, SeaBeam and camera

SeaBeam/SeaMARC transects across the Ridge connect the Herodotus site with the Pliny/Strabo site and the Sirte site with the Matapan site. The transect across the western part of the Ridge was planned to used the new CHIRP subbottom profiling system, rather than the 4.5kHz system. Additional short surveys using SeaBeam only were conducted at sites of opportunity: Deep Tow Cobblestone area 4 on the Calabrian Ridge, Victor Hensen SeaHill on the western flank of the Mediterranean Ridge, and the southern edge of the Mediterranean Ridge where it abuts the Libyan continental margin.

Acknowledgements:

Funding for this program was provided by the National Science Foundation through grant no. OCE81-18069. Cruise planning was aided by unpublished data shared by Gilbert Kelling and Derk Jongsma, and large scale SeaBeam maps provided by Philip Huchon. Special thanks go to W.B.F.Ryan, who conceived this field program and sheparded it through the early planning phases, and then was sadly unable to participate. The seamanship of the officers and crew of the R.D.Conrad contributed substantially to the success of the cruise.

OPERATIONS

(Throughout this discussion it may be useful to refer to the Chronology in the Appendix, and to the track charts, figures 1 and 2).

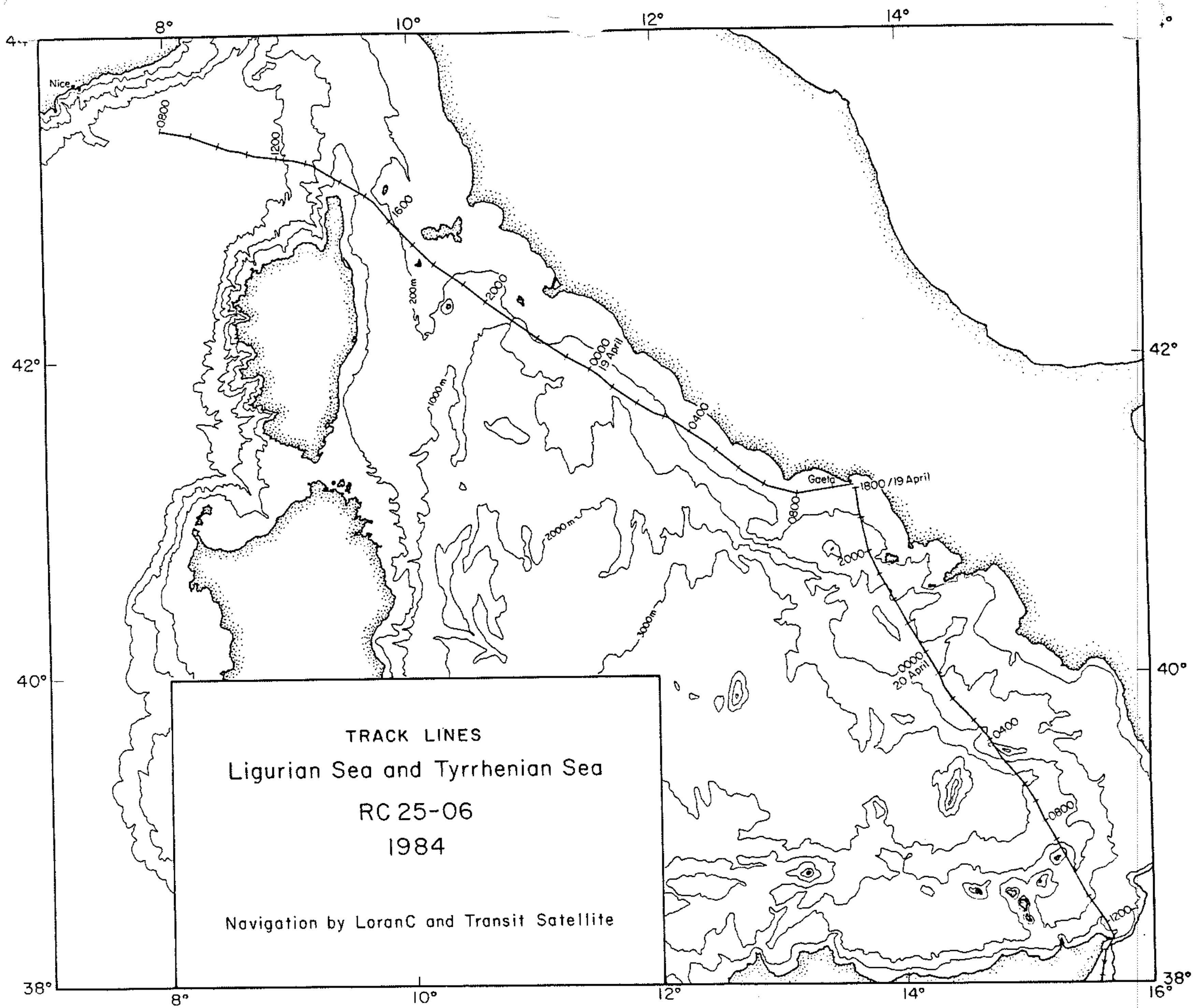
TRACK LINES
Ligurian Sea and Tyrrhenian Sea
RC 25-06
1984
Navigation by LoranC and Transit Satellite
Nice
Gaeta
0800
1200
1600
2000
0000 19 April
0400
0800
1800/19 April
2000
0000 20 April
0400
0800
1200
200m
1000m
2000m
3000m
8°
10°
12°
14°
16°
38°
40°
42°

Figure 1.

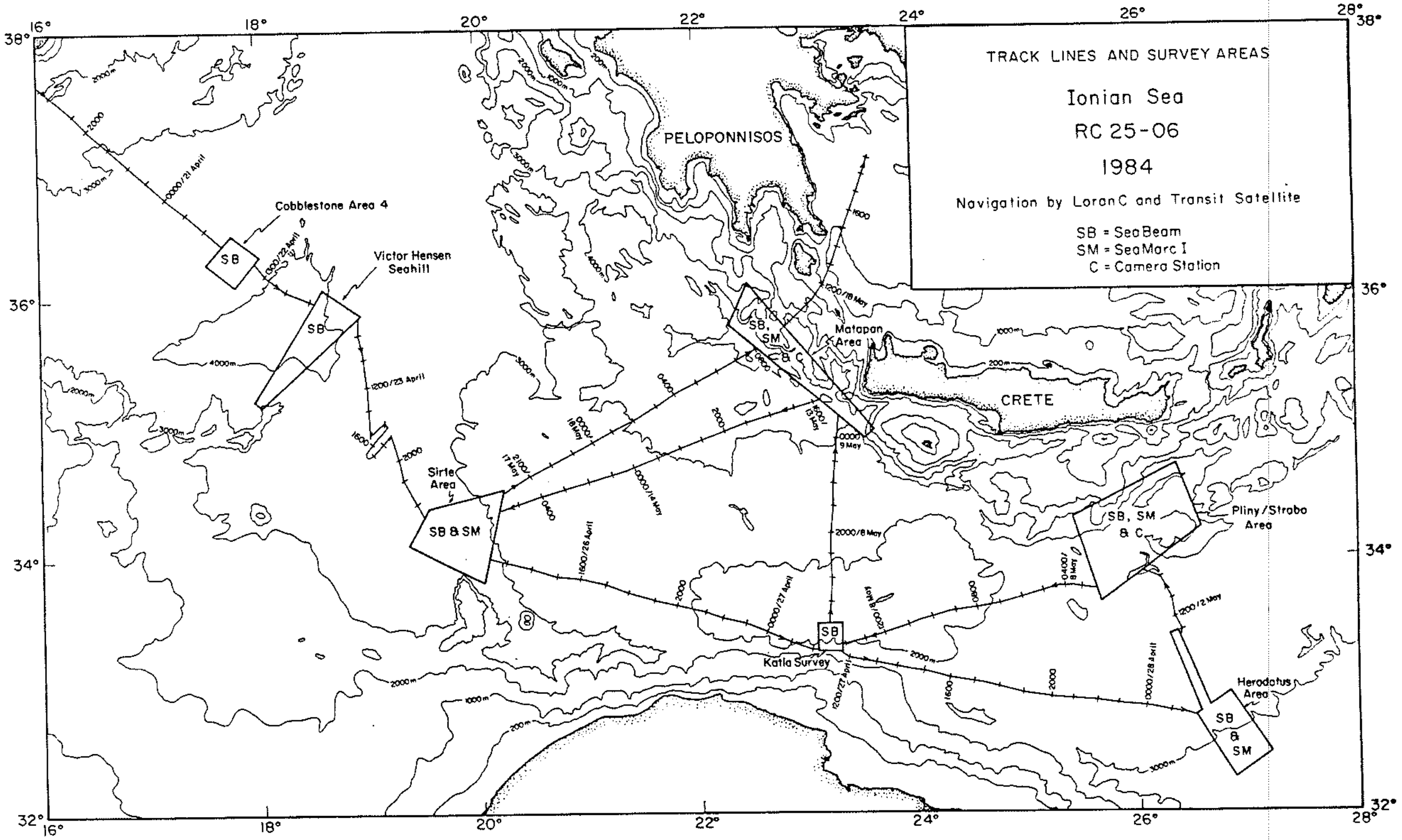
TRACK LINES AND SURVEY AREAS
Ionian Sea
RC 25-06
1984
Navigation by LoranC and Transit Satellite
SB = SeaBeam
SM = SeaMarc I
C = Camera Station
PELOPONNISOS
CRETE
Cobblestone Area 4
Victor Hensen Seahill
Sirte Area
Matapan Area
Pliny/Strabo Area
Herodotus Area
Katla Survey
SB
SB, SM & C
SB & SM
0000/21 April
1300/22 April
1200/23 April
1600/26 April
0000/27 April
1200/27 April
0000/28 April
1200/2 May
0400/8 May
1200/8 May
2000/8 May
0000/9 May
1600/13 May
0000/14 May
2100/17 May
0000/18 May
1200/18 May
1000m
2000m
3000m
4000m
200m
16°
18°
20°
22°
24°
26°
28°
32°
34°
36°
38°

Figure 2.

Nice, France to Victor Hensen Seahill:

Cruise leg RC25-06 began in Nice, France following a three day port stop. We transitted across the Ligurian Sea, passed north of Corsica, through the Ligurian Sea and to the U.S. Navy fuel depot at Gaeta, Italy. SeaBeam and 3.5kHz echosounder data were collected during the transit. Refueling required approximately 6 hours in port.

Upon departure from Gaeta we found that the interface connecting the SeaBeam system with the VAX 11/780 was not working properly. Therefore during the first part of the transit from Gaeta to the Straits of Messina, we have SeaBeam swath plots, but no logged SeaBeam data and no plots on Mercator grid. During the latter part of this transit, SeaBeam was off line for several short intervals when the water was shallower than 1000m and for various attempts at upgrading the SeaBeam software.

After we passed the Straits of Messina, SeaBeam was run continually throughout the cruise. We passed over the Calabrian Ridge, which is a structure associated with subduction beneath the toe of Italy and Sicily, and tectonically analogous to the Mediterranean Ridge. The transit line across the Calabrian Ridge was laid perpendicular to the strike of the Ridge and thus perpendicular to the regional structures in order to provide a comparison with the Mediterranean Ridge structures. A half-day SeaBeam survey was conducted on the Calabrian Ridge in the vicinity of Cobblestone Area 4. This area had been Deep Tow surveyed and sampled by the Melville and Eastward in 1978. The SeaBeam survey was intended to provide a comparison between SeaBeam and Deep Tow bathymetry and to extend the study area beyond the postage stamp mapped with Deep Tow. It was during this survey that we first became aware that in rugged terrain the 3.5kHz echo sounder can cause serious interference problems in the SeaBeam data (figure 3). This problem necessitated rerunning one line at a loss of about 3 hours of ship time.

We transitted across the Messina Abyssal Plain to the Victor Hensen Seahill. This is a steep-sided northeast/southwest trending ridge located a few kilometers west of the western edge of the contact between the Mediterranean Ridge and the Messina Abyssal Plain. This feature has been the focus of an intense coring and dredging campaign by the Italian vessel Bannock; a SeaBeam survey in this area was of particular interest to the Italian scientists on board the Conrad. Our half day SeaBeam survey in this area focused on the extention of the Seahill northeastward towards the Mediterranean Ridge and southwestward towards the African margin. Victor Hensen Seahill had been variously interpreted as a salt diapir or a volcanic feature; during the survey we formulated the alternative working hypothesis that it may be a fracture zone ridge.

Sirte Area:

The first detailed survey area was at the contact between the Sirte abyssal plain and the Mediterranean Ridge, on the southwestern flank of the Ridge. The site encompasses the south end of the transect of drill sites across the Mediterranean Ridge tentatively scheduled for the next phase of ocean drilling, the south end of a Conrad leg 9 seismic profile across the Ridge, the south end of an Italian multi-channel seismic

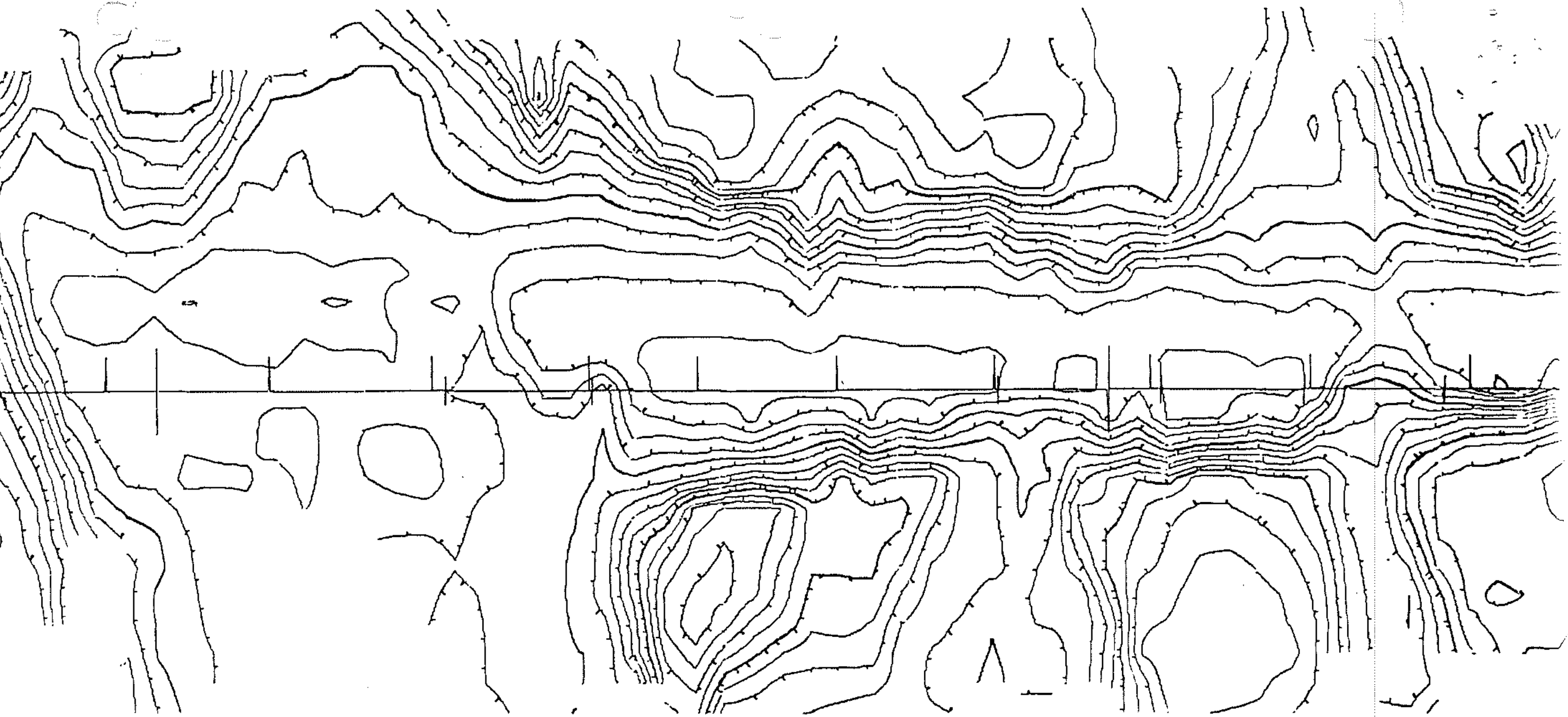

Figure 3. Portion of the SeaBeam swath plot from the Cobblestone area 4 survey showing an artifact resulting from 3.5kHz interference. The valley running parallel to the track, down the center of the swath, does not exist. This was confirmed by comparison with a Deep Tow map of the region, and by re-running the line using SeaBeam. This kind of artifact is particularly diabolical because it cannot be detected or rectified after the the ship has left the area.

rofile across the Ridge (line MS33 of Finetti and coworkers), and the outh end of a SeaBeam transect across the Ridge collected by the Jean narcot during Expedition Escarmed (B. Biju-Duval and coworkers). The outer edge of the Ridge in this area has a steeper portion (regional slope of 2.5°) along the contact with the abyssal plain, and a less steep portion (regional slope <1°) farther northeast. The break in slope occurs 10-15km from the deformation front. The survey was designed to cover the steeper portion and extend approximately 15km northeast into the flatter portion.

The Sirte survey began with an 8 hour SeaBeam reconnaissance. SeaMARC was then launched without incident at the northeastern (shallowest) end of the survey area. For this lowering, the ordinary 4.5kHz subbottom profiling system was used rather than the newer CHIRP system. During the descent, the seafloor trace from the 4.5kHz sonar was extremely weak, even when the receiver gain was turned up to the maximum. This was attributed to a failure of the time variable gain (TVG). However, when the winch was stopped and the vehicle was stabilized at near-constant depth, the subbottom return was strong enough that the fish could be flown safely and the altitude detect system worked properly. We therefore decided to continue the tow.

The steeper part of the outer flank of the Ridge, nearer the deformation front, is wrinkled into a series of tightly spaced ridges with amplitudes of approximately 50m and wavelength of about 1km. In plan form the ridges are gently sinuous, but generally subparallel to each other and to the deformation front. The southwesternmost presumably youngest?) ridge appears to be a doubly plunging anticline owing out of the abyssal plain (Figure 4). This suggests that the entire set of ridges can be interpreted as folds formed under a northeast-southwest compressional regime. The deformation in the northeastern part of the survey, farther from the deformation front, is more complex. Superimposed on a set of subparallel ridges similiar to those described above, are several sets of fine lineations slicing across the ridges (Figure 5). We tentatively interpret these fine lineations as conjugate strike-slip traces formed as a later stage of deformation in the same northeast-southwest compressional regime which formed the ridges.

We towed at the Sirte area for slightly more than three days. Throughout this lowering the quality of the sidescan records is superb, in large part because of a stable vehicle resulting from calm seas and careful fish flying and subdued terrain. The 4.5kHz records are mediocre, recording the shape of the seafloor, but showing little subbottom penetration except in the abyssal plain.

Katia Survey and Herodotus Area:

We recovered SeaMARC without incident and SeaBeamed along the southern edge of the Ridge. During this transit the problem with the SeaMARC TVG was traced to a scrap of tissue paper stuck in the back plane. The next survey was in the area where the Ridge is in closest contact with the African continent, near longitude 23°. This is the southern end of seismic profile "Katia," published by Sancho and o-workers. This controversial seismic profile was interpreted by the

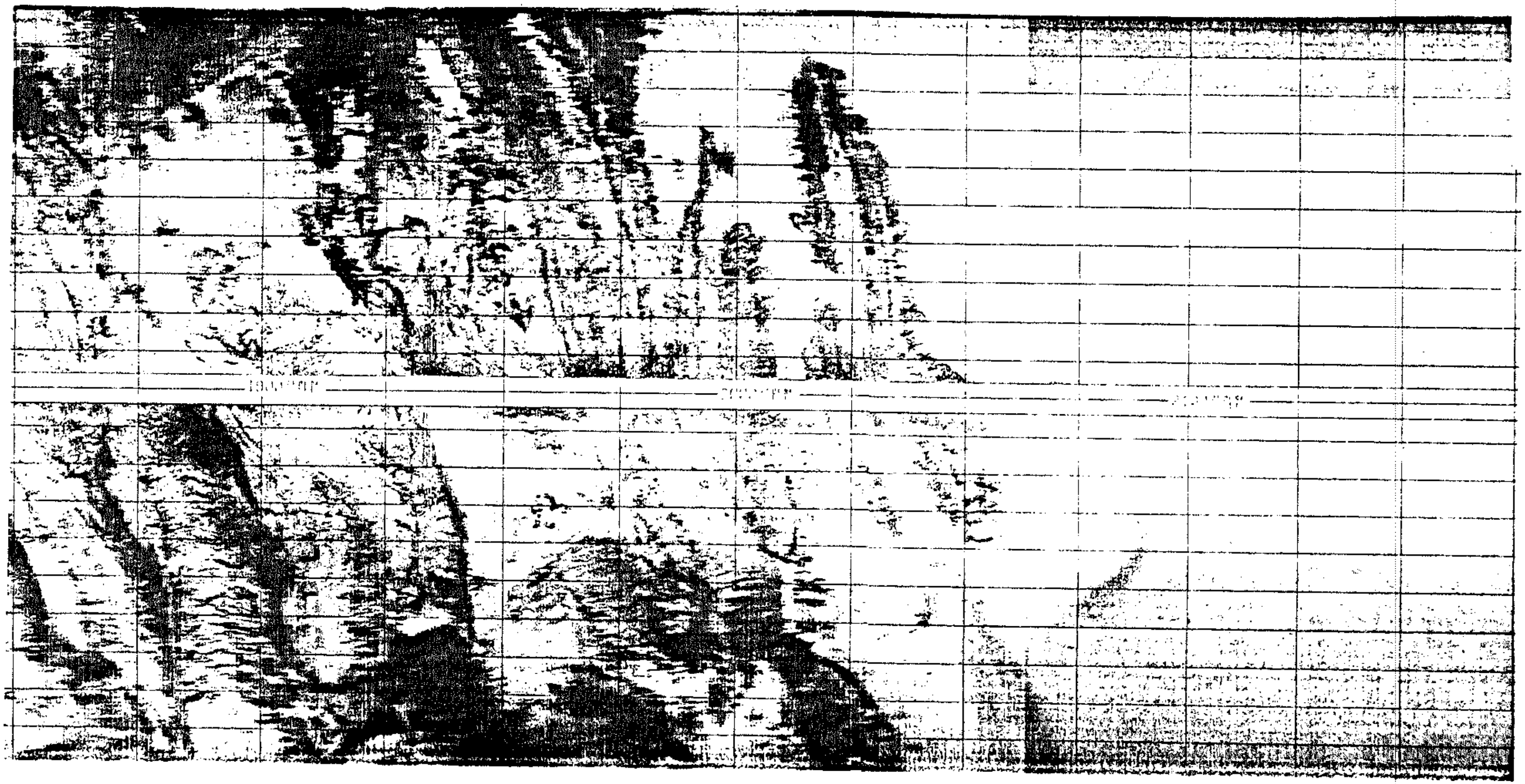

Figure 4 . Sea MARC I Processed side scan sonar record showing the abrupt contact between the Sirte Abyssal Plain (to the right) and the Mediterranean Ridge. The vehicle path is down the center of the image. Dark areas are regions of high acoustic reflectivity. The lineated features trend northwest - southeast, and are interpreted as folds. The width of the swath is 5 km, and the along track scale equals the across track scale.

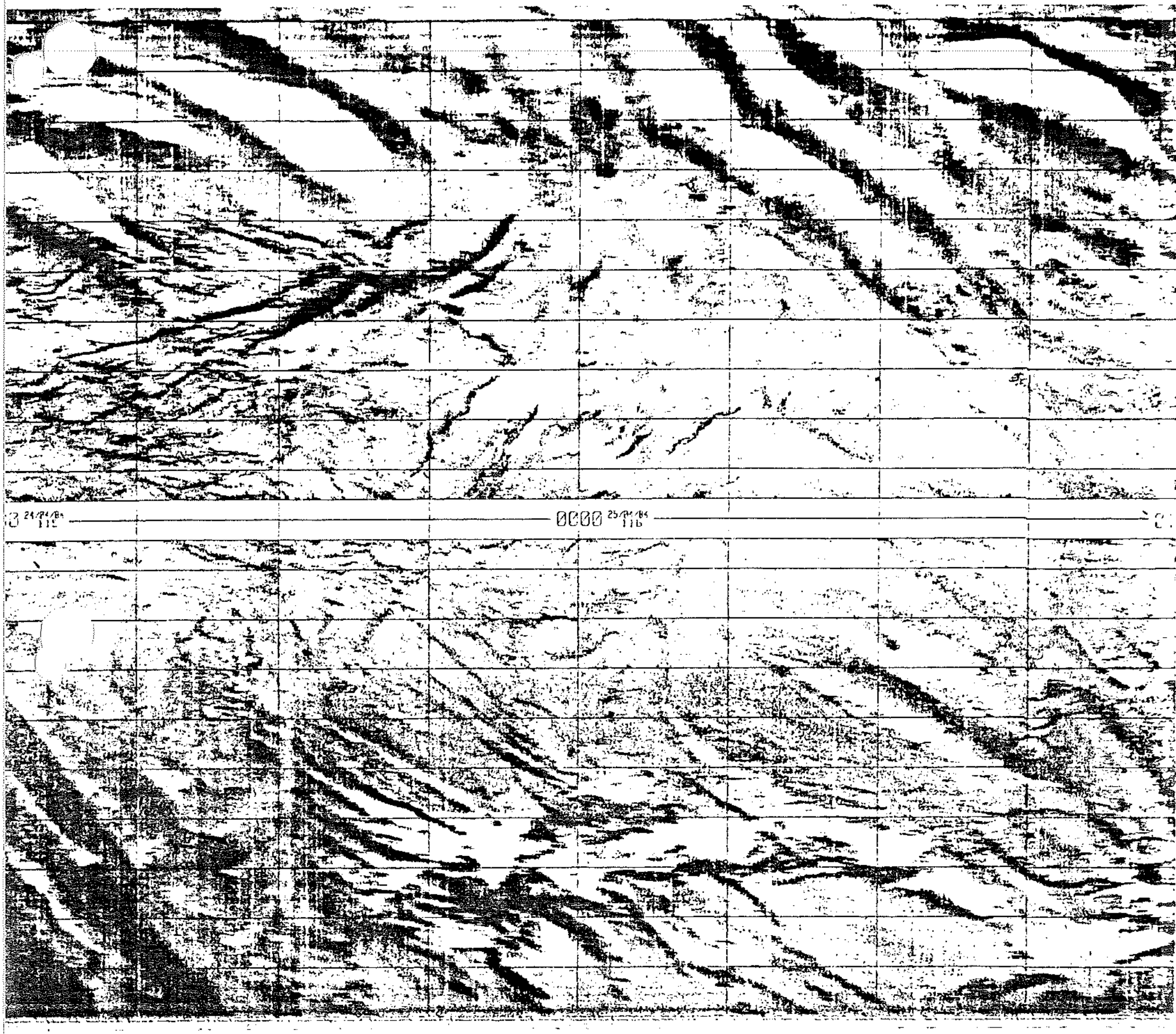

Figure 5 . This image is also from the Sirte area, from slightly higher on the Ridge than the previous image. In addition to NW/SE trending folds (?) as seen near the contact with the abyssal plain, a set of crosscutting, fine scale lineations is observed.

original authors as showing a normal fault on the southern flank of the idge. This often-cited interpretation lead to widespread confusion about the tectonic setting of the Mediterranean Ridge. The profile has since been re-interpreted as showing a northward dipping thrust fault. Our half day SeaBeam/3.5kHz survey in this area showed tightly spaced ridges similiar to those near the deformation front at the Sirte site. However, the Katia ridges are less sinuous in planform, more nearly parallel to each other and to the deformation front, and individual ridges extend further in the along strike direction than at Sirte (figure 6). As at Sirte, we interpreted the ridges as folds associated with compression perpendicular to the margin of the Mediterranean Ridge, in this case north/south.

As we left the Katia area, we followed the "trench" between the Mediterranean Ridge and the continental slope of Africa, steering the ship by the SeaBeam contours. At longitude 24°05'E, we turned to head directly towards the next detailed survey area, located at the contact between the Mediterranean Ridge and the Herodotus Abyssal Plain. Background data in this part of the Med are relatively sparse. The survey area was located along the transit of piston and gravity cores which were collected in 1982 by the Italian vessel Bannock (M.B.Cita and coworkers) across the deformation front. The regional slope on the outer flank of the Ridge is less steep than at the Sirte site, and the character of the "Cobblestone" topography is less regular on surface ship echosounder records.

The Herodotus survey began with a half-day SeaBeam reconnaissance. SeaMARC was launched at the northwestern (shallowest) part of the survey area. The first line proceeded down across the deformation front to the abyssal plain. We quickly noted that the evidence of surficial deformation was much less apparent here than at the Sirte site. Although the technical quality of the SeaMARC records could not be criticized, most of the area displayed a rather bland side scan character. This seems to result from sediment blanketing, which in turn could indicate a slower rate of deformation or a faster rate of sedimentation due to terrigenous input from the nearby Nile River.

At the end of this first line, when the vehicle reached the abyssal plain, the CHIRP subbottom system was tested. Approximately five hours of CHIRP data were logged, using 20msec and 40msec swept frequency pulses. The hardware and the data acquisition software appeared to work well. In contrast to the experience on the Hudson in 1983, the CHIRP return during this test provided an adequate bottom return for the altitude detect subsystem, so that the processed side scan records were unblemished. The fish flier's record (which ordinarily shows a profile of the seafloor and subbottom, plus a profile of the vehicle path) while CHIRPing was ugly because of the long pulse length, but perfectly adequate for safe operation of the vehicle.

As the Herodotus survey proceeded, it became apparent that the surficial deformation at the Herodotus site was much less straightforwardly organized that at Sirte. The area featured a variety of sidescan lineations, a jumble of topographic highs, and various closed contour depressions separated by sedimented plateaus. The one

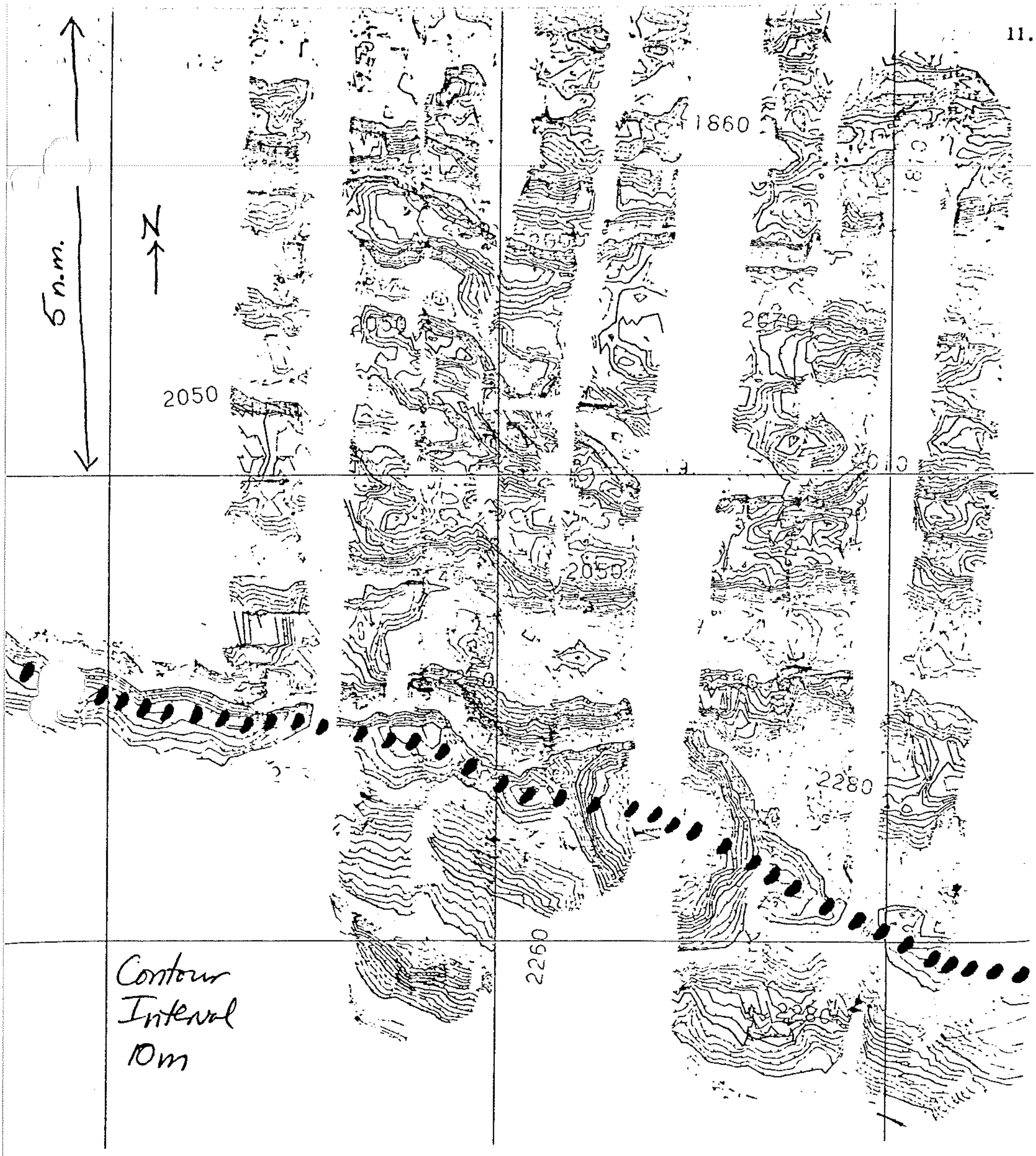

Figure 6. Example of the high quality SeaBeam plots which can be produced in real time on a Mercator grid, when the navigation is good. Note the agreement of features on ajacent tracks. This map segment is from the Katia survey. The heavy dotted line marks the "trench" which separates the African continental margin (to the south) from the Mediterranean Ridge.

unambiguous pattern to emerge at sea was that the intensity of surface deformation increased northwestward, with increasing distance from the deformation front. Since the deformation front itself had not proved to be a particularly good side scan target, we decided to persue this pattern and tow out of the detailed survey area across the Ridge towards the Strabo Trench.

When we had proceeded approximately two thirds of the way across the Ridge, all signals from the fish were abruptly lost. We terminated the lowering and recovered the vehicle. Rather than wait for SeaMARC's problem to be diagnosed, we completed the transect across the eastern limb of the Ridge with SeaBeam. The problem was later attributed to the CHIRP power interface board turning off spontaneously; the underlying reason for this was never discovered.

Pliny/Strabo Area:

The segment of the Hellenic Trench system east of Crete is characterized by a pair of northeast/southwest trending trenches: Pliny Trench farther north and Strabo Trench farther south. Among the questions we sought to address in this area was whether one trench was active and the other relict, and whether the nature of the deformation was different in the two trenches. Consequently the SeaMARC survey track for this area needed to cover both trenches. A Chacot SeaBeam survey (LePichon and coworkers, "HEAT" surveys) of several small sections of the trench system had shown a very complex topography with walls as steep as 45°. To minimize the chances of crashing the vehicle, and maximize the chances of understanding the side scan data, we felt it was essential to tow within a SeaBeam bathymetric map. We therefore pinned the western end of our survey to the HEAT Area 4, and spent most of the first day in the Pliny/Strabo area extending the SeaBeam coverage of the Pliny Trench farther eastward.

We launched SeaMARC at the west end of the Strabo Trench, as identified by Derk Jongsma and Conrad cruise participant Willem Huson during their 1983 cruise. SeaMARC died almost immediately after it hit the water and we recovered the vehicle. The problem was quickly diagnosed as a blown fuse in the CHIRP electronics. The fuse was replaced and we launched again at the same site.

We towed northeastward along the axis of the Strabo Trench, steering the ship by the SeaBeam contours. The trench is less than one SeaMARC swath wide, so we could compare the nature of the two sides of the trench easily. We found that the trench is highly asymmetrical: its northwestern side is characterized by sharp-edged, trench-parallel lineations, whereas its southeastern side is characterized by scallops reminiscent of erosional scars and lacks lineations.

The track then proceeded across Tyro and Kythira Basins, where young sapropels were recently discovered, and up onto the plateau which separates Pliny and Strabo Trenches. The plateau appears to be relatively inactive at present. It is difficult to envision that significant strike-slip motion is accommodated in the plateau, as had been suggested.

We then towed down into the Pliny Trench and laid in two parallel, ajacent 5km SeaMARC swaths, covering the flattish floor and wer walls of the Trench. The Charcot SeaBeam map of HEAT Area 4 ows several en echelon NNE/SSW trending basins, which LePichon and co-workers had interpreted as pull apart basins in a strike-slip regime. We found that this coherent story falls apart farther east, where the trench floor is covered with a delicate tracery of intersecting lineations. If these trends are tectonic, they imply a complex deformation history (Figure 7). We ended the tow just west of the western edge of the HEAT Area 4 map, after passing through a narrow notch buttressed on both sides by kilometer high walls.

Throughout the Pliny/Strabo tow the SeaMARC data quality was excellent. Meanwhile, we had succeeded in processing portions of the CHIRP data from the Herodotus area, using the off-line SeaBeam VAX 11/730, and displaying the results as wiggly line plots on the SeaBeam Houston plotter. This was the first time that CHIRP data had been processed as sea; major credit for this effort goes to Steve Cande who did most of the programming.

After SeaMARC had been recovered, we spent a night filling in our SeaBeam coverage of the eastern part of the SeaMARC area and readying the camera system for its first deployment.

The camera touched down in the axis of Strabo Trench in the region of highly asymmetrical side-scan texture described above. We towed obliquely up and then down the northwest trench wall and then up the southeast wall. During the tow we had real time black and white video from the Colmec video system. The video showed occasional utcrops on the northern trench wall with loose sediment in between. The outh wall in contrast, seemed to have a harder surface; when the camera sled hit bottom only a very small cloud of loose sediment was stirred up. Possibly this hard surface is a hard ground similar to those described from Cyana dives in the Hellenic Trench.

When the camera system was recovered, we found that one of the strobes for the still camera system had flooded. As a result the transparencies are rather dark, although not unuseable. Furthermore, the flooded strobe apparently caused the recharge time on the group of strobes to increase; the strobes fired half or a third as often as they should have, so the picture spacing is approximately every minute rather than every 28 seconds.

As we steamed westward out of the Strabo Area, we followed the axis of the trench, piloting the ship by the SeaBeam contours. The trench appears to deadend abruptly at a steep, 100m high wall. On the way to the Matapan survey area we detoured via the Katia area so we would have a perpendicular SeaBeam transect of the center of the Ridge to compare with the SeaBeam/SeaMARC transects across the eastern and western limbs of the Ridge.

Matapan Area:

The northwestern survey area was sited to take advantage of an existing French SeaBeam map, in the region of "HEAT Area 1." In addition to the SeaBeam map, background data available for this area includes one Cyana dive (LePichon and coworkers) and a etwork of seismic reflection profiles (Mascle and coworkers). This rea marks the northern end of the proposed transect of deep sea

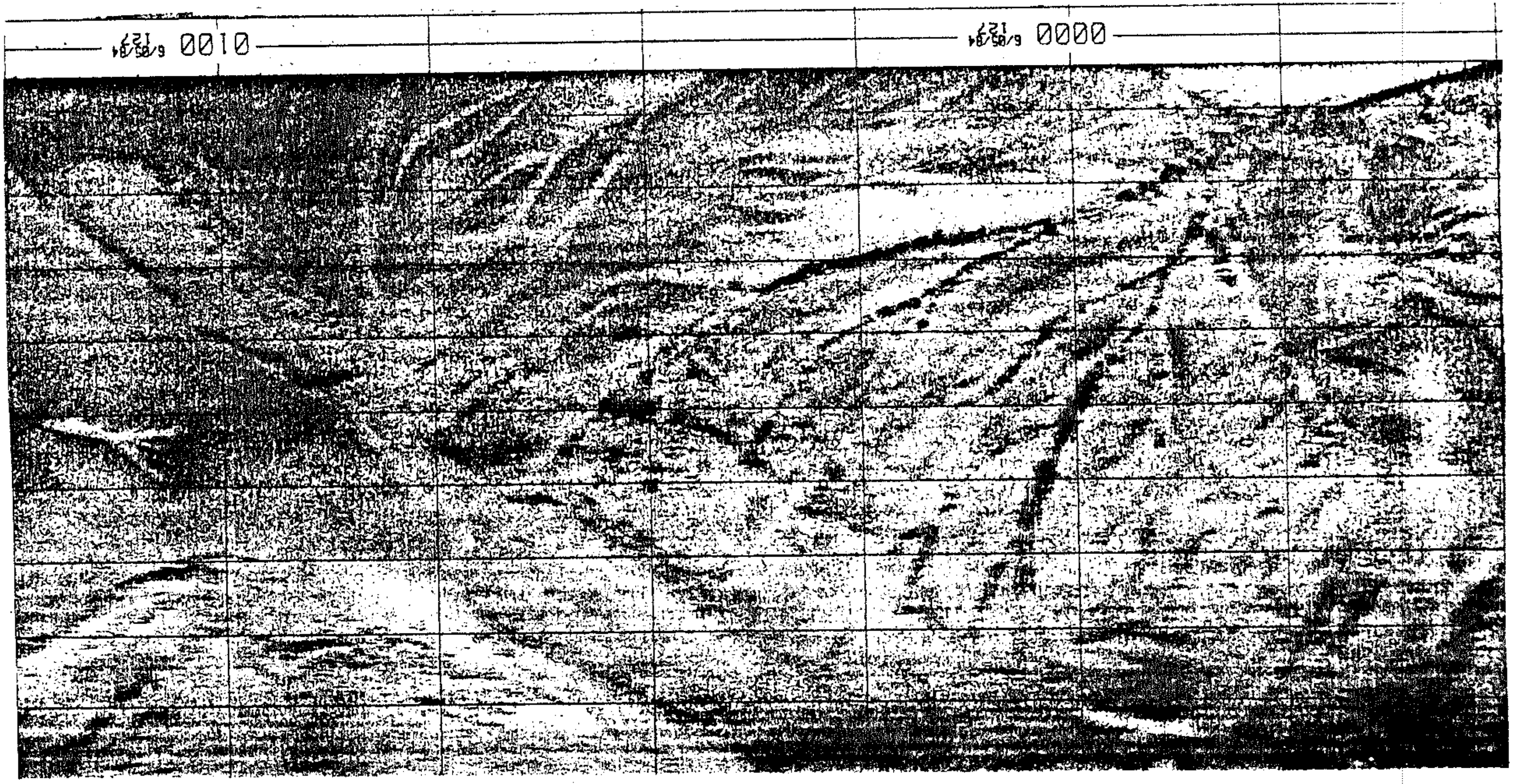

Figure 7. The relatively flat lying floor of the Pliny Trench is etched with a complex tracery of intersecting trends. The illumination in this image is from the top, and the illustrated portion of the image is 2.5 km across.

rilling sites across the Mediterranean Ridge.

Since we planned to tow within an existing SeaBeam map, we transitted directly to the launch site with no reconnaissance survey. We launched at the head of a canyon which indents the northern wall of the trench, with the intention of towing down the axis of the canyon to the trench floor. SeaMARC had reached a depth of 1500m when all signals from the fish were abruptly lost. We aborted the lowering and recovered the vehicle. We extended the French SeaBeam map to the northeast while SeaMARC's problem was traced to a chaffed spot in the tether which connects the depressor weight to the sonar vehicle. The bad spot was cut out and a new section of coax spliced in. We returned to the same canyon head, and launched again. This time all signals from the fish were lost almost immediately after the fish hit the water. Again, we aborted the tow and recovered the vehicle. We extended the SeaBeam map still farther to the northeast while SeaMARC's problem was traced once again to the CHIRP power amp. We returned to the same canyon head and launched again. This time SeaMARC appeared to be working properly, and we continued with the tow. The total loss of ship time for these problems was approximately 4 hours; in addition, 7 hours were spent SeaBeaming instead of SeaMARCing as planned.

As we towed down the axis of the canyon the data quality was mediocre because the vehicle is unstable when it is dropping rapidly. However, we were able to see that this active margin slope canyon is more blocky than the slope canyons we have SeaMARCed on passive margins, suggesting greater tectonic control of the morphology. As soon as the vehicle reached the trench axis and stabilized at working depth, the quality of the data improved significantly.

We turned southeast, and followed the northern edge of the trench floor. In contrast to Pliny Trench, where the trench floor is intensely deformed, the flat floor of Matapan trench lacks evidence of tectonic disturbance within HEAT Area 1. The subbottom records from this area show a near surface transparent layer which may be a rapidly deposited "homogenite," which has drowned out any tectonic indicators.

As we laid in our first trench parallel line towards the southeast, the wind gradually rose to 25-30 knots out of the southeast. As the sea state picked up, vehicle motion increased, and the data quality deteriorated somewhat. We also realized that in more than 4000m of water, with our 6000m wire, the only heading on which we could keep the vehicle close enough to the seafloor to collect useful data was our present heading towards the southeast. Therefore instead of completing a detailed survey of one small section of trench, we continued to drive towards the southeast following the axis of the trench on the SeaBeam contours. Although this strategy was unplanned, it turned out to be quite productive for learning about along-strike variability of the trench. The character of the trench changes from a broad, sediment-filled basin with no tectonic features on its floor, to a knife-edge notch, to a narrow, sedimented floor pierced by diapiric (?) lumps (Figure 8), over a distance of kilometers. We continued like this for three and a half days, until the wind and sea state dropped sufficiently that we could safely recover SeaMARC. During the

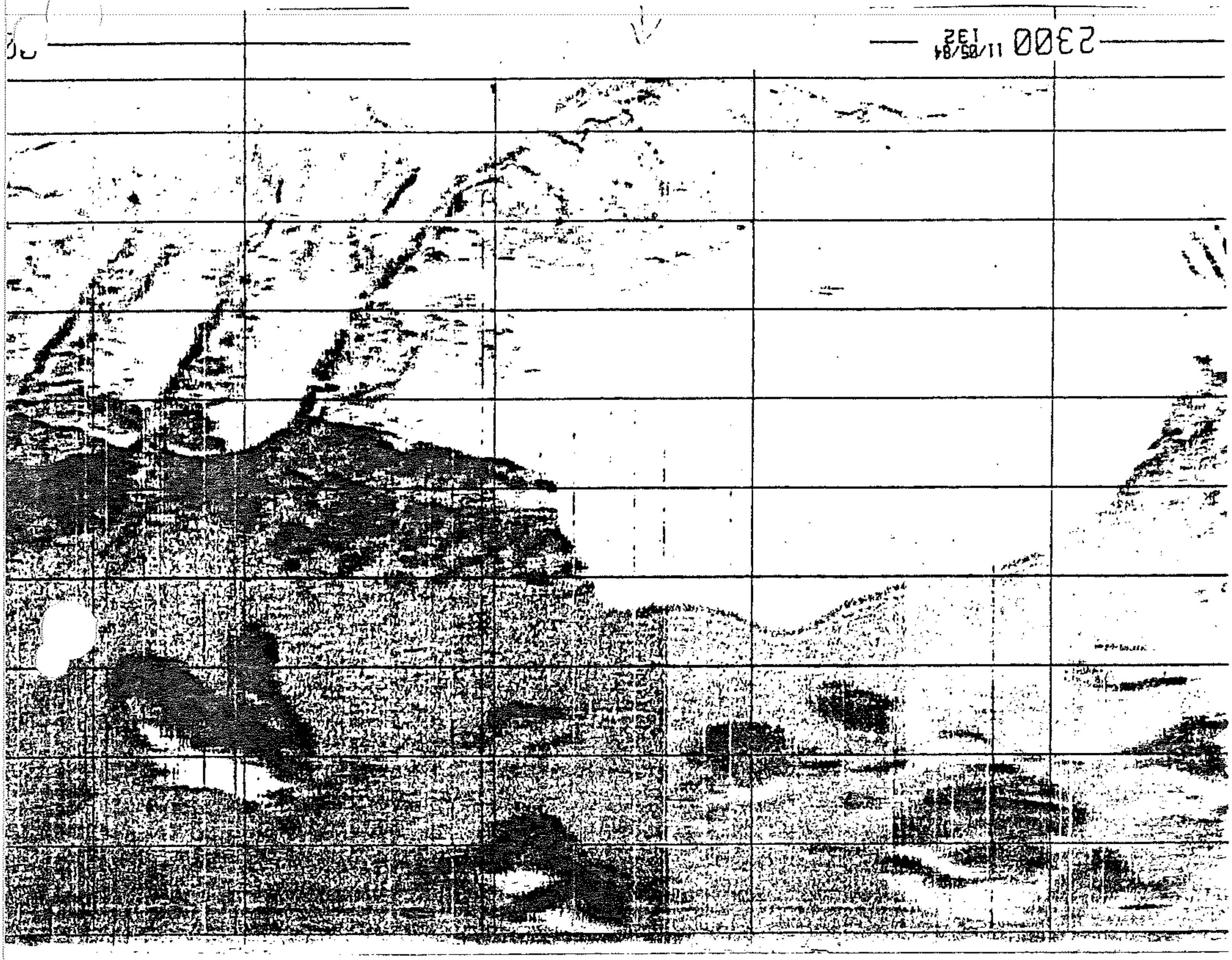

Figure 8 . The character of the Matapan Trench is highly variable along strike. In this image, the vehicle is passing along the outer (southern) wall of the trench (upper part of the image) and looking out over the sediment filled trench floor (lower part of the image) and looking out over the sediment filled trench floor (lower part of the image). Small bumps (mud volcanoes? diapirs?) protrude through the otherwise flat trench floor.

ecovery we found that one of the wire strands of the armor on the owing cable had broken and snarled, so we were delayed by about an hour while this mess was untangled.

After the recovery, we transitted back parallel to our SeaMARC track to the area shown in figure 8, for the second camera tow. We launched the camera on the north wall of the trench, towed obliquely down the wall and across several of the bumps shown in figure 8. However, the strobes and still camera worked perfectly, and we acquired over a thousand well-illuminated, well-focused transparencies. Photographs across the lumps show several cracks or fissures in the sediment, oriented approximately parallel to the long axes of the lumps.

Upon recovery we discovered yet another broken strand in the cable armoring. Both broken strands are in the outer 300m of the cable and are within 100m of each other. We are not aware of having stressed the wire in such a way as to break strands, except by the stress inherent in three days of rough weather towing. Again, approximately an hour of ship time was lost untangling this broken strand.

Following the camera tow we spent approximately half a day filling in the SeaBeam coverage of the area we had SeaMARCed.

CHIRP Transect:

This tow was planned as a transect across the western limb of the Mediterranean Ridge from the Sirte area to the Matapan area, along transect of proposed deep sea drilling sites. The CHIRP subbottom profiler was to be used continually throughout this tow. The line corresponds approximately to Italian multichannel line MS33, and to a Conrad leg 9 airgun line. As the transect had been proposed prior to our cruise, one of the proposed holes was located in the Sirte Abyssal Plain, two on the southern (Sirte) side of the ridge, one on the north side of the Ridge, and one in the Matapan trench.

We chose to begin the transect at its southern end, so that we could repair equipment during the transit, and so that three out of five holes would be close to the beginning of the tow. During the transit from Matapan to Sirte, both broken strands in the towing cable were shimmed, the towing cable was reterminated, and the coaxial conductor in the tether was replaced.

We launched SeaMARC over the Sirte Abyssal Plain, about 10km away from the deformation front. Although the deck checkout of SeaMARC and CHIRP had been satisfactory, there was no CHIRP signal once the vehicle was underwater. We aborted the launch and recovered the vehicle. Examination of SeaMARC's electonics revealed a massive failure in the CHIRP power amp and power interface. While SeaMARC was being diagnosed and repaired, we filled in the SeaBeam coverage of the Sirte area.

On the second launch, we had signals from the fish, but the warning lights which indicate a short to ground in either the center or shield conductor of the tow system were flickering wildly and erratically. Again, we aborted the launch and recovered the ehicle. We resumed SeaBeam surveying, this time exploring a region ast of the tow site where a protrusion of Africa (Cyrene Seamount) is olliding with the Mediterranean Ridge. In the region of this indentor, the small ridges along the deformation front are warped around from their NW/SE trend into trends more nearly parallel to the edge of the "seamount." Meanwhile, SeaMARC's problem was traced to water in one of the Burton connectors.

We launched yet a third time. This time the system worked satisfactorily, and we continued with the tow. The tow proceeded in a straight line across the outer three proposed drilling sites. CHIRP was used throughout the tow. Most of the CHIRPing used a 20msec pulse, since either the 40 or 100msec CHIRPs produced numerous unwanted unscheduled transmits between scheduled 4sec transmits. The side scan data while CHIRPing was of poorer quality than usual. In part this was because the altitude detect subsystem does not detect the seafloor as reliably in the complex CHIRP return, as it does in the usual 4.5kHz return. Secondly, the ocassional unscheduled transmits between the normal 4sec rep rate transmits, caused returns which were not coherent from sweep to sweep.

Since we had lost so much time in CHIRP equipment problems, we were forced to terminate the tow after one and a half days in order to reach Pireaus on schedule. The completed SeaMARC transect is approximately 100km long; and extends about a third of the way across the Ridge. We finished the transect to the Matapan Trench as a SeaBeam line.

During the transet from the Matapan Trench to Pireaus, SeaBeam as run when the water depth was greater than 1000m. The 3.5kHz echo sounder was run when the seafloor relief was gentle enough that the 3.5 did not interfer with SeaBeam, and when SeaBeam was turned off in shallow water.

EVALUATION

Vessel and Equipment:

On this cruise the Conrad proved once again to be a versatile and able vessel, well suited for the arduous routine of slow speed towing with frequent course and speed changes. Captain Joergenson and his officers and crew were competent, cooperative, interested and responsive to the needs of our science, and a pleasure to work with.

The new SeaBeam installation on the Conrad is working very well. We had only a few hours of SeaBeam down time in the entire month at sea. Most of that was due to a problem in the interface between the GIC SeaBeam system and VAX. However, provision should be made for providing better navigation inputs for producing real time SeaBeam plots. On this cruise, SeaBeam could only be plotted from Loran C positions derived from a Northstar 6000 receiver. In the future it would be desirable to plot from transit satellite/dead reckoning when Loran is poor or unavailable, and from GPS when that system comes on line this summer. Serious consideration should be given to eliminating or minimizing interference between the 3.5kHz echo sounder and SeaBeam. his will continue to be a frustrating problem on any survey where the errain is rough yet the investigators care about sediment cover. A ossible solution would be to control the timing of the 3.5kHz outgoing signal from the VAX 11/730.

The cruise narrative above emphasizes one outstanding virtue of SeaBeam which is perhaps underappreciated. SeaBeam is the perfect backup tool for any marine geophysical program which involves complex equipment. Any scrap of shiptime which falls between instrument deployments or which would normally be wasted fixing things, can be spent SeaBeaming. The chance of learning something useful is very high; the investment of personnel effort is very low.

The basic SeaMARC system worked very well. The real time side scan records from the Sirte and Pliny/Strabo areas are among the best quality SeaMARC records we have ever collected, and the other areas are highly satisfactory as well. We replayed portions of the taped data at sea, verifying that the data logging system worked properly throughout the cruise. The only serious problems in the basic SeaMARC system were a problem with the subbottom time variable gain on the first lowering and a chafed spot in the tether which cause one aborted lowering.

The CHIRP subsystem, on the other hand, must still be viewed as experimental. The major advances made on this cruise were to process CHIRP data at sea (although only a small subset and not yet in real time), and to collect CHIRP data on a mass production basis rather than a few minutes here and a few minutes there. Major problems remain in the CHIRP hardware. Four of our five aborted launches were directly attributable to CHIRP, causing significant loss of shiptime (one to two ours for each aborted launch, plus a total of about two days converted from planned SeaMARC time to SeaBeam time), not to mention untold wear and tear on the scientific party. The CHIRP top side electronics and data acquistion system seemed to be working fine, although the data acquisition software is spectacularly user-unfriendly. The most urgent need of the CHIRP system is to iron out the hardware bugs that cause the system to fail repeatedly within a few minutes of hitting the water. In my opinion, the next important goal should be to enable the use of the longer 40 and 100msec CHIRPs, since deeper penetration with high resolution is the motivation for CHIRPing in the first place. After that, we should strive towards real time processing and display of at least a fraction of the CHIRP data.

Camera work formed a relatively minor aspect of our work, but the results were quite rewarding. The one serious problem was in the flooding of a strobe on the first tow, which caused the loss of approximately every other picture, and rather dim illumination on the others. The real time video system has been a low-level development project of Ryan's group for several years, and its use on the first lowering of this cruise was only its second successful deployment. In addition to its utility for geologic interpretation, the realtime video proved to be an invaluable aid for flying the sled at the correct altitude.

Science:

We accomplished virtually completely our primary scientific oal of acquiring a data set which will allow us to compare and ontrast the nature of the deformation on the convex side of the Ridge ersus the concave side and the allegedly "convergent" side with the alledgedly "strike-slip" side. If the results had to be summarized in a sentence, I would have to say that what we learned is that the nature of the deformation along the margins of the Mediterranean Ridge is more complicated than the current literature would lead one to believe.

The major scientific disappointment was in being unable to complete the CHIRP transect across the Ridge, and in being unable to produce long duration CHIRPs which might have penetrated deep enough to trace the M-reflector.

APPENDIX 1

SCIENTIFIC PERSONNEL

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	Name	Affiliation	Nationality	Responsibility
(1)	Kim Kastens	LDGO	USA	Chief Scientist
(2)	Steve Cande	LDGO	USA	Scientist
(3)	Dale Chayes	LDGO	USA	SeaMARC engineer
(4)	Bernie Gallagher	LDGO	USA	SeaMARC technician
(5)	Anita Brosius	LDGO	USA	Camera technician
(6)	John DiBernardo	LDGO	USA	SeaMARC technician
(7)	Michelle Henrion	LDGO	USA	SeaMARC research asst.
(8)	Jim Smith	LDGO	Canada	Science Officer
(9)	Alberto Malinverno	LDGO	Italy	Graduate Student
(10)	Barry Allen	LDGO	USA	Ship's Technician
(11)	Kevin Little	LDGO	USA	Ship's Technician
(12)	Jean Champeau	LDGO	USA	Administrator
(13)	Jacqueline Grimm	Grimm Oil	USA	Industrial Observer
(14)	Willem Huson	Amsterdam Free U.	Netherlands	Student
(15)	Angelo Camerlenghi	U of Milan	Italy	Student
(16)	Massimo Giambastiani	U of Milan	Italy	Student
(17)	Massimo Croce	U of Milan	Italy	Student
(18)	Daniel Chayes	URI	USA	SeaBeam Technician
(19)	John Freitag	URI	USA	SeaBeam Technician

APPENDIX 2

CHRONOLOGY

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(All times are GMT)

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18 April	0445	Leave Nice, France
19 April	0940	Arrive Gaeta fuel depot
	1700	Leave Gaeta
20 April	0015	SeaBeam VAX 11/730 starts making plots on Mercator grid
	1300	Passing Straits of Messina
21 April	0034	Arrive Cobblestone Site 4, Begin SeaBeam/3.5 kHz survey
	1202	Leave Cobblestone Site 4
	1437	Arrive Victor Hensen Seahill, begin SeaBeam/3.5 kHz survey
	1455	Magnetometer deployed
22 April	0906	Leave Victor Hensen Seahill
	1008	Recover magnetometer
	2310	Arrive Sirte area, Begin SeaBeam reconnaissance
23 April	0600	Launch SeaMARC, Lowering #1
26 April	1105	Recover SeaMARC, Lowering #1
27 April	0220	Arrive Katia Area, Begin SeaBeam survey
	1435	Leave Katia Area
28 April	0200	Arrive Herodotus Area, Begin SeaBeam/3.5 kHz reconnaissance
	1700	Launch SeaMARC, Lowering #2
1 May	1000	Tow out of Herodotus Area and begin transit across Ridge
2 May	0453	Lost signal from SeaMARC, began recovery
	0830	Recover SeaMARC, Lowering #2, Resume transect across Ridge with SeaBeam
	1707	Arrive Strabo Trench, begin SeaBeam reconnaissance
3 May	1303	Launch SeaMARC, Lowering #3, Launch #1
	1330	Sea MARC died, began recovery
	1405	Fish on deck, Lowering #3, Launch #1
	1650	Launch SeaMARC, Lowering #3, Launch #2
6 May	1400	Recover SeaMARC, Lowering #3, Begin transit back to Strabo Trench
7 May	1100	Launch camera, Strabo Trench
	1441	Camera on bottom
	2302	Camera left bottom
8 May	0127	Recover camera, Begin transit to Matapan Area
9 May	0615	Arrive Matapan Area
	0652	Launch SeaMARC, Lowering #4, first launch MATAPAN

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	0755	Lost signal from SeaMARC, began to recover
	0943	SeaMARC on deck, resume SeaBeaming
	1536	Launch SeaMARC, Lowering #4, second launch
9 May	1545	SeaMARC CHIRP power supply failure
	1615	SeaMARC on deck again, resume SeaBeaming
	1950	Launch SeaMARC, Lowering #4, 3rd launch
12 May	1159	Recover SeaMARC, Lowering #4, begin transit to Matapan camera site
	1416	Launch camera, camera run #2
	1650	Camera on bottom
13 May	0220	Camera off bottom
	0625	Camera on deck, Resume SeaBeam survey of Matapan
	1600	Leave Matapan area, begin SeaBeam transit to Sirte Area to start CHIRP transect
14 May	1016	Launch SeaMARC, Lowering #5, 1st launch
	1047	No CHIRP signal, abort launch
	1148	Sea MARC on deck resume SeaBeam surveying
15 May	1040	Launch SeaMARC, Lowering #5, 2nd launch
	1100	Ground fault lights wildly erratic, abort launch
	1126	SeaMARC on deck, resume SeaBeam surveying
16 May	0358	Launch SeaMARC, Lowering #5, 3rd launch
17 May	2046	Sea MARC on deck resume transect across Ridge with SeaBeam
18 May	1000	Complete western transect of Ridge, back to Matapan Area
	1132	SeaBeam off, water too shallow
19 May	0226	Secured main lab watch
	0403	Tied up in Pireaus