I.O.S.

R.R.S. DISCOVERY

CRUISE 110

22 APRIL – 18 JUNE 1980

GEOPHYSICS AND GEOCHEMISTRY IN THE EAST PACIFIC OCEAN

CRUISE REPORT NO 102

1980

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Geophysics and Geochemistry in the East Pacific Ocean

Cruise Report No. 102

1980

Institute of Oceanographic Sciences,
Brook Road,
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Godalming, Surrey. GU8 5UB.
U.K.

"I have long been grieved and most sorry at the interminable length of the voyage (although I never would have quitted it); but ...... I could not make up my mind to return, I could not give up all the geological castles in the air, which I had been building ......"

Charles Darwin to his sister Catherine, from H.M.S. Beagle at Valparaiso, 1834.

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SCIENTIFIC PERSONNEL

		Leg
R.C. Searle	Principal Scientist	1 + 2
T.J.G. Francis	Geophysics	1 + 2
S. McGiveron	Geophysics	1
S.C. Maslin	Geophysics	1
C.L. Jacobs	Geophysics	1
M.R. Saunders	Geophysics	1 + 2
R.A. Glosby	Geophysics	2
I.T. Porter	OBS	1 + 2
C.A. Tew	OBS	1
R.E. Kirk	OBS	1
R.C. Lilwall	OBS	1
M.L. Somers	Gloria	1
J. Revie	Gloria	2
S.V. Bicknell	Gloria	1
B.J. Barrow	Gloria	2
D.G. Bishop	SRP	1
C. Flewellen	SRP	2
R.N. Bonner	Workshop	1 + 2
D. Lewis	Computer	1
A.R. Lewis	Computer	1 + 2
P. Mason	Computer	2
R.S. Robinson	Gravimeter	1 + 2
T.W.C. Hilde	Visitor, Texas A & M University	1
L.C. German	Observer, Costa Rica	1
T.R.S. Wilson	Chemistry	2
R.J. Morris	Chemistry	2
M.S.N. Carpenter	Chemistry	2
W.R. Simpson	Chemistry	2
P.S. Ridout	Chemistry	2
M.J. McCartney	Chemistry	2
E.H. Coyle	Chemistry	2

SHIP'S OFFICERS AND PETTY OFFICERS

	Leg 1	Leg 2
Master	P.H.P. Maw	P.H.P. Maw
Chief Officer	K.O. Avery	N.A.C. Jones
Second Officer	S. Sykes	S. Sykes
Third Officer	T.C. Harrison	G.P. Harries
Chief Engineer	D.C. Rowlands	D.C. Rowlands
Second Engineer	G.M. Batten	C.J. Latter
Third Engineer	H.J.C. Peck	H.J.C. Peck
Third Engineer	J.R. Richardson	
Fourth Engineer		B.J. Entwisle
Fifth Engineer	G. Gimber	J. Landry
Fifth Engineer	R. Cotter	R. Cotter
Electrical Engineer	P.E. Edgell	P.E. Edgell
Radio Officer	P.J. Robinson	P.J. Robinson
Doctor	M.A. Griffiths	M.A. Griffiths
Purser Catering Officer	R.M. Cridland	R.M. Cridland
Netman	R.G. Burt	R.G. Burt
Bosun	W.H.K. Stewart	W.H.K. Stewart
Carpenter	L. Cromwell	L. Cromwell
Bosun's Mate		D.S. Knox

CRUISE OBJECTIVES

A. GEOPHYSICS

1) To study the tectonics of a fast-spreading mid-ocean ridge (the East Pacific Rise), primarily using Gloria and the 36 kHz sonar. This was to include detailed studies of the spreading axis and at least one transform fault.

2) To make a similar study of a medium-spreading ridge (the Cocos-Nazca spreading axis). This was to include a study of a 'propagating rift' at 95 °W, where an offset in the spreading centre is apparently propagating along the ridge axis.

3) To make a detailed study of the tectonics of the Galapagos Triple Junction using primarily the side-scan sonars.

4) To determine the precise location of the Pacific-Nazca plate boundary between the Quebrada (3.5 °S) and Gofar (5 °S) fracture zones on the East Pacific Rise.

5) To deploy five ocean bottom seismographs (OBS) in one of the East Pacific Rise fracture zones.

6) To undertake a Gloria survey of the Peru Trench (in conjunction with T. Hilde, Texas A & M University).

7) To investigate the morphology and tectonics of the southern Panama continental margin.

8) To conduct Gloria surveys over IPOD sites 501/504 and 505 in the Costa Rica Rift.

B. GEOCHEMISTRY

1) To sample oxyhydroxide-rich sediment in the Bauer Deep.

2) To compare mineralogy, sedimentary history and pore-water profiles between the Bauer Deep and East Pacific Rise flank and crest.

3) To study variations in mineralogy and pore-water composition between stations above and below the carbonate compensation depth, and if possible across a buried redox horizon.

4) To obtain information on the biogeochemistry of the Peru shelf and slope sediments by coring and sediment trap deployment.

5) To core metal-rich sediments in Hess Deep for analysis by D. Cronan, Imperial College.

ITINERARY

Leg 1		
Departed Balboa, Panama	1980 April 22nd	Day 113
Arrived Callao, Peru	May 20th	Day 141
Leg 2		
Departed Callao	May 23rd	Day 144
Arrived Balboa	June 18th	Day 170

NARRATIVE (All times are in GMT)

LEG 1

Leg 1 was almost entirely devoted to underway geophysics and to laying Ocean Bottom Seismographs. The track chart is shown in Figure 1.

The departure from Balboa was delayed a few hours while we awaited news of the arrival of Dr. P. Lonsdale of Scripps Institution of Oceanography, and of a consignment of batteries for the OBS. By 1800 GMT (noon local time) we had learned that Lonsdale would not be able to join, and that the batteries would not arrive in the near future. It was then decided to sail as soon as possible and, after a wait for the pilot, we departed at 2330 GMT on day 113 (April 22nd).

The PES (echo-sounder) fish, Gloria, single-channel hydrophone array and 160 cubic inch air-gun were deployed between 0700 and0900 day 114, near the edge of the Panama continental margin. Gloria was operating at 40 second pulse-repetition rate. The 2kHz profiler was turned on and recorded through the SRP array and the hull-mounted sidescan was also switched on, although following the problems of the previous cruise we did not attempt to deploy it below the hull. We then proceeded WSW at 10 kts on passage to our first survey area on the Cocos-Nazca spreading axis at 95 °W. During day 114 we crossed the continental margin, a major E-W ridge just to its south (possibly a component of a Cocos-Caribbean transform plate boundary), and the Panama Trench near 6.5 °N, 80.5 °W. We obtained 4 seconds (two-way time) sub-bottom penetration to the top of the underthrusting Cocos plate beneath the trench, and evidence of recently active folding in the trench sediments.

At 114/2120 we began, belatedly, to record magnetics after some initial trouble with the plug connecting inboard and outboard cables.

We crossed Coiba Ridge and the Panama and Ecuador fracture zones on day 115. On day 116 we crossed Cocos Ridge. At 116/1634 the air-gun and SRP (seismic reflection profiling) array were recovered, and between 1800 and 2000 on 116 we tried receiving the 2 kHz on its own short array. This proved impossible because of excessive interference from the ship's A.C. mains. The array was recovered at 2000, but was eventually made usable by isolating it from the ship via a transformer and by driving its preamp from a battery supply.

At 116/2330 we recovered the streamed gear prior to passage through Galapagos waters. Gloria, magnetometer and 2 kHz array were redeployed on the far side of the Galapagos 200 mile limit at 118/0943, and at 118/1025 we began a survey of the 'propagating rift' on the Cocos-Nazca spreading axis at 95 °W (Figure 2).

On the run out from Balboa the maximum range obtained with Gloria had been very much reduced, to some 5 to 7 miles, by the very steep equatorial thermocline. At the start of the propagating rift survey we experimented with different ship speeds in an attempt to get the Gloria vehicle lower in the water and thus enhance the range. However, there was very little change for speeds in the range 8 to 10 knots, and little improvement unless the speed dropped considerably below 8 knots. It was therefore decided to continue at 10 knots.

The propagating rift survey was completed by 110/0946, and we then followed a shallow zig-zag course along the Cocos-Nazca spreading axis towards the Galapagos Triple Junction. We began a detailed survey of the Triple Junction region, with 10 mile spaced N-S and E-W lines, at 120/0740 (Figure 3). At 121/1840 we broke off this survey for 24 hours coring over Hess Deep (Figure 4). Six cores were attempted using the Calvert stainless steel corer. (Station numbers 10173 to 10178; see Table 1). Two of these recovered sediment, but three others, taken over a flat bottom in the deepest part of Hess Deep, returned only small samples of basalt. One attempt produced no sample at all. While hove to at station 10177 we also carried out a sound velocimeter dip to 2000m.

At 122/2055 we redeployed Gloria, 2 kHz and magnetometer, and resumed the Triple Junction survey. This continued until 124/0540, when we left the triple junction area and began to follow the East Pacific Rise (EPR) axis southwards. Gloria was switched to the 20 second pulse repetition rate at 124/1600 but this limited the coverage obtained (we had been getting maximum ranges of just over 20 seconds) and there was no significant improvement in the clarity of the records. We therefore reverted to the 40 second rate at 125/1200 and kept that for the remainder of the cruise.

At 125/1250 we began a detailed survey with N-S tracklines, of the EPR crest between 3 °S and 4 °S and from the spreading axis out to about 100km away (Figure 5). In the course of this survey a previously unknown volcano was seen by Gloria. At the beginning of the survey it was noted that slowing the ship now resulted in a much improved maximum range on Gloria, so the rest of this particular survey was conducted at 8.5 knots.

The survey ended at 126/1825, when we turned west to run along the active portion of the Quebrada fracture zone. At 127/0125 we turned southwest toward Gofar fracture zone, obliquely crossing the poorly-known system of spreading centres and fracture zones between Quebrada and Gofar (Figure 5). At 1624 we turned west again along the south side of Gofar fracture zone, followed it to its intersection with the EPR axis to the south, then turned north and later east to run back along its north side. At 128/0300 we slowed to recover the geophysical gear before laying the OBS.

We commenced laying a radar transponding dahn buoy at 0510 in the valley of Gofar fracture zone. By 0614 it was laid, and we began a small bathymetric survey prior to laying the first OBS. Although it had worked well on deck, no signal was received from the radar transponder after launching the buoy. However, we were able to get good returns from the 12 foot high passive reflector, ultimately to a range of over 13 miles. OBS 6A was laid at 1222 and OBS 3A at 1708 (Figure 6, Table 2). Then the magnetometer was streamed and two N-S survey lines were run. The magnetometer was recovered and OBS 7A was laid at 2307. We then launched Gloria, the 2 kHz array and magnetometer for an overnight survey, running two long lines perpendicular to the fracture zone. The streamed gear was recovered next morning and OBS 5A laid at 129/1404. We then conducted a second velocimeter dip to 2000m (station 10179) before laying the last OBS.

While manoeuvring into position for this, we suddenly lost contact with the dahn buoy, which until then had been showing clearly on the radar screen. OBS 4A was laid at 2005, and after it reached the sea bed at 2042 we began a search for the dahn buoy. In spite of clear daylight, a calm sea and an accurate fix on the buoy's last position, it was never found, and it was presumed to have sunk, probably by a combination of filed pellet floats and the anchor and mooring weights dragging down the steep slope of the fracture zone wall. The search was abandoned at 2152, and we proceeded to the starting point of a large air-gun run over the deployed OBS.

Two 1000 cubic inch air-guns, towed in parallel from a cross-bar, were launched at 130/0009, but one failed to fire and they were recovered. A fault in the trigger lead was repaired, and the air-gun recommenced at 0216. The magnetometer was streamed, and we continued at 4 knots in a pattern designed to pass over all the OBS to check the timing of their clocks, and to provide short-range refraction arrivals. This run was completed by 130/2315, when the gear was recovered and Gloria, 40 cubic inch air-gun, hydrophone array and magnetometer were launched.

We proceeded NE at full (2-engine) speed to obtain further cover of the Gofar-Quebrada area, but only made 8 knots against a moderate head wind and heavy swell. At 131/1438 we altered course to ESE, to insonify with Gloria a region of unusually large magnitude intra-plate earthquakes, and then to proceed on passage to the Peru Trench. By 131/2210 the speed was down to 7 knots, as we headed into force 6 trade winds. However this was the only period of poor weather during the whole cruise, and after a day the wind abated.

At 133/1753 a short circuit was noted on one of the Gloria transmit lines, and it was decided to recover the vehicle to investigate. Gloria was on board and the other gear redeployed by 2030, when we resumed our course at 10 knots. The Gloria trouble was eventually traced to a water leak in the main junction box, and the main gland was replaced. The 40 cubic inch air-gun was replaced by a 160 cubic inch at 134/1902. Gloria was relaunched at 135/0324, and we continued without incident to the Peru Trench.

At 138/0600 we began a 2½ day survey (Figure 7) of the Peru Trench (one day longer than planned, because of time gained on passage). This passed uneventfully, until shortly before the gear was recovered at the end of the survey. Just after we had decided to recover, the signal from the SRP hydrophone was lost. On recovering the array the lead-in cable was found to be very badly twisted, probably caused by an oil leak which caused the leading section to flatten and take up a helical shape around its contained nylon rope. The other gear was recovered without incident.

At 141/0023 we wire-tested an acoustic release prior to deploying a string of three funnel-type sediment traps. We began lowering the mooring at 141/0223 after a short bathymetric survey to choose the best site (Station 10180). However, the operation was hampered by a fresh breeze and strong current, which made it impossible to keep the ship on station - at one stage the wire angle was 45°. It was also found that one of the pre-cut lengths of rope supplied was 10% longer than specified, so we had to shorten the mooring by missing out the uppermost trap and 200m of wire. The mooring was finally laid by 0355, with traps at about 100m and 1700m above bottom in 2500m of water. The PES fish was recovered at 0413, and we arrived in Callao at 1500 GMT, day 141 (May 20th).

IN PORT

On May 22nd a party of eight visiting scientists from the Latin American Organisation for Maritime Investigation (ASELACMAR) visited the ship, which resulted in some interesting discussions and profitable exchanges. We were also pleased to welcome on board the British Ambassador and his guests. Several of the scientific party were changed at Callao, and we were joined by the geochemists from Wormley for Leg 2.

LEG 2

Discovery departed Callao at 1730 on day 144 (May 23rd). The PES fish was launched immediately, and we proceeded to the first of a series of chemistry stations running down the continental slope into the Peru Trench. We hove to for the first station, on the shelf edge, at 144/2046. A successful box core was taken. Station 10182, in 141m of water, began at 144/2256, and produced a successful sample with the square-box gravity corer.

Station 10183 began at 145/0144 with tows of Neuston and plankton nets, and ended with a successful box core at 0522.

At 0944 we began searching for the sediment traps laid on Leg 1, and recovered them and the mooring by 1400. The top trap was missing, with the shackles worn through, apparently because the mooring had been too long (in spite of the last-minute shortening) and the buoy had remained on the surface, being strongly tossed by waves. At 1500 a box corer lowering (10184) was made at the same site, but was unsuccessful, only a few hard pebbles being recovered.

We then proceeded downslope again, and at station 10185 lowered the square-box gravity corer onto a terrace on the Trench Inner Slope. This was also unsuccessful, the corer having bottomed on hard ground.

The final attempt at coring in this series was on station 10186 begun at 145/2305 over the Trench axis. The box corer was deployed, but a combination of wind and current made it impossible to keep the ship stationed over the narrow trench axis, and the station was aborted at 146/0115. A neuston net was deployed from 0308 to 0330 (station 10187) and we then streamed the geophysical gear - Gloria, magnetometer, SRP array (after replacing the damaged lead-in cable) and 160 cubic inch air-gun. All the gear was deployed by 0649, and we commenced surveying at 10 knots.

After a final traverse across the trench, at 147/1035 we set a westerly course on passage to the Galapagos Rise and Bauer Basin. We crossed the Galapagos Rise on days 149 and 150 and then, at 150/1950, we noticed hum appearing on two sections of Gloria. After testing the insulation, it was decided to recover the fish to investigate, and by 2108 Gloria was inboard. The SRP array, 160 cubic inch air-gun and magnetometer were redeployed, and the passage to Bauer Basin resumed. Examination of Gloria showed that there was still water in the main junction box and it was now ascertained that this was entering through a porous casting. A small amount had apparently been accumulating slowly over several months. The junction box was completely dried, several connections renewed, and the fish reassembled.

At 151/0740 we changed to a 40 cubic inch airgun, firing at 4 second intervals and recording on the EPC with a 3 second sweep. This produced an excellent record.

At 151/0809 we received the first of a series of bad satellite fixes, and it eventually transpired that the local oscillator frequency in the satellite receiver was unstable. No proper spare was available on the ship, but the oscillator from the disused receiver in the computer room was used to replace it, and eventually this worked well.

A complete failure of the ship's power supply (the first of two) occurred at 151/1220. The ship slowed to 0.5 knots, and power was restored after 15 minutes. The satnav system was restarted at 1415. However the computer room air-conditioning had failed as a result of the main power failure, and the IBM 1800 computer could not be restarted until about 1500. Inevitably this resulted in several hours' loss of data.

By 152/0700 we were over the Bauer Basin, and recovered the streamed geophysical gear prior to the next chemistry station, No. 10189. By 0900 we were hove to, and the box corer was lowered first, but recovered no sample. The Kasten corer was then lowered and recovered 1½m of clay. At 1637 the pore-water sampler was lowered but failed to operate, and this was followed by a second, successful, lowering of the box corer. Finally the pore-water sampler was tried again, and worked. The sampler was on board by 153/0335, and we immediately streamed the geophysical gear, including the repaired Gloria, and set off NW across the Bauer scarp.

Next day (154/0018) we recovered the geophysical gear and hove to for station 10190, on the East Pacific Rise Flank. This station consisted of a Kasten core, pore-water sample and box core (all successful).

Gloria, magnetometer, SRP array and 40 cubic inch air-gun were again streamed, and at 154/1241 we set off NNE at 10 knots to resume work on the Quebrada-Gofar fracture zone system.

The second ship's power failure occurred at 154/1325, as a result of a 600A overload. The source of the overload was never discovered. The power was restored after 10 minutes and the IBM 1800 restarted straight away. The ship's gyro compass was precessing, and for the next 3½ hours the ship was steered by magnetic compass.

By 155/1418 we had reached Quebrada fracture zone, and turned west to begin a fairly detailed survey aimed at precisely delineating the active plate boundary between it and the Gofar fracture zone.

About this time saw the culmination of trouble with the ship's refrigerators. After several breakdowns, which had been repaired, they were finally reduced to running on two, rather than the normal three, motors, with no further spares. For a while we were threatened with aborting the cruise at this point, and also losing all the chemistry core samples from this and cruise 108, which had to be kept refrigerated. However eventually the refrigerators were restored to full operation by using a motor from the spare containerised scientific air compressor.

We were due at the next coring station, on the southern margin of Gofar fracture zone, during the dark hours of day 157, and Gloria was therefore recovered at dusk (156/2350 GMT). We then redeployed the magnetometer and 2 kHz array and continued to the station position.

After a short survey to choose the best coring position, the rest of the streamed gear was recovered at 157/0845. The station (10191) consisted of a Kasten core, pore-water sample and box core. All were successful.

At 157/1958 we launched a single 1000 cubic inch air-gun and ran over the deployed OBS before recovering them, to provide a final time-check for their clocks. The air-gun was recovered by 158/0208, and OBS recovery began.

The OBS were recovered without incident in a single unbroken operation, the last being on board by 158/1827. Initial examination, however, revealed that in only two of the five buoys had the tape recorders run for the full 30-day period.

Gloria, 40 cubic inch air-gun, SRP array and magnetometer were redeployed at 158/1900, and at 1936 we set course for a final run across the Gofar-Quebrada area.

At 159/2117 we had crossed back onto the north side of Quebrada fracture zone, and turned east for a narrow-beam echo-sounder run across the East Pacific Rise crestal area which had been surveyed on Leg 1. Unfortunately we were heading into a moderate sea, which made a narrow beam (36 kHz) record very noisy. (We were unable to deploy the transducer below the hull, because of the mechanical problems encountered during cruise 109). We tried slowing the ship from 10 to 8 and even 6 knots, but with no improvement.

We altered course at 160/0330 to run over the top of the small volcano seen on Leg 1 Gloria survey, and crossed its summit at 0500, obtaining a narrow-beam profile of the crater interior. We then altered course to bring us back onto the eastern part of Quebrada fracture zone, and steamed along it to the next station position.

At 161/0012 we began recovering the streamed gear. We then carried out some experiments to check the e/m logs, since we had been experiencing large errors in the IBM 1800 dead reckoning. The ship was allowed to drift with the wind on either beam, and then hove to and steaming forward at 4 and 8 knots, while the log outputs were read manually and also recorded in the IBM 1800. These tests showed that the calibrations were not in error, and we subsequently searched for an error in the 1800 software.

These tests ended at 161/0330, and the next few hours were spent searching for a site for station 10192. This proved difficult because of hard ground indicated on the PES record, in spite of a thick sediment cover shown on the air-gun record. We hove to at 1122, and proceeded to deploy, successively, the Kasten corer, pore water sampler and another Kasten core. All were unsuccessful, presumably because they encountered hard ground, although there were traces of clay on the Kasten corer.

The station was abandoned at 161/1900; Gloria, magnetometer, SRP array and air-gun were launched, and we got underway at 10 knots, en route to the Galapagos Islands.

Twenty-four hours later we again recovered the geophysical gear, and performed station 10193, just outside the Galapagos 200 mile limit. A Kasten core recovered 2m of ooze and clay which was intensely burrowed and showed some novel burrowing features. This was followed by a successful box core and an unsuccessful deployment of the pore-water sampler.

At 163/0723 we resumed course for the Galapagos, recovering the PES fish at 1400. We passed just north of the islands on day 164, and at 1812 on day 165 we hove to to deploy the PES fish and commence the last station, on the far side of the Galapagos waters.

Station 10194 consisted of successful box and square gravity cores, and two deployments of the pore-water sampler, both of which were unsuccessful. At 166/0530 the geophysical gear (still with 40 cubic inch air-gun) was deployed for the last time. We steamed SE toward the Galapagos Rift, and conducted a small survey there (Figure 8) lasting until 167/0558, when we headed NE toward the Costa Rica Rift, crossing two major N-S fracture zones en route.

We arrived at the first Costa Rica rift area at 167/1311, and ran two 40-mile-long E-W lines, to insonify IPOD site 501/504 from both sides with Gloria. We then steamed 039° to the second drilling area, to survey IPOD site 505, also using two 40km E-W lines (Figure 9).

Following these two small surveys we headed for the Panama Trench, changing to the 160 cubic inch airgun on 169/0136. We crossed the Panama Trench at its westernmost end at 169/1830 and recovered the air-gun, SRP array and magnetometer at 169/2000. We then steamed parallel to the coast of the Azuero Peninsula, searching for a possible active transform fault along the continental margin until 170/0420, when we recovered Gloria and the PES fish before proceeding to Balboa.

Because of time saved on passage across the Panama Basin we still had time in hand, but it was decided to arrive earlier than planned in Balboa, to facilitate repairs to the ship's refrigerators before the beginning of cruise 111. We arrived in Balboa in the afternoon of day 170, June 18th.

R.C.S.

PROJECT REPORTS

1. TECTONICS OF THE EAST PACIFIC RISE

A detailed survey of a roughly 1 degree square area was made on the rise crest near 3.5°S (Figure 5). Track lines were N-S, parallel to the spreading axis and overlapping Gloria coverage was obtained with insonification both to the west and the east.

The tectonic pattern revealed by Gloria is remarkably similar to that on slow-spreading ridges. Major fault scarps tens of kilometres long run parallel to the spreading axis, being formed a few kilometres away from it. Their average spacing along a flowline is approximately 2 km. The majority face in toward the rise axis.

The axial linear volcano described by Lonsdale was clearly seen, and is continuous over at least 100 km, although its axial graben suffers minor en echelon offsets.

Approaching a fracture zone, both the axial volcano and the fault scarps curve toward the direction of offset, and the axial volcano tapers.

R.C.S.

2. COCOS-NAZCA SPREADING CENTRE

Two detailed 'mini-surveys' were made over the Cocos-Nazca spreading centre: one at 95°W over the 'propagating rift' (Figure 2); the other at 86°W, the 'Galapagos Rift' (Figure 8). Each survey consisted of three lines parallel to the spreading axis, some 40 miles long and spaced 8 miles apart. Thus the region between the outermost tracks was almost completely covered by overlapping Gloria swaths with opposite directions of insonification.

In the propagating rift area, the Gloria records clearly showed the wedge-shape of the propagating rift whose young sea-floor backscattered strongly in contrast to the older, sedimented sea-floor surrounding it.

Away from the propagating rift at 95 °W, and in the 86 °W area, the tectonic pattern of the sea-floor was again very similar to that seen on slow-spreading ridges.

Several small 'oblique spreading' offsets of the Cocos-Nazca spreading centre were observed between the 95 °W area and the Galapagos triple junction. We also saw what may be another, unknown, propagating rift at 99 °W.

R.C.S.

3. GALAPAGOS TRIPLE JUNCTION

This was the longest detailed survey carried out on the cruise, lasting three days. An orthogonal grid of tracks (Figure 3) was designed to allow Gloria insonification of each spreading centre from opposing directions, with tracks parallel to the spreading centre. The triple junction itself was viewed from all four directions (N, E, S and W). Valuable records were also obtained with the hull-mounted sonar, and magnetics, gravity and 2 kHz profiling were also carried out.

The tectonic pattern around the triple junction is rather complex, and careful study of all the data will be needed to elucidate it properly. However, we are confident at this stage of being able to recognise the positions of the main active spreading centres, and of the boundaries between crust spread from the different ridge axes.

4. QUEBRADA-GOFAR FRACTURE ZONE AREA

Before the cruise, major fracture zones had been mapped at 3.5 °S (Quebrada) and 5 °S (Gofar). The precise nature and position of the plate boundary between them was unclear.

Our surveys in this area interspersed the OBS and coring operations. The survey tracks comprised several lines parallel to the Gofar and Quebrada fracture zones; four NE-SW tracks crossing the area between them, mainly to provide good Gloria coverage; and a series of N-S lines over several of the fracture zones to obtain narrow-beam echo-sounder profiles using the hull-mounted sonar.

It was discovered that another, previously unknown, fracture zone exists between Quebrada and Gofar at about 4 °S. Following the convention for naming fracture zones in this area after the expeditions mapping them, we propose to call this the Discovery Fracture Zone.

We are now able to map out the precise position of the plate boundary between 3 °S and 6 °S, which consists of several short spreading sections offset by the fracture zones.

However, the most exciting discovery in this area was that each of the three major fracture zones contains up to four closely-spaced, parallel scarps, which we interpret as transform faults, within a zone some 40 km wide. We believe that in at least some of the fracture zones several transform faults are simultaneously active, and we think we can detect short spreading centres between such transforms.

R.C.S., T.J.G.F.

5. OCEAN BOTTOM SEISMOGRAPHS

Five MKII Blacknest Ocean Bottom Seismographs (OBS) were deployed on the Gofar fracture zone as shown in Figure 6 and detailed in Table 2.

OBS 6A, 3A and 7A were programmed to start to record at 129/0500 while OBS 5A and OBS 4A were programmed to start recording at 129/1600 and 129/1700 respectively. All the OBS back-up clocks were set for a 30 day recording period.

The position and nature of the OBS array was designed to record seismic activity along the Gofar fracture zone as evidenced by the teleseismically recorded epicentres shown on Figure 6, where the symbols show earthquake epicentres recorded teleseismically and relocated using the GEDESS programme of Lilwall and Douglas. The array might also have been expected to detect seismic activity on the East Pacific Rise axis north and south of the fracture zone.

Once the array had been deployed an air-gun survey using two 1000 cubic inch air-guns was run over it such that the ship passed directly over each OBS. The purpose of this survey was principally to assist in the location of the array but it was hoped that useful seismic refraction data would also be obtained. The air-gun survey started at 130/0015 and finished at 130/2315. A Gloria survey over the OBS position was also performed between the laying of OBS 7A and OBS 5A. Navigation during the laying of the OBS and the surveys was assisted by a moored radar transponder buoy which, due to failure of the radar, was used in the passive mode. However the buoy could be detected out to a range of over 10 miles and thus gave good navigational control.

Prior to the recovery of the OBS another air-gun survey was run, this time using only one 1000 cubic inch air-gun. The main purpose of this survey was to assist in the recovery of absolute time should the internal clocks of the OBS be affected by rough handling during recovery. Again the ship was navigated to pass directly over each OBS, on this occasion filling in any tracks missed during the first air-gun survey. This second air-gun survey started at 157/2014 and finished at 158/0152; the gun was fired every 2 minutes.

All the OBS were released from the bottom without major difficulty using the IOS Acoustic Command Release system and brought inboard without damage.

On opening the OBS it was found that OBS 6A had run a full tape, and OBS 3A had run a tape for approximately 26 days after which a power supply fault to the Vela clock had slowed the tape deck, OBS 4A had run a tape for approximately 2 days after which time the take up spool threw off a loop of tape causing the tape to reel around the capstan roller until it jammed. OBS 5A also ran for approximately 2 days before the tape was driven up between the capstan and pinch roller, possibly due to a misalignment of the axes of the capstan and pinch roller. This caused the tape deck to stop. On OBS 7A the tape broke at the moment of start up, possibly due to the tape sticking to the pinch roller, so no data was recorded.

The faults causing loss of data on the OBS are new ones that may be explained by the use of $\frac{1}{2}$ mil tape to extend recording time combined with high ambient temperatures in the labs and on deck prior to launch. This may well be the cause of the tape sticking to the pinch roller on OBS 7A. The cause of the fault on OBS 4A is inexplicable and may be resolved when the tape is replayed. OBS 5A showed no sign of the fault demonstrated on the sea-bed prior to launch; however none of the tape decks had their usual complete overhaul at AWRE after the LADLE cruise as they were left on board. Such a fault as that on OBS 5A would have been spotted and rectified.

After the smooth deployment and recovery of the five OBS the loss of data is particularly disappointing, however with two long tapes and two short ones it is hoped that on replay the tapes may provide interesting data on the seismicity of the fracture zone. Unambiguous location of most of any events recorded will not be possible with only two of the OBS operating for most of the time; however useful data has been obtained with two OBS deployments in the past. It is not possible to replay OBS tapes at sea so until replay at Blacknest no further comment can be made on data recovery.

The main conclusion of the experiment at this stage is that the reliability of the OBS, particularly the tape recorder, must be improved. On the previous cruise (LADLE) programming faults caused two of the OBS tape recorders to fail to start; on this cruise that fault has been cleared as all tape recorders unclamped and started, however they failed to continue to record. It is suggested that the Command Release Beacon be modified to indicate the start of tape motion by an extra or modified pulse. This would have indicated the fault on OBS 7A, allowing the OBS to be recovered, repaired and relaid - but it would have been of no assistance on OBS 4A and 5A. A programme of low and high temperature environmental tests should be run with the $\frac{1}{2}$ mil tape to find possible causes of the sticking of the tape to the capstan and pinch roller. The capstan should also be fitted with a tape guide to prevent loss of the tape out of the capstan/ pinch roller drive.

I.T.P.

6. PERU TRENCH

The first comprehensive survey of a trench using GLORIA was carried out during this cruise. Three days were spent surveying the Peru Trench between 10°S and 13½°S at the conclusion of Leg 1. In addition, a crossing was made of the Panama Trench at the beginning of the leg, following departure from Balboa, Panama.

The primary objective of the Peru Trench survey was to examine the intersection of graben fault structures in the ocean plate with the over-riding plate and the influence of the graben on subduction or accretion of the trench sediments. The graben formed in response to extensional stress in the upper part of the plate as it bends downward into the subduction zone, provide space within the subducting plate in which the trench sediment may be tectonically packed and subducted, provided sediment volume does not exceed the volume of the graben.

The graben were clearly defined in the GLORIA sonograph, some extending nearly 100 km. They strike subparallel to the trench and in roughly the same direction as the fault structures of the oceanic plate that were produced by spreading processes at the East Pacific Rise. However, they could be distinguished from the spreading fault structures by greater vertical displacement and horizontal separation, and a slightly different strike. Also, the spreading-produced fault blocks are predominantly tilted in one direction (away from the mid-ocean ridge axis) while these faults clearly dip both ways, forming graben.

Along most of the trench surveyed, the volume of sediment is greater than the volume of the graben and the toe of the over-riding plate is composed of folded, accreted sediment. GLORIA sonographs provided definitive evidence for the origin of the chaotic sedimentary structures commonly observed in trench axes at the base of the shoreward slope. Although lacking observable internal, coherent seismic reflection patterns these structures are in this case, and probably many others, folded oceanic and trench deposits and not slumps. Sonographs recorded during courses run sub-parallel to the trench, both seaward and shoreward of the axis, reveal that these features extend uninterrupted for tens of miles along the base of the shoreward trench wall.

Other features mapped include segmented en echelon trench axis segments, apparently controlled by the graben fault structure of the subducting plate; extensive, long troughs and ridges on the mid depth shoreward slope which strike roughly parallel to the trench; complex and possibly obducted structures in the shoreward slope where the Mendana Fracture Zone intersects the trench, and amazingly few canyons in the shoreward slope.

T.W.C.H.

7. PANAMA TRENCH AND CONTINENTAL MARGIN

The Panama Trench crossing showed extensive folded sedimentary structures shoreward of the flat lying sequence in the trench proper. These could be seen to extend for over 50 miles and to become more closely spaced as they curve to the north west, suggesting that convergence has been from a westerly direction. High resolution reflection profiles showed that the most recent trench sediments are being folded at the shoreward side, which indicates active convergence.

The distribution of the folds indicates a small component of northern as well as eastward convergence for the oceanic plate. A long steep scarp was observed in the sonograph of the mid slope region at the south central edge of the Gulf of Panama, which may mark the transform boundary between Panama and the Panama Basin. Numerous canyons cut the upper continental slope in this region, extending to the floor of a large mid-slope basin. The scarp referred to above forms the southern margin of this basin and extends west to at least 80°W.

Northeastward dipping oceanic basement was observed in the air-gun reflection profiles at more than 3.5 seconds beneath the folded sedimentary structures on the shoreward side of the Panama Trench. A large gravity low confirmed the presence of thick sediments; a large gravity high was found over the suspected transform structure.

In summary: with regard to the trench studies, GLORIA proved to be an exceptional method for high resolution mapping of structures associated with convergence, subduction and accretion.

T.W.C.H.

8. COSTA RICA RIFT IPOD SITE SURVEYS

Small Gloria surveys were carried out over IPOD sites 501/504 and 505 in the Costa Rica Rift (Figure 9). Each survey comprised two E-W tracks parallel to the spreading axis direction and 10 miles apart, straddling the site, so that the site was covered by over-lapping Gloria swaths with opposite directions of insonification. In the southern area (site 501/504) the survey confirmed the conclusion, based on earlier air-gun surveys, that few basement faults outcrop here. However, short fault scarps were seen near 1.2°N, 83.8°W, and a more extensive E-W scarp occurs at 1.0°N, running from 83.65°W to east of 83.45°W. Other buried fault blocks are reflected by subtle patterns in the sediment surface.

The northern area (site 505) is characterised by closely spaced parallel fault scarps running E-W and facing north toward the spreading centre. They are 2 to 7 km apart and are generally 20-30 km long. At 1.95°N is a more substantial volcanic ridge, at least 45 km long and also running E-W.

R.C.S.

9. OBSERVATIONS ON PASSAGE

Gloria, the magnetometer, gravimeter, hull-mounted sonar and 2 kHz sub-bottom profiler were run on virtually all our passage tracks (see Table 3 for details). As this was the first time Gloria had been used in the Pacific, we planned the passage tracks to make the best use of this opportunity. Between the East Pacific Rise and Callao, we planned tracks to fill in gaps in the existing geophysical coverage. Some highlights of the passage observations are given below.

A) CENTRAL VOLCANOES

Well over 100 central volcanoes were observed by Gloria. Their distribution is patchy; some regions contain none; in other regions we saw one or two isolated volcanoes; and in two areas we saw large fields of them with densities of around 10 per square degree. These fields were SW of the Galapagos Islands, and between the Galapagos Rise and the Peru Trench. The fields are hundreds of kilometres across, and do not have trends which are evident from our limited coverage. The volcanoes have a remarkably uniform morphology. They are circular in plan, with steep (up to 45^{0}) outer slopes and relatively flat but slightly convex tops. Their basal diameters are 7-10 km, and their heights about 700 to 1000m. Some have prominent central craters with diameters of about 2 km. Rarely, forms having a continuous cone up to the summit crater were seen. Occasionally several circular forms overlap, and complex craters containing several rings were also seen. The volcanoes occur on sea-floor of all ages. The youngest we saw had probably formed not more than a few kilometres from a spreading axis.

B) TECTONIC FABRIC AND SPREADING HISTORY

Because of the relatively young crust and slow sedimentation rate, the tectonic fabric of the sea floor, formed at the spreading axis, remained visible to Gloria over the whole of our passages across the Nazca plate, and over much of the Cocos plate. We can therefore directly infer palaeo-spreading directions from our data. These observations, when combined with compiled magnetic and other structural data, should enable a marked refinement of the sea floor spreading history of this area to be made.

R.C.S.

10. GEOCHEMISTRY

A) HESS DEEP (LEG 1)

Six attempts were made to core sediments at Hess Deep, on the axis of the Cocos-Nazca spreading centre, for David Cronan of Imperial College (Table 1, Figure 4). The first two produced cores approximately 1-metre long, with red-brown ooze overlying buff sand or green clay. Samples of the overlying water were also taken. These cores were obtained from the northern slopes of the Deep. The last four stations all attempted to sample the very deepest sea floor in the axis of the deep. This displayed a flat, hard reflector on the PES, which was taken to be a sediment surface. However, no sediment sample was recovered, the corer either returning empty or with small samples of basalt or black glass. It was concluded that the flat reflector was probably a sheet-type lava flow.

R.C.S.

B) LEG 2

The Leg 2 programme had the following objectives:

a) To sample oxyhydroxide-rich sediment in the Bauer Deep.

b) To compare mineralogy, sedimentary history and pore-water profiles between the Bauer Deep and East Pacific Rise and crest.

c) To study variations in mineralogy and pore-water composition between stations above and below the carbonate compensation depth, and if possible across a buried redox horizon.

d) To obtain information on the biogeochemistry of the Peru shelf and slope sediments by coring and sediment trap deployment.

Sampling for all those objectives was accomplished. Details are given in Table 1. The coring programme was particularly successful, with thirteen successful cores resulting from nineteen attempts. At each of the six deep water stations occupied, with the exception of 10192, a box core and a Kasten or a square gravity core were obtained. At 10192 conditions were unsuitable for the equipment and no cores or in situ pore-water samples were obtained. At two further stations, the in situ pore-water sampler pretripped due to an unusually intense thermocline, so that correct operation was obtained at only three of the six stations occupied.

Immediate on board studies included mineralogical smear slides and visual and photographic recording of cores. Pore-waters squeezed from cores and obtained by in situ sampling were analysed for micro nutrient, alkalinity and pH. Dissolved gas analyses were also made on in situ samples immediately upon recovery. Analyses for various organic constituents were also made on the Peru shelf and slope samples and pore-waters.

Unusual and unexpected bioturbation structures were observed within cores from Station 10193 with open tunnels up to a centimetre in diameter at all depths to the maximum sampled (2m). Authigenic calcium carbonate deposition and micro-manganese nodule formation is suspected within certain of the cores, although confirmation requires further analyses. No redox horizon was observed in the Panama Basin samples, although a colour change due to depositional variation was found at about 20 cm.

In spite of the wide variety of equipment installed on the poop during this cruise, with resulting crowded conditions, few problems were experienced in working the gear. This is mainly attributable to the good weather encountered, and to the experience of the crew, since, as noted in previous reports, the winch, deck gear and instrumentation are not well suited to the deployment of the samplers necessary to our work. These need delicate and accurate control close to the sea bed and a secure and shock-free launch and recovery: this is almost impossible to obtain reliably from the present equipment because of its design and its age.

T.R.S.W.

EQUIPMENT REPORTS

1. GLORIA

On leaving Balboa the vehicle was launched at 0840 GMT on day 114. Recording commenced at once and continued until midnight on day 116 when it was necessary to recover all the gear for passage through Ecuador territorial waters north of Galapagos. Thereafter, apart from one day's coring in Hess Deep, a couple of days for laying the OBS and two days on passage to Callao caused by a vehicle fault, recording was continuous until recovery at 2300 GMT on day 140 near the end of Leg 1.

The vehicle was launched at 0400 GMT on day 146, second day out on Leg 2 following a series of coring stations on the continental shelf and slope. A vehicle fault forced recovery at 2100 on day 150, one day before the next coring station. The vehicle was launched again after the coring station and recording continued successfully with a further two breaks for coring, one to recover the OBS and one to transit the Galapagos waters again. Final recovery was at 0430 GMT on day 170 at a point 100 miles south of Balboa. For the most part a speed of 10 knots was maintained with the vehicle towing at a depth of 105-120 ft.

The 16 mile range (40 second pulse repetition period) was used for all but one day, but it was noticeable, especially north of the Equator and in depths less than 3km, that propagation conditions limited the range obtained on the sonographs to just over halfway. The situation was improved when the vehicle ran deeper during periods of slower speed, though this effect was greater away from the equatorial region of very steep thermocline. Two velocimeter dips gave quantitative confirmation of this observed dependence of propagation range on speed caused by the position of the vehicle in the thermocline. Propagation was noticeably better in the Callao area with its greater water depth and cooler surface water and echoes were often still being received after the full 40 seconds. A propagation effect still not accounted for quantitatively is the band of patchy high signal level at the edge of the surface shadow zone, which appears frequently in tropical and sub-tropical waters and has been seen in other areas.

The vehicle faults on both legs had a common cause which was that a very small quantity of water had leaked into the main junction box. During the first leg this caused a short on one array section cable harness and on Leg 2 a further three harnesses failed. The leakage was caused by a porous casting but the rate of leaking was so slow that it was possible to run on with it and steps were taken to prevent the moisture reaching the inside of the array harness glands.

Tape usage was 65 tapes on Leg 1 and a further 49 tapes on Leg 2. This represented about 480 hours recording on Leg 1 and 360 hours on Leg 2 and during this time there were no other equipment faults which caused loss of data. The vehicle was launched and recovered six times on each leg with no damage more serious than abrasion of the cable cover in the outboard 30 metres.

M.L.S., J.R.

2. HULL-MOUNTED SONAR

The hull-mounted sonar was used through most of the cruise (Table 3). Where conditions allowed (shallow water, good sea-state) we generally used both beams in side-scan mode, but in deeper water and rougher seas, the starboard beam was used in its narrow-beam echosounder mode. Because of the mechanical problems encountered during cruise 109, we did not attempt to deploy the sonar below the hull. In spite of this, because of the excellent weather enjoyed throughout the cruise the performance was usually good. We obtained narrow-beam echo-sounder profiles in 4600m of water at 10 knots, in sea-state 2-3, and a maximum of 5200m over Hess Deep when hove to. However somewhat paradoxically performance was usually less good when hove to, probably because air bubbles became trapped round the sonar plates in the bottom of the asdic trunk.

R.C.S.

3. SEISMIC REFLECTION PROFILING

A) AIRGUN SYSTEM

After leaving Panama at 114/0940, the air-gun and array were streamed and a profile run at 10 knots until 116/1623. Both the analogue and digital tape recording systems were run with Channel 1 of the array monitored on the EPC recorder. Unfortunately, the ADC in the digital system appeared to be sampling only 1 in 4 samples, and it is not yet clear whether the data is going onto the tape at the correct sampling rate.

After the laying of 5 OBS, two 1000 ins^3 air-guns were successfully streamed at 130/0215 and run for 21 hours firing at a rate of once every 5 minutes. This provided refraction data and a check for the OBS clocks.

Normal profiling was resumed again at 131/0104 and continued at 10 knots throughout the remainder of Leg 1 until 2300, providing 2900 n.m. of track. Five minutes before the end of the survey all signals from the array stopped. On recovery, the array cable was found to be twisted beyond repair. The cause was probably loss of oil in the lead section, making it flatten out and take up a helical shape following the nylon rope within it.

Our own 3 air-guns were a constant problem, not one of them ever managing to last for more than 2 days without failing. They became less and less reliable. One air-gun having lost its tail clamps has been completely wrecked with the flanges of both the tail and top housing damaged beyond repair. The remaining 2 guns have distorted locating holes on the top housing, and both have to be packed with shims to enable the clamps to hold the top housing and tail firmly together. The only solution to this problem, which is getting worse, is to replace these guns with new ones.

For the first time we had the facility of entering sediment reflector data into the IBM 1800 computer and thus logging sediment thickness and basement depth. During Leg 1 all SRP records were read and the sediment thickness was routinely logged on the 1800, and plotted in a variety of ways using the subroutine SMERK. This was found to be very useful. However, although a start was made in Leg 2, shortage of manpower meant we were unable to keep up with the measurement and data input. The acquisition of a shipboard digitising table would be a great help in the implementation of this useful new facility.

B) 2 KHZ

After the first SRP profiling run had been completed at 116/1623, the short 2 kHz array was streamed and the system then run until the 5 OBS were layed, after which time Channel 1 of the SRP array was used to receive the 2 kHz signals for the remainder of the cruise.

The SRP array gave reasonable data except for the surface multiple doublet, which because the array was towing at twice the depth of the short array gave a wider doublet and therefore tended to confuse interpretation of the records. It is essential that some form of inverse filtering is incorporated on line to remove this surface multiple, not only for the SRP array but to a lesser extent for the short array.

One problem which seems to be forever with us regarding the 2 kHz is the 1000 Hz interference derived from the ship's 240 A.C. supply. Many hours have been spent trying to reduce it to a level below that of tow noise resulting in having to run the short array preamplifier from a battery in the aft rough lab. Even this has not reduced it sufficiently. Tighter B.P. filtering will help, but not enough to cure the problem, since the interference of 1000 Hz is too close to the 1.6 kHz start frequency of the FM pulse.

Maybe one solution to the problem would be to run all the electronic equipment from a separate scientific AC generator.

On Leg 2 it was discovered that a junction box near the transmitters had flooded, apparently by water creeping up the cables from the transducers. Performance was markedly improved after this fault was repaired!

D.G.B., R.C.S.

4. GRAVIMETER

At the beginning of Leg 1, a base reading was made near the WHOI base station at Balboa yielding g=978239.2 milligal (Potsdam), or about 978225.2 mgal (IGSN 71), at the meter.

On Leg 1 the following downtime occurred:

Day 117	1845-2045	(spring tension protection activated)
121	1430-1520	(spring tension protection activated)
140	1635-1820	(gyro failed causing the platform to oscillate violently).

During the period day 120-123 a grid-type survey was undertaken which allowed the gravity data for 17 crossovers to be compared. The average of later time - earlier time was -0.2 milligal and the mean of the modulus of the crossovers was 2 milligal, thus verifying the performance of the meter and indicating a drift of less than -0.1 milligal per day. Readings were also made in Callao at the beginning and end of the port call, to compare with the nearby IGSN71 station number 36827M.

The following downtime occurred on leg 2:

Day 151 1220-1510 (ship's power failed, meter without heat for 20 minutes)

Day 161/1820, and Day 162/0030 (VCC cross coupling amplifier failed and dragged the +15 volt DC power rail down to zero. Platform fell over and spring tension wound rapidly to over 16,000 within the 35 minutes before switching off).

Day 163 0430 Day 166/0030 (meter clamped during passage through Galapagos).

The meter reading on arrival at Balboa was g = 09482.0 mgal, compared with the previous reading at Balboa on pier 18 (beginning of leg 1) of 09485.4 mgal. (The leg 2 position was some 500m away from pier 18). The difference of 3.4 mgal, corrected by 0.5 mgal for a height difference gives a discrepancy of 2.9 mgal over the duration of the cruise.

R.S.R.

5. MAGNETOMETER AND PRECISION ECHO SOUNDER

After some initial trouble setting up the magnetometer, as a result of a broken connection in the plug at the outboard end of the inboard cable, the magnetometer worked well. We had trouble with the same plug once more in the cruise, but remaking the screen connection cured it. A servoscribe recorder was used instead of the old Hewlett Packard chart recorder, and worked admirably.

The PES gave trouble-free operation throughout the cruise. Only one fish was deployed, and it suffered no noticeable wear.

R.C.S.

6. NAVIGATION AND COMPUTING

The IBM 1800 performed routine sampling, data reduction and analysis satisfactorily throughout the cruise, with the notable exception of the on-line Dead Reckoning, which was consistently less reliable than that produced by the Magnavox Satellite Navigation System. A series of ship manoeuvres was performed on day 161 to test the EM log calibration constants, which proved to be sensibly correct. While steaming through Ecuadorian waters with all scientific gear inboard, the computer gyro repeater was disconnected and constant values fed into the Port EM Log interface for different fixed headings, to test the software. The DR software itself is part of the 2-minute filtering programs, and therefore it is necessary to terminate all sampling before any modification can be attempted. This fact hindered progress in investigation of this problem, which was still proceeding at the end of Cruise 110.

During the cruise a new offline navigation suite was installed replacing the earlier, sometimes unpredictable version, and is now functioning successfully. This has been further modified to incorporate automatic recalculation of gravity anomalies if requested, and to make re-correction of depths optional. A facility for logging depth as uncorrected fathoms simultaneously with uncorrected metres was installed by request and is now available if required via a switch in the computer room. A program for calculation of Depth of Basement and Mid-Sediment Reflector from supplied Sediment Thickness data has also been installed and is operating successfully.

A power failure on day 151 and resultant failure of the computer room air-conditioning, forced a shut-down of the computer system for some $2\frac{1}{2}$ hours. A second power failure on day 154 caused a further 10 minute shut-down of all computer operations. These are the only appreciable data gaps of the cruise.

The 5 MHz local oscillator within the Satellite Navigator became unstable due to overheating a few hours prior to the first power failure, and this was replaced by the unit from the back-up system in the computer room. This performed satisfactorily, although drifting to just within the acceptable limits, and the original was replaced on day 165. This now functions correctly.

A.R.L.

7. SHIP'S EQUIPMENT

Potentially the most serious problem on the cruise was the failure of the ship's refrigerators and the exhaustion of the supply of spare parts for them. This could have led to abortion of the cruise and loss of cores (which need to be kept refrigerated) from this and previous cruises. The seriousness of this situation from a scientific point of view cannot be overstated.

The next most serious problem was the occurrence, on two separate occasions, of a complete power failure. We were fortunate in having good weather, so that none of the towed equipment was damaged - loss of way when towing Gloria in heavy seas can cause serious damage to the towing cable. Other problems caused by the power failure are loss of computing facilities, data logging, and precise navigation, and failure of ship's gyros and the gravimeter, all for periods of several hours after a break in the power supply. Such power failures have become very common - there have been a total of four in the last four cruises I (RCS) have participated in. They usually appear to be caused by an overload around breakfast time. Every effort should be made to determine the cause and prevent future occurrences.

As noted in the Geochemistry report above, the cranes, main winch and associated instrumentation are not adequate for fine control of instruments being manoeuvered over the rail or near the sea bed. As these procedures become more common, thought should be given to providing winches and cranes with a higher degree of control.

The dynamometer system is in need of thorough overhaul. The wire out counters in the labs proved completely unreliable, and it was necessary to resort to the unpleasant practice of having someone on the poop deck to read the mechanical counters. The rate meter is also very inaccurate, and needs to be properly calibrated as modern coring operations require careful control of the wire rate.

Finally, the Mimco communication system needs overhaul. The set by the main trawl winch is quite inadequate, as it is frequently impossible or very difficult to hear messages from the winch to the Plot and vice versa. Even under quiet conditions (i.e. winch stopped) the signal level over that link is much lower than over other links in the system. The sets on the poop and in the Plot also proved unreliable from time to time.

TABLE 1 - STATIONS

Number	Equipment	Start Day/time	Start Latitude	Start Longitude	Start Depth (corr. m)	End Day/time	End Latitude	End Longitude	End Depth (corr. m)	Geographic Area	Remarks
10173	Stainless steel gravity (Calvert) corer	121/2030	2°15'.2N	101°27'.7W	4716	121/2235	2°15'.5N	101°27'.8W	4705	Hess Deep	Recovered buff foram sand overlain by red-brown mud
10174	"	122/0017	2°15'.2N	101°32'.5W	4572	122/0224	2°15'.9N	101°33'.2W	4271	"	Recovered stiff green clay
10175	"	122/0458	2°14'.9N	101°34'.0W	5193	122/0711	2°15'.3N	101°34'.4W	5121	"	No sample recovered
10176	"	122/0922	2°15'.2N	101°34'.7W	4900	122/1210	2°15'.0N	101°35'.0W	5121	"	Recovered 3 pillow basalt fragments and 1 Mn encrusted pebble
10177a	Sound velocimeter	122/1427	2°14'.4N	101°31'.1W	5240	122/1458	2°14'.4N	101°31'.0W	5229	"	
10177b	Calvert corer	122/1430	2°14'.4N	101°31'.1W	5235	122/1638	2°14'.6N	101°31'.1W	5235	"	Recovered numerous fragments of obsidian
10178	"	122/1825	2°13'.5N	101°30'.5W	5100	122/2032	2°14'.0N	101°30'.5W	5224	"	Recovered one small pellet of red mud and 4 basalt chips
10179	Sound velocimeter	129/1508	4°34'.4S	105°55'.7W	3601	129/1619	4°34'.7S	105°56'.1W	4098	Gofar fracture zone	
10180	DAFS sediment trap	141/0223	12°18'.8S	78°09'.4W	2501	141/0354	12°18'.5S	78°08'.0W	2332	Peru slope	Laying trap
10181	Box corer	144/2046	12°05'.8S	77°29'.3W	141	144/2114	12°05'.8S	77°29'.3W	141	Peru shelf	Successful - sample recovered
10182	Square gravity corer	144/2256	12°06'.6S	77°29'.8W	207	145/0036	12°08'.5S	77°36'.8W	262	Peru shelf	Sample rich in organic matter. Some H_2S present
10183/1	Neuston net	145/0144	12°12'.3S	77°47'.3W	1503	145/0213	12°12'.5S	77°49'.2W	1612	Peru slope	
10183/2	'Oxfam' net	145/0225	12°12'.7S	77°49'.6W	1633	145/0253	12°12'.6S	77°49'.3W	1610	"	
10183/3	Phytoplankton net	145/0253	12°12'.6S	77°49'.3W	1610	145/0319	12°12'.7S	77°48'.9W	1591	"	
10183/4	Box corer	145/0310	12°12'.6S	77°49'.0W	1585	145/0522	12°12'.6S	77°49'.1W		"	Good sample recovered. Less organic rich than 10182
10184/1	Sediment trap	145/0941	12°18'.6S	78°08'.2W	2287	145/1232	12°18'.4S	78°08'.9W	2417	"	Recovering trap laid at stn. 10180
10184/2	Box corer	145/1500	12°18'.3S	78°07'.7W	2272	145/1713	12°18'.2S	78°07'.4W	2155	"	Only 3 small pebbles (limestone?) recovered
10185	Square gravity corer	145/1918	12°27'.4S	78°24'.2W	3631	145/2127	12°27'.9S	78°23'.7W	3649	"	Unsuccessful - sediment too thin or seabed too hard
10186	Box corer	145/2316	12°33'.3S	78°36'.7W	5939	146/0015	12°34'.1S	78°34'.9W	2342	Peru trench axis	Station abandoned due to difficulty of keeping on station in strong wind and current
10187	Neuston net	146/0308	12°35'.7S	78°32'.8W	5741	146/0330	12°36'.8S	78°33'.7W	5907	Peru trench	

TABLE 1 (continued)

Number	Equipment	Start Day/time	Start Latitude	Start Longitude	Start Depth (corr. m)	End Day-time	End Latitude	End Longitude	End Depth (corr. m)	Geographic Area	Remarks
10188	Surface water sample	146/2014	11°49'.9S	80°34'.6W	4562	146/2100	11°48'.3S	80°42'.5W	4634	Peru basin	
10189/1	Box corer	152/0900	9°59'.0S	102°35'.9W	4460	152/1310	9°58'.5S	102°35'.4W	E/S OFF	Bauer basin	No sample recovered
10189/2	Kasten corer	152/1328	9°58'.4S	102°35'.3W	4452	152/1620	9°58'.3S	102°34'.7W	4444	"	1½m reddish-brown mottled sediment recovered
10189/3	Pore water sampler	152/1637	9°58'.3S	102°34'.6W	E/S OFF	152/1926	9°58'.5S	102°34'.0W	E/S OFF	"	Failed to operate
10189/4	Box corer	152/1942	9°58'.5S	102°33'.9W	4332	152/2353	9°58'.1S	102°34'.1W	4695	"	Successful
10189/5	Pore water sampler	153/0055	9°57'.8S	102°34'.2W	4444	153/0335	9°57'.0S	102°34'.1W	E/S OFF	"	Successful
10190/1	Kasten corer	154/0155	7°36'.5S	104°11'.6W	3743	154/0424	7°36'.7S	104°12'.1W	3743	East Pacific Rise flank	1½m of buff sandy ooze, extensively bioturbated
10190/2	Pore water sampler	154/0441	7°36'.7S	104°12'.1W	3743	154/0646	7°37'.1S	104°11'.9W	E/S OFF or 3743	"	Successful
10190/3	Box corer	154/0708	7°37'.1S	104°12'.0W	3763	154/0950	7°37'.7S	104°12'.3W	E/S OFF	"	Successful
10191/1	Kasten corer	157/0937	4°49',7S	105°57'.2W	E/S OFF	157/1144	4°49'.0S	105°57'.5W	3737	East Pacific Rise crest	Recovered foram ooze
10191/2	Pore water sampler	157/1155	4°48'.9S	105°57'.6W	3795	157/1512	4°48'.9S	105°56'.9W	3905	"	Successful
10191/3	Box corer	157/1533	4°48'.9S	105°56'.9W	3827	157/1827	4°49'.1S	105°57'.1W	3864	"	Sandy foram ooze recovered
10192/1	Kasten corer	161/1122	4°06'.2S	98°24'.9W	3657	161/1345	4°06'.0S	98°25'.5W	3617	East limb of Quebrada fracture zone	No core recovered. Traces of red-brown silty clay on corer
10192/2	Pore water sampler	161/1403	4°05'.9S	98°25'.6W	3617	161/1624	4°05'.8S	98°26'.0W	E/S OFF	"	Unsuccessful
10192/3	Kasten corer	161/1636	4°05'.8S	98°26'.1W	3636	161/1853	4°05'.9S	98°26'.6W	3674	"	No core. Probably over hard ground
10193/1	Kasten corer	162/2050	2°09'.5S	95°33'.4W	3334	162/2310	2°10'.5S	95°34'.0W	3346	SW of Galapagos	2m core recovered. Red-brown ooze overlying green clay. Whole core intensely and unusually burrowed and bioturbated
10193/2	Box corer	163/0135	2°12'.1S	95°33'.1W	3311	163/0411	2°12'.8S	95°33'.3W	3350		Successful
10193/3	Pore water sampler	163/0516	2°13'.2S	95°33'.3W	3361	163/0723	2°13'.9S	95°33'.3W	E/S OFF		Failed to operate
10194/1	Box corer	165/1903	1°36'.2N	86°47'.5W	2687	165/2210	1°36'.2N	86°45'.6W	E/S OFF	NE of Galapagos	Successful
10194/2	Pore water sampler	165/2324	1°35'.8N	86°47'.3W	2696	166/0118	1°35'.6N	86°46'.3W	2716	"	Failed to operate
10194/3	Square gravity corer	166/0138	1°35'.2N	86°46'.8W	2716	166/0315	1°32'.1N	86°48'.6W	2713	"	Mottled and burrowed core, brown on top, green below
10194/4	Pore water sampler	166/0330	1°31'.3N	86°48'.8W	2711	166/0524	1°33'.3N	86°49'.2W	E/S OFF	"	Failed to operate

TABLE 2

OCEAN BOTTOM SEISMOGRAPHS

OBS No.	Date/Time Laid	Position		Water Depth (corr. m)	Date/Time Recovered
		Latitude	Longitude		
6A	128/12.22	4°36'.2S	105°52'.0W	3063	158/03.40
3A	128/17.08	4°35'.9S	105°47'.0W	3588	158/07.21
7A	128/23.07	4°31'.5S	105°49'.6W	3361	158/11.24
5A	129/14.04	4°33'.8S	105°55'.1W	3881	158/14.45
4A	129/20.06	4°40'.2S	105°52'.5W	3229	158/18.27

N.B. All times are GMT

TABLE 3

Underway Geophysical Observations

Leg 1

	From	To	Total Hours
P.E.S.	0740/114	2330/116	63.8
	1025/118	0413/141	545.7
			609.5
GLORIA	0853/114	2330/116	62.6
	1025/118	1840/131	80.1
	2110/122	0300/128	125.8
	2353/128	1205/129	12.2
	2345/130	1818/133	66.5
	0348/135	2332/140	139.7
			486.9
MAGNETOMETER	2120/114	2330/116	30.1
	1025/118	1840/121	80.1
	2110/122	0300/128	125.8
	1806/128	2230/128	4.4
	2353/128	1205/129	12.2
	0222/130	2315/130	20.9
	0100/131	1707/134	88.1
	0348/135	2332/140	139.7
			501.3
SRP	1030/114	1636/116	54.1
	0100/131	1707/134	88.1
	1902/134	2332/140	148.5
			290.7
2 kHz	1025/118	1840/121	80.1
	2110/122	0300/128	125.8
	2353/128	1205/124	12.2
			218.1

TABLE 3 continued

	From	To	Total Hours
SIDESCAN (36 KHZ)	1020/114	1955/131	417.5
	1950/133	2139/133	1.8
	1340/135	0310/139	85.5
	1149/139	2340/140	35.8
			540.6

Leg 2

	From	To	Total Hours
P.E.S.	1800/144	1400/163	452.0
	1812/165	0500/170	106.8
			558.8
GLORIA	0500/146	1950/150	110.8
	0515/153	0018/154	19.0
	1241/154	2350/156	38.8
	1936/158	0012/161	53.0
	2000/161	1930/162	23.5
	0637/166	0420/170	93.7
			338.8
MAGNETOMETER	0604/146	0700/152	144.9
	0515/153	0018/154	19.0
	1241/154	0845/157	68.1
	1936/158	0012/161	53.0
	2000/161	1930/162	23.5
	0637/166	1924/169	84.8
			393.3
SRP	0649/146	0700/152	144.2
	0515/153	0018/154	19.0
	1241/154	2350/156	38.8
	1936/158	0012/161	53.0
	2000/161	1930/162	23.5
	0637/166	1924/169	84.8
			363.3

TABLE 3 continued

	From	To	Total Hours
2 kHz	0045/157	0845/157	8
SIDESCAN (36 KHZ)	1810/144	0330/145	9.3
	0650/145	1250/145	6.0
	2140/145	2300/145	1.3
	0720/146	0400/147	20.6
	0600/147	0730/152	121.5
	0500/153	0010/154	19.2
	0300/154	1114/161	152.2
	2040/161	0420/164	55.6
	1600/165	0530/170	13.5
			399.2

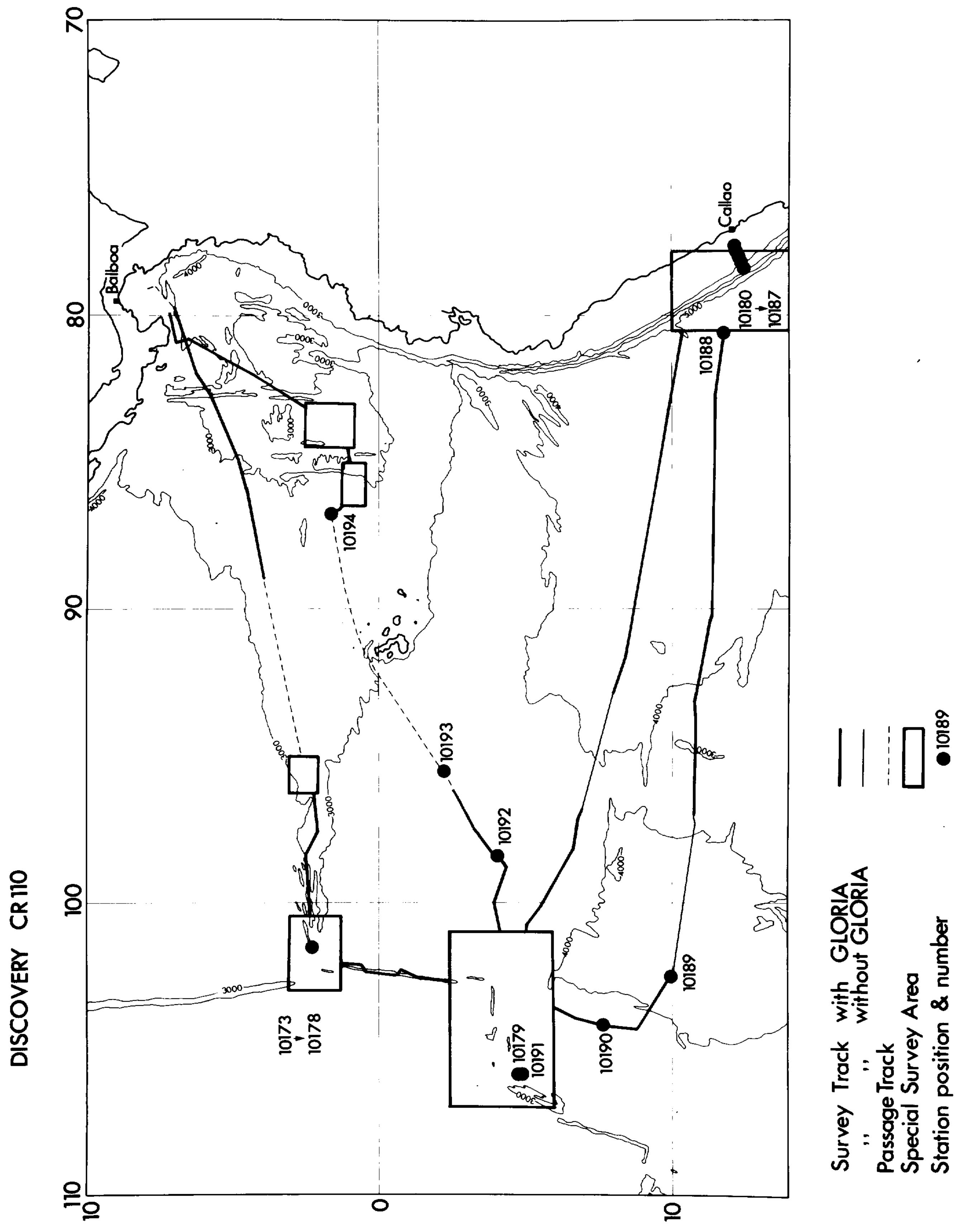
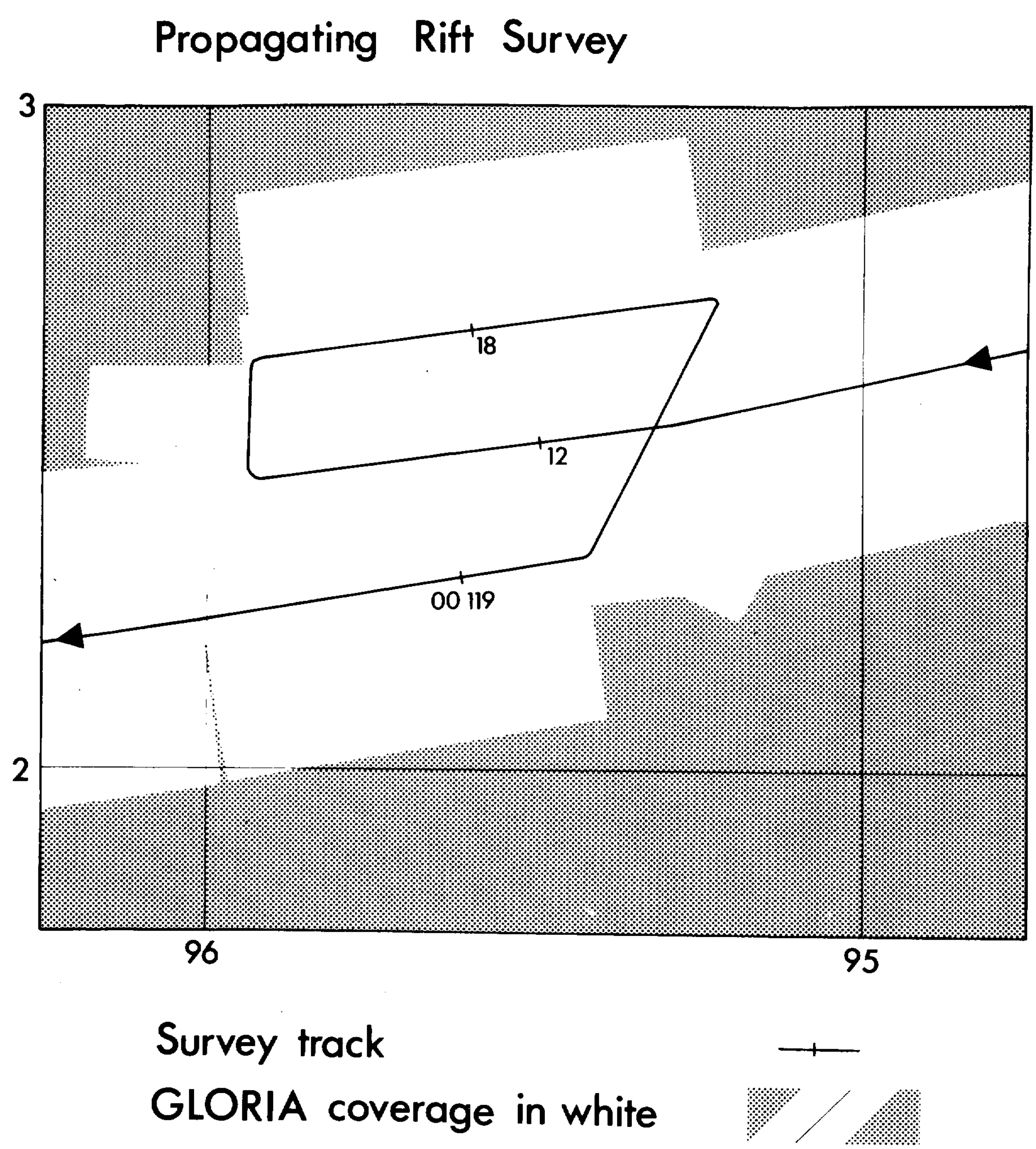
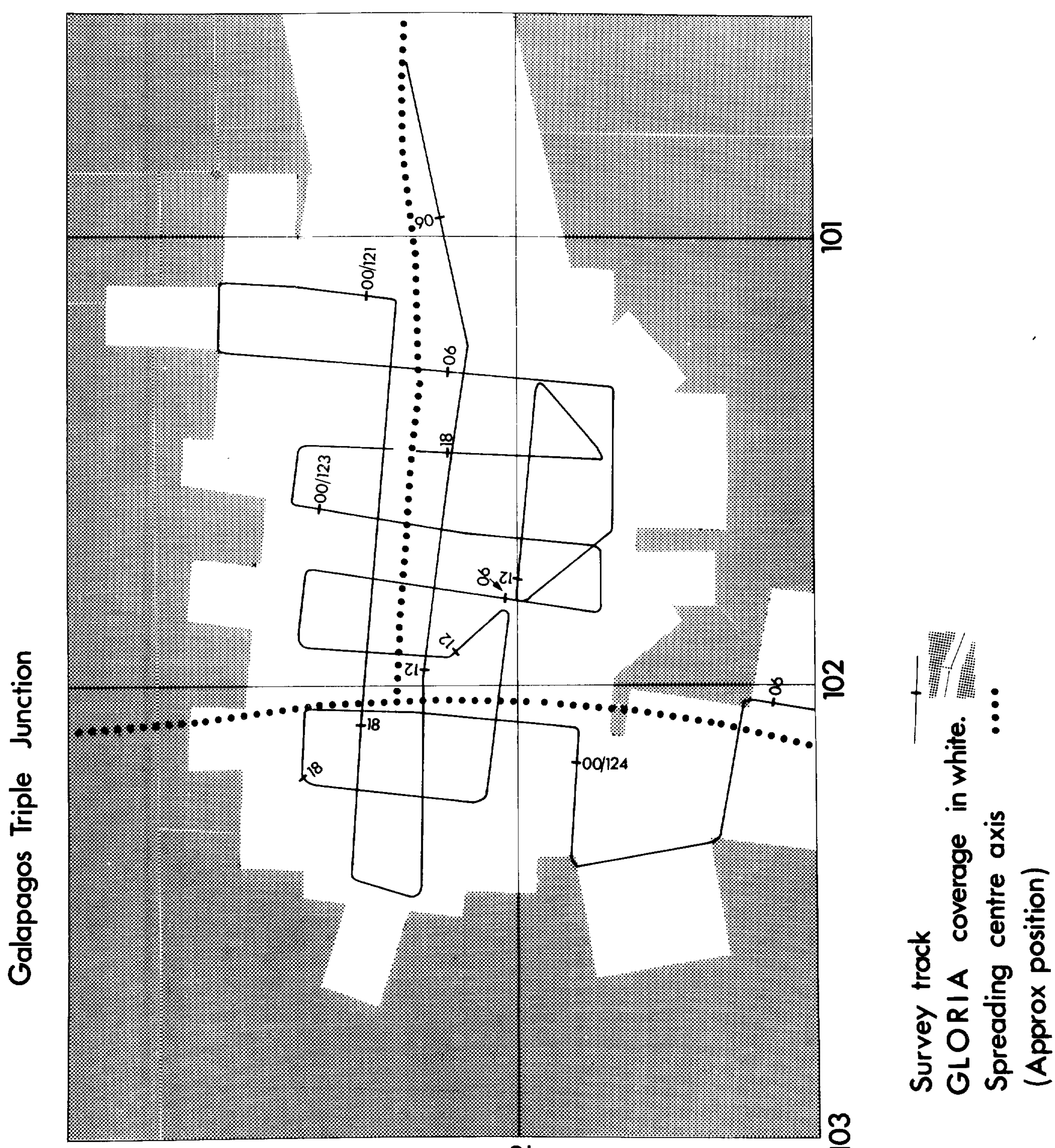

DISCOVERY CR110
Balboa
Callao
10173 → 10178
10179
10191
10190
10189
10188
10180 → 10187
10192
10193
10194
3000
4000
Survey Track with GLORIA
" " without GLORIA
Passage Track
Special Survey Area
Station position & number
10189

FIG. 1



Propagating Rift Survey
3
2
18
12
00 119
96
95
Survey track
GLORIA coverage in white

FIG. 2



Galapagos Triple Junction
3
2
103
102
101
00/121
00/123
00/124
06
18
12
Survey track
GLORIA coverage in white.
Spreading centre axis
(Approx position)

FIG. 3

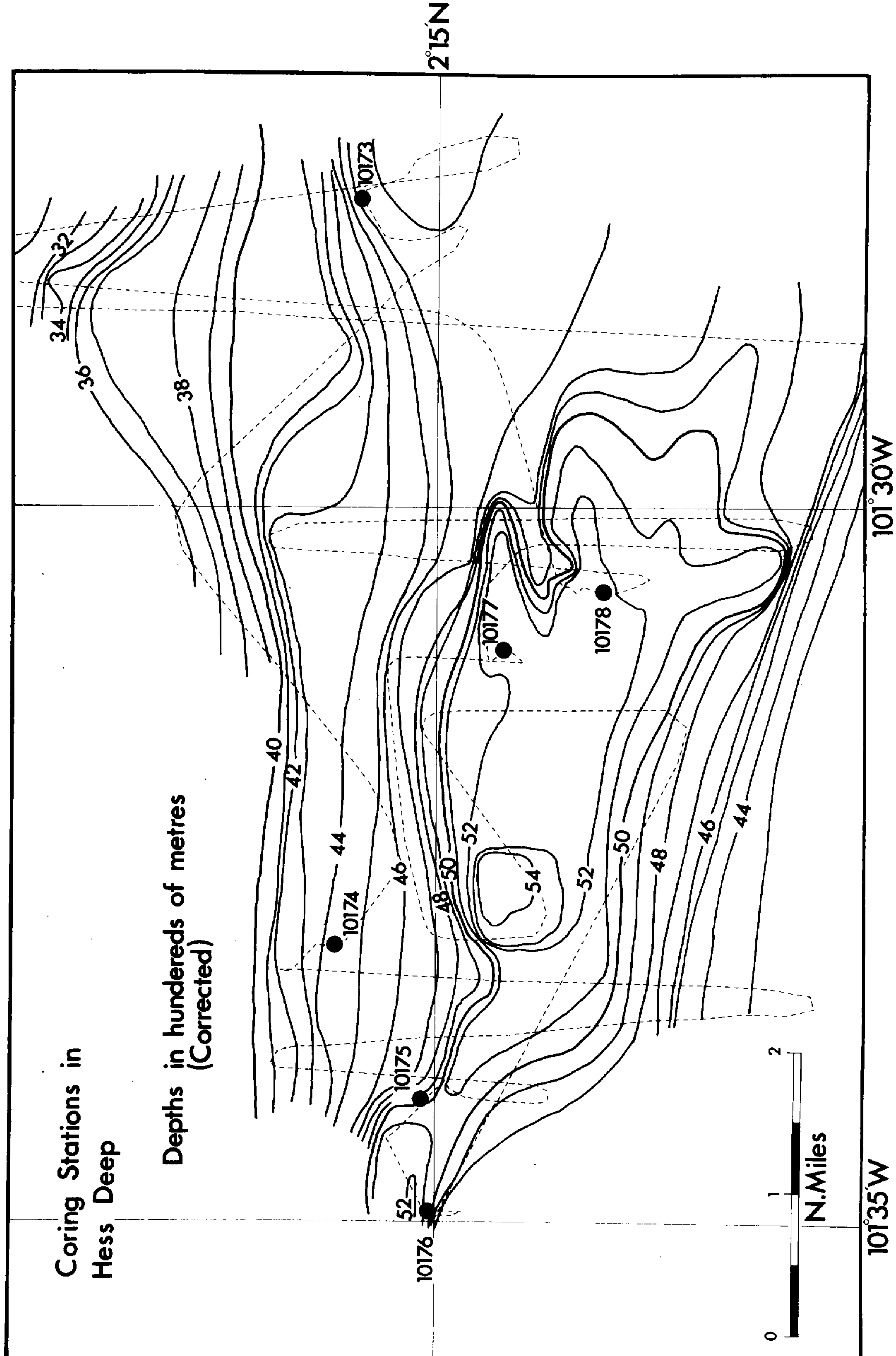

Coring Stations in Hess Deep
Depths in hundereds of metres (Corrected)
2°15'N
101°30'W
101°35'W
N.Miles
0
1
2
10173
10174
10175
10176
10177
10178
32
34
36
38
40
42
44
46
48
50
52
54

FIG. 4

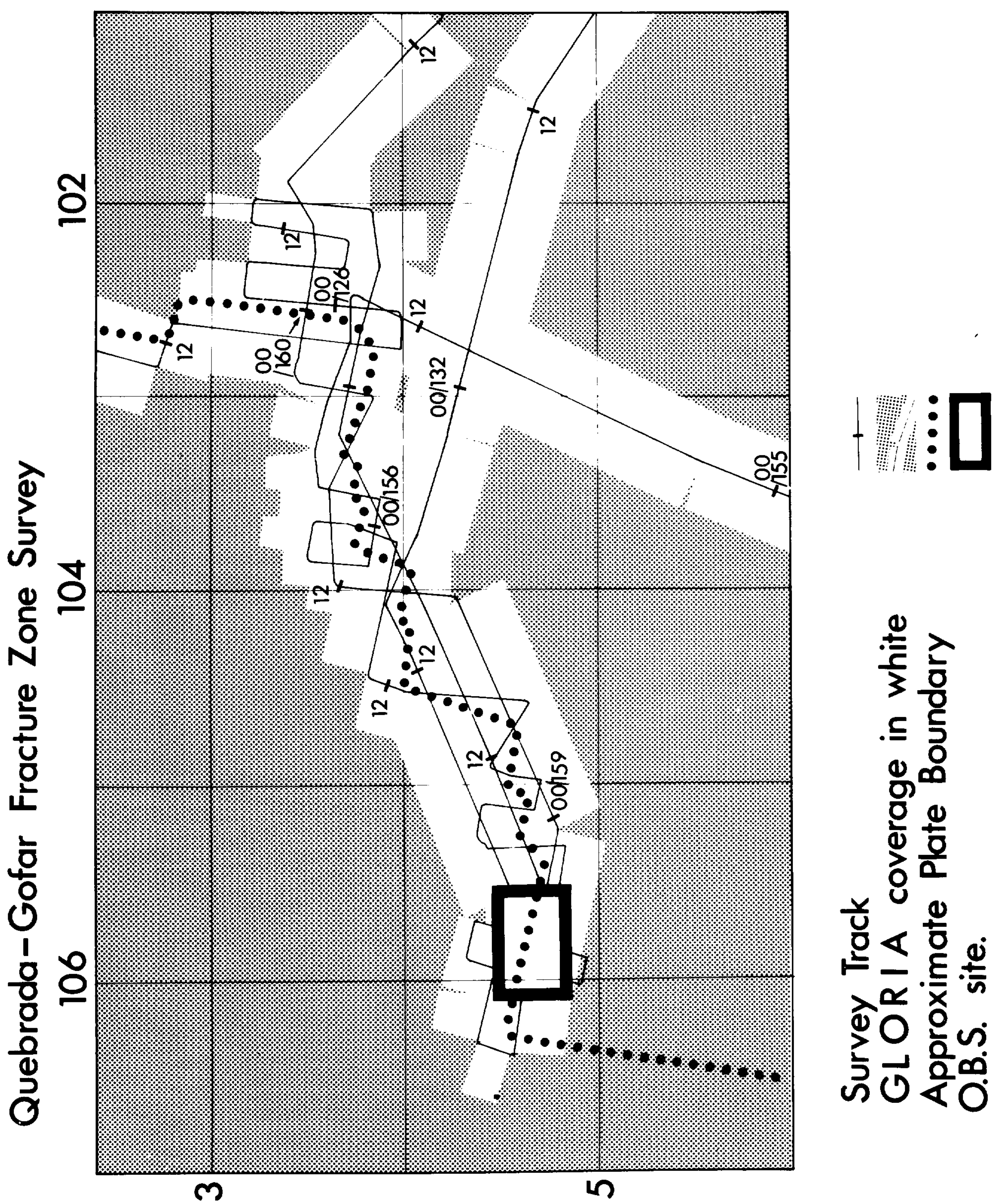
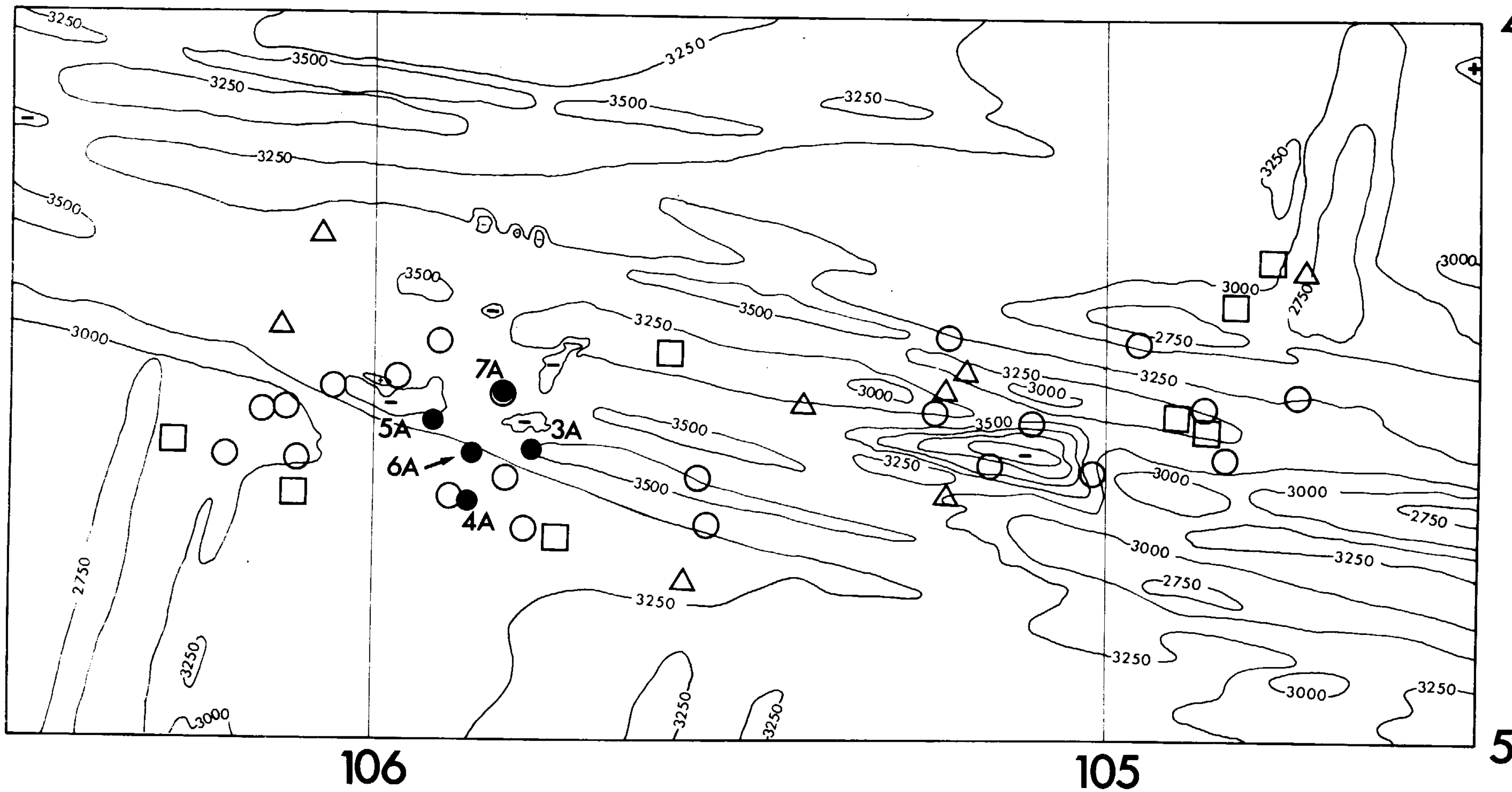

Quebrada-Gofar Fracture Zone Survey
106
104
102
3
5
00/156
00/159
00/132
00/155
00/160
00/126
12
Survey Track
GLORIA coverage in white
Approximate Plate Boundary
O.B.S. site.

FIG. 5

GOFAR FRACTURE ZONE OBS SURVEY



O.B.S. positions			● 4A
Epicentre fixes		Good	○
"	"	Poor	△
"	"	Very poor	□
Bathymetry in metres		(250m interval)	~3000~

FIG. 6

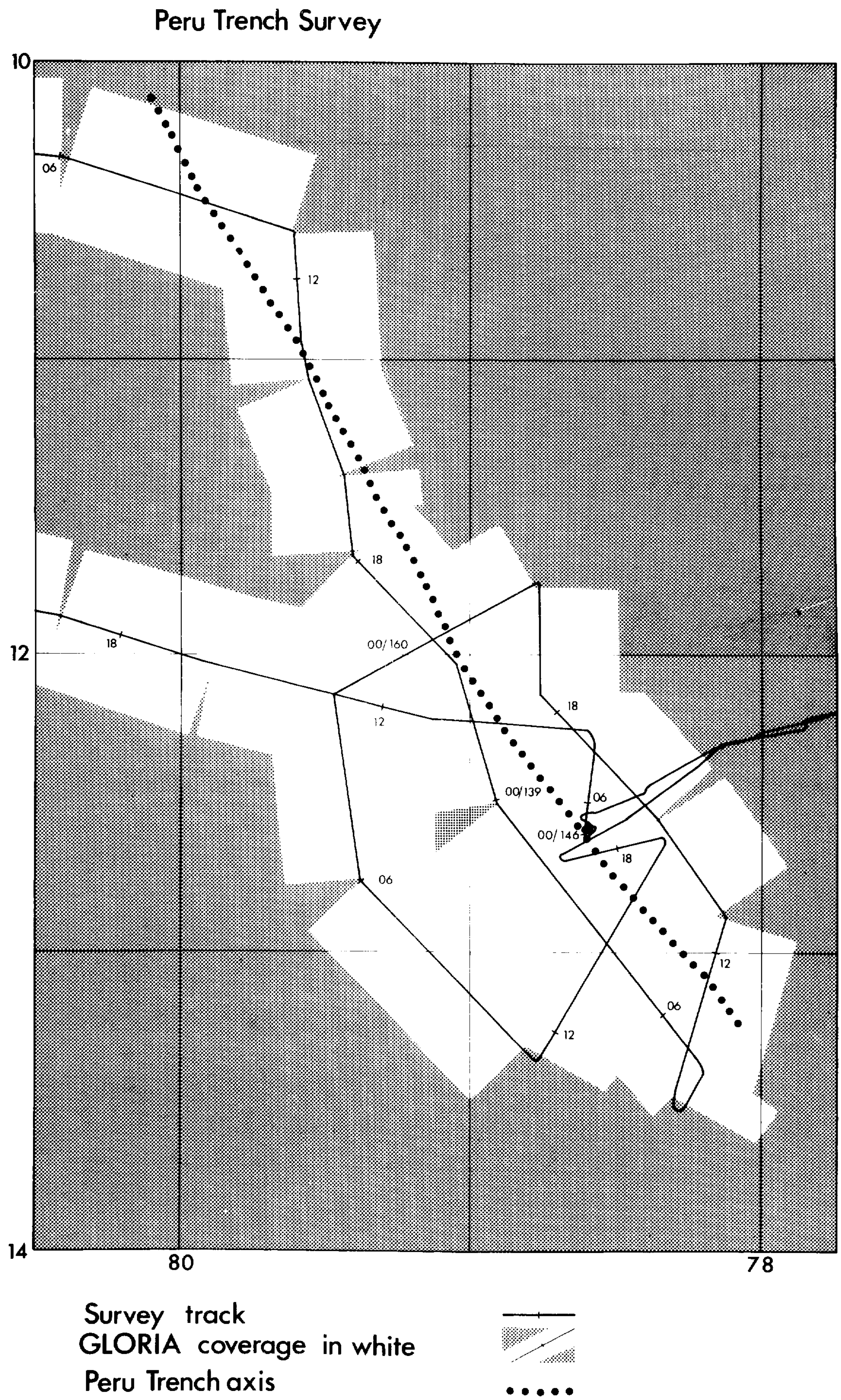
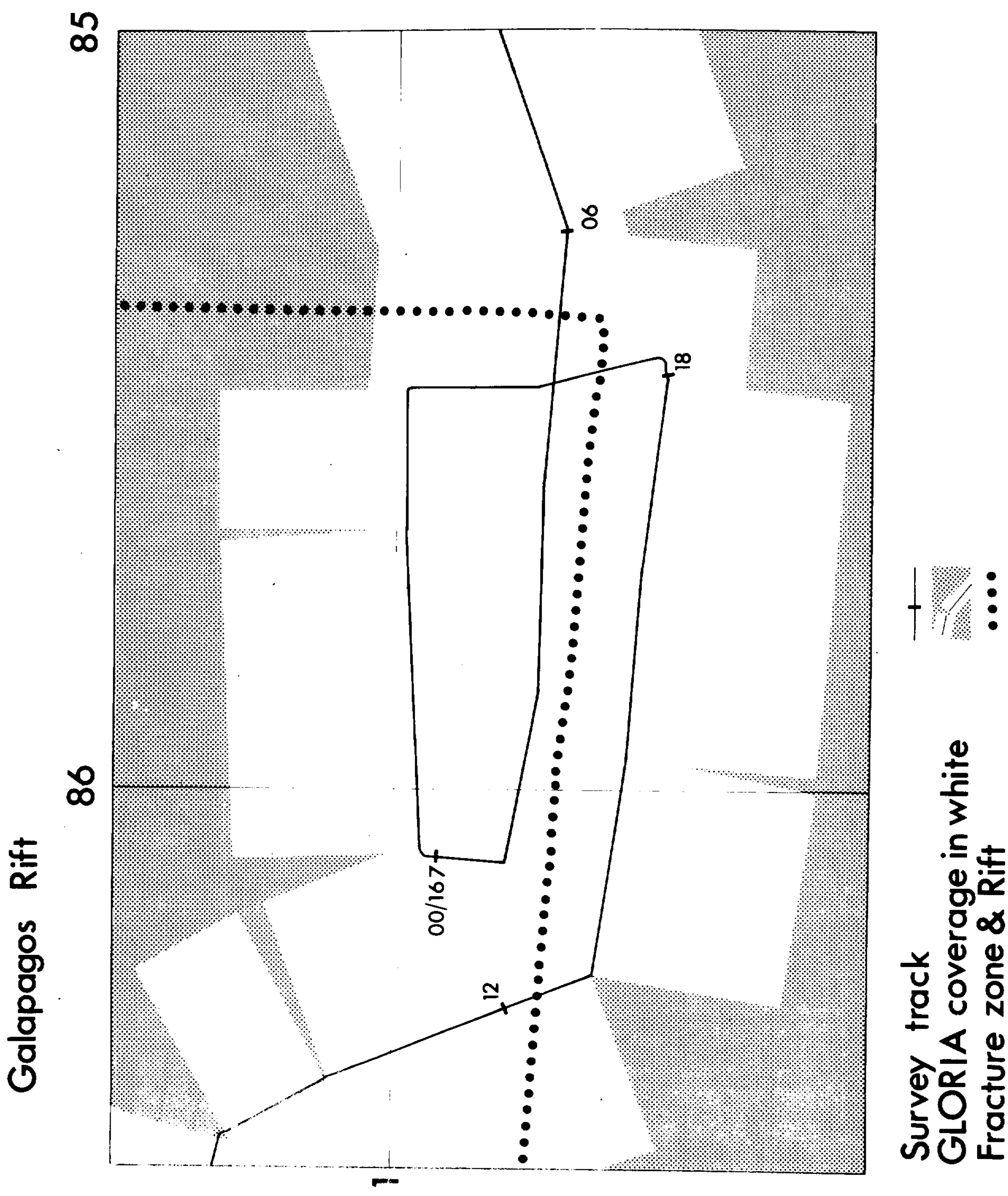

Peru Trench Survey
10
12
14
80
78
06
12
18
00/160
00/139
00/146
Survey track
GLORIA coverage in white
Peru Trench axis

FIG. 7



Galapagos Rift
85
86
1
00/167
12
18
06
Survey track
GLORIA coverage in white
Fracture zone & Rift

FIG. 8

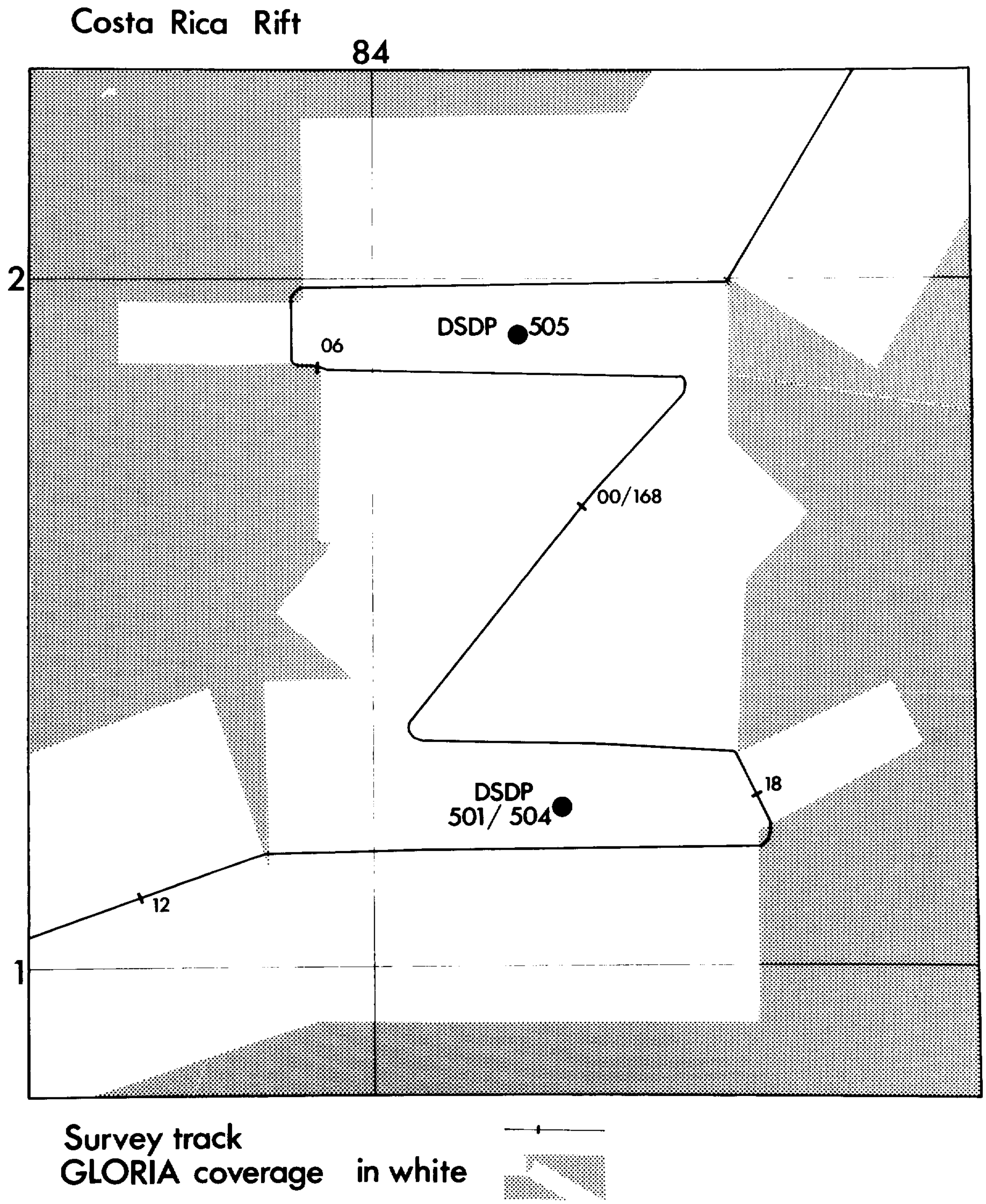

Costa Rica Rift
84
2
1
DSDP 505
06
00/168
DSDP
501/ 504
18
12
Survey track
GLORIA coverage in white

FIG. 9