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DEACON LABORATORY

RRS CHARLES DARWIN

CRUISE 30~~87~~ 88

2 FEBRUARY – 6 MARCH 1988

ACTIVE MARGIN TECTONICS IN EASTERN INDONESIA
A STUDY WITH GLORIA AND UNDERWAY GEOPHYSICS

CRUISE REPORT NO. 202

1988

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
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RRS CHARLES DARWIN

Cruise 30

2 February - 6 March 1988

Active margin tectonics in eastern Indonesia: a study with GLORIA and underway geophysics

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ABSTRACT

The cruise consisted of a short passage leg between Singapore and Jakarta, Indonesia followed by a near continuous geophysical survey between Jakarta and Darwin, Australia. RRS *Charles Darwin* left Singapore on 2nd February and docked in Jakarta on 4th February. After leaving Jakarta on 6th February, a survey of the eastern Java Trench was begun on 8th February, continuing into the south-eastern Savu Sea and along the north slope of the island of Timor on 14th February. A short break in the underway survey on 18 February allowed two dredge hauls to be completed on the north coast of Timor. Following this, a single survey line was completed across the Banda Sea, ending south of the island of Halmahera on 22nd February. A short passage was then made into the south-west Pacific where surveys of the southern end of the Philippine Trench and the eastern end of the New Guinea Trench were completed between 23rd February and 1st March. A second survey line was then run across the Banda Sea whilst on passage to Darwin. All geophysical equipment was recovered on 4th March before reaching Australian waters. *Charles Darwin* docked in Darwin on the morning of 6th March.

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* joined in Jakarta

SHIP'S PERSONNEL

MAW, P.	Master
JACKSON, S.	Chief Officer
LOUCH, A.	2nd Officer
LEATHER, C.	3rd Officer
BROWN, C.	Radio Officer
BATTEN, G.	Chief Engineer
GIMBER, G.	2nd Engineer
LOVELL, V	3rd Engineer
PARKER, P.	Electrical Officer
WISEMAN, D.	C.P.O.
TREVASKIS, M.	Seaman
DRAYTON, M.	Seaman
ROACH, A.	Seaman
BENNETT, P.	Seaman
JONES, G.	Seaman
WILLIAMS, M.	Motorman
PETERS, K.	Cook/Steward
ALCOTT, L.	Cook
BROWN, L.	2nd Steward
HOBBS, K.	Steward
FREW, T.	Steward

ITINERARY

The cruise consisted of a short passage leg between Singapore and Jakarta, Indonesia followed by a near continuous geophysical survey between Jakarta and Darwin, Australia. RRS Charles Darwin left Singapore on the 2nd February and docked in Jakarta on the 4th. After leaving Jakarta on the 6th February, a survey of the eastern Java Trench was begun on the 8th February, continuing into the south-eastern Savu Sea and along the north slope of the island of Timor on the 14th February. A short break in the underway survey on the 18th February allowed two dredge hauls to be completed on the north coast of Timor. Following this, a single survey line was completed across the Banda Sea, ending south of the island of Halmahera on the 22nd February. A short passage was then made into the south-west Pacific where surveys of the southern end of the Philippine Trench and the eastern end of the New Guinea Trench were completed between the 23rd February and the 1st March. A second survey line was then run across the Banda Sea whilst on passage to Darwin. All geophysical equipment was recovered on the 4th March before reaching Australian waters. Charles Darwin docked in Darwin on the morning of 6th March.

INTRODUCTION AND CRUISE OBJECTIVES

The major aim of the cruise was the study of tectonic processes occurring in two areas of eastern Indonesia, namely the eastern end of the Java Trench, where it is being overridden by the Australian continent, and the south-western Philippine Sea, where a complex intersection of destructive and strike-slip plate boundaries occurs. The main survey tools were: GLORIA II long-range sidescan sonar, single channel airgun seismic profiler, 3.5 and 10 kHz high resolution profilers, magnetometer and gravimeter. A limited period was also devoted to rock dredging. Navigation was principally by transit satellite, although GPS was in use for up to 6½ hours per day.

The Java Trench:

There is considerable uncertainty concerning the eastward continuation of the Java Trench subduction zone into the area where it is being overridden by the Australian continental margin. One model suggests that the trace of the plate boundary continues east through the Timor Trough; an alternative suggests that it is transferred north of the island of Timor. Our aim was to map the morphological evidence of recent tectonics, thus following the surface expression of the active plate boundary in the region of Timor.

The south-western Philippine Sea

This is a complex area in which the Philippine Trench, Yap-Palau Trench and New Guinea Trench intersect with major strike-slip fault systems known from northern New Guinea. Little is known of the structure of the area simply because it is poorly studied. Our aim was to make a reconnaisance mapping foray across the area, attempting to locate the major plate boundaries.

NARRATIVE

RRS Charles Darwin departed Singapore at 1000, 1st February (all times are local). After swinging compasses, the ship anchored in Singapore roads to take on bunkers and to await clearance from the Indonesian authorities. Clearance to operate in Indonesian waters was finally signalled by the British Embassy in Jakarta at 1230, 2nd February and the ship departed Singapore roads at 1300.

During the passage to Jakarta, the scientific party maintained a nightly presence on deck to discourage 'pirates'. All entrances to the ships accommodation except one were also battened down. Local information, however, suggested that the dangers of piracy had been grossly exaggerated by RVS management. The ship arrived off Jakarta at 0900, 4th February, but had to stand off until 1400 awaiting a pilot. By 1430, however, we were berthed in Tanjung Priok (the port of Jakarta).

The programme for the 5th February consisted of an 'open ship' during the day and an official reception on board in the evening. The evening reception was a great success with a good attendance of both Indonesian and ex-patriot U.K. guests.

While in Jakarta, it was discovered that the clutch on the mechanical engine drive, which had given trouble during the passage from Singapore to Jakarta, required new bearings. Since no spares were available in Jakarta, it was decided that the ship should sail with only electric drive operative. This made no difference to the cruise objectives, since all survey work was planned using electric drive.

RRS Charles Darwin departed Jakarta at 1500 on the 6th February and began passage at maximum speed (11½ kts) towards the working area in calm seas. At 0400, 7th February, a problem with the control system for the main engine reduced the ships speed to a maximum of 6 kts. The engines had to be stopped to trace this fault, which proved unusually hard to find. Finally, at 1630, repairs were completed, and we were once more able to proceed at full speed.

Meanwhile, logging of bathymetry and gravity were begun at 0600 on the 7th. Short tests on the GLORIA system, to check the new compass housing, and on the 3.5 kHz profiler, to test whether the new towing position aft on the starboard side would give acceptable signal/noise ratios were carried out between 1700 and 2000. Both sets of tests gave positive results. However, in view of the time lost through engine problems, it was decided to retrieve all towed equipment and steam at full speed overnight, with the aim of beginning the survey during the morning of the 8th February.

At 0800 on the 8th February, we had reached a position just north of the Java Trench at 106½°E. GLORIA, the 3.5 kHz and 10 kHz profilers and the magnetometer were deployed between 0830 and 1030 to run a single, 1200 km long, survey line along the Java Trench. The airgun seismic profiler was not deployed so that a survey speed of 10 kts. could be maintained until we reached the first of the main survey areas at 120°E. The seas remained calm, a situation that was to remain unchanged for the entire cruise.

Problems arose with the GLORIA system as soon as it was brought on line. The major problem was one of timing, so that data logging was not synchronised with the transmit/receive sequence. This problem was eventually traced to the clock unit, but only after the loss of 9 hrs. of data. A second problem related to the malfunction of a number of the power amplifiers, and by 2100 on the 8th February only the minimum requirement of six amplifiers (out of a possible 12) were operational. Fortunately, these six continued to operate for the next nine days, when a break in survey allowed repairs to most of the others to be effected.

The problems highlighted above were the start of incessant irritating electronic failures which plagued the GLORIA system for the entire cruise. Most were concerned with the real-time monitor display and with the replay system (see section on GLORIA operations). The cause of the majority of these problems was that the equipment had been stored in a container with no air-conditioning on board Charles Darwin for several months prior to cruise 30. A thermometer left in the container exploded in the heat, indicating temperatures in excess of 50°C. This is clearly excessive for the storage of electronic components. It is to the credit of the GLORIA support team (assisted by the RVS computer engineer) that, after the initial problems, less than 8 hours of data were lost during 23 days of survey.

Between 2100, 8th February and 1400, 11th February, a 1200 km long, 45 km wide GLORIA swathe was obtained along the Java Trench between 108° and 119°E. By 1400, 11th February, we had reached the first of our detailed survey areas where the Java Trench intersects the Australian continental margin south of the island of Savu. At this point we deployed a single 300 in^3 airgun and the two channel hydrophone, decreasing the survey speed to 8 kts. Some initial problems were apparent in the seismic system, but it was fully operational by 1930. As we worked from the very deep water of the Java Trench (>7000m) to the shallower water of the Australian/Indonesia collision zone, it soon became apparent that the high surface water temperatures (30°C) and the assumed strong thermocline would combine to strongly reduce the GLORIA swathe width in relatively shallow water. Even with much reduced ships speed, allowing the GLORIA vehicle to sink to a depth of over 70 m, a water temperature of 28°C was recorded. Thus it was not possible to ameliorate the range reduction by slowing down and allowing the GLORIA vehicle to sink below the thermocline. At its worst, the total GLORIA swathe width was reduced to < 10 km in 1500 m of water. Since we did not consider this narrow swathe an adequate return for our survey time, we decided to abandon the proposed survey work in shallow water around Savu, concentrating instead on the deep waters of the Savu and Wetar Basins. Consequently we completed our survey work south of Savu at 2000, 14th February and proceeded north-east into the Savu Sea. Between 2000, 14th February and 2200, 17th February, we completed a 24 hr survey in the southern Savu Basin before proceeding north-westwards along the continental slope of Timor towards the Wetar Basin. Survey of the Wetar Basin was completed by 2200, 17th February, and GLORIA and the airgun seismic profiling equipment was recovered in preparation for dredging on the northern continental slope of Timor. Dredging was preceded by a short (6 hr) 3.5 kHz survey to attempt to find the best dredging station. Two dredge hauls were then made between 0600 and 2030, 18th February. At the first dredge station (between 8° 15' and 8° 18'S, and at 126° 23½'E) we dredged the lower slope between 3300 and 2200 m water depth. Although the dynamometer showed little evidence for the dredge snagging on the seabed, we recovered a large amount of highly cohesive mud which completely clogged the

dredge mouth. Cut faces on coherent lumps of mud showed structures suggestive of slumping. The mud contained abundant foraminifera and will be dated when returned to the laboratory. The second dredge station was located some 10 km to the east (between 8° 15' and 8° 16'S and at 126° 28½'E) and also sampled the lower slope between 3100 and 2650 m water depth. This dredge became stuck soon after reaching the seabed and was only freed when the three-ton weak link broke, inverting the dredge and closing the dredge bag. On recovery, the dredge contained two moderate-sized pieces of andesitic volcanic rock and one very small piece of indurated fine-ground sedimentary rock. Dredging was terminated with the completion of the second station at 2030, 18th February.

GLORIA and the magnetometer were redeployed between 2030 and 2130, 18th February. Between 2130, 18th February and 0200, 20th February, we completed a GLORIA survey of an offset of the Wetar Thrust to the west and north of the island of Wetar before beginning northward passage across the Banda Sea. During this passage, a 90 km long, NW-SE orientated airgun seismic reflection profile was run through a potential Ocean Drilling Programme (ODP) site in the Banda Sea at 4° 56'S, 124° 56'E. Passage across the Banda Sea was made at 10 kts, with GLORIA deployed, in order to obtain crossings of important geological features such as the Hamilton Fault and the Sorong Fault Zone. At the end of the passage leg, however, beginning at 2200, 21st February, all towed equipment had to be recovered for a period of approximately 24 hours to cross an area of shallow water to the SE of Halmahera.

Between 1900 and 2000, 23rd February, all geophysical equipment, including the seismic reflection profiling system, was redeployed to begin a survey of the southern end of the Philippine Trench, west of the island of Halmahera. This was completed by 2000, 26th February. A single SE survey line along the continental slope between Halmahera and NW Irian Jaya was followed by survey of the western end of the New Guinea Trench between 1200, 27th February and 0200, 1st March, after which all towed equipment was recovered for passage back into the Banda Sea.

By 1900, 1st March, we had cleared the shallow water area west of Irian Jaya, and GLORIA was redeployed in deep water north of the island of Ceram. After a short survey of the Sorong Fault Zone, we passed between the islands of Buru and Ceram, into the Banda Sea. At 2130, 2nd March, the airgun and hydrophone were deployed to conduct surveys of two further potential ODP drill sites in the Banda Sea. For the first site, situated at 5° 03'S, 127° 11'E, a 35 km long line was run in a SE direction. For the second, situated at 5° 58'S, 128° 07'E, a 35km long line was run in a SW direction. Following completion of the site survey work, the seismic profiling equipment was recovered at 2200, 3rd March and passage southward across the Banda Sea was continued. A short GLORIA survey northeast of the island of Wetar occupied the remaining few hours of survey time between 0500 and 1830, 4th March. By 1930, 4th March all towed geophysical equipment had been recovered and the ship began passage to Darwin Australia. Logging of gravity and bathymetry continued until 0700, 5th March, in order to obtain a crossing of the Timor Trough, but was terminated as we approached the Australian 200 mile limit.

RRS Charles Darwin docked at Darwin at 0800, 6th March.

REPORT ON GLORIA OPERATIONS

Problems were experienced at one time or another with virtually every part of the GLORIA system, and on occasion faults arose in different sections simultaneously.

Most of these difficulties were almost certainly caused during the 7 month period that the equipment had been lying idle, when it had been stored in a Deck Container in the Tropics without benefit of air conditioning.

On arrival in Singapore the more obvious manifestations of trouble in store included: the broken thread of mercury in the Portakabin thermometer indicating failure well beyond 50°C; the seizure of the laser deflection mirror, the surface of which was coated with corrosion products, and the very low level of electrolyte in the PPA battery pack. Insofar as these cells were concerned, the

Chloride agent declared them to be in a terminal condition; however, since delivery for new cells was in excess of 6 months they were in fact successfully revived - but even by the end of the cruise no single cell had returned to a fully charged state.

Evidence of corrosion was widespread from the aluminium housings of the Tandberg motors to the legs of the light sensors in the PPA fault detection circuits, and the oil had seeped from the capacitors in the PPA dummy load.

The IBM AT used in the replay system also caused some concern during the refit period when it proved necessary to replace all the RAM on the mother board. This repair proved illusory however as intermittent faults progressed slowly to complete failure. Recourse was made to boards and chips from a Tandon PC which had been obtained in Singapore - but it was not until the IBM from the RVS Doppler log was pressed into service that the mosaic was completed, although even with this machine it proved impossible to download the data from cartridge to 9 track archive via the ODI card.

The opportunity was taken to field test a digital flux gate compass in the vehicle and although initially encouraging this unit failed after only 5½ days continuous use. It had been hoped to run some beam steering trials with this device but by the time more pressing problems with logging, laser and LSRs had been overcome it proved to be too late.

The Cetrek was replaced by the Digicourse for the remainder of the cruise.

PRINCIPAL RESULTS

(1) The Java Trench:

The single GLORIA swathe along the Java Trench yielded spectacular sonographs of the lower part of the accretionary wedge, of the trench itself, and of the landward edge of the oceanic plate.

The wedge is characterised by a strongly lineated fabric parallel to the deformation front. Sharp re-entrants in the front occur where seamounts on the oceanic plate are being subducted. Initial interpretation of these structures suggests that the toe of the accretionary wedge may be torn off by the advancing seamount and subducted, leading to oversteepening and erosion of the lower wedge. The oceanic plate shows a typical horst and graben fabric caused by extension in the upper plate as it is bent down into the trench.

(2) The Australia/Indonesian Arc collision zone:

The classic trench physiography of the Java Trench west of 120°E is replaced between 120 and 122°E by a progressively broader, more diffuse compressional zone. At 119° 45'E there is a relatively sharp change in trend of the collisional structures from E-W in the west to ESE further east. East of 121°, structures trending slightly north of east are also seen; these appear to be westward continuation of the Timor Trough compressional zone. Survey lines run to the north of the main, presently active, deformation zone show no evidence of recent tectonics. This applies both east and west of Savu, along the north coast of Timor, and in the Savu and Wetar Basins. Only between the islands of Wetar and Alor, where the volcanic arc is apparently offset to the north do we see evidence for a deep, ? pull-apart basin and possible strike-slip faulting. Overall, our interpretation of the superficial tectonics of the Australia/Indonesia collision zone supports models in which the Java Trench subduction zone continues with only a slight deflection into the Timor Trough. We see no evidence for active transfer structures which might link the eastern Java Trench with compressional structures north of the Indonesian Arc.

(3) The Banda and Ceram Seas:

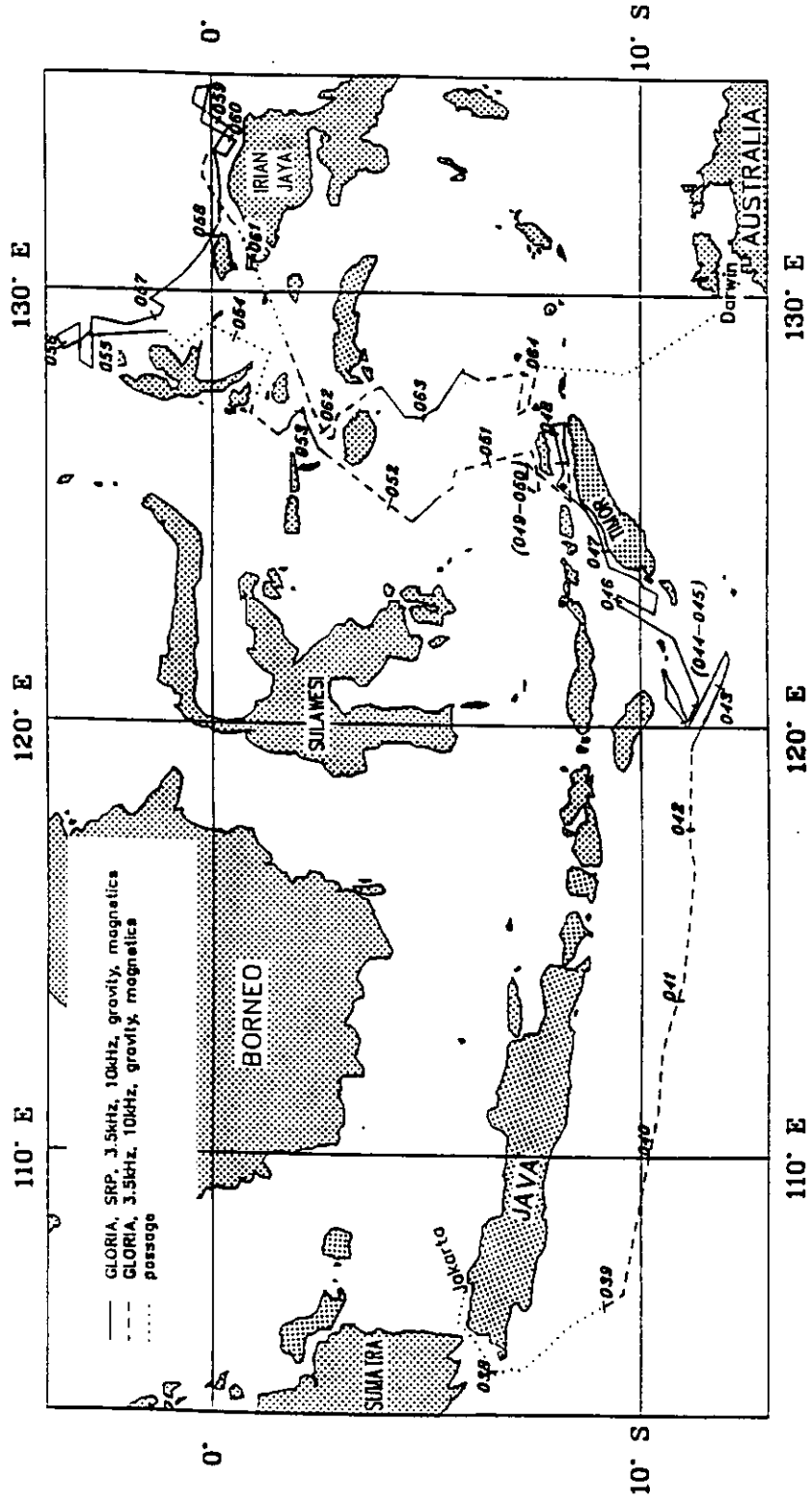
Single GLORIA swathes, collected during passage across the Banda Sea, show glimpses of several of the major tectonic lineaments crossing the area, but were often somewhat disappointing. The Sorong Fault Zone, for example, proved to be a broad zone of lineated, E-W trending structures, as would be expected of an area dominated by E-W strike-slip tectonics. However, we saw no features which we might interpret as currently active loci of strike-slip motion, as have been seen on GLORIA data elsewhere, particularly in oceanic fracture zones and along the Aleutian Arc.

(4) The Philippine and New Guinea Trenches:

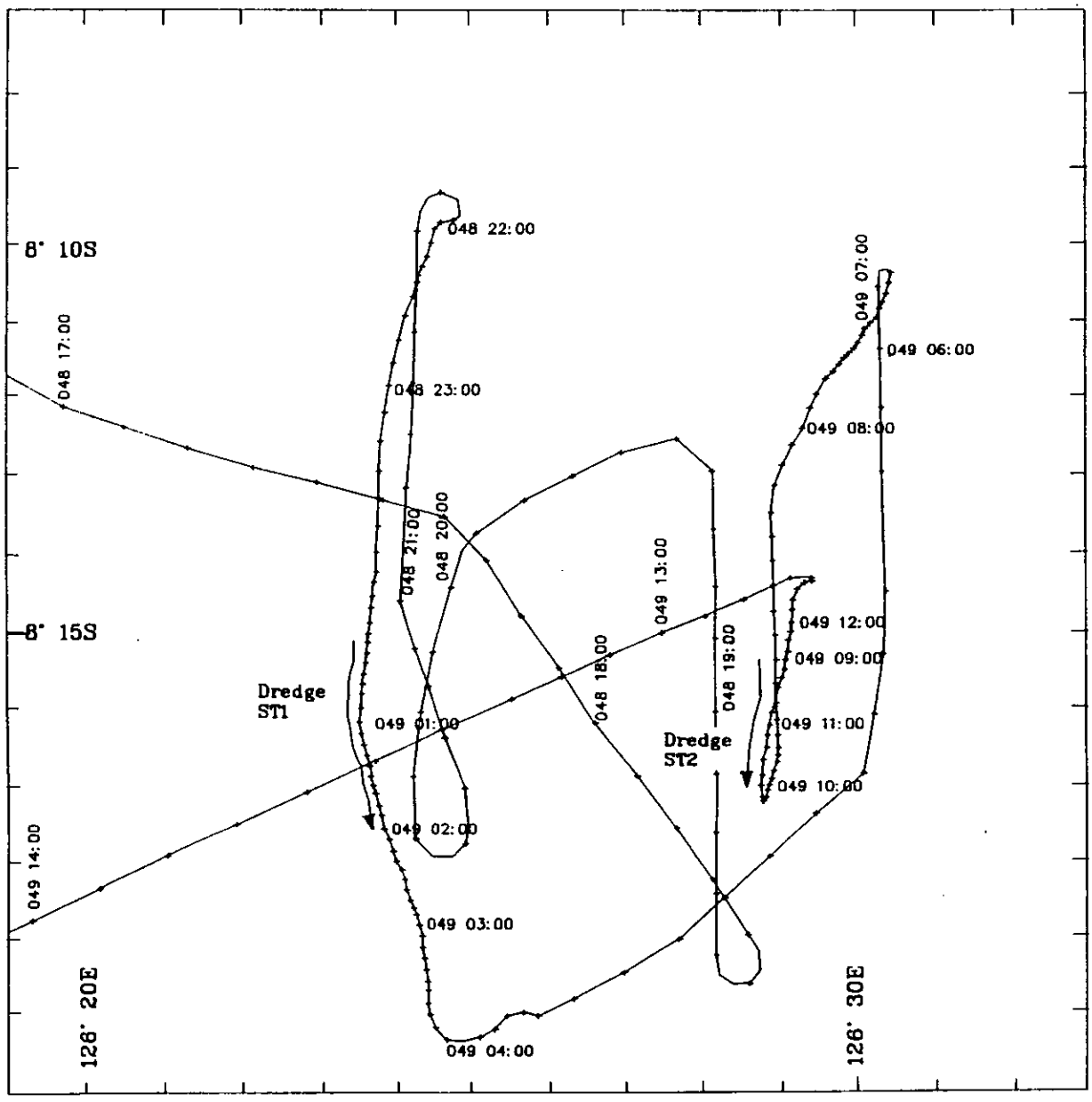
North-east of Halmahera, the Philippine Trench is clearly defined north of 2° 50'N, but southward it is truncated abruptly against a relatively shallow region of seafloor. We tentatively interpret this anomalously shallow block as a oceanic plateau which has overridden the subduction zone between 1° 50' and 2° 50'N, and which may be in the process of being accreted to the western margin of Halmahera. Further south, between 1° 20' and 1° 50'N we again see evidence of a trench with deformed sediments on its landward side, suggesting that the Philippine Trench extends south to at least 1° 20N, where it appears to terminate against a major E-W trending basement ridge with a relief in excess of 2 km.

Further east, to the north and north-west of Irian Jaya, the margin between 131° and 133°E is dominated by a major, east-west trending, strike-slip fault system which we were able to trace for over 200 km. East of 133°, this links with a northwest trending trench which we were able to map to 133° 45'E from where it may link with active tectonic areas onshore Irian Jaya. All of these features are new discoveries, proving once again the usefulness of the GLORIA system as a reconnaisance tool.

Our final survey area, at the western end of the New Guinea Trench, showed an apparently inactive, sediment filled, trench with the continental margin dominated by downslope sediment transport rather than along slope tectonic lineaments.



Track Chart 1: for RRS Charles Darwin Cruise 30, 2 February - 6 March, 1988 Day numbers show position at 0000 hrs GMT on any marked day.



Track Chart 2: Track chart showing location of Dredge Stations 1 and 2 plus 3.5 kHz profiles recorded in the vicinity of these stations.

Times are given in GMT