CRUISE REPORT

RRS CHARLES DARWIN 36/88

1-28 DECEMBER 1988

VALPARAISO TO PUNTA ARENAS

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Objectives

The objectives of the cruise were to discover how the continental margin of Chile has reacted to the subduction of an actively spreading ocean ridge (the Chile Ridge). To accomplish this, the cruise was to survey the region of subduction of the active ridge, just north of the Taitao Peninsula, the area to the north where subduction of the ridge has not yet occurred, and the area to the south where subduction of the ridge has taken place between 14 and 3 My ago. Techniques employed were GLORIA long-range sidescan sonar to image the patterns of structure and sedimentation expressed in the shape and roughness of the seafloor, seismic reflection to image subsurface structure (3.5 kHz for the top few tens of metres of unconsolidated sediment, small airgun for high resolution of sedimentary layering, large airgun for following igneous oceanic basement and other deep structures), magnetics to determine the magnetic anomaly reversal sequence across the oceanic crust and the structure of magnetic basement, and gravity to aid the interpretation of the deep structure of the continental margin.

Geographical Area

Offshore of the continental margin of Chile between 40 S and 52 S, and as far west as 82.2 W. (see Fig. 1)

Weather Conditions

During the cruise the winds were nearly constantly from the west, varying in direction from NW to SW. For nearly half the cruise, windspeed was above 20 knots, reaching 40 knots at times. There were occasional rain squalls during the passage of fronts through the area. The swell, always present to some degree, ranged in height from 2 m to 7 m. During calmer periods, fog occurred.

Conduct of the Cruise

The cruise started late (left Valparaiso 2105, 1 December), because of continuing repairs to the ship's radio. GLORIA, magnetometer, 10 kHz and 3.5 kHz fishes were deployed on 2 December en route to the survey area, which was reached on 4 December. Airguns for seismic reflection were deployed on 4 December, and run with only short breaks until 17 December when they were brought in to enable the ship to make more than 8 knots for the remainder of the cruise and provide the intended GLORIA coverage, except for a period of 36 hours on 22 and 23 December. Strong winds and large swell slowed the progress of the ship to between 5 and 7 knots for about a quarter of the cruise, and fog slowed the ship to 8 knots during periods when it was expected to make 10 knots for a total of about 20 hours. On 23 December, the ship broke off scientific work for 12 hours to collect two pilots from Ancud for the passage of the Magellan Straits at the end of the cruise. Data collection stopped at 0600 on 27 December prior to the ship entering the Magellan Straits.

The cruise was successful in surveying virtually all of the intended area with GLORIA, although this was at the expense of the loss of seismic reflection coverage of areas for which seismic reflection was not critical. This was achieved despite the magnetometer, gravimeter and seismic reflection system developing problems that put them out of action for various periods of time (details are given in the next section).

Equipment Performance

GLORIA: Initial problems with interference from the 3.5 kHz profiler, produced by a fault in the earthing, were significantly reduced during the first day of deployment. Although several hours of data were lost, they were from outside the main survey area. A new fluxgate compass for the heading of the GLORIA vehicle produced rapidly varying

values that led to dropouts, especially when the ship was heading into the sea. This problem was "solved" in the interim by switching off the beam steering, and after the visit to Ancud by replacing the compass with the old one. During the deployment of GLORIA after Ancud, the hydraulic system driving the GLORIA launcher and its winch, apparently from becoming overpressured. Except for a few hours on the first day, none of these problems led to any substantial loss of data. For large parts of the survey area, a maximum range of insonification of 22.5 km was achieved or nearly so.

Digital Seismic Acquisition System SAQ1: This failed after some 30 hours running, because of a fault with the disk drive. The system had crashed a few times before finally failing altogether. Despite much time and effort expended by D. Booth, J. Campbell and A. Harris, the system could not be made to work and was not used for the rest of the cruise. Seismic data were recorded in FM analogue form on a Store 4 tape recorder, leaving the digitisation of the data to be accomplished in the future.

Geomechanique Seismic Streamer: The streamer was remarkably quiet at a towing speed of 8 knots. The effect of changing speed upon the sea-surface ghost suggests that it towed too shallowly for the signatures of the large air guns (300 cu.in., 466 cu.in.). Unfortunately, the depth indicator was neither calibrated nor did it give consistent readings.

Air Guns: The airgun array on the 5-metre beam (2 x 300 cu.in. at each end, 30 + 40 cu.in. in the middle) worked well at 8 knots, towing at a depth of about 7 metres without much support from a surface buoy, the first of which broke off after two days. It was straightforward to deploy and to recover. The one serious problem was the abrasion of hoses and cables caused by the guns swinging upward as they were dragged backward on their chains, so that their hoses and cables chafed against the beam and the following guns and their chains. This was especially so for the leading 1500C gun which was on longer chains than the two following 600B guns. The aftermost 1500C gun did not suffer

serious chafing problems. Four hoses, two trigger leads and four shot hydrophones were broken while in use on the beam. Three shot phones had their cables broken at or close to the junction between cable and phone.

A 466 cu.in. gun and, later, a 300 cu.in. gun were towed singly from the port and starboard quarters. Initially, the 466 was towed from beneath the gantry, on the starboard side, but this proved to be too close to the GLORIA tow cable, which it crossed while the ship was turning. To avoid this occurring again, the ship slowed to 5 knots before turns so that the gun, which was weighted more heavily than before, sank deeper than the GLORIA two cable and could not cross over it. A 200 kg weight of chain was attached to each of the guns to get them to two at a useful depth at 8 knots. Chafing against the tow wire cut the cables on one occasion, and a hose blew on another, but in general, this method of deployment was kinder on the cables and hoses at a speed of 8 knots than the array on the beam. The beam would, however, be the most efficient means of deploying more than one gun with GLORIA, if the chafing problem could be overcome.

In the absence of a water gun, the high resolution seismic profiling was hampered by the absence of a second 40 cu.in. chamber with wave-shape kit (Plenty of wave-shape kits for 40 cu.in. chambers, but no second 40 cu.in. chamber, although requested).

Ref Tek Airgun Synchroniser: Both the monitors for the Ref Tek developed faults that hampered its operation for several hours.

Bolt Airgun Firing Boxes: The two firing boxes that were provided to fire guns ahead of the others by one or two seconds could not fire the guns on the array connnected through the umbilical. After modification by adding a larger capacitor, one box would fire a 600B gun, but not a 1500C gun.

Waverley Thermal Printer/Plotter: The plotter would not accept analogue input and could not be used.

Magnetometer: The bottle and cable on the aftermost reel were faulty, possibly a faulty connector. The signal was swamped by noise when they were used. The bottle and cable on the forward reel were OK.

Lacoste Romberg Air-Sea Gravity Meter: The meter was out of operation for four days, because the gyro stabilised table tilted over to port, and it was switched off. From inspection of the gravity records, it was clear that this problem had occurred several times before in the cruise for short periods (5-10 minutes or less), but it had never persisted long enough to discover that the table had gone off level. No obvious fault was found, and after the system was restored the problem did not occur again during the cruise. The cause of the problem is not known beyond it being in the cross-axis gyro or the circuits related to it.

Rubidium Frequency Standard for GPS Navigation: The frequency standard did not appear to being used by the Trimble GPS receiver. No good fixes were obtained with only two satellites, even immediately following a period of operation with three or four satellites. The frequency generator was producing the correct signal, as far as could be determined, and all hardware and software switches were set use the frequency standard.

12 kHz PES: Gave satisfactory performance throughout the cruise.

3.5 kHz Profiler: Worked well, giving a penetration approaching 150 m in some areas.

Ship Performance

The ship performed well throughout the cruise. The ship's officers produced the high standard of competence that one has come to expect of them. The deck crew were distinctly better than on some cruises in which I have taken part. They were cooperative, cheerful, and did their work well. Some inconvenience was caused by the absence of operational floodlights on the port side of the stern gantry during deployment and retrieval of air guns from the port quarter in darkness.

Recommendations

In addition to remedying the equipment faults noted above, some attention might be paid to the following:

a) When towing airguns, a boom on either side of the after deck would be of great benefit to two the magnetometer clear of the guns, and leave the cranes for handling the air guns.

b) Some means of calibrating the depth sensor on the hydrophone streamer without having to dangle the streamer in the water, such as a jacket surrounding the sensor that could be pressured with air would be very welcome.

c) During the poorer weather, the rear laboratory door had to be kept shut, because of the risk of water entering the laboratory. This made access to the after deck awkward because of the heaviness of the door, which makes it difficult and dangerous to handle when the ship is moving about. Another, lighter door with a sill would be better, preferably with a lobby and another door inside it. The present double doors could be kept for moving equipment in and out of the lab.

d) Air guns and GLORIA mosaics do not mix well in the same lab. Servicing of the guns should be kept separate by providing another space on main deck level.

e) Some form of direct track plotting on the bridge and in the lab, with a means of entering waypoints and other information would greatly aid the communication of navigational information.

Preliminary Evaluation of Results

The GLORIA images and seismic reflection profiles obtained on the cruise, with data already available in the area, enable a preliminary assessment to be made of the structure and geological processes active in the area of the survey.

The active spreading segments of the Chile Ridge were characterised by a bright area of high backscattering on the GLORIA sonographs, produced by the rough nature of the new ocean floor with no, or very little, sedimentary cover. The active traces of transform faults joining the active ridge segments were very narrow and simple in their form. The normal faults associated with the rifting along the ridge axes curved in towards the active transform faults, presumably as a consequence of the reorientation of the principal stresses.

Seaward of the ridge segment between the Guafo and Guamblin fracture zones the oceanic magnetic anomaly sequence was clearly established back to Anomaly 5.

The continental margin of Chile showed a marked change in structure north and south of the triple junction. To the north, that part of the margin which appears to be formed of sediments accreted from the ocean floor is narrow, the structures are of very short wavelength and the layer of sediments that is currently being accreted is thin (c. 200 m). To the south, the accreted part of the margin is several times wider than that to the north.

Structures have long wavelengths, and it appears that nearly the whole sedimentary section is accreted. In the south the accretionary complex has developed in an en echelon fashion, building further out southward with overlapping frontal ridges. The narrowness of the margin to the north could be a consequence of a high degree of sediment subduction or periods of tectonic erosion, or both. In the region of the triple junction, the subsidence of slope sediments strongly indicates tectonic erosion.

Canyons are a prominent feature of the continental margin. In many places in the south, canyons in the upper continental slope feed down into amphitheatre like basins that are each drained by a single large canyon that eventually feeds on to the ocean floor.

Two "artefacts" complicated the GLORIA sonographs in several areas. One was the occurrence of multiple reflections, between the sea surface and the seabed, that produced extra ridge like features usually at the horizon of the GLORIA sonograph. The other was the occurrence of diffraction fringes locally developed over the trench where the flat ocean floor could be superficially covered by a thin layer of low acoustic impedance.

Scientific Party

G.K. Westbrook (Principal Scientist)	University of Birmingham
N. Hardy	
R.D. Heath	
R. Rusby	
Wu Qiang	
H. Upshall	
J. Campbell	Institute of Oceanographic Sciences
A. Harris	Deacon Laboratories
D. Booth	Research Vessel Services
H. Evans	
C. Rymer	
J. Wynar	
N. Bangs	Lamont-Doherty Geological Observatory
S. Tebbins	
H. Padilla	ENAP, Chile

Ship's Company

Master	P. Maw
Chief Officer	S. Jackson
Second Officer	R. Chamberlain
Third Officer	G. Proctor
Chief Engineer	G. Batten
Second Engineer	G. Robertson
Third Engineer	V. Lovell
Electrician	P. Parker
Radio Officer	J. Baker
CPO (DECK)	D. Wiseman
Seaman	M. Drayton
"	W. Downe
"	M. Robinson
"	A. Marren
"	R. Cove
Motorman	K. Pratley
Cook/Steward	K. Peters
Ship's Cook	L. Alcott
2nd Steward	M. Stephen
Steward	G. Cairns
Steward	R. Pope

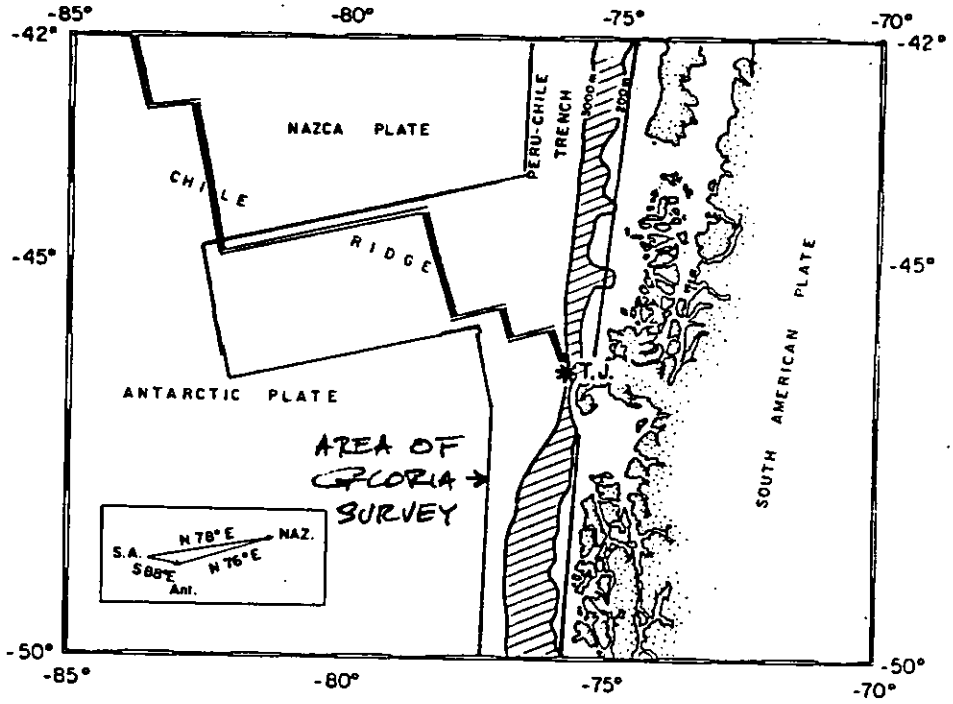


Fig. 1 The position of the triple junction between the Nazca, Antarctic and South American plates where the Chile Ridge is subducted beneath the continental margin of South America.

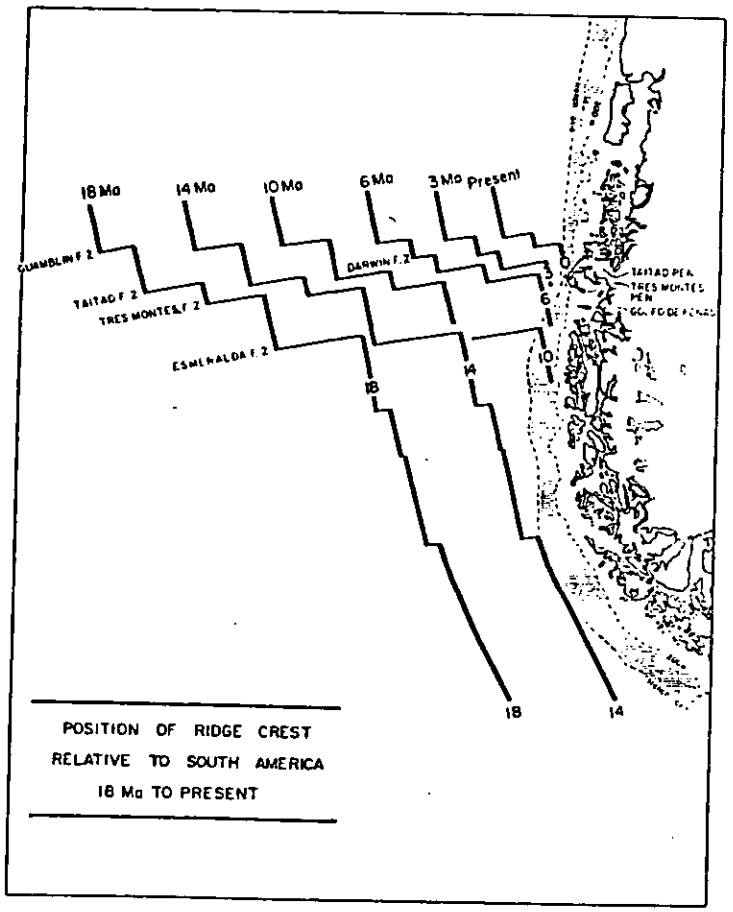
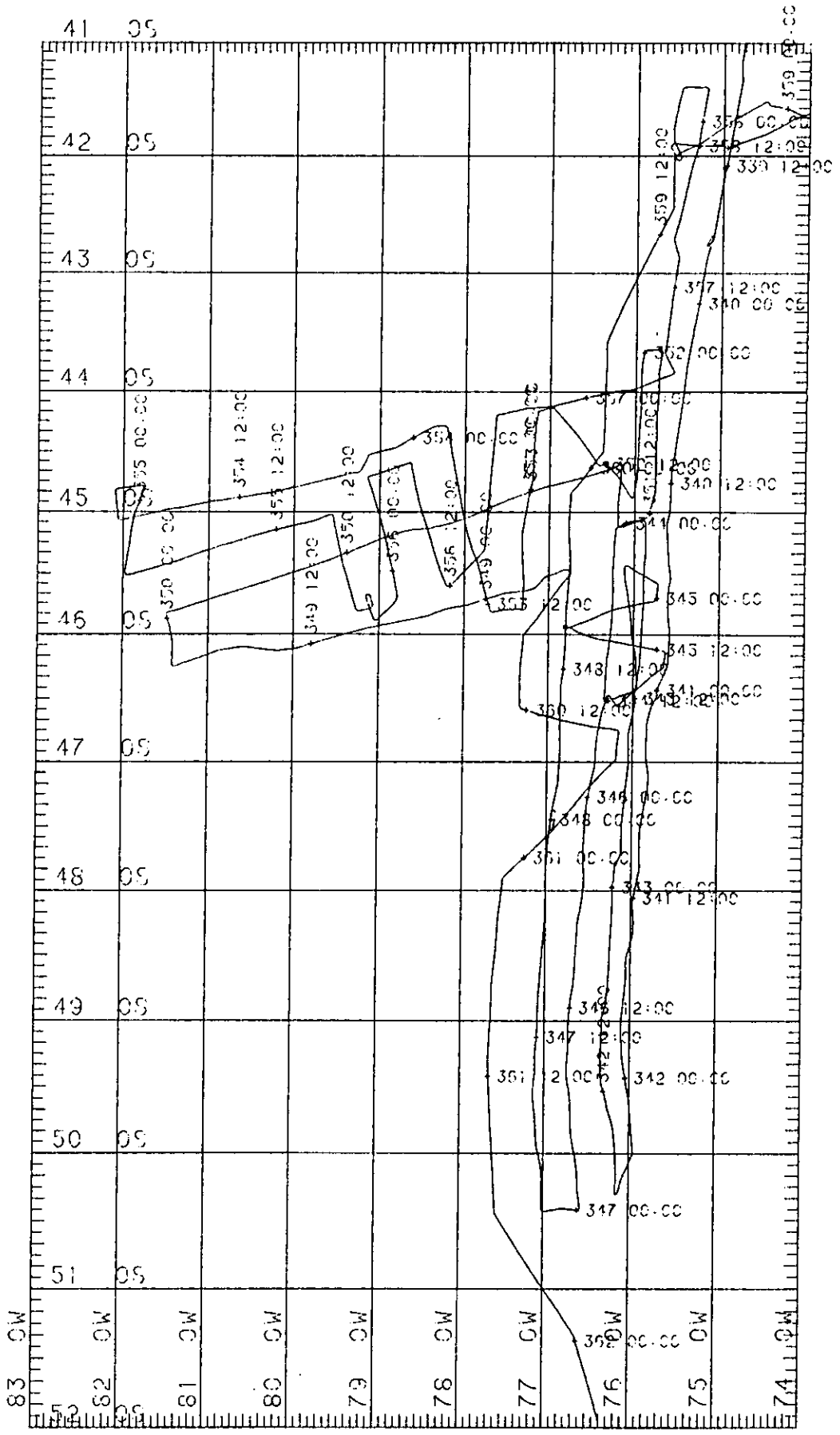


Fig. 2 Reconstruction of the position of the Chile Ridge relative to the South American margin during the Neogene. South of the Esmeralda Fracture Zone, the ridge had long spreading segments with only small offsets on transform faults. North of it, shorter ridge segments are displaced large distances to the west along transform faults (from Cande and Leslie, 1986).



MERCATOR PROJECTION

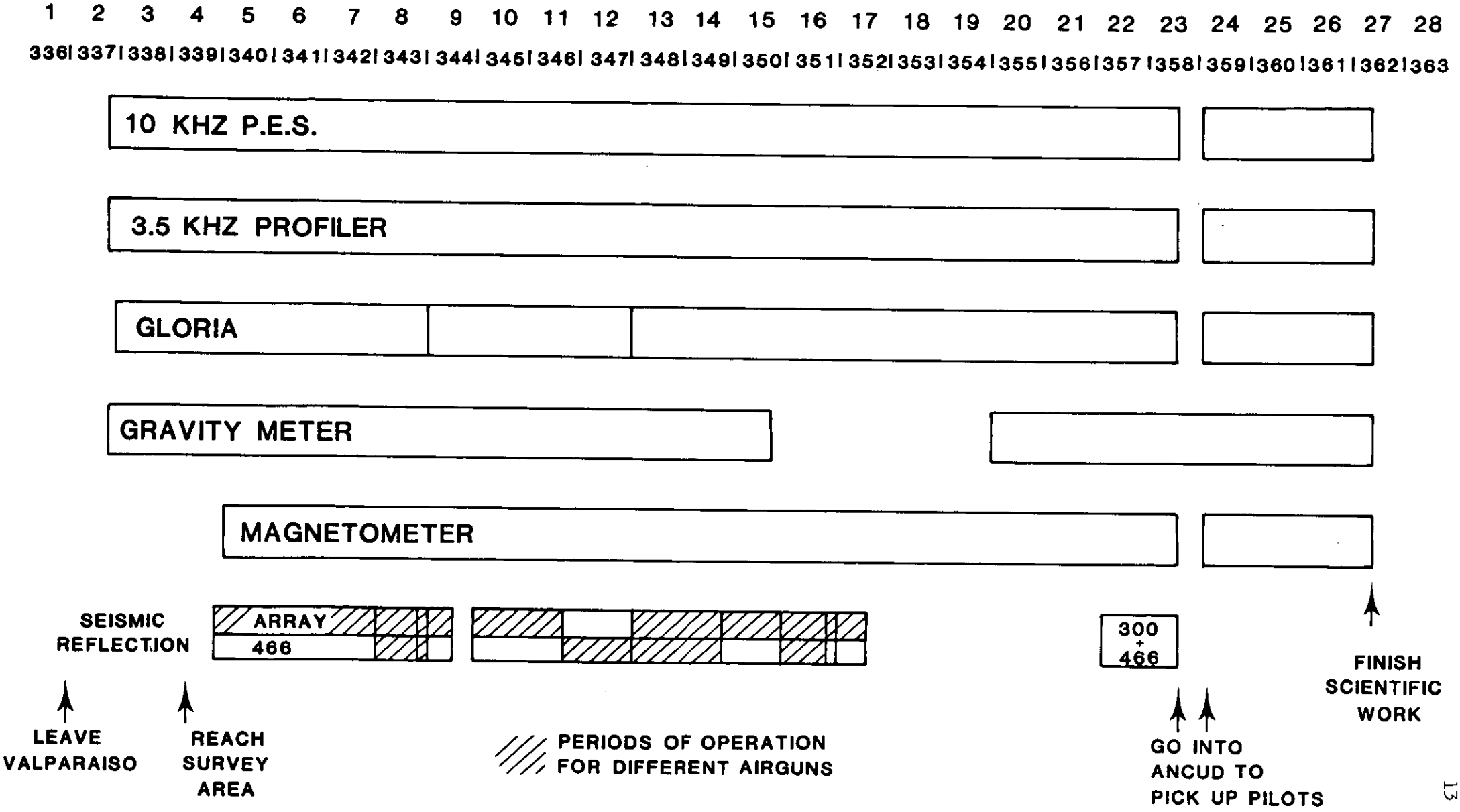
GRID NO. 1

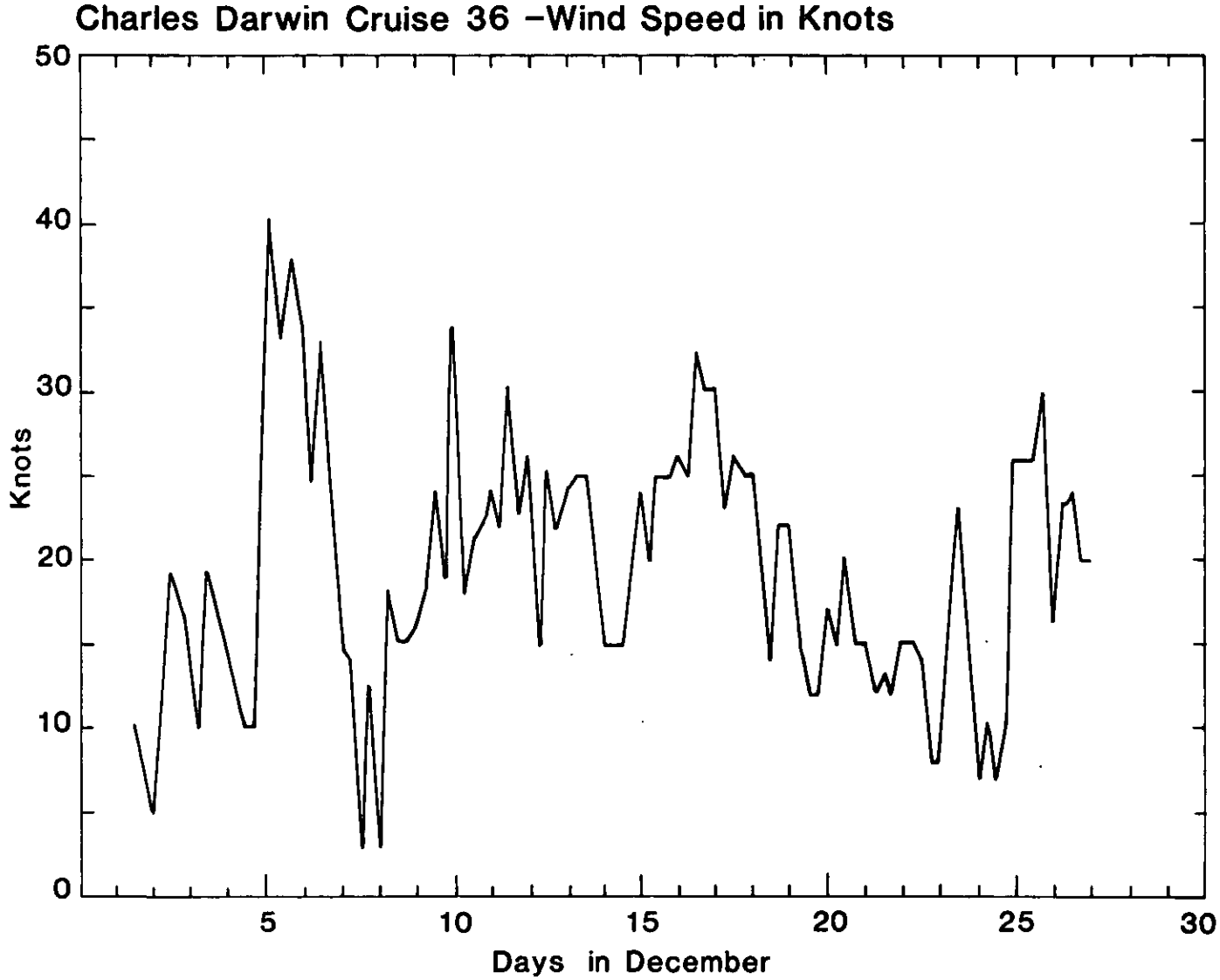
SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. -45)

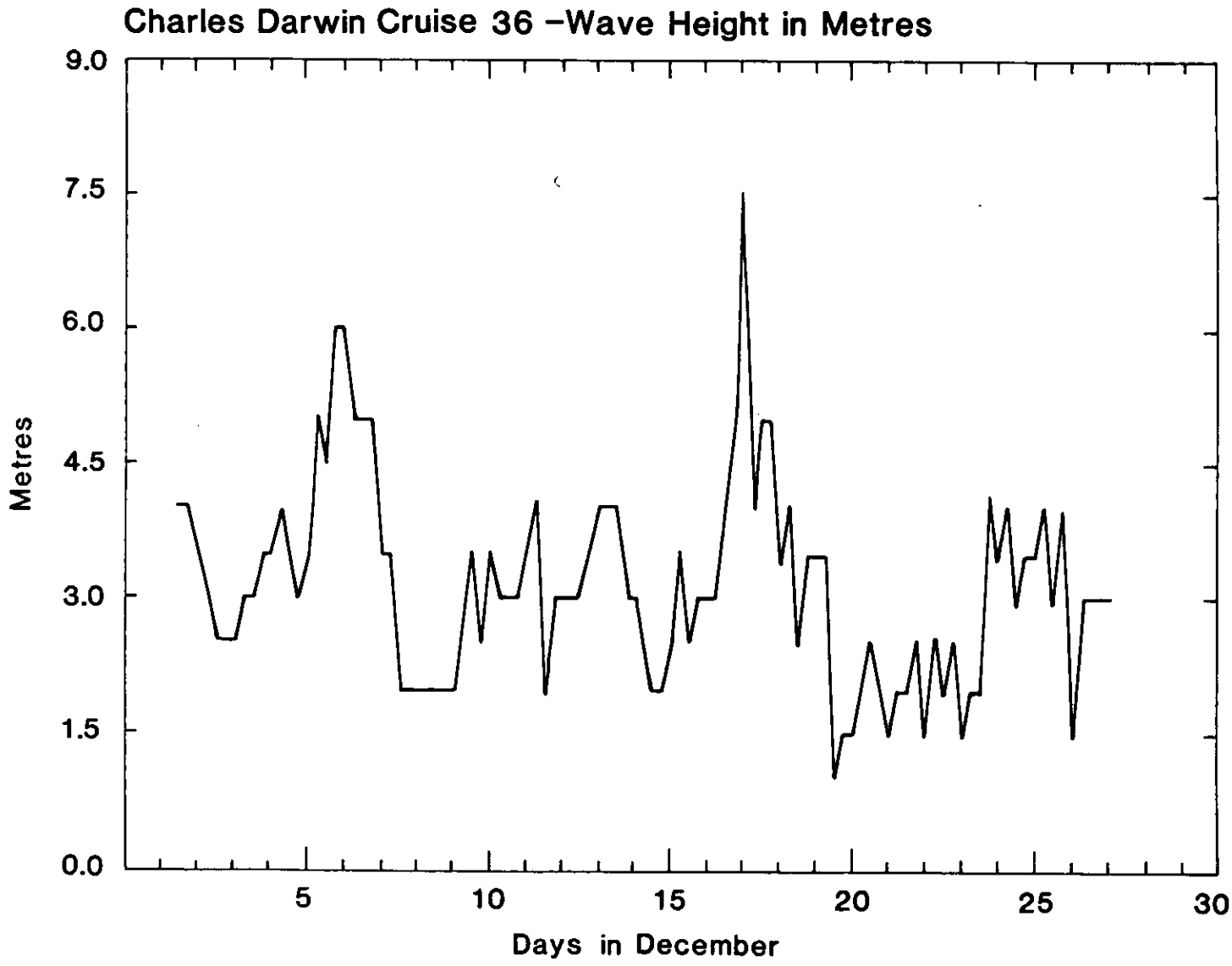
INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin cruise 36/88

PERIODS OF OPERATION OF EQUIPMENT DURING R.R.S. CHARLES DARWIN CRUISE 36/88 DECEMBER




Charles Darwin Cruise 36 –Wind Speed in Knots
Knots
0
10
20
30
40
50
5
10
15
20
25
30
Days in December


Charles Darwin Cruise 36 –Wave Height in Metres
9.0
7.5
6.0
4.5
3.0
1.5
0.0
Metres
5
10
15
20
25
30
Days in December

GLORIA SONOGRAPH OF TRIPLE JUNCTION