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I.O.S.

RRS DISCOVERY

CRUISE 161

15 AUGUST (227) – 19 SEPTEMBER (262) 1986

PORTUGUESE OCEAN-CONTINENT BOUNDARY, PLATE BOUNDARIES WEST OF IBERIA AND SEISMIC STRUCTURE OF SEDIMENTS OFF MADEIRA

CRUISE REPORT NO. 188

1986

INSTITUTE OF OCEANOGRAPHIC SCIENCES

NATURAL ENVIRONMENT RESEARCH COUNCIL

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WORMLEY

RRS DISCOVERY
Cruise 161
15 August (227) - 19 September (262) 1986

Portuguese ocean-continent boundary, plate boundaries west of Iberia and seismic structure of sediments off Madeira

Principal Scientist

R.B. Whitmarsh

CRUISE REPORT NO. 188

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E. Dowell	Chief Officer
R.J. Chamberlain	Second Officer
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P.E. Jago	Chief Engineer
N.A. Wilson Deroze	Second Engineer
R.J. Perriam	Third Engineer
P.F. March	Jun. 3rd Engineer
B.A. Smith	Electrician
D.P. Riddle	Radio Officer
F.S. Williams	Bosun
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R.A. Wild	IOS, Wormley

* joined at Cascais on August 28th, Day 240.

CRUISE DATES

Departed Falmouth, U.K. 15th August, 1986	Day 227
Anchored off Cascais, Portugal 28th August, 1986	Day 240
Arrived Funchal, Madeira 19th September, 1986	Day 262

OBJECTIVES

The cruise had three main objectives

i) to study the ocean-continent transition zone on the western margin of Portugal.

ii) to study the Azores-Gibraltar plate-boundary and past plate-boundaries of the Iberian plate.

iii) to conduct experiments east of Madeira to characterise the seismic properties of the upper 1000m of sediment.

The first objective was attained by the execution of a series of seismic refraction profiles, recorded by digital ocean-bottom seismographs (DOBS), and of reflection profiles which reached basement. The refraction profiles were shot in the eastern Iberia Abyssal Plain (4 profiles) and over the Tagus Abyssal Plain (1 profile).

The Azores-Gibraltar plate-boundary was studied using GLORIA, seismic reflection profiles and a 7-day DOBS deployment close to the supposed boundary to attempt to record microearthquakes. Similar underway profiles were obtained further north in a search for fracture zones cutting anomaly 34, and older, crust.

Lastly experiments were conducted with two DOBS at each of three sites about 130' east of Madeira. A variety of bottom seismic sources was used to measure the P and S-wave velocity of the sediments together with airguns and disposable sonobuoys near the surface.

NARRATIVE

RRS Discovery cast off from the County Quay, Falmouth at 1000 hours on August 15th (Day 227) to move to the North Arm to take explosives on board. This was completed by 1620 and the ship finally cast off at 1650 to begin a passage to the first work area in the eastern Iberia Abyssal Plain.

The following day PES fish No. 2 was deployed near the shelf edge and the seismic array drum was fitted to the capstan. The ship transferred from BST to GMT during the night of Days 228/229.

Early on Day 230 the first of three north-south refraction profiles (station 11349) was begun over the east Iberian Abyssal Plain ocean - continent transition zone. Thirty-nine shots of 25, 50 and 125 kg were fired and recorded by a digital ocean-bottom seismograph (DOBS) at each end of the profile. Four 1000 ins^3 airguns were also fired at two-minute intervals along the whole profile although the portakabin compressor was out of action for part of the time. The station was completed at 1324/231 when the last DOBS was recovered.

After some gun-depth measurements and a few minor gun problems a 300 ins^3 airgun and the array were deployed at 1730/231 at the start of a reflection profile which continued to the WNW for the next 24 hours in a preliminary effort to locate the ocean-continent boundary and the J magnetic anomaly and to tie in with previous French reflection profiles. The gear was brought inboard at 1745/232 and the ship then got into position at the south end of the next refraction profile.

Station 11350 began with the deployment of the southern DOBS at 2110/232. A second DOBS was deployed at the north end of the profile. Twenty-eight 50 and 125 kg shots were fired between 0600 and 0948 after which the four 1000 ins^3 guns were deployed. Again the containerised compressor gave trouble. Recovery of the guns began at 2230. Shortly afterwards one of the guns caught on the rail while being lifted by the crane and a quick-fit fitting opened up and parted. The gun fell back into the sea but fortunately the hose attached to the stern manifold was strong enough to hold it. With great difficulty the gun was retrieved, at the expense of damaging the hose, by 0115. The station was completed with the recovery of the DOBS by 1043/234.

A reflection profile, initially along profile 11350 but which then turned to the east as far as the next north-south refraction profile, was executed next until 0500 the next day. During this profile the array began to generate intermittent noise. Station 11351 was begun at 0724/235. Again a DOBS was laid at each end of the profile and 30 shots of 50 and 125 kg were fired. These were followed by a series of two-minute shots from the four 1000 ins^3 guns between 2304 and 0630 the next day during which no compressor problems were experienced. Both the DOBS had been recovered by 1546/236.

The reflection array, which had been undergoing tests during the day, was ready for redeployment by 1700 and improved data was recorded when profiling recommenced at 1830. This profile began by passing southwards down the station 11351 line and then heading northwest and west along the proposed track of the next refraction profile. This continued until 1515/237 and included the successful recording of signals from a disposable sonobuoy launched at 1014.

Once the profiling gear had been recovered the launching of three DOBS from west to east heralded the start of refraction profile 11352. The deployment of the four 1000 ins^3 airguns followed at 2300/237. One gun would not seal and continued to leak air and so had to be isolated. The remaining guns were fired from 0108 until 1100/238. Unfortunately during this period the laboratory clock which fired the guns jumped (probably by exactly 1 minute) so that the guns were firing outside the DOBS recording window. The fault was not discovered until 0816 causing the loss of over 5 hours of data. At 1400 shotfiring began and 45 shots of 50 and 125 kg were fired from west to east along the profile during two sessions over the next 8 hours with some shots being used to fill in the worst gaps caused by the loss of airgun data. All three DOBS were recovered by 1106/239.

A short reflection profile was then carried out to the northeast to link with an earlier reflection line. This ended at 1800 when the gear was recovered and course was set for Cascais near Lisbon where four scientists and stores were to be embarked.

At 1030 the next morning the PES fish and magnetometer were recovered in the face of a fresh northerly wind and by 1430 the ship was at anchor off Cascais.

By 1800 the transfer of personnel and equipment (as well as the dental treatment ashore of one scientist) had been completed and the ship departed. PES No. 7 and the magnetometer were deployed and passage resumed to the westsouthwest. In the evening the laboratory clock again jumped forward, this time by precisely 1 minute.

Preparations for the final refraction line (station 11353) began next day at 0737/241 with the deployment of a DOBS at each end of a northnortheast/southsouthwest profile. Thirty-one 50 and 125 kg shots were fired over a 5 hour period running before the northerly wind after which no more opencast gelignite remained on board. The plan to use the four 1000 ins^3 airguns was abandoned due to the large seas running, it being judged too dangerous to attempt to deploy them in the cramped conditions on the after deck. Therefore we began to recover the two DOBS, a difficult procedure in the rough conditions, but one which was safely completed by 0800/242. Finally a reflection profile was obtained along the line of station 11353 and this was completed by 1715.

GLORIA was then deployed in rather difficult conditions but this was completed successfully by 1930. The vehicle was towed at 8 knots using a 30 second (45 km swath) repetition rate. Data was soon being acquired as the ship headed southwest across the Tagus Abyssal Plain towards the Azores-Gibraltar plate-boundary. This survey continued without incident and with mainly E-W tracks until about 0730/246. When GLORIA had been recovered two DOBS were deployed (station 11354) on the north side of an east-west ridge which the evidence of GLORIA and other data indicated was a likely site for the active plate-boundary. The DOBS were intended to record microearthquakes associated with the transform plate-boundary.

The GLORIA survey was resumed at 1305/246 with a westward track until 1900 when the magnetometer was recovered and the array and a 40 ins^3 airgun were deployed. The ship then headed northwards towards the SE flank of the Azores-Biscay Rise. Surveying continued during grey and damp weather as a series of fronts passed until the morning of Day 248 when it became evident that the GLORIA tow-cable had to be replaced. Recovery began at 0830 during which the array caught on a projection from the davit almost causing it to part. At 1045 a

larger 160 ins^3 airgun was put out (the 40 ins^3 gun was evidently too weak) and by 1324 the repaired array had also been deployed. An airgun survey was carried out to the SE for 11 hours while a new GLORIA cable was installed.

By 0236/249 GLORIA and the reflection profiling equipment had been re-deployed and the survey resumed to the northeast. The only incident was a burst airgun hose which had to be replaced.

At 1436/250 the ship reached the point where a decision was needed to continue either northeast or to return to the south. The results so far indicated that it was likely to be more profitable to head southeast. At 2346 the ship headed east for a survey to search for a fracture zone (flowline) on crust older than anomaly 33/34. This lasted 24 hours after which we resumed our original southward track.

At 1600/252 the ship turned east to add a short east-west track to the earlier Azores-Gibraltar plate-boundary survey before turning south-west at 2348 to run in to the position of the two DOBS (station 11354). After recovering the gear the DOBS recoveries began at 0815 and both the buoys were inboard by 1159/253.

GLORIA was deployed for the last time by 1430, together with the 160 ins^3 gun and array, and surveying continued eastwards to attempt to follow the plate-boundary as far as time allowed. Time ran out at 0001/255 when GLORIA, the array and the airgun were recovered and a passage was begun at full speed towards Madeira towing just the magnetometer.

At 0415/256 the ship arrived at the first of three work areas (Point L) chosen by the Admiralty Research Establishment, Portland for sediment studies as part of a commissioned research contract. There followed five and a half days of intensive effort at these sites (stations 11355 - 11357). A 36 hour cycle of experiments followed by a period of upto 12 hours of steaming and other activities was repeated at each site.

The first cycle began with the deployment of two DOBS (station 11355). Bottom shots were then deployed which had fired by 1225. Next a water-trapping

impacting weight was lowered to the bottom and 8 thumps were generated. This came inboard at 1700 and was followed by further bottom shots. In the late evening five free-fall 1 ton weights were deployed following which the array of four 1000 ins^3 airguns was fired every 2 minutes out to about 30 km range. The two DOBS were recovered by 1325/257.

A seismic reflection profile along almost the whole length of the ARE experimental line was then conducted during which two disposable sonobuoys were used. The profile ended at the second site (point NN) at 0300/258.

Here two DOBS were deployed by 0543 and bottom shots were laid (station 11356). The weather proved to be too rough (the wind reached 30 knots at times) to risk using the water-trapping weight, so the remaining five 1 ton weights were deployed in the recording interval assigned to the "thumper". Further bottom shots were laid in the evening and these had fired by 2255. By 0204/259 the large airgun array was out and firing and a profile was shot up wind to the southwest. The guns were recovered at 0554 and the ship returned to the vicinity of Point NN where a 300 ins^3 airgun with wave-shape kit was fired to look at near vertical incidence reflections. Finally the DOBS recoveries began at 1144 and were completed by 1525. The ship then set course for Point MM en route deploying a third disposable sonobuoy to pick up and transmit signals from a 300 ins^3 airgun. During the night hours a 3.5 kHz profile was conducted to the northwest over an area of GLORIA coverage from a previous cruise.

DOBS deployments at the third site were delayed by engine trouble but ended finally at 0618/260 (station 11357). Following several crossings of the DOBS-to-DOBS baseline for acoustical navigation purposes the first bottom shot was let go at 0903. Shooting ended at 1120 when the rubber dinghy was put out to examine a rope caught around the stern. Part of this was pulled clear; the remainder was judged to be not safely accessible at sea so scientific activities were resumed. The "thumper" was deployed at 1424 and was impacted over a 27 minute period. It was recovered at 1841. Further bottom charges were laid followed by another 30km refraction profile shot with the 4x1000 ins^3 airgun array. Clocks were advanced 1 hour at midnight. Lastly the 300 ins^3 airgun with waveshape kit was used from 0710 to 1112/261 for near vertical incidence studies. While the first DOBS was ascending the 3.5kHz fish was brought

inboard. The two DOBS were on deck by 1530. Following a short "Hands to bathe" PES fish No. 2 was also recovered and the final course was set for Funchal, Madeira. The gravimeter was left running on the passage which ended when the ship docked at about 0920 next day.

SEISMIC REFRACTION PROFILES (Fig. 2).

Four seismic refraction profiles (stations 11349 - 11352) were shot in the eastern Iberia Abyssal Plain and one (station 11353) in the Tagus Abyssal Plain (Table 1). All profiles were intended to be reversed (although it turned out in one case that the reversal was incomplete) and varied in length from 80 to 105km. Shot sizes varied from 25 to 125kg. The largest shots generated strong first arrivals even at maximum range. An array of four 1000 ins^3 airguns was also fired at about 5 knots along all profiles except the last when bad weather made it unsafe to deploy the guns.

A reflection profile to basement was obtained along all profiles except the first (which was shot along an existing Discovery Cruise 90 profile) to assist with subsequent travel-time modelling. Sediment thickness was usually 2 to 2.5 seconds.

R.B.W.

SEISMIC REFLECTION PROFILING (Figures 2,3,4)

There were three major seismic reflection objectives,

1) To collect seismic profiles along and in the vicinity of the seismic refraction profiles in the Iberian and Tagus Abyssal Plains with the major aims of identifying the position of the continent-ocean transition (independently of the refraction results) and of establishing the structure of the basement and the sedimentary layers for input into the refraction models. Thick sediments were anticipated in this area and so profiling was accomplished using a 300 ins^3 airgun towed at 5 kts to maximise penetration.

2) To collect seismic reflection profiles along the GLORIA survey tracks with the aim of identifying major structural features and to assist in GLORIA interpretation. Thinner sediments were anticipated in the GLORIA survey area and profiling was undertaken using a 40 or 160 ins^3 airgun at the normal GLORIA survey speed of 8 to 8.5 kts.

3) To collect a seismic reflection profile along the line of the A.R.E. acoustics profile to discover sediment thickness and structure. This profile was undertaken using a 300 ins^3 airgun fitted with a wave-shaping kit.

Excellent seismic profiles were obtained throughout the cruise. In the Iberian and Tagus Abyssal Plains penetration to between 2 and 3 secs (two-way time) below the seabed was achieved on all lines and only where basement lay deeper than 3 secs below the seabed was a basement reflector not seen. The lack of time-varying gain on the seismic reflection monitoring system somewhat hindered the detection of deep reflectors but post-cruise T.V.G. replays should substantially improve record quality. No unequivocal continent-ocean transition was identified using the seismic reflection profiles although a N-S trending, westward-up basement step coincident with the J magnetic anomaly is a possible candidate. This step, of between 0.5 and 1 sec, coincides with a westward increase in basement roughness, giving the basement reflector to the west the typical diffractive appearance of the top of oceanic layer 2. However no block-faulting typical of thinned continental crust was seen to the east, so that the existence of continental crust could not be unequivocally proven by the seismic reflection profiling.

Good profiles were also obtained during the GLORIA survey despite survey speeds up to 8.5 kts. Some evidence for faulting and sediment deformation was seen in the vicinity of the Azores-Gibraltar Plate boundary, although sediment thicknesses rarely exceed 1 second (twt).

A single profile was obtained in the Madeira Abyssal Plain. Penetration of up to 2 seconds was obtained and a clear basement reflector seen.

D.G.M.

MICROEARTHQUAKE RECORDING

To test whether the currently active Europe-Africa plate-boundary passes just north of the east-west ridge at 37.5°N,16.5°W two DOBS were deployed on the north slope of the ridge (station 11354, Figure 3, Table 1) where the sea-floor was unusually rough suggesting recent tectonic activity. The two DOBS (each with a single vertical geophone) ran sequentially for 6.7 days with a 10 hour gap between recordings. The data have yet to be fully replayed but a small number of weak events have already been recognised, on slow-speed chart records, which have some of the characteristics of microearthquakes.

R.B.W.

SEISMIC PROPERTIES OF SEDIMENTS (Figures 4,5,6,7)

A series of experiments was conducted at three sites about 130' east of Madeira under a contract with the Admiralty Research Establishment, Portland. The experiments were designed to study the compressional and shear-wave velocity structure of sediments within about 1000 metres of the sea-bed. The IOS digital ocean-bottom seismographs (DOBS) were the primary receivers (Table 1) although disposable sonobuoys were also employed. Acoustic navigation with the DOBS 10kHz transponders was used. Nevertheless it proved quite difficult in the prevailing weather conditions to manoeuvre the ship along the 1000 to 2000m baseline between the DOBS.

The following sources were used at least twice.

i) bottom shots of RDX 80-grain Primacord fired by electrical high-pressure detonators and timer clocks.

ii) free-fall 1 ton impacting weights.

iii) a water-trapping impacting weight lowered on the coring warp.

iv) a 4 x 1000 ins^3 airgun array.

v) a 300 ins^3 airgun with wave-shape kit.

The bottom shots were of an entirely new design. They detonated reasonably reliably but it became apparent after the first recordings were replayed that, instead of being fired vertically under a float, they should be laid out on the sea-bed. Even so the initial indications are that this source may be too weak and/or too high frequency to generate arrivals over ranges of more than a few hundred metres.

Both the impacting weights (free-fall and lowered) were designed to generate shear waves and Scholte waves. The one ton free-fall weight had already been used successfully in this role at ranges in excess of 1000m but not previously with the digital OBS. The water trapping weight appears to have been successful. It was used on two occasions. Once clear signals were received at 1000m range.

Airguns are a well-known source for medium range profiles recorded by OBS. The large array was used to generate a record section encompassing arrivals down to the lower crust. The smaller gun was intended to enable a study of near vertical incidence reflections.

The rate at which the data was collected, and the large volume of it, have precluded a thorough preliminary survey of the results at sea. However the DOBS functioned almost faultlessly and the traces replayed at sea are very encouraging with the possible exception of the bottom shot data.

R.B.W.

SHOT FIRING

The shot firing work was divided into two separate and different exercises.

Opencast Gelignite

Following assurances from Nobel's Explosive Co., Bulk Pack Opencast Gelignite was purchased instead of the more familiar Geophex. Flighted charges were fired, ranging in size from 25kg to 125kg, all equipped with a single No. 8 star detonator attached to LIA2 slow burning safety fuse. Some 174 shots were fired totalling 14 tonnes in weight. Only 5 misfires were recorded. It is believed that these were due to slightly slack banding together of Bulk Pack boxes and insufficient support of the fuse.

It was found desirable to pierce each box in several places to ensure quick escape of any air contained within the packaging and thus establish a consistent rate of sinking. However, there remains a conviction that LIA2 safety fuse is more variable in its burning characteristics than its predecessor LIA1.

RDX 80 Primacord

In contrast to the first exercise it was necessary to explode this material on, or close to, the sea bed in greater than 4,000 metres of water. Again, acting on advice from Nobel's Explosive Co., the products chosen for this extremely high pressure application were RDX 80 Primacord and high pressure electrical detonators. Initiation of detonators was accomplished via precise delay electronic circuits developed by IOS and contained, with battery packs, in sealed pressure cases. Some 30 shots had been planned, 10 at each of 3 separate sites. A full week was necessary to prepare the lengths of detonating cord, firing cables, sub-surface floats, timer circuits etc.

From the results at the first site it was apparent that sub-surface buoyancy was detrimental to the coupling between the charge and the sea bed and it was abandoned on all further shots. One unfortunate result of this was to rule out any possibility of recovering the timer delay circuits and pressure housings.

Since it was thought that successful coupling was achieved only with the charge in contact with the sea bed two charges were sent down as tightly wound coils on cardboard reels. This was not successful and they appeared not to explode. The reason is unknown.

The proportion of successful shots out of a total of 28 shots deployed was high. The results are listed below.

Explosive charges laid	28
Successful explosions	22
Possible premature explosion	1
Explosion of detonator only	1
Misfires	4

Conclusions

1. The detonating cord and high pressure detonators were suitable for the required duty.
2. The delay circuits worked very well.
3. Thought could be given to a simplified rig to reduce the degree of pre-preparation and the time taken to lay each charge.
4. The inclusion of a hydrostatic pressure switch in the detonator circuit could have reduced station time by half.
5. Investigation might reveal a more suitable high explosive than 80 grain cord.

K.G.R.

AIRGUNS AND COMPRESSORS

Compressors

Three units were used. These were the two compressors permanently installed aboard RRS Discovery and one containerised direct-current-powered compressor. They ran for a total of 518 hrs between them. Apart from routine maintainance and a new lubricating oil pump fitted to the No. 2 unit, the Discovery compressors were trouble free. However, the containerised unit did have some problems. The power supply had been connected in port with reversed polarity; the ship's electrical officer has since made some changes which should help prevent a repeat performance. The Vee belts linking the compressor and the electric motor "ran off" and had to be replaced.

R.A.W.

Airguns

Airgun work was done with either a three metre boom, supporting four 1000 ins^3 guns, towed from the main coring wire or with a 150 or 300 ins^3 gun towed from the same wire.

In launching and recovering this gear serious problems occurred only once when, on recovering the large array, one of the 1000 ins^3 guns caught under the outboard edge of the ship's bulwarks. The "englefield clips", used to suspend the gun from the boom, parted. The gun fell back into the sea and was eventually hauled in on its own air hose using the ship's capstan.

Towing speeds were normally below 5.5 knots but it was found that the smaller guns could be towed with no detrimental effects at 8 knots alongside GLORIA, thereby vastly increasing the scientific efficiency of the ship.

R.A.P.

DIGITAL OCEAN BOTTOM SEISMOGRAPHS (Table 1)

Eleven instrument deployments were made during the early part of the cruise to record airguns and explosives fired during five seismic refraction experiments. These lines in the eastern Iberia Abyssal Plain and the Tagus Abyssal Plain were designed to study the deep structure of the continental margin. All recordings were in programmed windows during these deployments. Water in a hydrophone connector gave noisy hydrophone recordings during one deployment, however this problem was soon found and rectified. Some data was lost because a tape deck skipped tracks and stopped recording prematurely. This caused one major loss of data and minor data losses on three other tapes. This fault will be investigated in the lab.

Two instruments reprogrammed to sample at a rate of twenty samples per second were deployed at the east end of the Azores-Gibraltar plate boundary to record microseismicity. Using the continuous recording mode of the instrument and a low sampling rate, records of twenty minutes in length could be written to tape with a data loss of less than ten seconds between each record. The two DOBS were programmed to record for four and a half days continuously with one day of overlapping data. Premature termination of recording in the first instrument after a little over three days meant that no dual receiver data was collected. However almost seven days of single receiver recordings were obtained before the instruments were recovered.

Six instrument deployments were made in the third DOBS phase of the cruise. Three were short range seismic experiments carried out for ARE, Portland. During each experiment a pair of DOBS was deployed to record airguns, dropped weights and bottom explosives. Recordings were made in both programmed and continuous modes. A preliminary listing of the data tapes indicated that the instruments operated successfully.

Nineteen DOBS deployments were made without loss during the cruise bringing the total number of deployments for these new IOS instruments to thirty three. Recovery of the instruments went smoothly with both shipboard and DOBS acoustic release systems performing flawlessly. Reliable relocation aids (radio beacons and flashing lights) on the DOBS together with tracking the acoustic transponder during ascents ensured that each instrument was on the deck of Discovery within half an hour of surfacing day or night.

R.E.K.

DISPOSABLE SONOBUOYS

Six sonobuoys were deployed (Table 2). Two were model SB6E4 (old type) and four the model SB109 with self-inflating aerial supplied by RVS. The first two stations gave poor reception which was traced to a damaged connector on the RVS starboard inboard cable. The port cable was used thereafter.

Data was recorded unfiltered on a Sony tape-recorder and monitored in the band 15 - 80Hz on an EPC recorder. No playbacks were possible without a trigger pulse amplifier. The new aerial and cable were not used.

In the ARE program three stations were occupied along the survey base line.

Data reception was average with ranges of 12-18km using a survey speed of 5-5.5 knots and weather conditions were moderate. Reception over a greater range should have been possible but each station was consistent.

P.R.M.

TABLE 2: SONOBUOY DEPLOYMENTS

Number	Start/End Time/Date	Buoy Location	Airgun Volume (ins^3)	Ship's Course	Area
1	1245-1410/231	40°27.2'N 13°29.7'W	300	015°	Iberia A.P.
2	2135-2253/236	40°11.5'N 11°55.5'W	300	197°	Iberia A.P.
3	1014-1230/237	40°37.1'N 12°51.7'W	300	285°	Iberia A.P.
4	1915-2108/257	32°11.2'N 14°23.1'W	300 + WSK	230°	ARE area
5	2118-2300/257	32°03.6'N 14°32.4'W	300 + WSK	228°	ARE area
6	1606-1805/259	31°39.8'N 15°02.7'W	300 + WSK	034°	ARE area

WSK = waveshape kit

NAVIGATION

The prime navigational aid was the Transit Satellite system and Magnavox receiver. The latter system provides useful D.R. positions updated with the most recent estimate of the "surface current" vector. The only problem we encountered was when a poor satellite pass preceeded a good one by less than about 15 to 20 minutes. There appears to be no way to prevent the system from tracking the poor satellite; therefore acquisition of the good satellite pass may be prevented.

A Trimble model 4000A Global Positioning System (GPS) Locator receiver was installed for the cruise. At first it was difficult to obtain fixes due to lack of familiarity with the initialisation procedure but subsequently fixes were available for about 14 hours per day according to the calculated Alerts. Occasionally fixes were lost because the system was waiting to be re-initialised after a period of several hours with insufficient space vehicles. The Level ABC system display in the Plot was inadequate. Properly presented fixes calculated in degrees and minutes (NOT decimal degrees) are required on a simple hard copy device. Eventually the option to use GPS as the prime navaid will be required.

To make full use of the GPS system in the future (e.g. for station keeping) a slave display (digital or graphical) beside the propulsion controls on the Bridge will be essential.

Unfortunately the GPS satellite constellation became unreliable in the last week of the cruise giving us only about 3.5 hours/day of fixes, instead of the anticipated 13 to 15 hours/day, at the time when it was most needed.

R.B.W.

QUANTITATIVE UNDERWAY GEOPHYSICS

Depths were measured at an assumed sounding velocity of 1500 m s^{-1} and were corrected using Carter's (1980) Tables.

Total magnetic field measurements by the Scintrex V75 magnetometer were converted to anomalies using the 1985 International Geomagnetic Reference Field (IGRF85).

Gravity values measured with La Coste and Ramberg meter S84 were converted to free-air anomalies by use of the 1967 International Gravity Formula and with reference to base stations in Falmouth and Funchal linked to the 1971 International Gravity Standardisation Network (IGSN71). The base station checks were made using a Worden Prospector land gravimeter.

K.G.R., R.B.W.

GLORIA SYSTEM

The GLORIA vehicle was deployed and recovered without difficulty on four separate occasions. Three deployments were to dovetail the data collection into the requirements of the cruise programme and the fourth was due to the failure of the tow cable. This breakdown caused the only serious interruption in the data gathering process, which apart from minor irritations, due chiefly to the age of the tapes, went fairly smoothly. A 30 second repetition rate was used throughout because the strong thermocline appeared to limit the maximum range to about 22km.

A software failure in the range correcting area of the replay system defeated all attempts with onboard resources to correct it. The mosaic will consequently be produced at Wormley, hopefully with the new laser replay system.

E.D., A.J.K.H.

PRECISION ECHO-SOUNDER

Both Mark III Mufax P.E.S's were used during the cruise. The FN3 Mufax was faulty almost from the start. FN8 was used until Day 255 by which time the various faults in FN3 had been rectified and the motor bearing noise in FN8 was giving cause for concern.

No. 2 fish became excessively noisy and was therefore recovered. The towing strut pivots were so badly worn that a spare cable strut assembly was fitted. No. 7 fish also gave trouble. Upon investigation it was found to have an electrical short within the cable which was almost certainly situated in the moulded gland for the junction box entry. The original No. 2 fish cable was therefore resurrected, the strut towing pivot bearing bushed and the damaged fairing replaced.

R.B.W., R.A.W.

3.5 kHz PROFILING (Figures 2,3,4)

The major objectives of the 3.5 kHz surveys were to map changes in seabed and sub-seabed character which might be related to back-scattering variation seen on GLORIA records and to map in detail the structure of the upper 50m of sediment in the eastern Madeira Abyssal Plain.

The 3.5 kHz profiler was deployed at the beginning of the GLORIA survey at 2100/242 and was used almost continuously until 0500/260.

Excellent records were obtained for most of this period although an apparently speed-dependent 'noise' appeared near the end of the cruise. No source for this noise could be ascertained but a problem within the fish was suspected.

D.G.M.

D.M.W. CRYSTAL CLOCK

On three separate, random occasions the master clock suddenly gained one complete minute. Each time it was possible to reset with reference to the 60 kHz MSF transmission from Rugby but this took some considerable time and the effect on the cruise, which relied for some of its success on accurate timing of shots and airguns, could have been considerable. It is understood that the

manufacturers are investigating a permanent solution to the occasional malfunction.

K.G.R.

SHIPBOARD COMPUTING SYSTEM

The shipboard computing system consisted of the R.V.S. "A-B-C" system. It samples and checks (filters and calibrates where required) various navigational and scientific equipment. These pre-processed data are logged onto magnetic tape and transferred into the 'level C' computer where final data processing is carried out and plots, profiles, listings etc., are produced.

Navigational data sampling started at 1300/227
The ship sailed from Falmouth at 1650/227
Depth entries started at 0618/228
Magnetic data sampling started at 1906/231
Gravity data sampling started at 1540/233
G.P.S. data sampling started at 2018/234

The sampling, logging and processing of data were carried out continuously for the duration of the cruise. Data were available for interpretation in almost real-time for most of the cruise.

Data profiles were checked visually for spurious readings. Where necessary navigation was recalculated and gravity re-processed. Gravity data were reduced in status either during speed changes, at low speeds when station work was going on or during sharp course changes. A considerable number of plots, profiles and listings were produced during the cruise.

Although problems were experienced, mainly with the 'level C' system, only about four hours of data were lost, due to the 'level B' system stopping.

In general the shipboard computing system proved to be reliable. The data produced appeared to be of a high quality and it fulfilled most of the demands made of it by the scientists on board.

P.J.M.

EXPENDABLE BATHYTHERMOGRAPHS (XBT's)

XBT's were used to obtain near surface velocity/depth profiles for acoustic navigation and DOBS data processing (Table 3). The on-board velocimeter could not be made to function reliably, nor could the ARE supplied XBT unit and deck launcher be made operational. Four T4 400m probes were expended in attempting to fix this system.

The IOS Marine Physics Group Hewlett Packard micro XBT unit (put on board for Discovery 162) was located and set up. This functioned first time to give a 400m drop in the Tagus Abyssal Plain. No water column velocity information was obtained in the Iberia Abyssal Plain area as the IOS XBT system was not set up then. Five drops were made in the ARE area 120' east of Madeira. Two used 900m and four used 600m temperature probes. The HP unit did not support the velocity probes supplied with the ARE equipment. In addition, one probe was lost.

In the ARE area the data showed a double sound channel with a thermocline between 20 and 40m.

P.R.M., A.C.

TABLE 3: XBT DEPLOYMENTS

Number	Time/Date	Latitude (N)	Longitude (W)	Area
41A	1502/242	37°59'	11°53'	Tagus Abyssal Plain
4102A	0435/256	32°15'	14°10'	Point L, ARE Area
7103A	0444/256	32°15'	14°10'	Point L, ARE Area
4104A	2009/257	32°8'	14°27'	Midpoint L to MM, ARE Area
7105A	0658/258	31°39'	15°5'	Point NN, ARE Area
4106A	1909/259	31°51'	14°51'	Point MM, ARE Area

TABLE 1 : DOBS DEPLOYMENTS

Station	Activity	DOBS	Position Latitude N	Position Longitude W	Water Depth (corr.m.)	Comments
11349	Crustal	1	40°34.35'	10°54.53'	4749	Recorded only 7 shots, DOBS fault
	refraction	2	39°48.46'	10°57.12'	4896	Recorded 20 shots plus 198 airgun shots
11350	Crustal	2	40°14.96'	12°56.65'	5324	Recorded 28 shots, 208 airgun shots
	refraction	4	40°56.95'	12°40.35'	5324	Recorded 28 shots, 38 airgun shots
11351	Crustal	1	40°41.99'	11°47.15'	5108	Recorded 30 shots, 223 airgun shots
	refraction	2	39°59.77'	11°58.34'	5174	Recorded 30 shots, 207 airgun shots
11352	Crustal	1	40°44.13'	13°25.06'	5355	Recorded 45 shots) shipboard clock jumped
	refraction	2	40°35.33'	12°39.29'	5319	Recorded 44 shots) 1 minute during airgun
		4	40°29.04'	12°14.07'	5296	Recorded 25 shots) shooting.
11353	Crustal	1	37°46.20'	12°02.20'	5103	Recorded 31 shots) No airgun shots
	refraction	2	38°24.18'	11°32.10'	4989	Recorded 31 shots)
11354	Microearthquake	1	37°43.38'	16°30.25'	4834	Recorded from 1200/246 to 1355/249
	recording	2	37°43.39'	16°30.22'	4834	Recorded from 0000/250 to 1420/253

Station	Activity	DOBS	Position Latitude N	Position Longitude W	Water Depth (corr.m.)	Comments
11355	Sediment studies	1	32°20.63'	14°11.13'	4373	8 bottom shots (1 misfire), 8 thumps, 5 free-fall weights, 106 4x1000 ins^3 airgun shots.
		2	32°19.57'	14°11.90'	4374	
11356	Sediment studies	1	31°40.01'	15°04.07'	4394	11 bottom shots (3 misfires), 5 free-fall weights, 92 4x1000 ins^3 and 78 300 ins^3 airgun shots.
		2	31°39.10'	15°04.74'	4392	
11357	Sediment studies	1	31°54.70'	14°45.70'	4393	9 bottom shots (2 misfires), 11 thumps, 120 4x1000 ins^3 and 90 300 ins^3 airgun shots.
		2	31°53.74'	14°46.31'	4393	

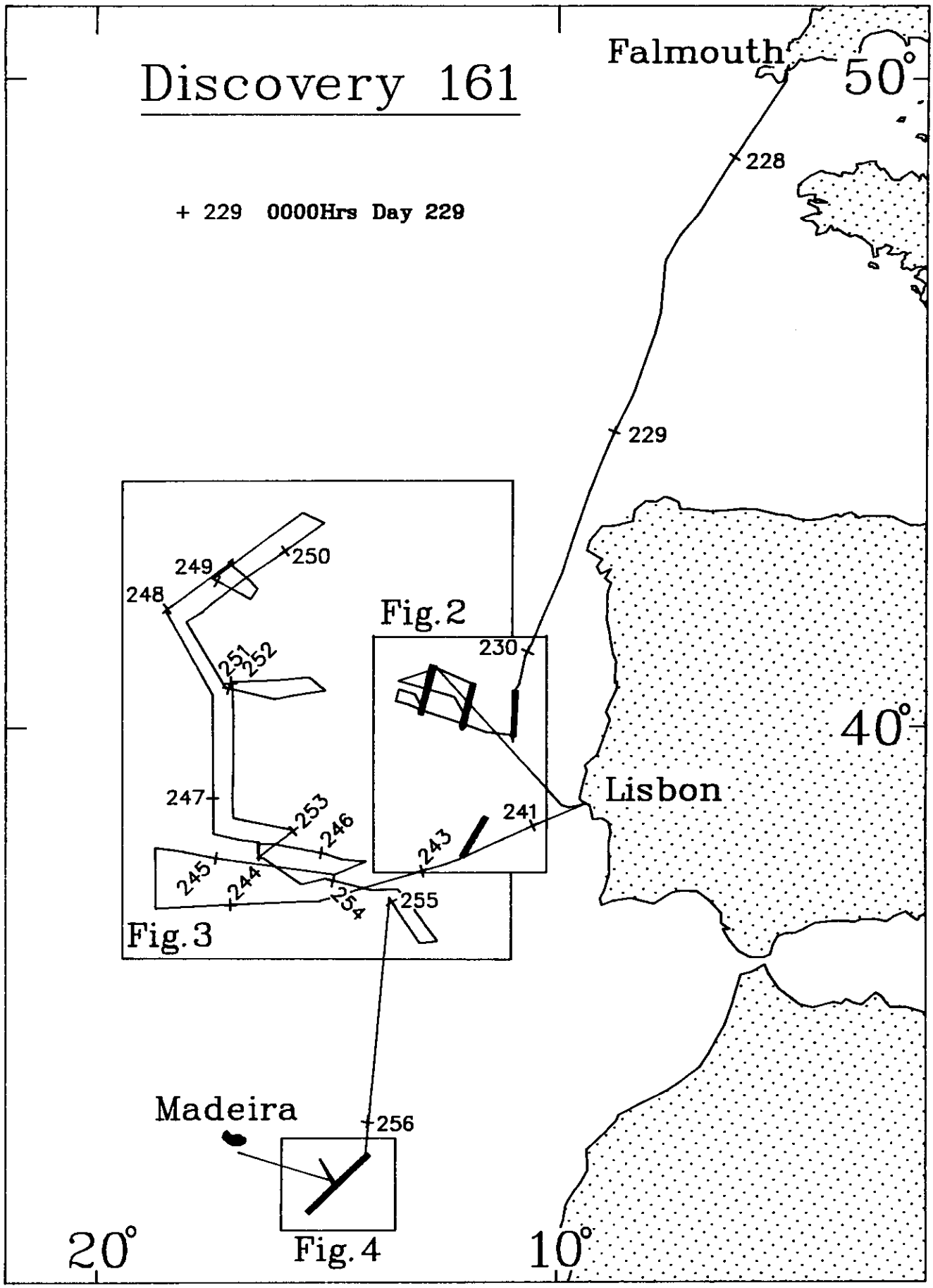

Figure 1. Summary track chart showing working areas (boxes) shown in more detail in subsequent figures.

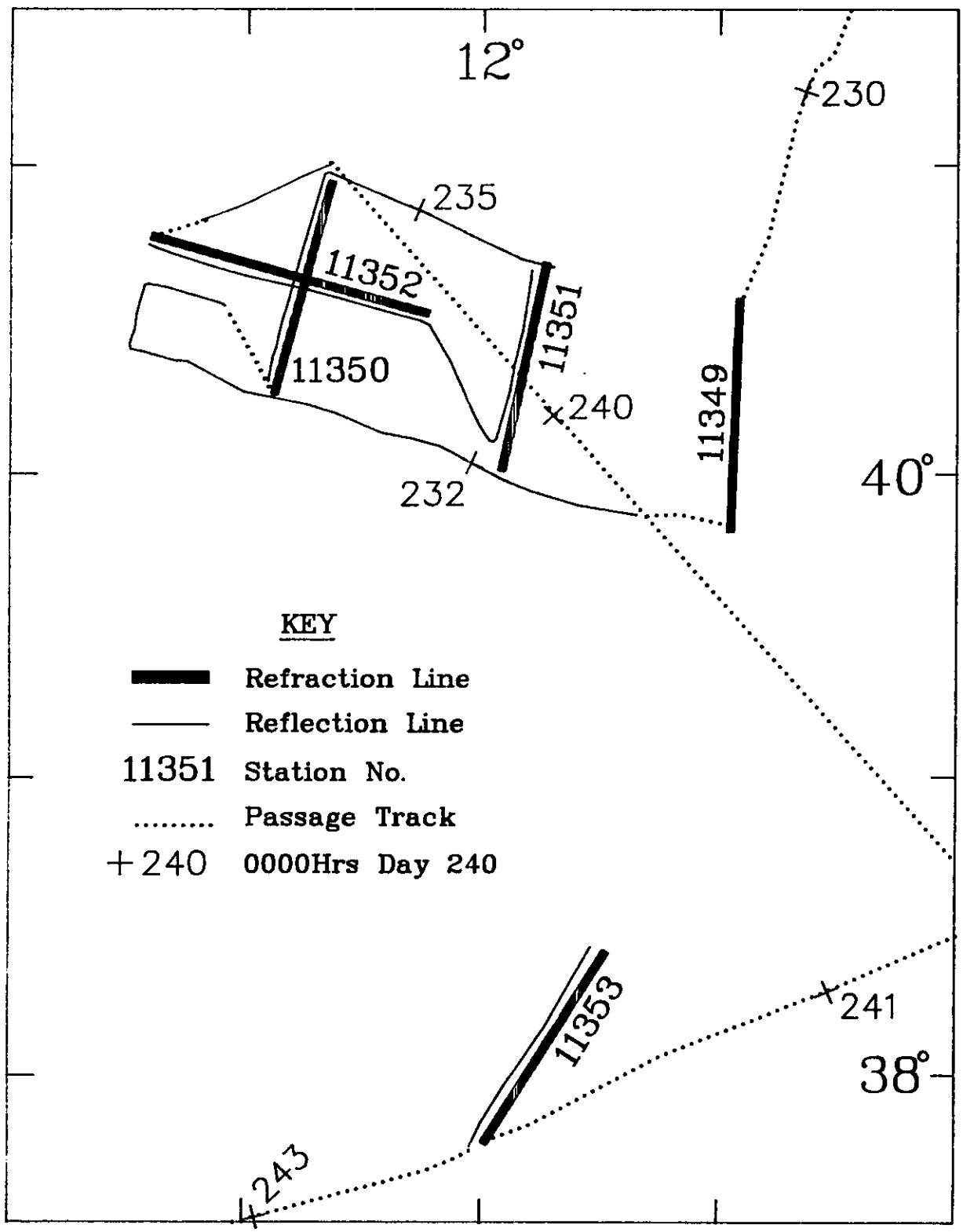

Figure 2. Seismic refraction and reflection profiles shot in the eastern Iberia Abyssal Plain (Stations 11349-11352) and the Tagus Abyssal Plain (Station 11353)

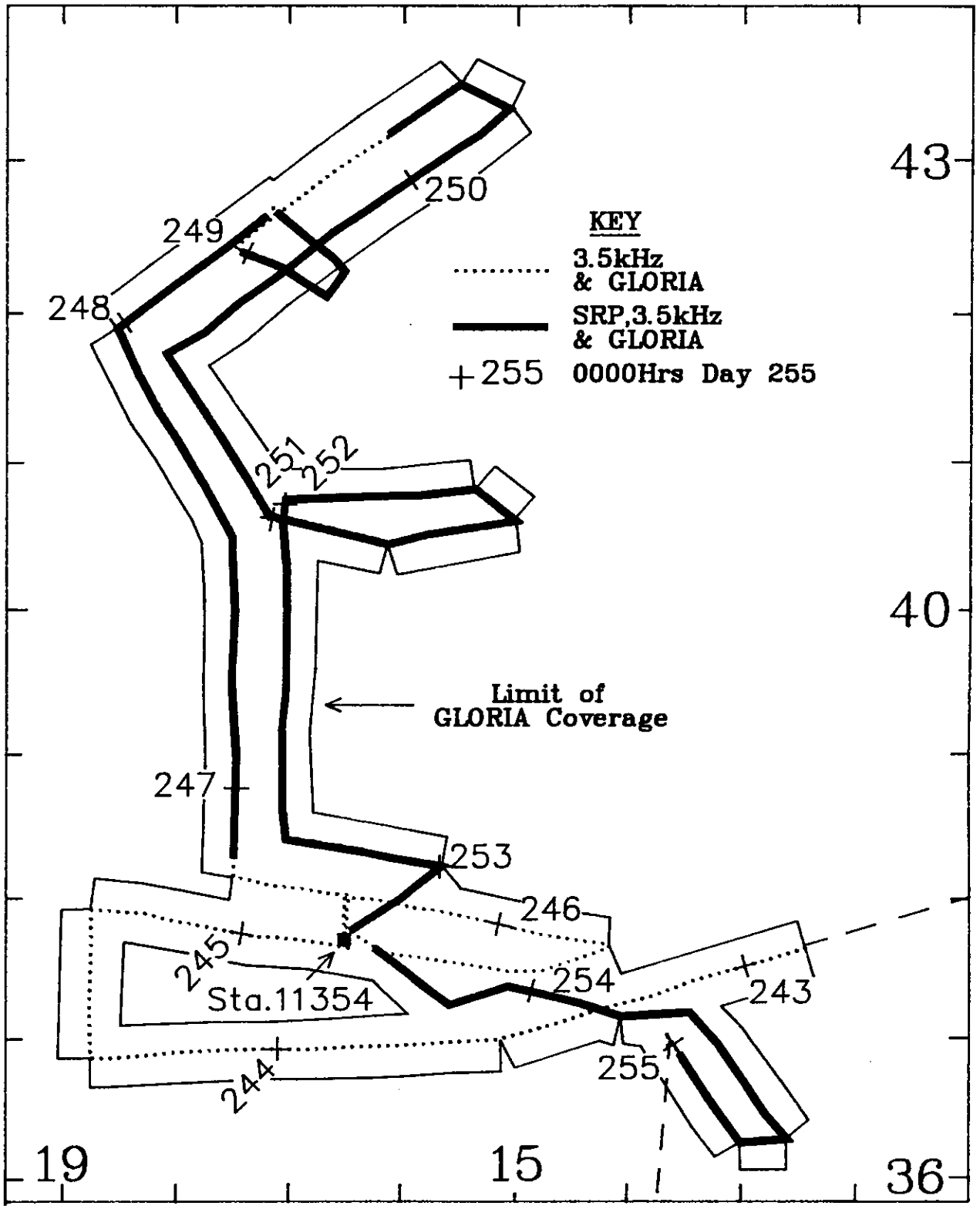

Figure 3. Track chart showing GLORIA coverage over the Azores-Gibraltar plate-boundary and the region to the north. The box (station 11354) marks the site of two OBS deployed to record microearthquakes.

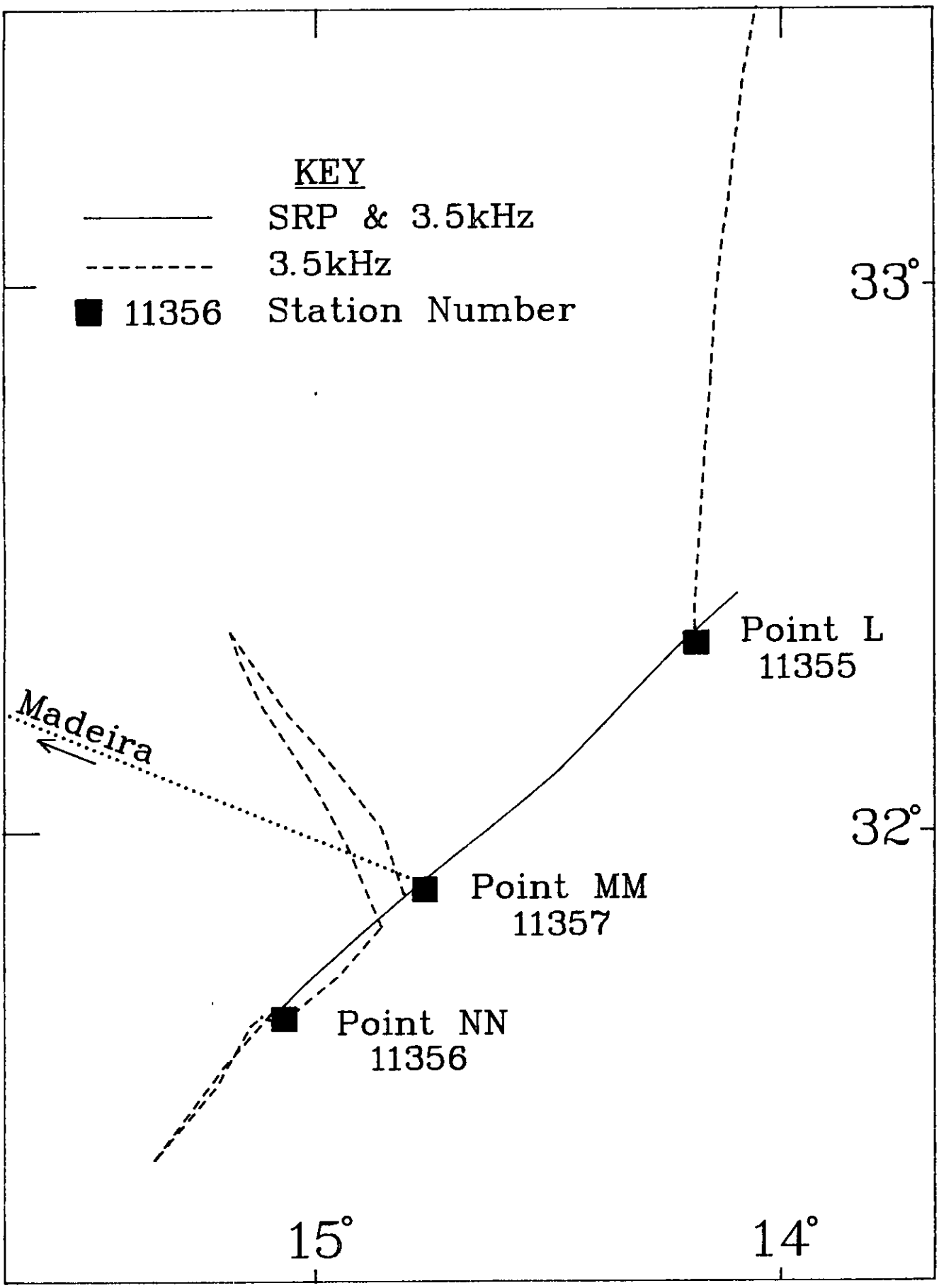

Figure 4. Summary of the three seismic experiments conducted for the Admiralty Research Establishment, Portland between Day 256 and Day 261.

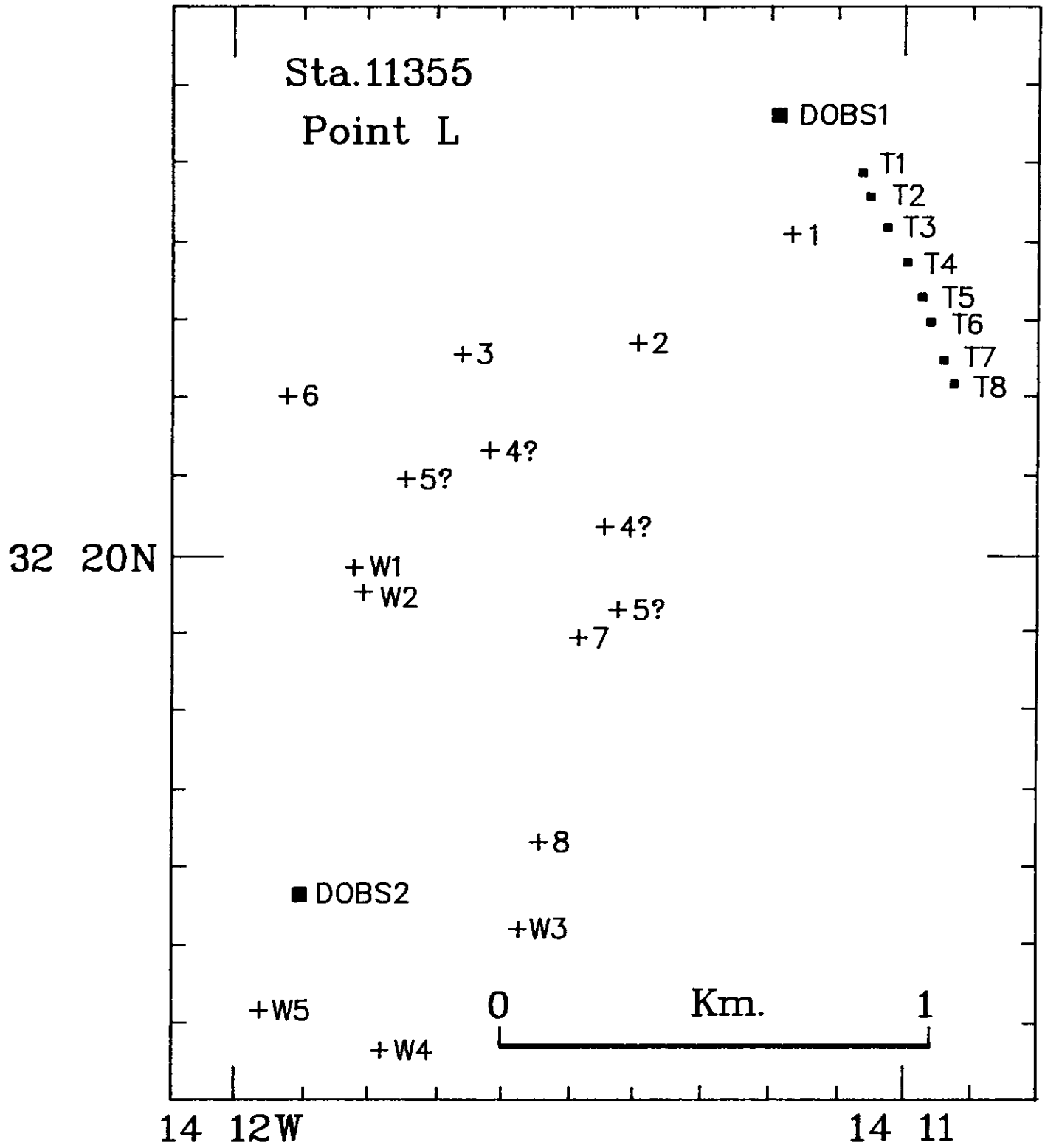

Figure 5. Distribution of bottom shots (1-8), free-fall weights (W1-W5) and thumps of the water-trapping weight (T1-T8) around the two DOBS at Point L. The crosses mark the acoustically navigated ship position for each seismic source. The ambiguity of the navigational system could not resolve the correct position of shots 4 and 5.

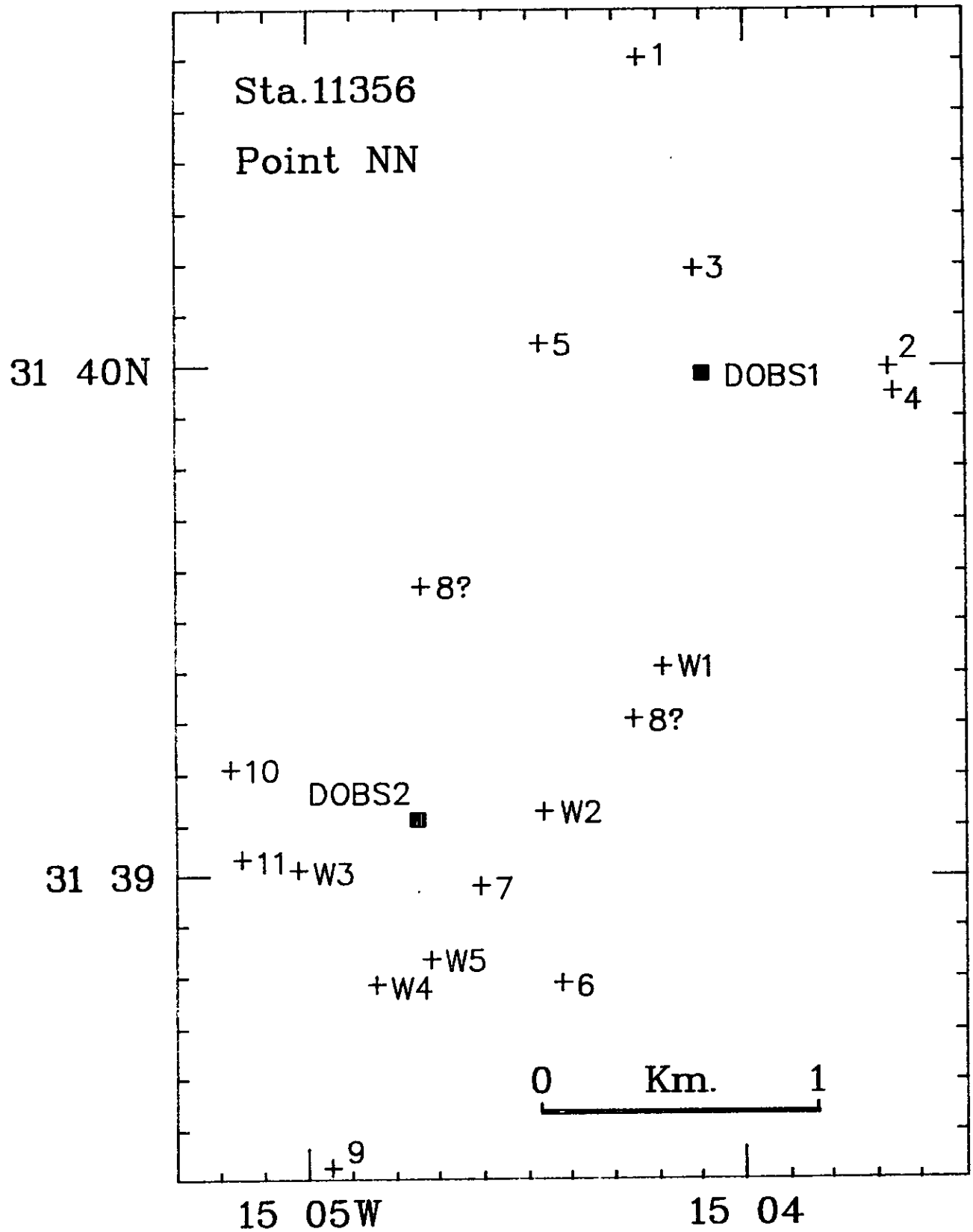

Figure 6. Distribution of bottom shots (1-11) and free-fall weights around the two DOBS at Point NN. The crosses mark the acoustically navigated ship position for each seismic source. The ambiguity of the navigational system could not resolve the correct position of shot 8.

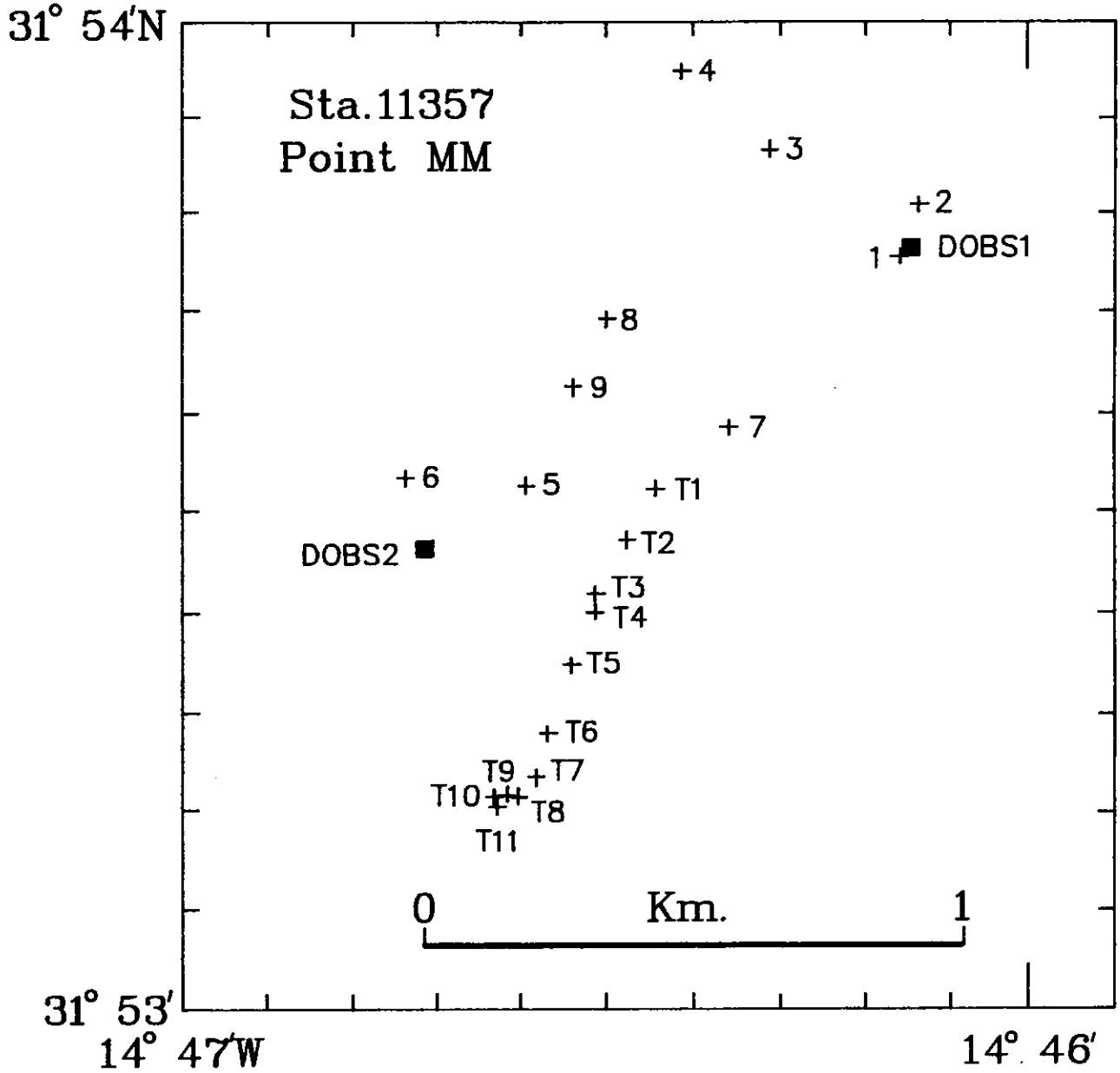

Figure 7. Distribution of bottom shots (1-9) and thumps of the water-trapping weight (T1-T11) around the two DOBS at Point MM. The crosses mark the acoustically navigated ship position for each seismic source.