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RRS *CHARLES DARWIN* CRUISE CD157
28 MAY – 13 JUN 2004

Sediment transport through the
Setubal and Nazare Canyons

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2004

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ABSTRACT

The main objective of the cruise was to groundtruth the sidescan sonar coverage of the Setubal and Nazare Canyons that was collected on the RV *Pelagia* in November 2003. A range of corers including box, mega, kastenlot and piston provided a range of possibilities to core sediment of varying grainsize from gravel to mud. In addition a deeptowed profiler was used to collect subsurface profiles across the canyons, but plans to use SHRIMP were abandoned due to problems with the conducting cable.

The coring was a success given the difficult topography; site location was aided by the TOBI sidescan survey completed in 2003, making it possible to hit relatively small targets just a few hundred metres across. Careful choice of corer type ensured core recovery in the sequence of mixed sands and muds. No corers worked well in the Nazare thalweg due to presumed hard or sandy seabed.

The data will be used to groundtruth the TOBI sidescan and to determine the flux of sediment through the Setubal and Nazare Canyons. Initial interpretations suggest significant differences between the canyons and strong changes in the amount of activity with time.

KEYWORDS
Charles Darwin, cruise CD157 2004, EUROSTRATAFORM, Iberia, Nazare Canyon, Portugal, sediment cores, Setubal Canyon, submarine canyons

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Departed	Santa Cruz, Tenerife	28th May 2004
Arrived	Vigo	13th June 2004

OBJECTIVES

The main objective of the cruise was to groundtruth the sidescan sonar coverage of the Setubal and Nazare Canyons that was collected on the R.V. Pelagia in November 2003. A range of corers including box, mega, kastenlot and piston should give a range of possibilities to core sediment of varying grainsize from gravel to mud. In addition a deeptowed camera and video (SHRIMP) will be used to identify seafloor features within the canyons and a deeptowed profiler will be used to collect subsurface profiles across the canyons. The data will be used to understand how sediment moves from the shelf edge to the deepsea and especially to identify any sediment remobilisation related to earthquakes.

NARRATIVE

24th to 28th May In port Santa Cruz, Tenerife. All equipment was loaded on time in port prior to sailing at 10.00 on the 28th May.

28th May Safety briefing at 0830. Ship sailed at 10.00 heading north for Portugal.

29th May Attempted to stream conducting cable at 0830 to fix poor connections in fibre optics. Dynamometer for recording wire out and load was not functioning so operation delayed whilst problem fixed. This was completed by 15.00 and the cable was then streamed. A speed of 8 knts through the water was maintained to keep sufficient drag on the cable. With approx 7000m of cable paid out the fibre optic connections began to work and proceeded to keep working until the cable was hauled in to the same 7000 m position when they lost connectivity again.

30th May The cable was finally hauled in at 0500 and secured at 0900. We then proceeded at full speed to the first site. The 3.5 kHz fish was launched at 22.40 as we approached the Tagus Abyssal Plain.

31st May Arrived at site CD56401 at 0305 and deployed 2 m kasten with a half ton head weight. This site was at the southern end of the Tagus A.P. Corer arrived back on deck at 0650 with 1.10 m of good quality core. Proceeded to site CD56401 at the northern end of the plain. Here we were planning to take a core just above the level of the plain to sample the turbidite tails. The 3.5 kHz records showed hard seabed so we fitted a 6 m piston core barrel. As operations began the crane developed a hydraulic leak requiring a couple of hours to repair. We therefore took a megacore (CD56402#1), which worked well with 20 cm of mud. The piston corer was then deployed at the same site (CD56402#2)

1st June Piston corer back onboard at 0100. It contained 3.96 m of thin turbidites with mud (c30% sand in total). We proceeded south onto the proximal abyssal plain to core presumed sand deposits. A 6m piston corer was deployed (CD56403) but returned empty except for the trigger corer that contained 48 cm of mud with turbidites and sand at the base. We presumed that there was a thick sand that prevented corer penetration. The trigger core provided as much data as a megacore or box core and so we moved to the next site. Here we planned to sample one of a series of large scours on the seabed seen on TOBI records. A short 3.5kHz survey was carried out to choose core sites across a single large scour. A 6m piston core CD56404#1 was attempted in the deep of the scour. On recovery the trigger core had recovered a sample of mud with sand at the base, but the piston corer was empty with traces of coarse sand on the cutter and mud up the outside of the barrel but not on the core head. It was not certain if the corer had penetrated partly or fully or if it had fallen over. The core was repeated (CD56404#2) with modification to the piston – insertion of 2 springs and pressure increased to 1.8 bar. This time the corer recovered 2.63m of coarse sand over mud.

2nd June We moved to a site adjacent to the scour and deployed the 6 m piston corer again (CD56405). This time the corer was empty and the liner had imploded. The trigger corer recovered some mud. We presumed the failure was due to sand at the seabed. 0500. started a multibeam survey of the canyon mouth.

3rd June Multibeam survey completed at 0530. Moved to megacore station CD56406 in the canyon axis. The corer recovered 3 tubes of mud. Moved to second megacore station (CD56407) in an area of sand waves just south the deepest part of the channel but down-canyon from previous station. This attempt produced 6 tubes of mud with a distinct sand in the middle (c25 cm depth). We followed with a 6m piston core at the same site (CD56407#2). The core cutter was lost but the barrel retained a 3.11 m long core with coarse sand at the base and debris flow above. The next coring attempt was a 12 m piston core just to the north of the channel on an apparent levee. The 3.5 kHz record showed a transparent layer a few metres thick at the surface. This core (CD56408) produced 4.61m of thin turbidites with a small debris flow.

4th June We then moved to a core transect on the slope on the south side of the canyon mouth. Two cores had been taken previously (CD155 cores 6 and 7) at 4692 and 4715 m water depth. We collected piston cores at 4711m (CD56409 8.9 m), 4798 m (CD56410 8m) and 4845 m (CD56411 3.9 m). Cores CD56409 and CD56410 both contained mud representing presumed rapidly deposited turbidite tails. Core CD56411 was from the channel floor and contained mainly sand, though the trigger core contained mud. Piston cores CD56407-56410 all had imploded liners. The walls of these 90mm liners were 2.2mm thick compared to 2.7 mm thick for the 110 mm corer. Core CD56411 utilised the 110 mm diameter corer but the sand clogged the catcher which proved impossible to remove. We resampled site CD56411 with the megacorer, and recovered 6 tubes of mud.

5th June In an attempt to have a complete sequence at site CD56411 we tried a kasten core. Two kasten core attempts failed due to the catcher doors not closing. We therefore moved to site CD56412 located just above the channel floor on the southern levee. The 6m barrel piston corer produced 4.5 m of mud with thin turbidite silts.

The kasten catcher was now mended so we had one more attempt at coring site CD56411 but this also failed. We moved to site CD56413 further west on the channel floor in a smooth facies on TOBI. We attempted a megacore that produced 60cm mud and then tried a piston core (CD56413#2) that recovered 1m mud overlying debris flow.

6th June Piston core (CD56414) was taken on the relatively smooth facies on the TOBI record of the distal area and produced 4.5 m containing surface mud over debris flow and a very large cobble 10cm across. We then moved to another area just north of the main channel to plot the extent of the debris flow. This core CD also showed debris flow with mud above. Our next coring attempt was a 2 m kasten at site CD56407 where we had obtained piston and megacores so that we could be certain of a complete sequence. The kasten was intended to bridge the sample gap between the other 2 cores. Two metres of mud was recovered showing turbidites above a thick debris flow. We moved to sample the channel floor with a megacorer (CD56415#1) which recovered 6 tubes of mud. This encouraged us to try to piston core the expected coarse deeper layers. The piston core (CD56415#2) recovered 1.4 m of gravel and cobbles with mud above. We then moved up the canyon to two sites located on terraces.

7th June Piston core CD56416 was taken on a terrace just above the canyon floor. The 12 m barrel produced 4.5 m of mud including thin turbidites. At the second terrace site (CD56417) we also tried a 12 m barrel. This time the corer hit a very hard substrate, possibly rock, that severely damaged the core cutter and broke the barrel attachment at the core head. On recovery at the ship's side the barrels parted from the head and were only retained by the piston. They were eventually landed on deck and a 2 m core was retrieved. We then completed a short multibeam survey to fill a gap in the existing coverage before heading for a core site near the canyon head. This proved impossible to core because of a series of nearby telecommunications cables. From here we moved to a point off Cascais to collect a package containing a new multiplex for the conducting cable. Although the package had been delivered it arrived without paperwork and could not be released from customs. We therefore sailed directly for Nazare Canyon.

8th June Arrived at the first core site on a terrace within the Nazare Canyon at 01.40 and deployed a 6 m piston core (CD56418). This recovered 4.5 m of mud with a debris flow in the bottom metre containing clasts up to 13 cm and pieces of lithified mud. Slightly further downslope we attempted a megacore on the canyon floor (CD56419). This produced 6 tubes of sediment – the longest being 15 cm and consisting of mud. The short nature of these cores may be due to a sandy layer just beneath the seabed. We moved to a terrace on the north side of the canyon and attempted a 6m piston core (CD56420) that recovered 2.73 m of turbidites with thin silty bases over sand at the base of the core. We then attempted to core the thalweg using the megacorer (CD56421). The first attempt failed to recover any core.

9th June A second attempt was made to megacore the thalweg but this also failed. We presumed this was due to very coarse sediment at the seabed within the thalweg. We moved back to site CD56419 to attempt a 6 m piston core. This produced 3.9 m of highly disturbed sand. This indicated that the predominant sediment type at the

seabed was sand with very little mud. No trigger core sample was recovered. We moved to site CD56422 on the channel floor and attempted a 6m piston core. The piston and trigger corers both returned empty except for a small amount of sand and a broken piece of Lophelia coral, suggesting sand at or near the seabed. To verify if there was a thin muddy layer at the seabed we deployed a megacorer (CD56422#2). This also returned empty confirming our suspicions that this was an active canyon with sand at the seabed in the main channel. We still wanted a sample from the channel thalweg and so we returned to site CD56421 to deploy a giant gravity core (3 m long barrel of 160 mm diameter). This hit the seabed and fell over but did recover a small amount of coarse sand with pebbles.

10th June We moved downcanyon to core a terrace about 80 m above the canyon floor (site CD56423). A 6m barrel piston corer recovered 4.75 m of mud with thin turbidite bases. We identified a site (CD56424) in the channel but slightly elevated by about 10m and tried a megacore , that produced 10cm mud. Next we attempted a megacore on a terrace about 40 m above the canyon floor (CD56425), and it recovered four full subcores with a high proportion of sand. We set off for a 3.5 kHz survey towards the west to investigate a series of bedforms seen on the TOBI sidescan. This took us to the distal end of the channel where we tried a megacore on the channel floor (CD56426) that recovered only a few cm of mud with presumed plant remains. In an attempt to core deeper into the channel floor we launched a 1m barrel kasten corer at this site (CD56426#2) and ran this into the seabed at 106m/min. This also failed to recover a core. From here we surveyed to the channel mouth and then southwards where the bathymetry map suggested there was a levee. All we found was a gently downward sloping seabed and so we mover a little to the east where we found the base of the continental slope.

11th June Core CD56427 was taken about 20m above the level of the plain on the lower slope. It produced a good core with 8m of hemipelagic and turbidite mud. From here we re-entered the channel to core some bedforms on a terrace on the southern side. Site CD56428 was located on a darker area of TOBI sidescan and produced 7m of mainly turbiditic mud. Core CD56429 was located on a brighter area of TOBI sidescan. This core produced 4.4m of sands with mud layers. The sand had passed up between the steel core barrel and the liner making it impossible to extract the core. After much effort the core had to be subcored by pushing a small diameter core liner through the length of the core. This worked well after much effort, though the deepest 2 sections may have been considerably disturbed. We then attempted a 6m piston core on the channel floor adjacent to the bedforms (CD56430). This returned bent with no core, again presumable due to a hard (sandy?) seabed.

12th June We carried out a short swath survey just north of the canyon as we ran east to the next core site on a terrace on the north side of the canyon. Here we attempted a 6m piston core (CD56431) that recovered 3m of thin sandy turbidites. The last station was a reoccupation of site CD56425, where we attempted a 6m piston core. The corer returned empty. With 2 hours left to the beginning of the passage to Vigo we carried out a swath survey eastwards along the canyon. We then sailed directly for Vigo.

13th June Arrived Vigo and picked up pilot at 0800.

SEDIMENTOLOGICAL OBSERVATIONS

Southern Tagus AP

Station: 56401-1
Location co-ordinates: 37o10.07'N/12o13.06'W
Location description: Depth = 5178 m. Southern margin of Tagus AP
Core type: Kasten
Core summary: Sequence of olive grey turbidite muds with thin fine sand bases interbedded with pale grey/brown pelagites/hemipelagites. Disturbed muddy top of core with silty blebs may be recent turbidite (1755 event?).

Northern Tagus AP

Station: 56402-1
Location co-ordinates: 38o23.80'N/11o33.90'W
Location description: Depth = 4990 m. Northern margin of Tagus AP
Core type: Megacore
Core summary: Greyish turbidite at top with thin fine sand/silt base and oxidized top, overlying turbidite/hemipelagite mud.

Station: 56402-2
Location co-ordinates: 38o23.98'N/11o34.09'W
Location description: Depth = 4990 m. Northern margin of Tagus AP
Core type: Piston with trigger
Core summary: Sequence of ~55 stacked thin-bedded turbidites with sandy bases up to 14 cm thick and medium sand size. Some bases show Bouma sequence development. Overall ~30% sand. Grey-brown or brown-grey colour with scattered sulphide patches/layers. Core is almost 100% turbidites.

Station: 56403-1
Location co-ordinates: 38o13.72'N/11o16.38'W
Location description: Depth = 5050 m. NE Tagus AP beyond Setubal Channel mouth. TOBI shows this to be a transitional zone, with SW-oriented lineations indicating presence of reworked sandy deposits near surface.
Core type: Trigger core only (piston core empty)
Core summary: Soupy oxidized mud at surface (1755 event?), with turbidite underneath becoming sandy (up to coarse sand) near base of core at ~40 cm. Similar to trigger core of 56402-2. Piston core presumably empty due to hitting coarse sand layer at ~40 cm.

Eastern Tagus AP

Station: CD155T Core 6
Location co-ordinates: 37o59'N/10o31'W
Location description: 4618 m. Eastern margin of Tagus AP just south of Setubal Channel mouth. TOBI data shows this is an area of uniform low backscatter on the lower rise (about 8 km south of the Setubal Channel mouth).

Core type: Piston (without trigger)
Core summary: ~8.5 m thick sequence of hemipelagite/turbidite muds with scattered patches (some with concentric rings) of organic-derived sulphide. Numerous thin greenish-grey mud layers probably represent individual turbidites. Rare pyritized worm burrows.

Station: CD155T Core 7
Location co-ordinates: 37o59'N/10o31'W
Location description: 4692 m. Eastern margin of Tagus AP just south of Setubal Channel mouth. TOBI data shows this is an area of uniform low backscatter on the lower rise (about 8 km south of the Setubal Channel mouth).
Core type: Piston with trigger
Core summary: ~7.5 m thick sequence of hemipelagite/turbidite muds with scattered organic-derived sulphide patches/flecks. Numerous thin greenish-grey mud/silt layers probably represent individual turbidites.

Setubal Canyon-Channel System

Station: 56404-2
Location co-ordinates: 38o12.74'N/10o56.56'W
Location description: Depth = 5020 m. Just below an erosive scarp in the Setubal Channel mouth. TOBI shows fairly high backscatter and widespread scouring. 3.5kHz shows core site is in topographic low without a hard surface reflector, but in an area of low penetration and no obvious stratification.
Core type: Piston with trigger
Core summary: Top of core contains ~45 cm of fine-grained turbidite/hemipelagite. Below this is ~120 cm of coarse-grained, largely massive, turbidite sand (possibly affected by coring disturbance) underlain by a large folded clast of remobilised thin-bedded turbidites that is at least 100 cm thick. This is interpreted to be a local slump deposit.

Station: 56405-1
Location co-ordinates: 38o12.67'N/10o56.54'W
Location description: Depth = 5020 m. Just above an erosive scarp in the Setubal Channel mouth. TOBI shows fairly uniform moderate-high backscatter. 3.5kHz shows site is in an area with a hard surface reflector.
Core type: Trigger core only (piston core empty)
Core summary: Hemipelagite/turbidite mud overlying turbidite with medium sand at base of core at ~45 cm. This turbidite may have been thick and coarse-grained leading to failure of the piston core to penetrate (see 56404-2).

Station: 56406-1
Location co-ordinates: 38o06.98'N/10o04.02'W
Location description: Depth = 4588 m. Floor of Setubal Channel. TOBI shows presence of small transverse bedforms with 'blocky' character that are interpreted as coarse-grained sediment waves, probably gravel-rich.
Core type: Megacore
Core summary: ~40 cm of grey-brown turbidite/hemipelagite mud.

Station: 56407-1
Location co-ordinates: 38o07.00'N/10o15.99'W
Location description: Depth = 4762 m. Bottom of distal Setubal Channel. TOBI data shows surprisingly uniform moderate backscatter, in contrast to the highly variable area of channel floor bedforms just to the south. May indicate that this is an area of debris flow?
Core type: Megacore
Core summary: ~45 cm of turbidite/hemipelagite mud with one turbidte from 6-17 cm having a fine/medium-sand base.

Station: 56407-2
Location co-ordinates: 38o06.99'N/10o15.95'W
Location description: Depth = 4762 m. Bottom of distal Setubal Channel. TOBI data shows surprisingly uniform moderate backscatter, in contrast to the highly variable area of channel floor bedforms just to the south. May indicate that this is an area of debris flow?
Core type: Piston with trigger
Core summary: Trigger core contains mostly hemipelagite with a couple of thin turbidites (indicating little recent activity in the channel?). Top ~40 cm of piston core contains thin-bedded and laminated brownish-grey muddy turbidites with thin fine sand/silt bases. Scattered organic-derived sulphide patches. A locally-derived debrite is present from 40-200 cm and consists of contorted and mixed remobilised thin-bedded turbidites, with a few lithic clasts up to 2 cm in size in the basal few cm.

Station: 56407-3
Location co-ordinates: 38o06.96'N/10o15.92'W
Location description: Depth = 4762 m. Bottom of distal Setubal Channel. TOBI data shows surprisingly uniform moderate backscatter, in contrast to the highly variable area of channel floor bedforms just to the south. May indicate that this is an area of debris flow?
Core type: Kasten
Core summary: Note top few cm of core missing. Top 85 cm consists of grey-brown turbidites/hemipelagites, including one turbidite with a thin sand base up to medium sand size. Below this is a locally-derived debrite at least 1 m thick made up of contorted remobilised thin-bedded turbidites.

Station: 56408-1
Location co-ordinates: 38o07.99'N/10o14.00'W
Location description: Depth = 4650 m. Terrace within distal Setubal Channel. TOBI shows this site is located on a the northern edge of an erosive scarp, which forms a distinct intra-channel terrace. Uniform moderate-low backscatter.
Core type: Piston with trigger
Core summary: Sequence of thin-bedded and laminated brownish-grey turbidite muds, some with thin blackish organic-rich sand/silt bases (up to fine sand size). Several hundred individual thin turbidites can be recognised. Abundant organic-derived sulphides. A single 30 cm thick locally-derived debris flow, consisting of remobilised thin-bedded turbidites, is present from 270-300 cm.

Station: 56409-1

Location co-ordinates: 38o00.99’N/10o30.94’W
Location description: Depth = 4711 m. Lower rise ~5 km south of Setubal Channel mouth. TOBI shows uniform low backscatter.
Core type: Piston with trigger
Core summary: Note that core slightly disturbed in places due to liner implosion and splitting difficulties. Sequence of interbedded grey-brown hemipelagite/turbidite muds about 8.3 m in thickness. Scattered organic-derived sulphide patches and layers.

Station: 56410-1
Location co-ordinates: 38o02.85’N/10o31.09’W
Location description: Depth = 4798 m. Lower rise ~1.5 km south of Setubal Channel mouth. TOBI shows uniform low backscatter.
Core type: Piston with trigger
Core summary: Sequence of interbedded grey-brown turbidites/hemipelagite muds about 8 m in thickness. Some turbidites have thin silty bases. Abundant organic-derived sulphide patches. Single lithic clast at ~250 cm may be ice-rafted debris.

Station: 56411-1
Location co-ordinates: 38o04.55’N/10o31.00’W
Location description: Depth = 4845 m. Southern margin of Setubal Channel mouth adjacent to lower rise. TOBI shows patchy moderate backscatter with km-scale scours.
Core type: Piston with trigger
Core summary: Core severely affected by sand flow-in at base. Trigger core contains 52 cm of muddy turbidite/hemipelagite, so the medium-coarse sand layer responsible for the flow-in must lie beneath this.

Station: 56411-2
Location co-ordinates: 38o04.46’N/10o31.01’W
Location description: Depth = 4845 m. Southern margin of Setubal Channel mouth adjacent to lower rise. TOBI shows patchy moderate backscatter with km-scale scours.
Core type: Megacore
Core summary: ~45 cm of grey-brown turbidite/hemipelagite mud. Note that after this three kasten cores were attempted at this site but all failed, presumably because they hit hard sand layer beneath surface.

Station: 56412-1
Location co-ordinates: 38o03.71’N/10o31.05’W
Location description: Depth = 4829 m. Lower rise just south of Setubal Channel mouth. TOBI shows fairly uniform low backscatter.
Core type: Piston with trigger
Core summary: Sequence of thin-bedded and laminated grey-brown muddy turbidites/hemipelagites. Some turbidites have thin green/grey sand/silt bases up to 3.5 cm thick with maximum grain size of medium sand. Abundant organic-derived sulphide flecks, patches and rings.

Station: 56413-1
Location co-ordinates: 38o09.82’N/10o39.02’W

Location description: Depth = 4906 m.
Core type: Megacore
Core summary: ~40 cm of grey-brown turbidite/hemipelagite mud.

Station: 56413-2
Location co-ordinates: 38o09.42'N/10o39.32'W
Location description: Depth = 4906 m. Just beyond Setubal Channel mouth. Fairly uniform moderate backscatter (debris flow?) adjacent to more irregular scoured area.
Core type: Piston with trigger
Core summary: Top 30 cm of core comprises thin-bedded grey-brown turbidites/hemipelagites, with one well-developed turbidite base containing coarse sand/gravel. From 30-400 cm a polymictic locally-derived debris flow is present with upper part containing contorted layers of black/grey-brown pre-deposited turbidites rich in mica and organic-derived sulphides. Lower part contains muddy coarse sands/gravel, becoming more gravel-rich near base with pebbles to 3 cm. Sharp boundary at 370 cm may represent top of an underlying debris flow or may be an internal boundary.

Station: 56414-1
Location co-ordinates: 38o08.54'N/10o21.29'W
Location description: Depth = 4788 m. Just inside Setubal Channel mouth. TOBI shows curious blocky texture with moderate backscatter interpreted as blocky debris flow. Just to south is a small channel-like feature that may be part of the debris flow. Fabric orientation indicates debris flow came from a nearby ridge on the northern edge of the channel mouth.
Core type: Piston with trigger
Core summary: Top 80 cm of core comprises grey-brown weakly-stratified muddy turbidites/hemipelagites, with only one or two thin sandy bases. Polymictic, locally-derived debrite present from 80-446 cm, mostly made up of contorted pre-deposited turbidites/hemipelagites, with intervening structureless sand/silt horizons and some patches of apparent 'concrete' facies. Scattered pebbles up to 10 cm.

Station: 56415-1
Location co-ordinates: 38o05.02'N/10o14.62'W
Location description: Depth = 4752 m. Distal Setubal Channel. TOBI shows this is an area of 'tiger stripe' backscatter, interpreted as transverse coarse-grained sediment waves. WL = ~1 km. Site is just north of southern channel margin.
Core type: Megacore
Core summary: ~45 cm of grey-brown turbidite/hemipelagite mud.

Station: 56415-2
Location co-ordinates: 38o04.97'N/10o14.62'W
Location description: Depth = 4752 m. Distal Setubal Channel. TOBI shows this is an area of 'tiger stripe' backscatter, interpreted as transverse coarse-grained sediment waves. WL = ~1 km. Site is just north of southern channel margin.
Core type: Piston with trigger
Core summary: Top 65 cm of core comprises grey/grey-brown muddy turbidites/hemipelagites with just one thin basal sand. Core from 65-203 cm contains a polymictic locally-derived debrite with contorted layers of black/brown-grey pre-

deposited turbidites floating in a coarse sand/gravel matrix with pebbles to 6 cm. Basal 30 cm is almost totally made up of sub-rounded pebbles with a variety of rock types represented.

Station: 56416-1
Location co-ordinates: 38o04.48'N/09o49.56'W
Location description: Depth = 4015 m. Terrace within Setubal Canyon. TOBI shows fairly uniform moderate backscatter on terrace, although adjacent areas are affected by large rockfalls!
Core type: Piston with trigger.
Core summary: ~60 cm of grey-brown turbidite/hemipelagite mud overlying 4.2 m thick sequence of stacked, mostly thin-bedded, muddy turbidites with fine sand bases.

Station: 56417-1
Location co-ordinates: 38o03.81'N/09o46.37'W
Location description: Depth = 3893 m. Terrace within Setubal Canyon. TOBI shows fairly uniform moderate backscatter on terrace. However, terrace is small and very close to area of apparent rock outcrop!
Core type: Piston with trigger
Core summary: ~200 cm of largely muddy interbedded turbidites/hemiplagites with rare thin fine sand bases. Corer apparently hit something very hard below this!

<u>Nazare Canyon-Channel System</u>

Station: 56418-1
Location co-ordinates: 39o29.46'N/09o57.46'W
Location description: Depth = 3447 m. Terrace on southern edge of Nazare Canyon just above thalweg. TOBI shows fairly uniform moderate-low backscatter, with area of rock outcrop a few hundred metres to the south.
Core type: Piston with trigger
Core summary: ~3.5 m of homogeneous dark olive grey-brown silty mud with abundant organic-derived sulphide flecks. Interpreted as semi-continuous dilute flow deposits. Base of core contains slump/rockfall deposit of lithic clasts/pebbles up to 11 cm across in a muddy matrix, underlain by very stiff (semi-consolidated) banded silts and fine sands that may be 'in situ' exhumed sediments or could be part of remobilised deposit.

Station: 56419-1
Location co-ordinates: 39o35.03'N/10o20.50'W
Location description: Depth = 4414 m. Floor of Nazare Canyon about ~1 km north of thalweg. TOBI shows slightly patchy moderate-high backscatter with scattered possible scours.
Core type: Megacore
Core summary: ~15 cm of dark grey-brown silty mud.

Station: 56419-2
Location co-ordinates: 39o35.02'N/10o20.47'W

Location description: Depth = 4414 m. Floor of Nazare Canyon about ~1 km north of thalweg. TOBI shows slightly patchy moderate-high backscatter with scattered possible scours.
Core type: Piston (without trigger – washed out)
Core summary: ~3.9 m of structureless med-coarse sand. Core useless as affected by flow-in, but it does prove that a thick sand occurs fairly close to surface at this location. Note that three attempts at coring the nearby thalweg (two megacores and a piston core) all failed due to hard seafloor! A further two attempts to core the channel floor ~15 km downstream (using piston core + megacore) also failed due to hard seafloor!

Station: 56420-1
Location co-ordinates: 39o36.18'N/10o18.89'W
Location description: Depth = 4373 m. Terrace close to floor of Nazare Canyon. TOBI shows fairly uniform moderate backscatter.
Core type: Piston with trigger
Core summary: Sequence down to ~2.5 m consists of thin-bedded/laminated, dark olive-grey, muddy turbidites with thin fine sand bases, underlain by ~20 cm of structureless med turbidite sand.

Station: 56423-1
Location co-ordinates: 39o44.52'N/10o40.77'W
Location description: Depth = 4742 m. Terrace on southern margin of Nazare Channel. TOBI shows fairly uniform moderate backscatter.
Core type: Piston with trigger
Core summary: ~50 cm of silty turbidite/hemipelagite mud underlain by 4.3 m thick sequence of olive grey-brown turbidite/hemipelagite muds, some with thin green/grey silt/fine sand bases. Towards base of core paler foram-rich hemipelagite intervals become better defined.

Station: 56424-1
Location co-ordinates: 39o45.53'N/10o39.20'W
Location description: Depth = 4750 m. Lower terrace on southern margin of Nazare Channel. TOBI shows slightly mottled moderate backscatter. Low 3.5kHz penetration.
Core type: Megacore
Core summary: Megacorer hit hard (coarse sand/gravel?) layer just beneath seabed so only a short sample recovered. Contains ~10 cm of brown silty mud with blackish fine sand at base hinting at what may have stopped the corer penetrating further.

Station: 56425-1
Location co-ordinates: 39o44.78'N/10o39.86'W
Location description: Depth = 4798 m. Terrace on southern margin of Nazare Channel. TOBI shows slightly mottled moderate backscatter. Low 3.5kHz penetration.
Core type: Megacore
Core summary: ~46 cm thick sequence of thin-bedded turbidites (med-coarse sand grading into mud tops) almost up to sediment-water interface. Possibly 1-3 cm of

oxidized mud/silt at top. A piston core was also taken here but is presumed to have failed.

Station: 56427-1
Location co-ordinates: 39o46.39'N/11o03.49'W
Location description: Depth = 4050 m. Lower rise south of Nazare Channel mouth. No TOBI record.
Core type: Piston with trigger
Core summary: ~8 m thick sequence of interbedded turbidite muds and hemipelagic/pelagic marls/clays. Some turbidites have thin greenish-grey silt/fine sand bases. Abundant organic-derived sulphides. Stage 5 apparently present in middle of core with Stage 7 (stiff coccolith ooze) near base, but this needs to be confirmed by coccolith analysis. Note: large sample retained from core catcher.

Station: 56428-1
Location co-ordinates: 39o48.72'N/10o53.43'W
Location description: Area of reworked large-scale bedforms on southern edge of Nazare Channel mouth, on terrace just above channel floor. TOBI shows core site is located in low backscatter zone, while 3.5 kHz shows site is on lower (downstream flank?) part of bedform where there is increased penetration and stratification and loss of strong local surface reflector.
Core type: Piston with trigger
Core summary: ~20-40 cm of oxidized hemipelagite mud at top, underlain by ~6.5 m of interbedded turbidite/hemipelagite muds. Turbidites have thin greenish-grey silt/fine sand bases. Top 3.5 m of core almost totally dominated by turbidites, whereas lower sections have increasing hemipelagite.

Station: 56429-1
Location co-ordinates: 39o49.20'N/10o54.78'W
Location description: Area of reworked large-scale bedforms on southern edge of Nazare Channel mouth, on terrace just above channel floor. TOBI shows core site is located in high backscatter zone, while 3.5 kHz shows site is on higher (upstream flank?) part of bedform where there is reduced penetration and stratification and presence of a strong local surface reflector.
Core type: Piston (without trigger)
Core summary: Sequence of thin- to medium-bedded turbidites interbedded with thin hemipelagite muds. Turbidite sands up to ~40 cm thick, becoming thicker downcore. Up to med sand size. Note: core disrupted as liner jammed in barrel and core recovered by sub-coring from either end – probable compression and disturbance, especially towards base. Note that a piston core taken just to the northeast of this site, in the channel floor proper, failed (presumably due to hard seafloor). A kasten core was also attempted in the channel floor ~10 km downstream but this also failed.

Station: 56431-1
Location co-ordinates: 39o47.15'N/10o36.47'W
Location description: Terrace on north side of Nazare Channel. TOBI shows fairly uniform moderate backscatter, possibly with some indication of downstream-oriented lineations/scours.

Core type: Piston with trigger
Core summary: ~2 m thick sequence of thin-bedded olive grey-brown turbidite muds with thin dark silt/fine sand bases. Abundant organic-derived sulphide layers/flecks. Below this is ~1 m of structureless fine-med sand (possible flow-in) with a couple of muddy thin-bedded turbidite intervals.

Russell B Wynn

EQUIPMENT REPORTS

Piston corer

On CD157 we used the NIOZ piston corer, which will replace the SOC piston corers. We began using the smallest diameter tubes that take 90 mm cores. The trigger corer worked on every occasion and the trigger arm and mechanism worked well, being easier to deploy and recover than the SOC equivalent. Many of our cores were into sand or harder material but the corer coped well recovering cores on most attempts and not bending. The main problem was with implosion of the liners. The liner walls are thin (2.2 mm) and some of the stiffer cores showed that the liners had folded and then returned to near-round shape leaving a crease in the liner. We tried changing the piston pressures but this had little effect. The plastic catchers worked well in mud but were chafed in sandy deposits.

The medium barrel piston corer that recovers cores of 90 mm diameter worked well. The small vent diameter at the corer head may be a problem that should be rectified as this may impede coring due to the speed with which the barrel full of water has to be ejected. The core catcher would be easier to remove if all nails were inserted in the same direction. Rotating the catcher would then tend to free all nails rather than freeing some and tightening others.

Kasten corer

The kasten corer worked well in muddy sediments but failed to core hard substrates even with a 1m barrel length.

Megacorer

The megacorer worked well in all situations except where the seabed was too hard (canyon floor in Nazare Canyon).

Summary of condition of the fibre optic deep tow cable

Prior investigations during RRS Charles Darwin cruise CD155T indicated substantial damage to the fibre optic cable located at approximately 2km from the drum end of the cable. (Approximately 7km from the attachment point to the underwater vehicle). Optical transmission is conducted at two separate frequencies, 1550nm and 1310nm. (The vast majority of optical fibre transmission systems use these frequencies) The

damage causes a substantial loss is signal transmission at 1550nm resulting in a total breakdown in the optical data/video link. The damage was so great that the signal loss was beyond the range of the test equipment used (an optical time domain reflectometer). The loss in signal strength is also apparent at 1310nm but to a lesser degree, and within the parameters of the vehicle communication specification. It was also noted there is minor loss of signal strength occurring approximately mid way (4.5km) in the cable at both frequencies.

In an attempt to rectify these problems the fibre optic deep tow cable was streamed on 29/05/04 to a maximum length of approximately 9km. The cable remained deployed for approximately 10 hours during which time, as expected, the loss in signal transmission disappeared on both frequencies. However, during recovery it was immediately apparent that the major fault had not been rectified and signal loss reoccurred to the same magnitude. The minor signal loss at approximately 4.5km did not return. Although cable streaming was successful in the past, the substantial signal loss at 2km outboard from the drum represents a new fault not encountered before when the SHRIMP fibre optic system was used in prior deployments. It is concluded that the current deep tow cable on the RRS Charles Darwin is unusable for fibre optic communications when used on the current winch system.

The problems with the fibre optic deep tow cable prevented any use of SHRIMP.

James A Cooper

Low Frequency Mini Profiler Vehicle (LF-MPV)

The Low frequency Mini Profiler Vehicle was developed through SOC's Technology Innovation Fund, to provide a sedimentary analysis tool in coarse sandy regions. The higher frequency system (6-10 kHz) has limited penetration in such regions.

The project plan forecasted a field trial and assessment during May/June 2004, which was to be based in the laboratory and some assessment time at a test facility. The programme was accelerated with the opportunity of trial runs in CD157. A trial in CD155T, the previous month, was cancelled due to deep-tow cable problems.

Development and construction continued during CD157 with system testing and integration ongoing during the 14 days at sea. The system achieved chirp generation in the 1 – 4 kHz band, as designed, using a 30-millisecond sweep, repeated at 0.25 – 4-second intervals. Power start-up sequences and load balancing was required to achieve a stable and sustained pulsed power output for the performance parameters above. The final integration of the control software through electrically programming ("burning") the control programme into the sonar system proved a major stumbling block. The development system repeatedly failed to embed the control software into the sonar system; this would allow the sonar to self-start and run under basic synchronising trigger and commands.

The result was that the system did not achieve its first ever test dip in the sea. The prototype system is within its project time period but unfortunately was not quite

ready for full science use. The system is being returned to SOC to continue its projected test and integration timetable.

Duncan R. Matthew

Octopus Seismic Logging System, for 3k5 ship-based profiler

The unit was loaned from CodaOctopus to be assessed in parallel with the development of a deep water version to replace our existing, ageing, 3k5 sub-bottom profiler logging system. The Octopus 760 system was known to have only single 1-second phase capability, which causes phase wrap on the display. This issue was discussed with CodaOctopus prior to the cruise as an essential feature to be corrected, for deep-water work, before the commencement of purchase.

The system has a good multi windowed interface with a 7-element keypad minimising finger trouble associated with the full QWERTY keyboards of PC based systems. A comprehensive help manual is built into the system capable of being accessed during real-time logging. Logging to built-in DVD-RAM drive (4.7 GB capacity) was successful. Logging to the network was possible but there are some issues to be resolved. The system ran without problems during its required time, assisting in assessing possible coring sites.

Replay software is easy to use; accessing previously logged files on the network. Access was through a wireless modem link allowing logged files to be processed from a remote laptop PC. The data could be rerun at fast/slow speeds. Facilities included built in TVG and user defined versions to amplifier deeper sedimentary layers. A zoom function, up to 4x, allowed magnification in the vertical direction. Further features provide a capability to export a window of sonar data: raw, applied tvg, zoom and/or band-passed filtering to bitmap files for import into documents.

Overall the system looked a very good replacement once the above issues can be resolved. Feedback and further discussion to CodaOctopus during and post CD157 will pursue these issues.

Duncan R. Matthew

The Classroom@Sea Project

Two teachers, Elena Fernandez Lee and Ian Lewis, were selected a year prior to the cruise to increase the outreach potential of the EUROSTRATAFORM project. Prior to the cruise pupils from both schools designed activities to be performed whilst at sea. These included tests on the response of polystyrene to compression, a sea sickness survey and a wildlife watch. The results of these were placed on the web site whilst we were at sea.

A major feature of the interactive component was for the teachers to act as ‘reporters’. Armed with camera, videos and notebooks the two teachers recorded some of the ship’s daily routines and built profiles of some of the crew, the technicians and the

scientists in action. These were e-mailed to SOC where they were placed on the web site as soon as possible. The final component was to organise the seaward end of the e-mail question system where pupils from schools could forward to us relevant questions that could be answered by the experts at sea.

The whole venture was a great success, with one disappointment being the limited range of schools who were involved in the e-question aspect. Despite significant attempts to advertise and stimulate interest we received the bulk of our questions from five schools.

Ian lewis and Elena Fernandez-Lee

SUMMARY OF RESULTS

The coring was a success given the difficult topography. However, site location was aided by the TOBI sidescan survey completed in 2003, making it possible to hit relatively small targets just a few hundred metres across. Careful choice of corer type ensured core recovery in the sequence of mixed sands and muds. We used long piston cores in expected muds, short piston cores in expected sand/mud sequences, megacores where we expected a veneer of mud at the seabed overlying thicker sands. The kasten corer provided sediment sample in the difficult interval between the base of the megacore and the top of the piston core. No corers worked well in the Nazare thalweg due to presumed hard or sandy seabed.

The data will be used to groundtruth the TOBI sidescan and to determine the flux of sediment through the Setubal and Nazare Canyons. Initial interpretations suggest significant differences between the canyons and strong changes in the amount of activity with time.

The problems with the conducting cable prevented any use of the SHRIMP video and limited our ability to verify our theory that the seabed in the thalweg was very coarse grained or even rocky.

TABLES

Core number	Type	Latitude°	Longitude°	Water depth m (cor)	Core length m	Comments
56401-1	kasten	37°10'.07N	12°13'.06W	5677	1.10	1 section, split into slabs and 50mm and 75mm conduit
56402-1	mega	38°23'.80 N	11°33'90W	4990	approx 0.20	6 tubes taken - 4 retrieved (2 very good), 1 didn't trigge
56402-2	piston	38°23'.98 N	11°34'.09W	4990	3.96	3 sections (0.96m, 1.50m, 1.50m)
"	trigger	"	"	"	0.42	
56403-1	piston	38°13'.72N	11°16'.38W	5055	-	core liner empty - no sample recovered
"	trigger	"	"	"	0.48	
56404-1	piston	38°12'.77N	10°56'.61W	4973	-	core liner imploded - no sample recovered
"	trigger	"	"	"	?	
56404-2	piston	38°12'.74N	10°56'.56W	4968	2.63	2 sections (1.13m, 1.50m)
"	trigger	"	"	"	0.50	
56405-1	piston	38°12'.67N	10°56'.54W	4963	-	core liner imploded - small lump of mud recovered
"	trigger	"	"	"	0.75	
56406-1	mega	38°6'.98N	10°4'.02W	4588	0.38	4 tubes taken - 3 retrieved, 1 didn't trigger
56407-1	mega	38°7'.00N	10°15'.99W	4762	0.44	6 tubes taken - 6 retrieved (0.40-0.42m), 3 kept for geo
56407-2	piston	38°6'.99N	10°15'.95W	4762	3.11	3 sections (0.39m, 1.50m, 1.22m)
"	trigger	"	"	"	0.49	
56407-3	kasten	38°6'.96N	10°15'.92W	4762	1.83	2 sections, split into slabs and 50mm and 75mm condu
56408-1	piston	38°7'.99N	10°14'.00W	4690	4.61	4 sections (1.04m,1.5m, 1.49m, 0.58m)
"	trigger	"	"	"	0.50	
56409-1	piston	38°0'.99N	10°30'.94W	4711	8.38	7 sections (0.34m, 1.51m, 1.50m, 0.54m, 1.49m, 1.50m
"	trigger	"	"	"		units out of sequence (over penetrated then bounced)
56410-1	piston	38°2'.85N	10°31'.09W	4798	8.03	6 sections (1.50m, 1.50m, 0.53m, 1.50m, 1.50m, 1.50)
"	trigger	"	"	"	0.75	
56411-1	piston	38°4'.55N	10°31'.00W	4845	3.86	3 sections (1.50m, 1.50m, 0.86m) 110mm diameter
"	trigger	"	"	"	0.75	
56411-2	mega	38°4'.46N	10°31'.01W	4845	0.45	6 tubes taken - 6 retrieved (~0.40m), 4 kept for geology
56411-3	kasten	38°4'.48N	10°30'.93W	4845	-	kasten door didn't shut - no sample recovered
56411-4	kasten	38°4'.53N	10°31'.18W	4850	-	kasten door didn't shut - no sample recovered
56411-5	kasten	38°4'.52N	10°31'.02W	4862	-	corer fell over - top washed out
56412-1	piston	38°3'.71N	10°31'.05	4829	4.49	3 sections (1.50m, 1.50m, 1.49m)
"	trigger	"	"	"	0.75	
56413-1	mega	38°9'.82N	10°39'.02W	4906	0.38	
56413-2	piston	38°9'.42N	10°39'.32W	4906	3.99	3 sections (1.00m, 1.49m, 1.50m)
"	trigger	"	"	"	0.75	
56414-1	piston	38°8'.54N	10°21'.29W	4788	4.50	3 sections (1.50m, 1.50m, 1.50m)
"	trigger	"	"	"	0.75	
56415-1	mega	38°5'.02N	10°14'.62W	4762	0.45	6 tubes taken - ?
56415-2	piston	38°4'.97N	10°14'.62W	4752	2.03	2 sections (0.53m, 1.50m)
"	trigger	"	"	"	0.75	
56416-1	piston	38°4'.48N	9°49'.56W	4015	4.50	3 sections (1.50m, 1.50m, 1.50m)
"	trigger	"	"	"	0.57	
56417-1	piston	38°3'.81N	9°46'.37W	3893	2.26	2 sections (0.76m, 1.50m)
"	trigger	"	"	"	0.39	
56418-1	piston	39°29'46N	9°57'.46W	3447	4.51	3 sections (1.50m, 1.51m, 1.51m)
"	trigger	"	"	"	0.76	
56419-1	mega	39°35'.03N	10°20'.50W	4414	0.15	6 tubes taken - 5 retrieved, 3 kept for geology
56419-2	piston	39°35'.02N	10°20'.47W	4419	3.92	3 sections (0.91m, 1.51m, 1.50m)
"	trigger	"	"	"	-	no sample recovered

56420-1	piston	39°36'.18N	10°18'.89W	4373	2.73	2 sections (1.23m, 1.50m)
"	trigger	"	"	"	0.75	
56421-1	mega	39°34'.59N	10°19'.50W	4421	-	no sample recovered
56421-2	mega	39°37'.50N	10°19'.50W	4421	-	no sample recovered
56421-3	gravity	39°34'.51N	10°19'.46W	4403	-	small amount of sand recovered
56422-1	piston	39°37'.81N	10°31'.80W	4670	-	small amount of sand recovered, lophylia fragment (wa
"	trigger	"	"	"	-	no sample recovered
56422-2	mega	39°37'.79N	10°31'.73W	4670	-	no sample recovered
56423-1	piston	39°44'.52N	10°40'.77W	4742	4.75	4 sections (0.25m, 1.50m, 1.50m, 1.50m)
"	trigger	"	"	"	0.76	
56424-1	mega	39°45'.52N	10° 39'.20W	4814	0.07	
56425-1	mega	39°44'.78N	10° 39'.86W	4798	0.46	
56425-2	piston	39°44'.77N	10°39'.93W	4783	?	
"	trigger	"	"	"	?	
56426-1	mega	39°51'.63N	11°3'.02W	4999	?	
56426-2	kasten	39°51'.67N	11°2'.99W	4999	-	no sample recovered
56427-1	piston	39°46'.39N	11°3'.49W	5040	8.06	6 sections (1.13m, 1.51m, 0.93m, 1.50m, 1.50m, 1.49m
"	trigger	"	"	"	0.76	
56428-1	piston	39°48'.72N	10°53'.43W	4860	6.53	5 sections (1.10m, 0.93m, 1.50m, 1.50m, 1.50m)
"	"	"	"	"	0.75	
56429-1	piston	39°49'.20N	10°54'.78W	4880	4.52	4 sections (1.53m, 1.53m, 0.76m, 0.70m)
"	trigger	"	"	"	-	no trigger core recovered (?)
56430-1	piston	39°50'.51N	10°54'.04W	4949	-	barrel bent - core liner empty, small amount of sand rec
"	trigger	"	"	"	-	(?)
56431-1	piston	39°47'.15N	10°36'.47	4742	3.00	2 sections (1.50m, 1.50m)
"	trigger	"	"	"	0.76	
56432-1	piston				-	no sample recovered
CORE 6	piston	37°59'N	10°31'.00W		8.65	7 sections (0.17m, 1.52m, 1.52m, 0.97m, 1.51m, 1.50m
CORE 7	piston	37°19'.00N	10°31'.00W		7.63	6 sections (1.36m, 1.52m, 0.64m, 1.08m, 1.50m, 1.53m
"	trigger	"	"		0.77	

Table 1: Coring stations

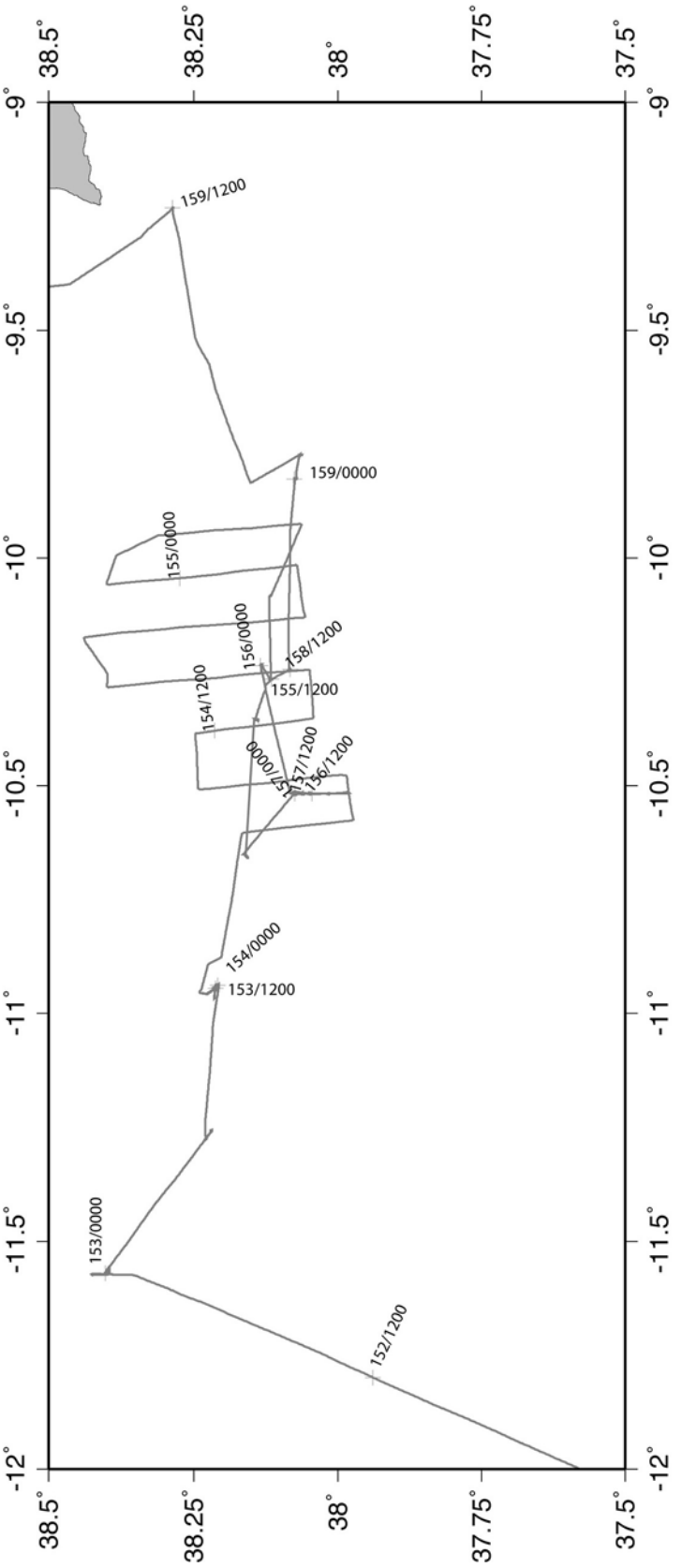

Fig. 1 Track chart for the Setubal Canyon area.

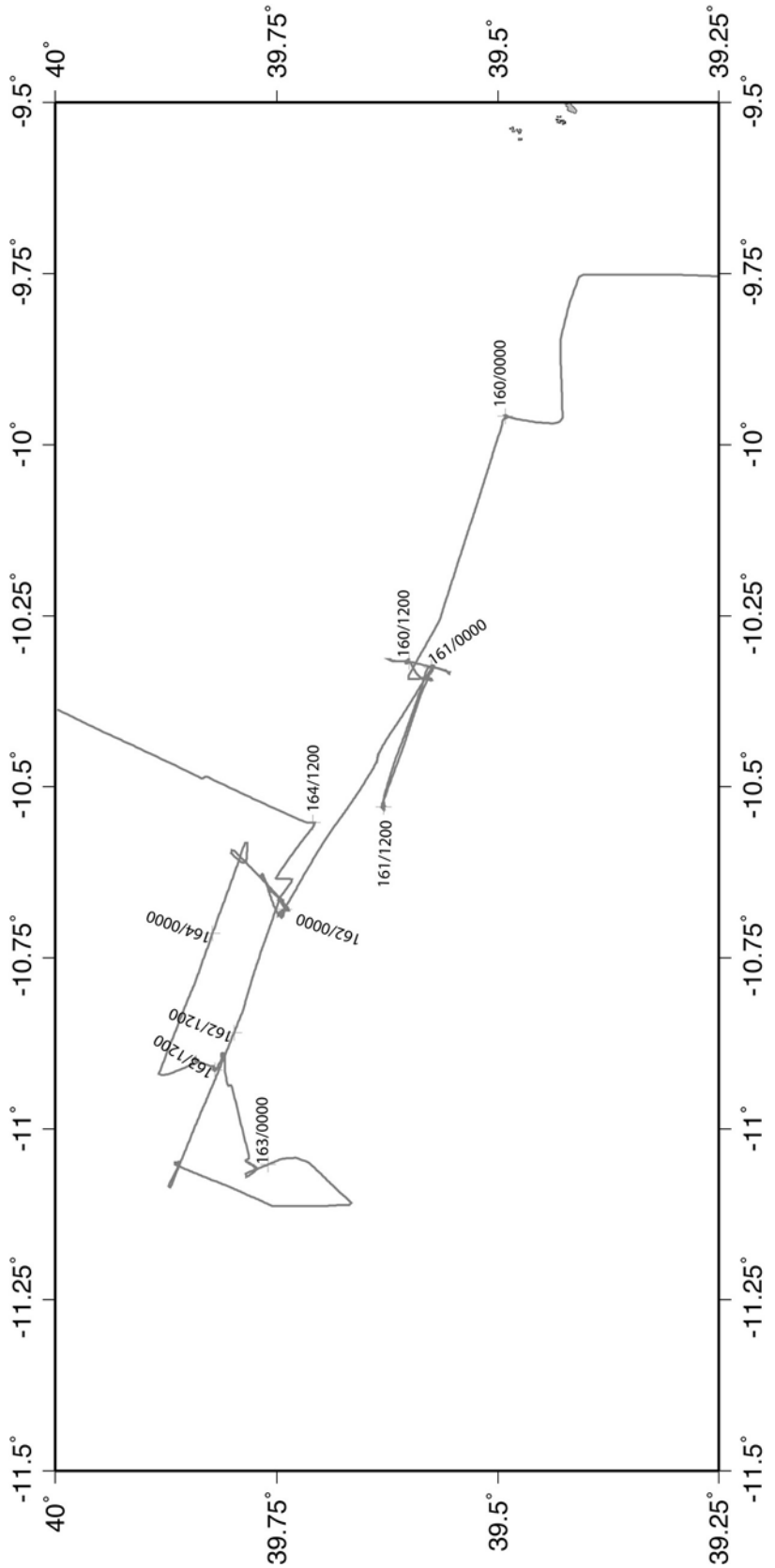

Fig. 2 Track chart for the Nazare Canyon area.