November 15, 1985

ERRATA

The bottom line of the text on page 1 of the Ocean Drilling Program Leg 107 Scientific Prospectus, Tyrrhenian Sea, is missing. This line should read:

disturbance of sediment during drilling have stymied previous attempts to

OCEAN DRILLING PROGRAM

LEG 107 SCIENTIFIC PROSPECTUS

TYRRHENIAN SEA

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INTRODUCTION

The present day Mediterranean Sea basins result from the consumption of the former Mesozoic Mesogean and Tethyan ocean areas and from the subsequent opening of young arc basins: the Western Basin, the Aegean and Tyrrhenian basins (Rehault et al., in press; Fig. 1). Drilling in the Tyrrhenian Basin has three main objectives, each of which considers the Tyrrhenian in a slightly different light:

(1) as a stratigraphic type locality,
(2) as a young passive margin (Fig. 2),
(3) as a back-arc basin.

The Tyrrhenian Sea (Fig. 3) also appears to be one of the rare examples of a tectonic basin where there is interference between collision and subduction processes creating a marginal basin. It may provide a reference model for other collisional basins of the Tethyan (Banda-Sunda) and Caribbean realms. The Tyrrhenian basin may also be a model for the evolution of previous Mediterranean basins and for those still to evolue.

To meet these objectives, JOIDES Resolution will depart Malaga, Spain on 1 January 1986 and return to Marseilles, France on 18 February 1986, with a total of 48 days at sea (6 days of transit and 42 operational days).

BACKGROUND AND SCIENTIFIC OBJECTIVES

(1) The Tyrrhenian Sea as a stratigraphic type locality:

The first goal of Leg 107 is to obtain as complete as possible recovery of a near-continuous pelagic Plio-Pleistocene sequence. This sequence will serve as a "deep-sea type section" in which various chronologies based on biostratigraphy, magnetostratigraphy, tephrachronology, and stable isotope stratigraphy can be correlated.

This goal is seen as particularly urgent because many of the Neogene stages and stage boundaries which are now used worldwide were originally defined and stratotyped in the circum-Mediterranean region (Thunnel et al., 1984). But unfortunately, Mediterranean sections represent deposition in a restricted basin rather than the open ocean. There have been numerous attempts to demonstrate the isochroneity and/or diachroneity of various Neogene microfossil datums between the Mediterranean and the rest of the world (Cita et al., 1965; Cita, 1973; Ryan et al., 1974; Berggren, 1977; Thunnell, 1979; Spaak, 1983; Rio et al., in press), but no clear consensus has emerged. Thus, there remains a suspicion that the timing of biostratigraphic events or isotopic events at the type localities in the enclosed Mediterranean may be different to that of the open ocean.

A major stumbling block has been the lack of a reliable Neogene paleomagnetic record from either the deep sea or land throughout the Mediterranean region. Open ocean biostratigraphic data have been directly calibrated to the magnetic polarity time scale, but problems with chemical overprinting, low intensities of magnetization, poor sections and disturbance of sediment during drilling have stymied previous attempts to make this correlation in the Mediterranean (Nakagawa et al., 1971 and 1975; Watkins et al., 1974; Arias et al., 1980; Ryan, 1973). Reliable magnetostratigraphy can provide the essential absolute time scale against which biostratigraphic and isotopic time scales can be calibrated, thus tying the Mediterranean stratigraphy to that of the rest of the world. We hope to obtain such a record by oriented double APC coring at Site TYR 2.

(2) The western Tyrrhenian Sea as a young passive margin:

The western Tyrrhenian is an example of the class of margins in which continental crust has been stretched and thinned by listric faulting (Fabbri et al., 1981) prior to the onset of formation of basaltic oceanic crust (Moussat, 1983; Steinmetz et al., 1983). As off the coasts of Spain or New Jersey, seismic reflection profiles reveal tilted fault blocks, each with a pre-rift sequence of uniformly tilted strata, a landward thickening and landward tilted syn-rift sequence, and an untilted post-rift sequence.

A goal of much of the work on passive continental margins has been to work out the timing and rates of extension and subsidence during the stretching phase, as well during the stage of oceanic crust formation (Watts and Ryan, 1976; Steckler and Watts, 1982). A major problem in such studies has been the relatively poor control during the stretching phase and during the earliest stages of oceanic crust formation. This problem has arisen because the classic localities for study of passive margins adjoin mature ocean basins. Thus, the earliest stages of opening occurred so long ago that the sedimentary record for the critical interval may be too deeply buried to reach by practicable drilling, and in any case the resolution of micropaleontologic age and paleodepth indicators in such old sediment is fairly poor.

The passive margin on the west side of the Tyrrhenian has the advantage that it adjoins a young oceanic basin and has a relatively low sedimentation rate (Rehault et al., 1984a). Thus, the syn-rift/post-rift and even the pre-rift/syn-rift contact are easily accessible to drilling. Furthermore, the paleontological resolution of both paleodepth and age during the interval of extension (roughly Burdigalian to the present) is quite precise.

We plan to address the timing of extension and subsidence on the western Tyrrhenian passive margin at Sites 1, 3, and 4, and possibly 6. By drilling several syn-rift sequences along a transect from the upper margin to the oceanic crust we can test the hypothesis that extension did not occur uniformly in space and/or time. The possibilities which have been suggested include: (1) the whole basin was affected by an early (18 Ma to 10 Ma) rifting phase and then a second phase of rifting (10 Ma to 6 Ma) was concentrated in the central area; (2) an early, abortive phase of extension occurred on the Sardinian margin, and later extension was confined to the central area; and (3) the entire basin was affected by two distinct, but superimposed, rifting phases.

A secondary passive margin objective of the leg is to test the hypothesis that during the transition from stretching of continental crust to injection of oceanic crust, there is a brief interval when mantle material rises quite close to the seafloor (Boillot et al., 1980). This hypothesis can be tested by drilling Site 5A into a ridge at the contact between continental and oceanic crust. This ridge has a magnetic signature (Bolis et al., 1981) , which may indicate altered mantle material, e.g., serpentinized ultramafics (or simply oceanic crust).

(3) <u>The Tyrrhenian Sea as a back-arc basin:</u>

The Tyrrhenian Sea is an example of the class of small basins, floored with oceanic crust, which have opened behind the overriding edge of a subduction plate boundary (Ryan, Hsu et al., 1973; Hsu, Montadert et al., 1978). In common with other back-arc basins, the Tyrrhenian exhibits:

- a 450 km deep Benioff zone dipping to the northwest beneath the Calabrian arc (the toe of Italy, Fig. 4) (Gasparini et al., 1982),
- a calcalkaline volcanic belt (the Eolian Islands) on the arcward edge of the basin (Barberi et al., 1974; Selli et al., 1977),
- a thinned crust on the margins linked to an important uprising (oceanic crust?) of the upper mantle and asthenosphere beneath the central part of the basin (Panza et al., 1980; Recq et al., 1984; Fig. 5),
- a positive gravity anomaly (250 mgal) located in the central part of the basin (Morelli, 1970; Fig. 4),
- tholeiitic vulcanism in the central part of the basin (Barberi et al, 1978; Dietrich et al., 1978),
- a high heat flow (200 mW/m^2; Rehault, et al. 1984b, Hutchison et al., 1985),
- a high amplitude magnetic anomalies (Bolis et al., 1981).

As in most back-arc basins, it is difficult to identify well-organized seafloor spreading magnetic anomalies in the Tyrrhenian. However, several lines of evidence growing from heat flow studies (Della Vedova et al., 1984), refraction experiments (Ferruci et al., 1982; Recq et al., 1984), and distribution of dredged basalts (Beccaluva et al., 1985; Colantoni et al., 1981), suggest that there may be or have been two discrete geographic focuses of oceanic crust formation: A western oceanic center in the Vavilov basin and an eastern center in the Marsili basin. Several investigators have suggested that the Marsili center is older than the Vavilov center and that the site of oceanic crust formation has moved towards the subduction zone (southeastward) over time (Moussat, 1983; Hutchinson et al., 1985; Maliverno and Ryan, in press). Thus, the Tyrrhenian provides a site at which to test the hypothesis of expansion of a back-arc basin through seaward migration of the arc and subduction zone (Boccaletti et al., 1976; Ritsema, 1979). We plan to compare the age and geochemistry of Vavilov basin basalt versus Marsili basin basalt by drilling to basement at sites 5B and 7.

A secondary back-arc basin objective of the leg is to explore the balance between volcanic arc volcanism and back-arc basin volcanism along the eastern edge of the basin. Dredging on Marsili seamount has recovered both calc-alkaline rocks typically indicative of arc volcanism, and tholeiitic basalt more typically indicative of mid-ocean ridge volcanism (Beccaluva et al., 1985). At Site TYR 8 located on the flank of Marsili Seamount, we hope to recover flows and volcanoclastics of both calc-alkaline and tholeiitic geochemical families in true stratigraphic position. The timing of the two types of volcanism, the nature of the contact between them, and the presence or absence of intermediate chemistry rocks, provide critical constraints on the "plumbing system" and magmatic processes which could give rise to such widely divergent dredge samples.

Although linear magnetic anomalies cannot be identified with confidence, several lines of reasoning suggest that the direction of opening of the Tyrrhenian basin is oriented WNW-ESE (Moussat, 1983; Maliverno and Ryan, in press). The direction of opening is controlled by two collision boundaries (the Apennines chain on the east and the Sicilides on the SW) (Boccaletti et al., 1976; Rehault et Al. in press; Fig. 1), which constrain the direction of back-arc opening towards the only remaining active subduction boundary, towards the Calabrian arc, towards the southeast (Fig. 1, 2 and 4). The opening of the basin appears to have begun in at least Tortonian time (Rehault et al., in press; Fig. 1). This age is coherent with the evolution of the Apennines after the Burdigalian collision.

The final objective of Leg 107 is to compare the history of extension and subsidence in the Tyrrhenian with the history of collision in the surrounding mountain chains. Careful mapping from the Apennines to the Sicilides has documented discrete phases of compression in the Messinian, middle Pliocene, and Pleistocene (Ghisetti and Vezzani, 1981; Tortorici, 1981). Based primarily on seismic stratigraphy, particularly across normal faults Moussat et Al. (in press) have suggested that the evolution of the Tyrrhenian basin is characterized by a long period of continuous extension and subsidence (upper Tortonian-Pleistocene) during which brief paroxysmal phases of accelerated subsidence and/or extension occured. We suspect that these inferred phases of extension/subsidence in the basin may be related to well documented phases of compression in the mountain chains. By drilling through key seismic reflectors in different areas of the basin we will be able to test this hypothesis by (1) calibrating the seismic stratigraphy of the basin and thus the activity of many of the normal faults of the basin. (2) determining whether some reflectors are caused by changes in sedimentation regime related to changes in basin subsidence rate.

PREVIOUS WORK

Numerous geological and geophysical studies have been conducted in the Tyrrhenian Sea by groups from Italy, France, United States, United Kingdom, and West Germany. Site surveys used for location of these proposed sites include geophysical surveys by IFP/IFREMER Paris, IGM Bologna, LGSM Villefranche sur Mer, and OGS Trieste, geological sampling by IGM-CNR. CNRS submersible observations from "Cyana" and "Seabeam" mapping of the central plain and surrounding margins have also contributed to the site selections. The area was drilled by both of the previous DSDP cruises in the Mediterranean Sea: Leg 13 (Site 132) and Leg 42A (Site 373).

Site 132 is located at the junction between the western and central abyssal plains. Plio-Pleistocene fossiliferous pelagic oozes of deep-water facies were drilled at Site 132 (Ryan and Hsu, 1973). The topmost interval of the evaporitic series was penetrated, demonstrating the late Miocene (Messinian) age of this pan-Mediterranean event.

Site 373A is located on the flank of a small seamount in the Vavilov Basin. This site reached a buried magnetic basement. This hole penetrated to 457 m depth. A 270-m Plio-Pleistocene sequence of nannofossil marls, zeolite marls, and volcanic ashes and sands overlies a mid-ocean ridge basalt (MORB) and breccia complex (Hsu and Montadert, 1978). This complex was dated between 7.3 Ma and 3.5 Ma by radiometric measurements (Kreuser et Al., 1978). However, since Hole 373A lay on the flank of a seamount this data does not necessary coincide with the regional emplacement of oceanic crust. Also, the contact between sediments and volcanics was not sampled.

DRILLING PROGRAM: SPECIFIC SITE OBJECTIVES

The Tyrrhenian Sea drilling program planned for Leg 107 (Tables 1 & 2) spans the upper Sardinian margin and the two deep oceanic basins, thus providing a transect (Fig. 6), along the inferred maximum extension direction (WNW-ESE) of this back-arc basin.

PRIORITY 1 DRILLSITES:

Site TYR 1B (Fig. 8) will be drilled on the Sardinian upper margin where the crust is thought to be 25 Km thick. The prime objective of this 800 m single-bit hole is to date the contacts between pre-rift, syn-rift and post-rift sequences. Dating of these 'events' is necessary as input to models for stretching and subsequent subsidence of the continental margin.

Site TYR 2 (Fig. 9) is located in a similar setting to the former DSDP Site 132. This will be a double oriented APC hole that will penetrate to 200 m BSF. Site TYR 2 will allow us to establish a "deep-sea stratigraphic type section" comprising biostratigraphy, magnetostratigraghy, isotope stratigraphy and tephrachronology for the Plio-Pleistocene series. Such a section will provide a standard for correlations between inter-regional land-based stratotypes and open ocean records. In particular, a direct calibration of Mediterranean biostratigraphy with the geomagnetic polarity time scale should be established.

Site TYR 3A (Fig. 10) lies on the lower Sardinian margin (continent-ocean transition), on the last of the tilted blocks occurring east of the Central Fault, where continental crust appears most stretched. This site will be drilled through assumed Plio-Pleistocene, Messinian and pre-Messinian syn-rift sediments, and possibly also pre-rift sediments. This 900 m single-bit hole will provide timing for the stretching phases and for crustal thinning in the central area. This timing of events will be compared to those of Site TYR 1B.

Site TYR 5B and Site TYR 5B' (Fig. 14 & 15) are located in the region inferred to be oceanic on the basis of heat flow, refraction and magnetic measurements. A 550 m depth continuously cored single-bit hole is planned, for one of those two sites, to penetrate 50 m into the basaltic basement. The petrology and geochemistry of the basalt and any hydrothermal deposits at the basalt-sediment contact will be compared to results from other back-arc and oceanic basins. A secondary objective is to determine the nature and age of a widespread diffuse seismic unit which occurs at around 400 msec subbottom; this sequence has been interpreted as either volcanoclastic or subaerial clastic sediments. The age of the basement and of the youngest sediments here will be compared with sites in the Marsili Basin.

Site TYR 7B (Fig. 18) is located in the eastern deep basin of the Tyrrhenian Sea (Marsili Basin). Several indications (heat flow, volcanism, hydrothermal activity) as well as the hypothesis of a south eastward migration of the subduction zone suggest that Marsili Basin is younger than the Vavilov Basin (Site TYR 5A and B). Neither the basement nor the sedimentary section of the Marsili Basin has ever been drilled. A 420 m single bit hole is planned to penetrate 50 m into the acoustic basement. The primary goals are to verify whether basalt is present and to compare the age and geochemistry of Marsili Basin with Vavilov Basin. Above basement is an acoustically weak but widespread seismic sequence (Volcanoclastics?, basalt flows?, Late Miocene clastics?) which may shed additional light on the formation and evolution of the basin. Site TYR 7B will also be important for tephrachronologic studies; as our easternmost priority, Site TYR 7B can be used to study the explosive volcanism in the Tyrrhenian volcanism arc.

PRIORITY 2 DRILLSITES:

Site TYR 4 (Fig. 12): like Site TYR 3A, Site TYR 4 is located on thin crust, at the base of the continental margin. This site lies on the western flank of an assymetric basement ridge (De Marchi Seamount). Mesozoic sediments have been sampled from the eastern flank of this ridge. If Site TYR 3A fails to reach the prerift-synrift contact, Site TYR 4 offers an opportunity to sample this contact at a shallower depth.

Site TYR 5A (Fig. 13) is a limited penetration hole located on a highly magnetic N-S trending ridge which lies near the contact between continental and supposed oceanic crust. The nature of the ridge is unknown but analogies with other continent-ocean transition zones (eg. Galicia Bank ODP Site 637) suggest that lherzolite or serpentinite are present. If we confirm the presence of ultramafic rocks on this ridge it will support the hypothesis that mantle uprising occurs at the commencement of rifting. Note that, unlike the Galicia Margin ridge drilled at Site 637, this ridge is associated with a magnetic anomaly.

Site TYR 6 (Fig. 16) lies on the western edge of the Marsili Basin. Numerous subparallel northwestward dipping reflectors may indicate the top of a recently tilted block associated with the stretching and opening of the Marsili Basin. It is proposed to drill a single-bit hole to 600 m depth in order to pinpoint the time of tilting by dating the contact between units 1 and 2.

Site TYR 8 (Fig. 19) is located at the base of Marsili Seamount. A 400 m single-bit hole is proposed to be drilled to document sequences of lava flows intercalated with marine sediments. This site is planned to clarify the history of volcanic activity in this region.

ALTERNATE DRILLSITES:

Site TYR 1A (Fig. 7) is located on the Sardinian margin which has been interpreted as the location of two superimposed rifting episodes, the first related to the rifting of the Western Mediterranean Basin and the second related to the opening of the Tyrrhenian Sea. Drilling at this site (Fig. 7) could penetrate the alleged syn-rift sediments of the first episode (Unit 2) and the second episode (Unit 3), as well as pre-rift (Unit 1) and post-rift (Unit 4) sediments.

Site TYR 1B' is located on the Sardinian margin on the same tilted block as Site TYR 1B (Fig. 8) and slightly updip. A 500 m single bit hole is proposed to document the pre-rift sequences and their contacts with the underlying acoustic basement if this basement cannot be sample at Site TYR 1B.

Site TYR 3C (Fig.s 11) is planned as alternate if the presence of salt is confirmed at Site TYR 3A. This site is located in the same geologic setting as Site TYR 3A and represents the same objectives.

Site TYR 7A (Fig. 17) is an alternate of Site TYR 7B and lies in a similar structural and stratigraphic setting than Site TYR 7B.

TABLE 1: PROPOSED LEG 107 DRILLING PROGRAM

Site	Location	Travel Time (days)	Time at Site (days)	Departure Date (approximate)
	Depart: Malaga (Spain)			1 January 1986
	Underway	3.0		
TYR 2	40°04'N 11°29'E		4.0	8 January 1985
	Transit	0.2		
TYR 1B	40°35'N 10°42'E		7.5	15 January 1985
	Transit	0.3		
TYR 3A	40°21'N 12°09'E		11.5	27 January 1986
	Transit	0.1		
TYR 5B	40°09'N 12°41'E		9.0	5 February 1986
	Transit	0.2		
TYR 7A	39°29'N 14°08'E		9.0	14 February 1986
	Transit	0.2		
TYR 5A	40°10'N 12°13'E †	One of these two sites will be drilled if time is available.		
TYR 8	39°10'N 14°13'E †			16 February 1986
	Transit	2.0		
	Arrive: Marseilles (France)			18 February 1986
		6.0	42.0	48 days

TABLE 2: ODP LEG 107 PROPOSED SITES

Site	Location	Water Depth (m)	Total Penetr. (m)	Operations	Objective
TYR 1A	40°04.00'N 10°13.00'E	1875	850	RCB	Multirifting evolution of the Sardinian margin
TYR 1B	40°35.45'N 10°42.00'E	2175	800	RCB	To sample pre-, syn- and post-rift series of Sardinian margin
TYR 1B'	40°33.00'N 10°44.00'E	2210	550	RCB	Same as TYR 1B
TYR 2	40°04.28'N 11°29.00'E	2810	200 or more	Double APC	To establish a deep-sea bio-, magneto-, tephra- stratigraphy
TYR 3A	40°21.08'N 12°09.28'E	3375	900 or more	RCB	To determine nature and age of pre-, syn- and postrift series.
TYR 3C	40°28.00'N 12°07.85'E	3340	900	RCB	Same as TYR 3A
TYR 4	40°11.33'N 12°10.00'E	3525	860	RCB	Same as TYR 3A
TYR 5A	40°10.00'N 12°24.86'E	3525	100	RCB	To determine nature of a highly magnetic N-S trending ridge.
TYR 5B	40°09.61'N 12°44.00'E	3510	550	RCB	Nature of oceanic crust, mineralizations at basement contact.
TYR 5B'	39°55.00'N 12°47.00'E	3510	500	RCB	Same as TYR 5B, to determine reflector at 400 msec subbottom.
TYR 6	39°20.37'N 13°46.28'E	3420	600	APC/XCB	Contact between pre- and synrift sediments, to sample prerift.
TYR 7A	39°30.00'N 14°08.28'E	3450	520	APC/XCB	Nature and age of sediments and basement in the Marsili basin.
TYR 7B	39°19.25'N 13°52.85'E	3435	420	APC/XCB	Same as TYR 7A
TYR 8	39°10.00'N 14°12.85'E	3500	400	APC/XCB	Volcanic activity of SE Tyrrhenian Sea, nature of the basement

FIGURE CAPTION

Figures 1: General geological setting (After Rehault et al., in press):
1: Suture lines, major intracontinental overthrusts and paleo-subductions.
2: Active subduction and overthrusts.
3: Transform fault and strike-slip faults.
5: Major distensive sructures.
6: Highly deformed zone on the subduction fronts.
8: Ante-Paleozoic out-cropping.
9: Neogene oceanic crust.
10: Northern limit of stable African craton.

Figure 1A: 21 m.y. ago - Upper Aquitanian: End of Western Mediterranean rifting epoch (linked to Apulian African Northward subduction).

Figure 1B: 18 m.y. ago - Lower Burdigalian: End of oceanic accretion within Western Mediterranean collision between Apulia-Africa borderlands and Europe remnants of inner Arc (Calabria, Kabyles blocks, etc..).

Figure 1C: 6 m.y. ago - Lower Messinian: Opening of the Tyrrhenian Sea. Continuous subsidence of the Western Mediterranean Sea (cooling); progress of rifting within the whole Tyrrhenian basin especially in the central basin with first emplacement of oceanic crust in Vavilov basin. South-Eastward progression of the Calabrian Arc.

Figure 1D: Present: Continuity of subsidence of the whole basins and margins since the last 6 m.y., including paroxysm events linked to outer compression phases (Apennine-Calabria-Sicily). Progress of oceanic accretion in Southern central basins, progress of rifting Northward, calc-alkaline magmatism of the Eolian Arc, drifting of the Calabrian Arc toward the deep Ionian Basin.

Figure 2: The western third of the Tyrrhenian Sea is an Atlantic-type stretched continental margin, characterized by tilted and rotated fault blocks and by thinned continental crust. This figure, (from Maliverno et Al., 1981) points up the similarities between the Biscay Atlantic margin (upper profile after Montadert et Al., 1979) and the Sardinia Tyrrhenian margin (lower profile, after Finetti and Morelli, 1972; Fabbri et Al., 1980; and Giese and Morelli, 1973).

Figure 3: Bathymetric Map of the Tyrrhenian Sea in meters. (After U.S. Defence Mapping Agency Hydrographic Topographic Center, 1979).

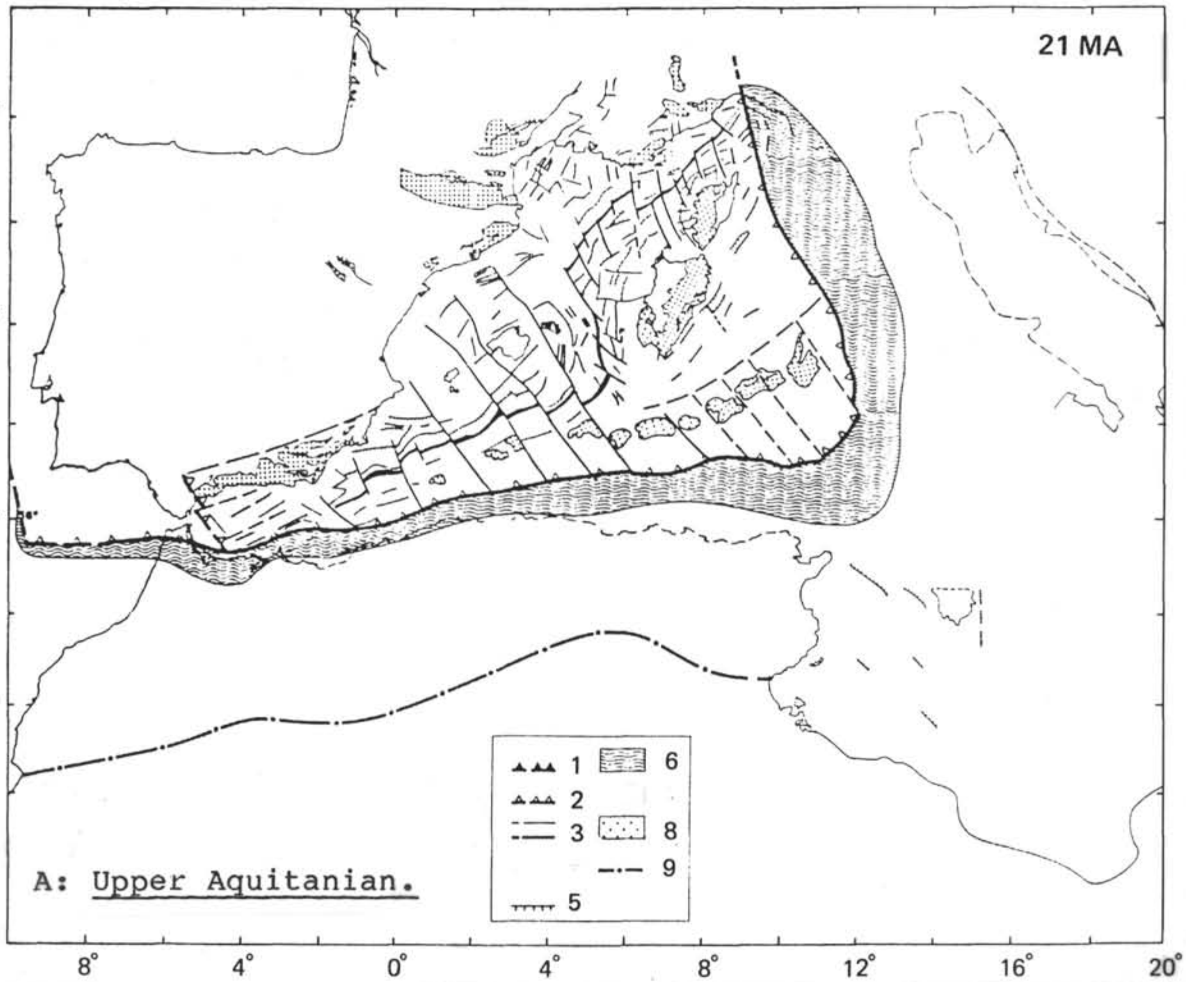
Figure 4: Simplified seismotectonic map of the Calabrian Arc (After Gasparini et al, 1982; Moussat, 1983). Note: the subduction is attested by a 450 km deep Benioff plane beneath Tyrrhenian Basin.
1: Isobath of the Benioff plan, in Km.
2: Deep faults deduced from earthquake mechanisms.
3: Strike-slip faults on land.
4: Bouguer gravity anomalies.
6: Front of the allochtonous nappes.
5: Emerged Quaternary volcanoes.

Figure 5: Moho depth distribution showing uprising of the upper mantle (up to 10 km) under the Tyrrhenian basin, correlated with large positive gravity anomaly (250 mgal) (After Recq et al., 1984). Note: the depth of the Moho decreases under the two separated basins (Vavilov and Marsili).

Inset: Lithosphere thickness (After Panza et al., 1980):
1: Isolines of the lithosphere-astenosphere boundary.
2: Low velocity oceanic lithosphere.
3: Continental lithosphere.
4: Anomalous upper mantle.

Figure 6: Site survey seismic lines map showing previous DSDP sites and ODP Leg 107 site locations.

Figures 7 to 19: Detail of IFREMER-IFP-CNRS Seismic lines showing Leg 107 sites locations.



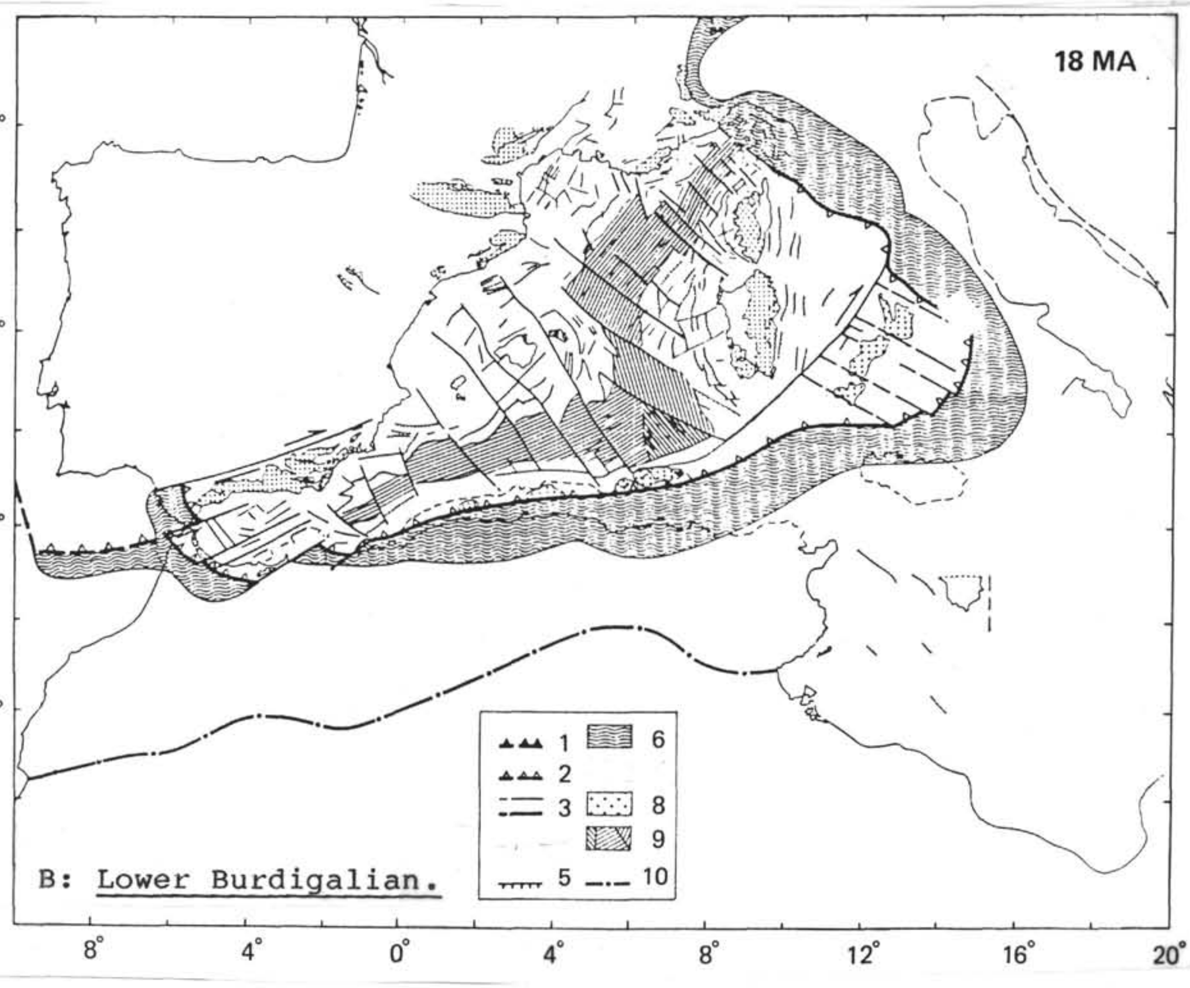
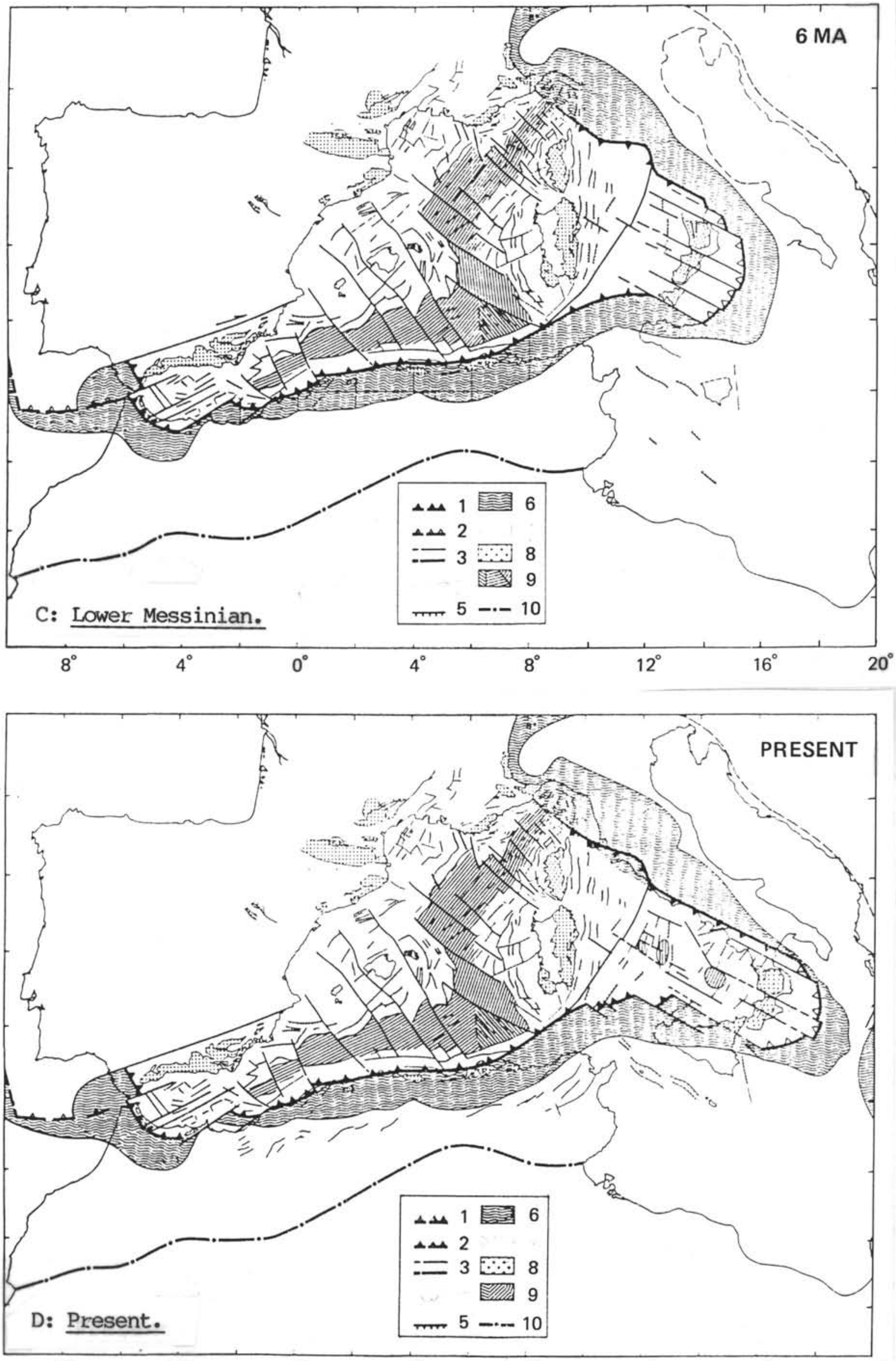


Figure 1: General geological setting (After Rehault et al., In press).



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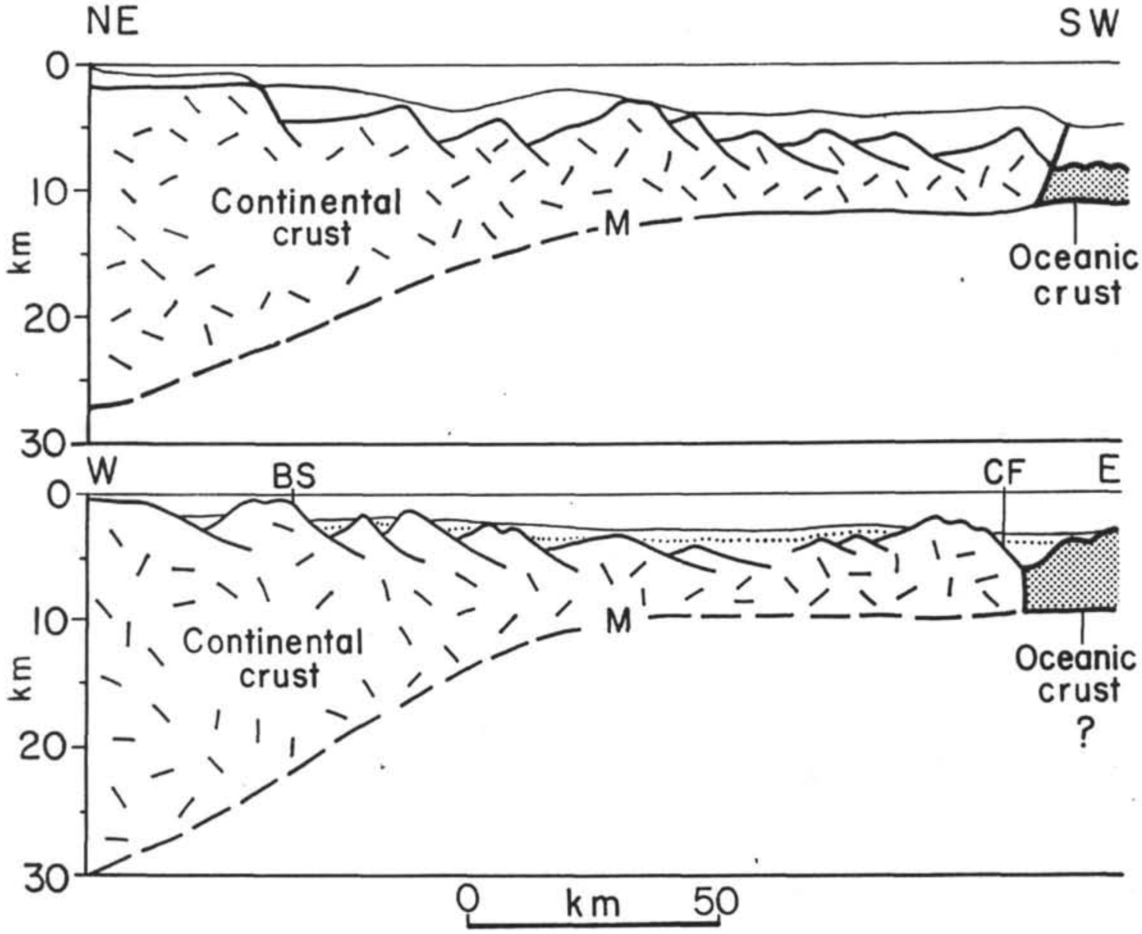
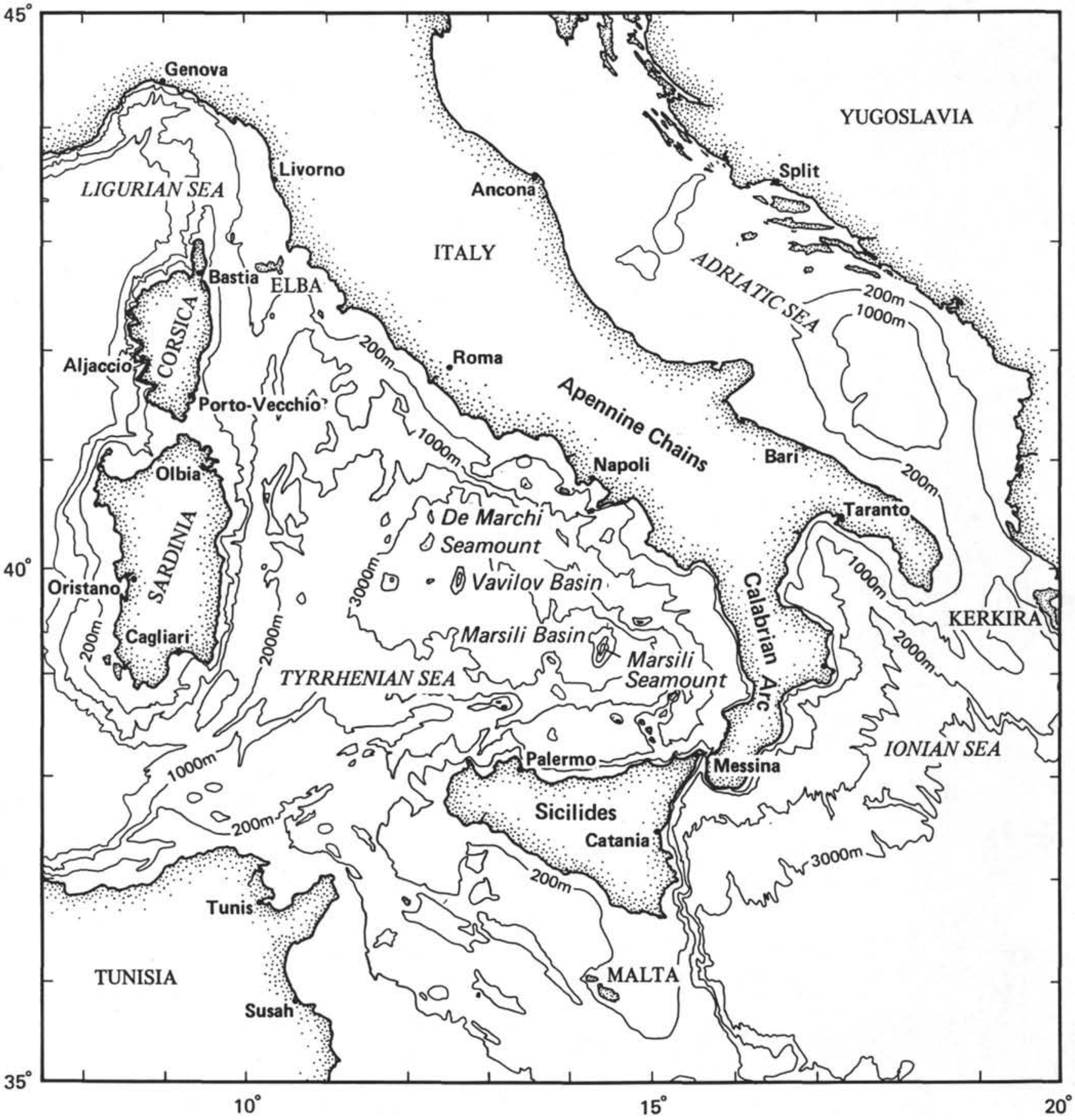


Figure 2: Comparison between a crustal section across the Atlantic continental margin in the Bay of Biscay (top) and a crustal section across the Sardinia Tyrrhenian margin (bottom, after Maliverno et Al., 1981).



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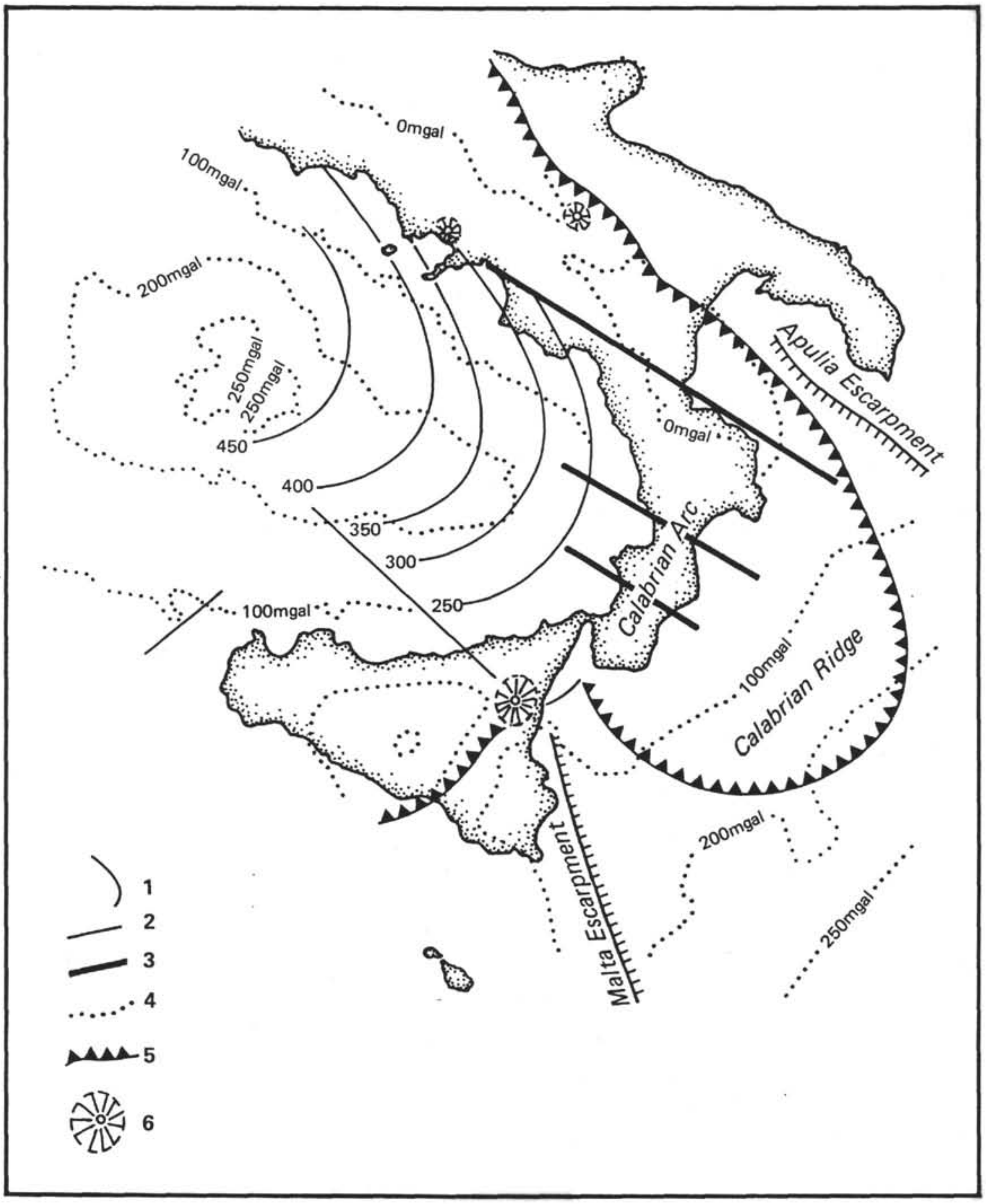

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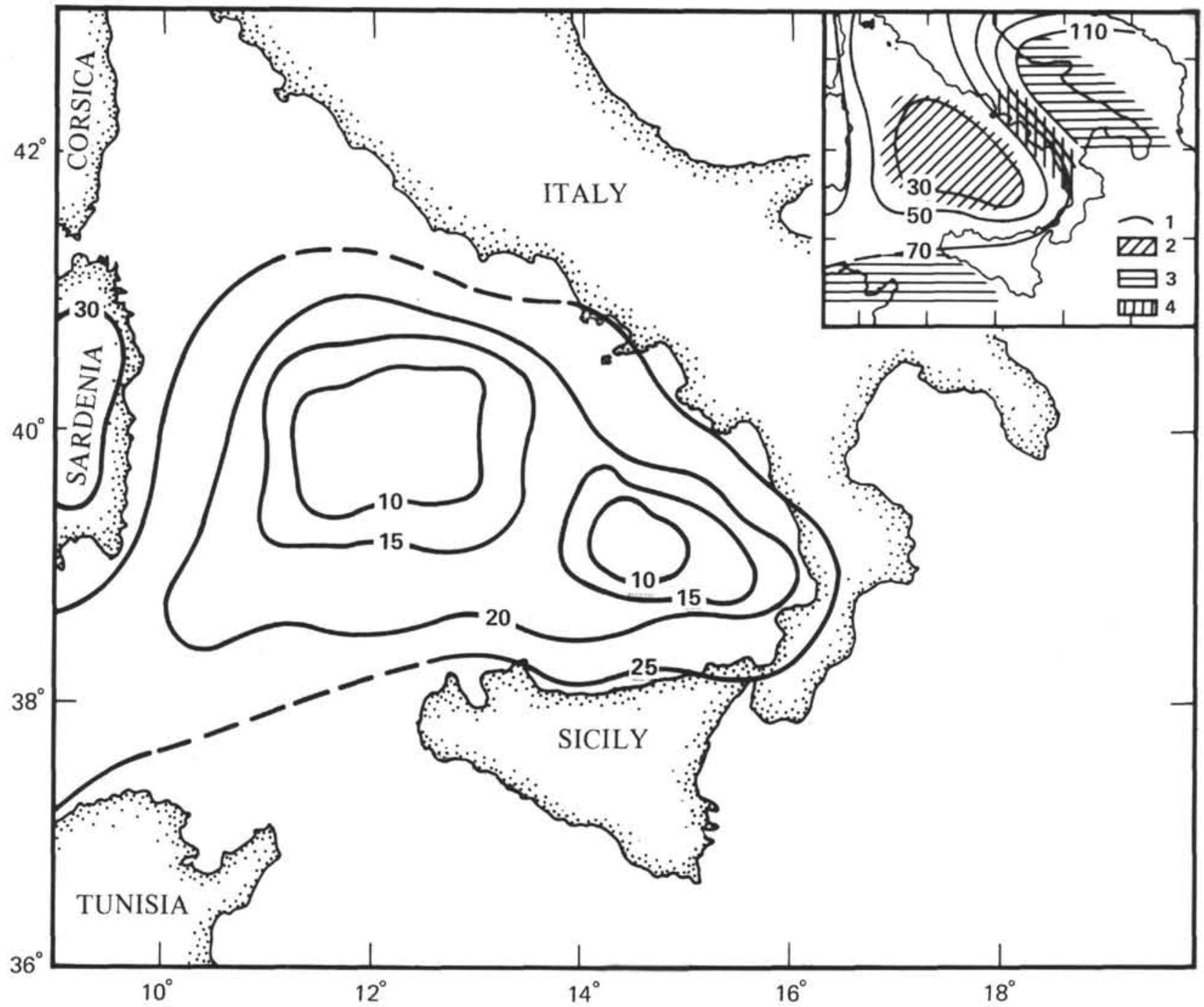

Figure 5: Moho depth distribution in the Tyrrhnian basin (After Recq et al., 1984). Inset: Lithosphere thickneess (After Panza et al., 1980).

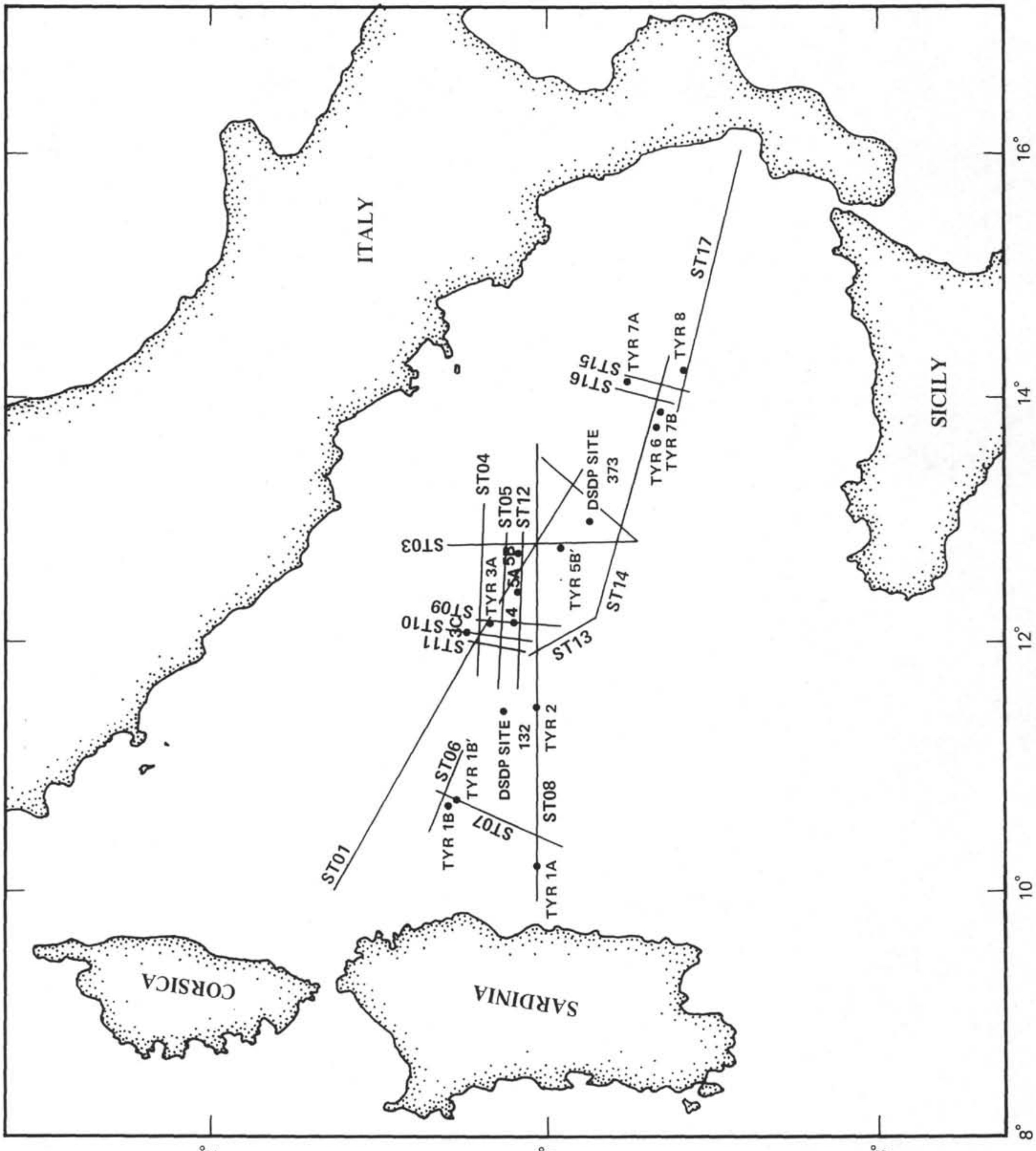

Figure 6: Site survey seismic lines map showing previous DSDP sites and ODP Leg 107 site locations.

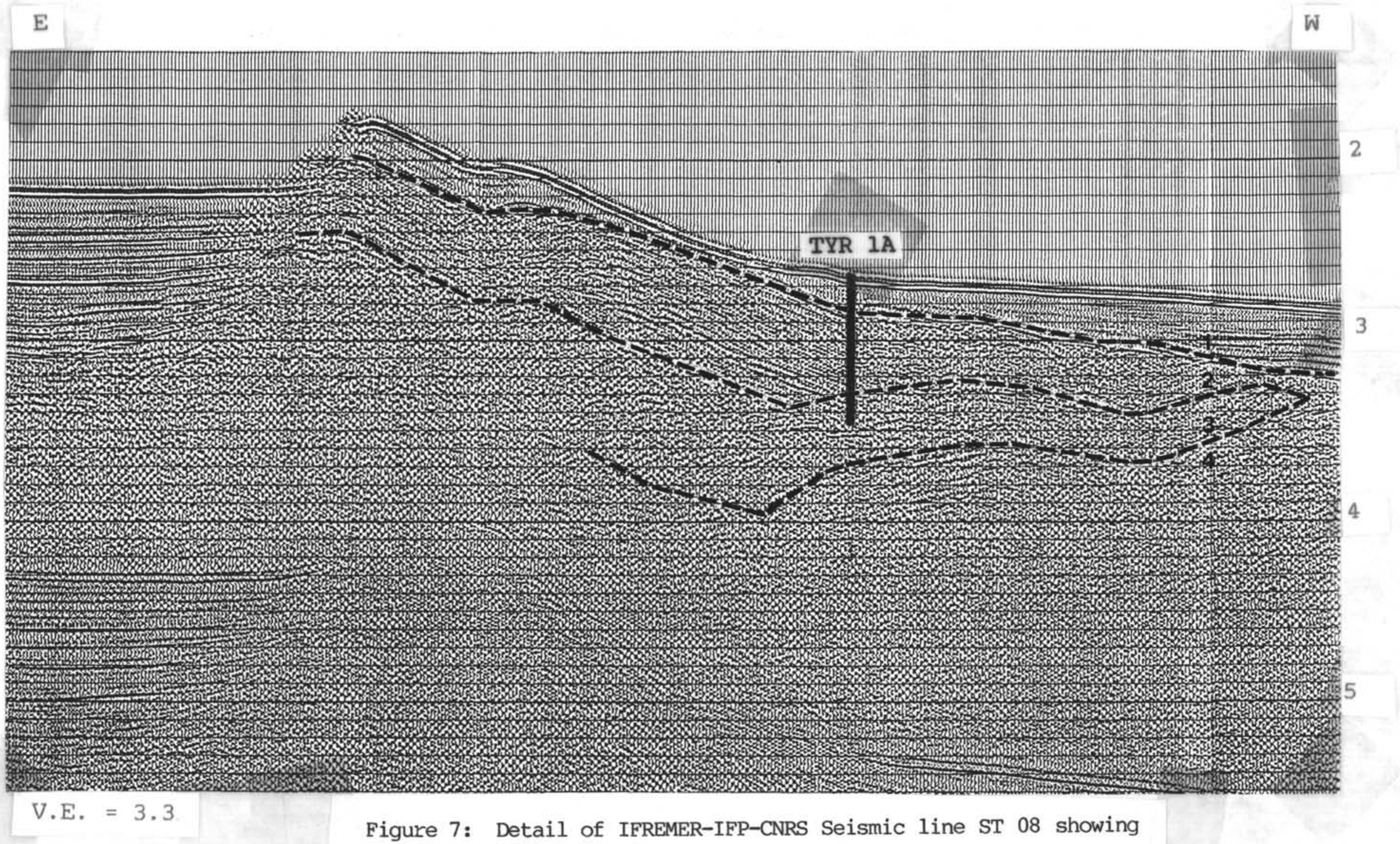

Figure 7: Detail of IFREMER-IFP-CNRS Seismic line ST 08 showing Site TYR 1A.

SITE NUMBER: TYR 1A (Southern Sardinian Margin)

POSITION: 40°04'N 10°13'E

SEDIMENT THICKNESS: > 1000 m

WATER DEPTH: 1875 m

PRIORITY: 1 (alternate)

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 850 m.

SEISMIC RECORD:

Single channel line TY 60, CEPM line OD 717,
IFREMER-IFP-CNRS multichannel line ST 08 (Shotpoint 485).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To sample the pre-, syn- and post-rift sediments on a tilted block in order to decipher the multirifting evolution of the Sardinian margin.

SEDIMENT TYPE:

- 0-40 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidite of Plio-Pleistocene age,
- 40-820 m: Pre-Messinian synrift sediments: layered seismic character suggests turbidites,
- 820-850 m: Pre-rift: age and lithology Unknown.

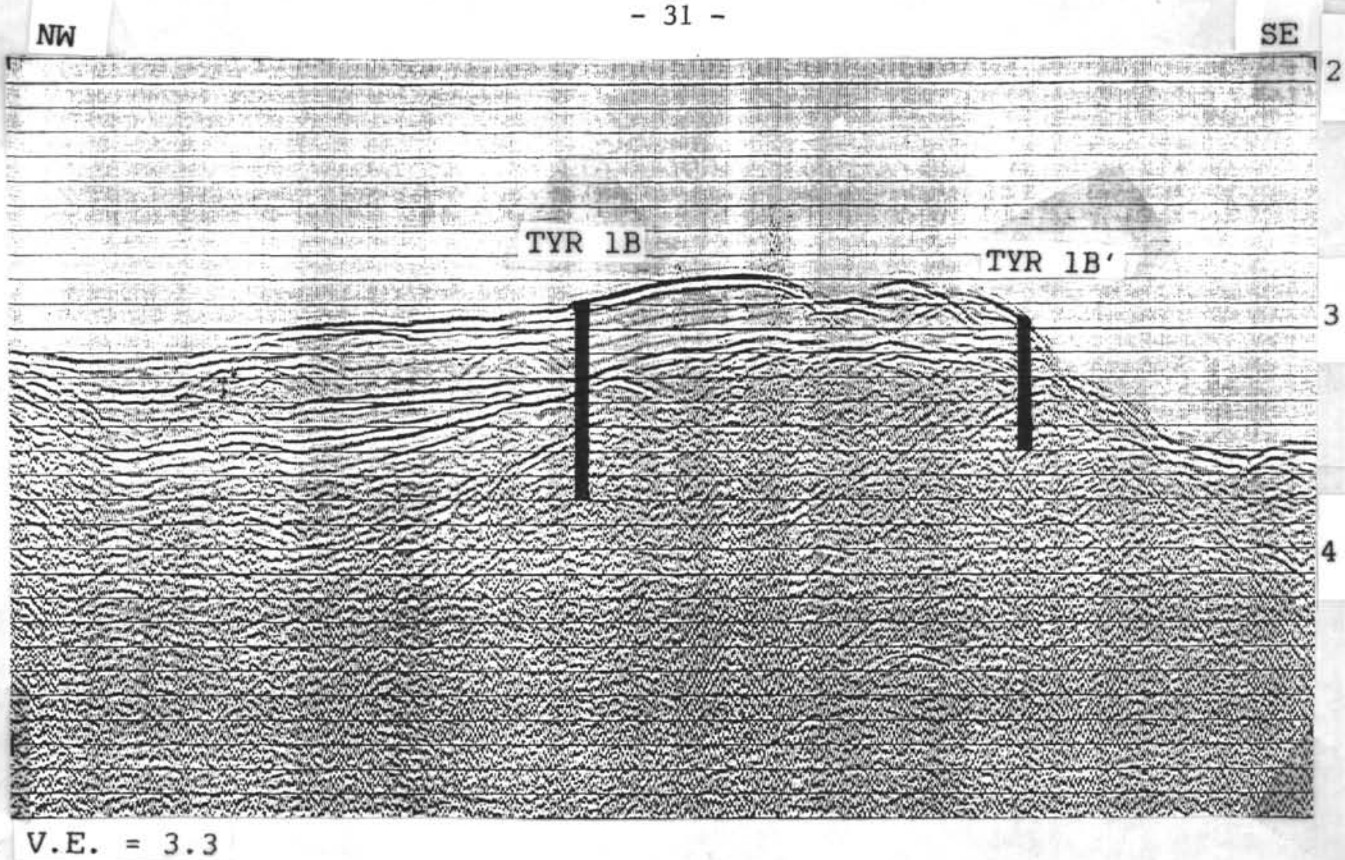

Figure 8: Detail of IFREMER-IFP-CNRS Seismic line ST 06 showing Site TYR 1B and Site TYR 1B'.

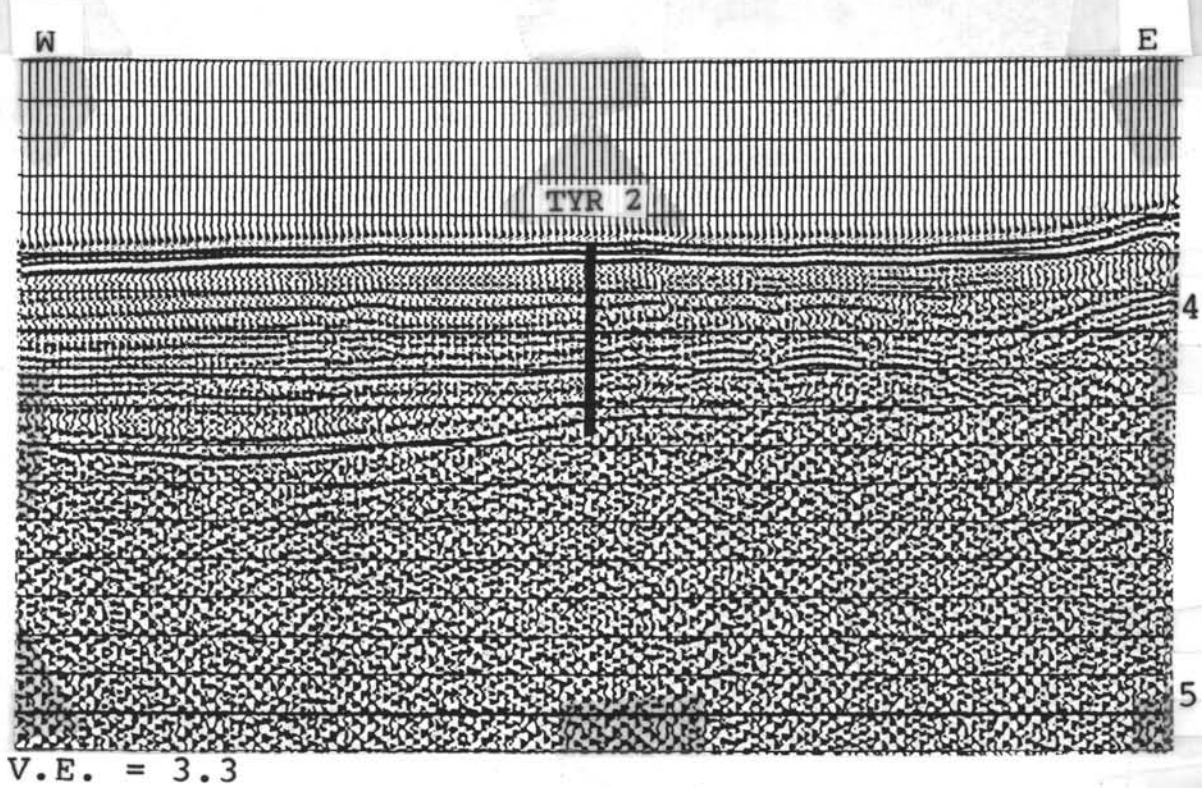

Figure 9: Detail of IFREMER-IFP-CNRS Seismic line ST 08 showing Site TYR 2.

SITE NUMBER: TYR 1B (Northern Sardinian Margin)

POSITION: 40°35'N 10°42'E

SEDIMENT THICKNESS: 800 m

WATER DEPTH: 2175 m

PRIORITY: 1

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 800 m.

SEISMIC RECORD:

Multichannel line MS 1,
IFREMER-IFP-CNRS multichannel Line ST 07,
IFREMER-IFP-CNRS multichannel Line ST 06 (shotpoint 1548).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To determine lithology, stratigraphy and age of pre-, syn- and post-rift series, to document pre-Messinian sediments and to date the regional stretching.

SEDIMENT TYPE:

- 0-250 m: Thin turbidites, hemipelagic marls, oozes and ashes of Plio-Pleistocene age,
- 250-330 m: Syn-rift: Subaerial facies and/or evaporites similar to Site 133 or alternatively Sabka facies similar to Site 134, upper Miocene age,
- 330-560 m: Pre-Messinian syn-rift series: possibly turbidites, marls, calcarenite, clays.
- 560-800 m: Pre-rift: age and lithology unknown, can be marls or shallow water carbonates including calcarenite, marble or dolomite.

SITE NUMBER: TYR 1B' (Northern Sardinian Margin)

POSITION: 40°33'N 10°44'E   SEDIMENT THICKNESS: > 500 m

WATER DEPTH: 2210 m   PRIORITY: 1 (alternate)

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 550 m.

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel Line ST 06 (shotpoint 1360).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To determine lithology, stratigraphy and age of pre-rift sequences.

SEDIMENT TYPE:

- 0-170 m: Pelagic and hemipelagic marls, oozes ashes and thin turbidites of Plio-Pleistocene age,
- 170-250 m: Syn-rift: Subaerial facies similar to Site 133 of Messinian age or erosional Messinian,
- 250-440 m: Syn-rift: Pre-Messinian, can be turbidites, marls, calcarenite, clays.
- 440-500 m: Pre-rift, age and lithology unknown. Possibly marls or shallow water carbonates including calcarenite, marble or dolomite,
- 500-550 m: "Basement", age and lithology unknown. Possibly schist, phyllite, gneiss, granite, sandstone or conglomerate.

SITE NUMBER: TYR 2 (Middle Sardinian Margin)

POSITION: 40°04'N 11°29'E

SEDIMENT THICKNESS: 200 m (to top of "M" reflector)

WATER DEPTH: 2810 m

PRIORITY: 1

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous oriented double APC to 200 m or more.

SEISMIC RECORD:

Multichannel line MS1 ,
IFREMER-IFP-CNRS multichannel Line ST 08 (Shotpoint 2590).

HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:

To establish a "deep-sea stratigraphic type-section" (biostratigraphy, magnetostratigraphy, isotope stratigraphy, and tephrachronology).

SEDIMENT TYPE:

- 0-200 m: Marls, oozes, tephra, sapropel, thin sand layers of Plio-Pleistocene age.
- 200-Bottom of the hole: Messinian evaporite facies.

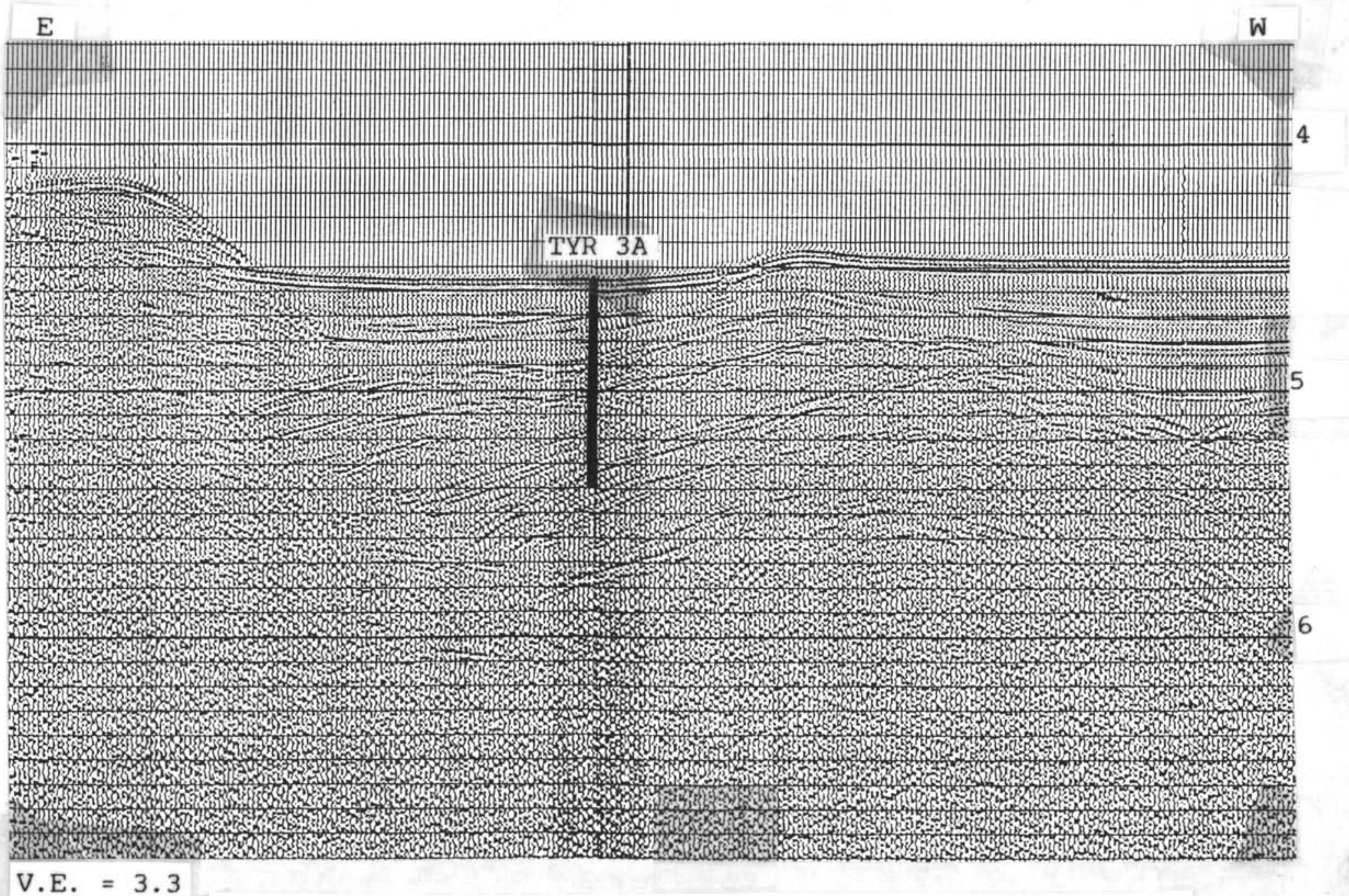

Figure 10: Detail of IFREMER-IFP-CNRS Seismic line ST 01 showing Site TYR 3A.

SITE NUMBER: TYR 3A (Lower Sardinian Margin)

POSITION: 40°21'N 12°09'E

SEDIMENT THICKNESS: > 1000 m

WATER DEPTH: 3375 m

PRIORITY: 1

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 900 m or deeper if possible.

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel Line ST 01 (Shotpoint 4250).

HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:

To determine the nature and age of pre-, syn- and post-rift sediments on the continental thinned crust, to compare these data with the results of Site TYR 1B and to correlate intra-Pliocene unconformities with Apennine tectonic activity.

SEDIMENT TYPE:

- 0-210 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 210-400 m: Messinian syn-rift sediments: Subaerial facies (?) including silts, shales and alluvial gravel,
- 400-755 m: Pre-Messinian syn-rift sediments: possibly turbidites, marls,calcarenite, clays,
- 755-900 m: Pre-rift series, age and lithology unknown. Possibly siltstone, sandstone, or shallow water carbonates including calcarenite, marble or dolomite.

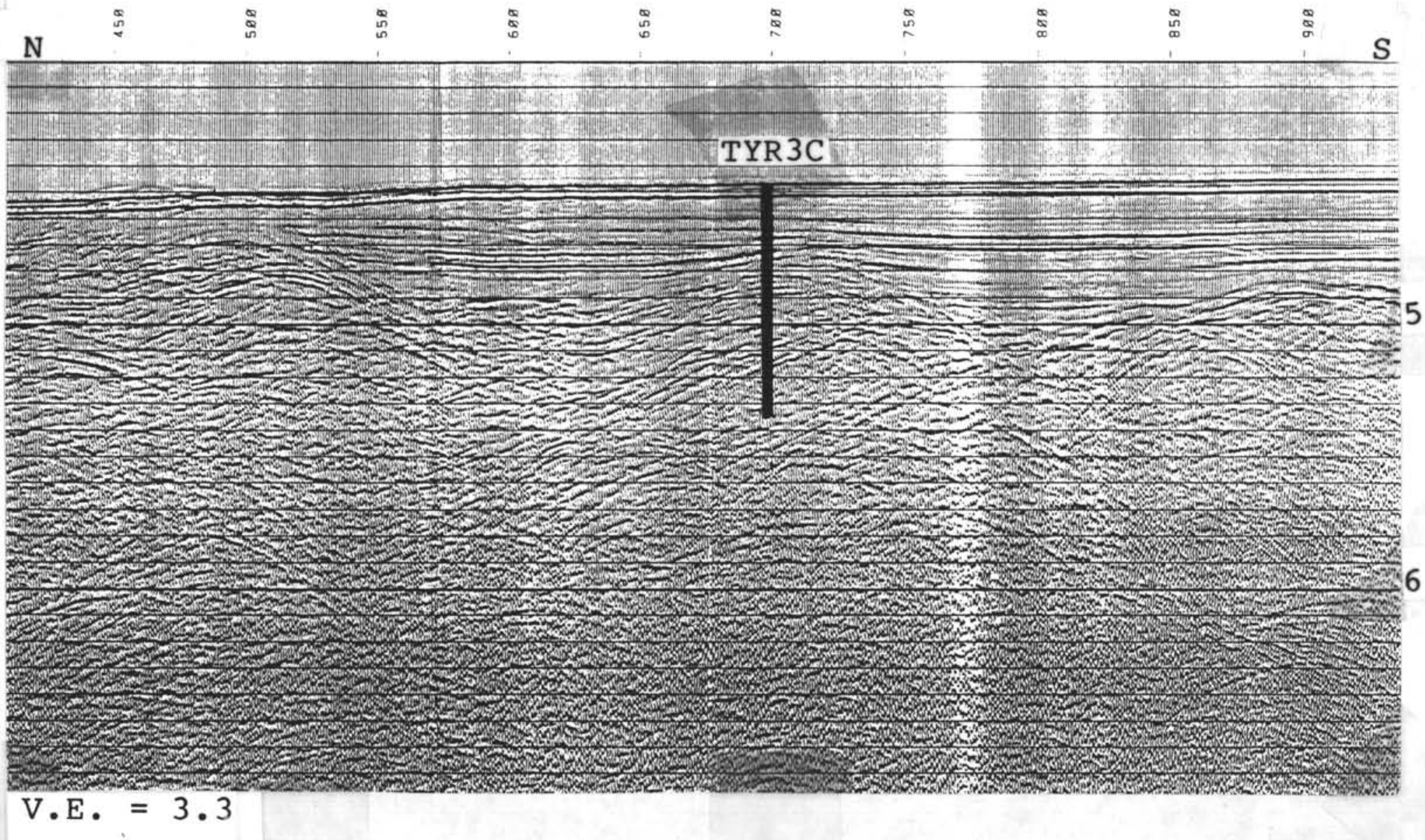

Figure 11: Detail of IFREMER-IFP-CNRS Seismic line ST 10 showing Site TYR 3C.

SITE NUMBER: TYR 3C (Lower Sardinian Margin)

POSITION: $40^{o}28'N$ $12^{o}08'E$

SEDIMENT THICKNESS: > 1000 m

WATER DEPTH: 3340 m

PRIORITY: 1 (Alternate)

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 900 m.

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel line ST 10, (Shotpoint 1700).

HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:

Same as TYR 3A.

SEDIMENT TYPE:

- 0-270 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 270-390 m: Messinian syn-rift sediments: Subaerial facies (?) including silts, shales and alluvial gravel,
- 390-690 m: Pre-Messinian syn-rift sediments: possibly turbidites, marls,calcarenite, clays,
- 690-900 m: Pre-rift series, age and lithology unknown. Possibly siltstone, sandstone, or shallow water carbonates including calcarenite, marble or dolomite.

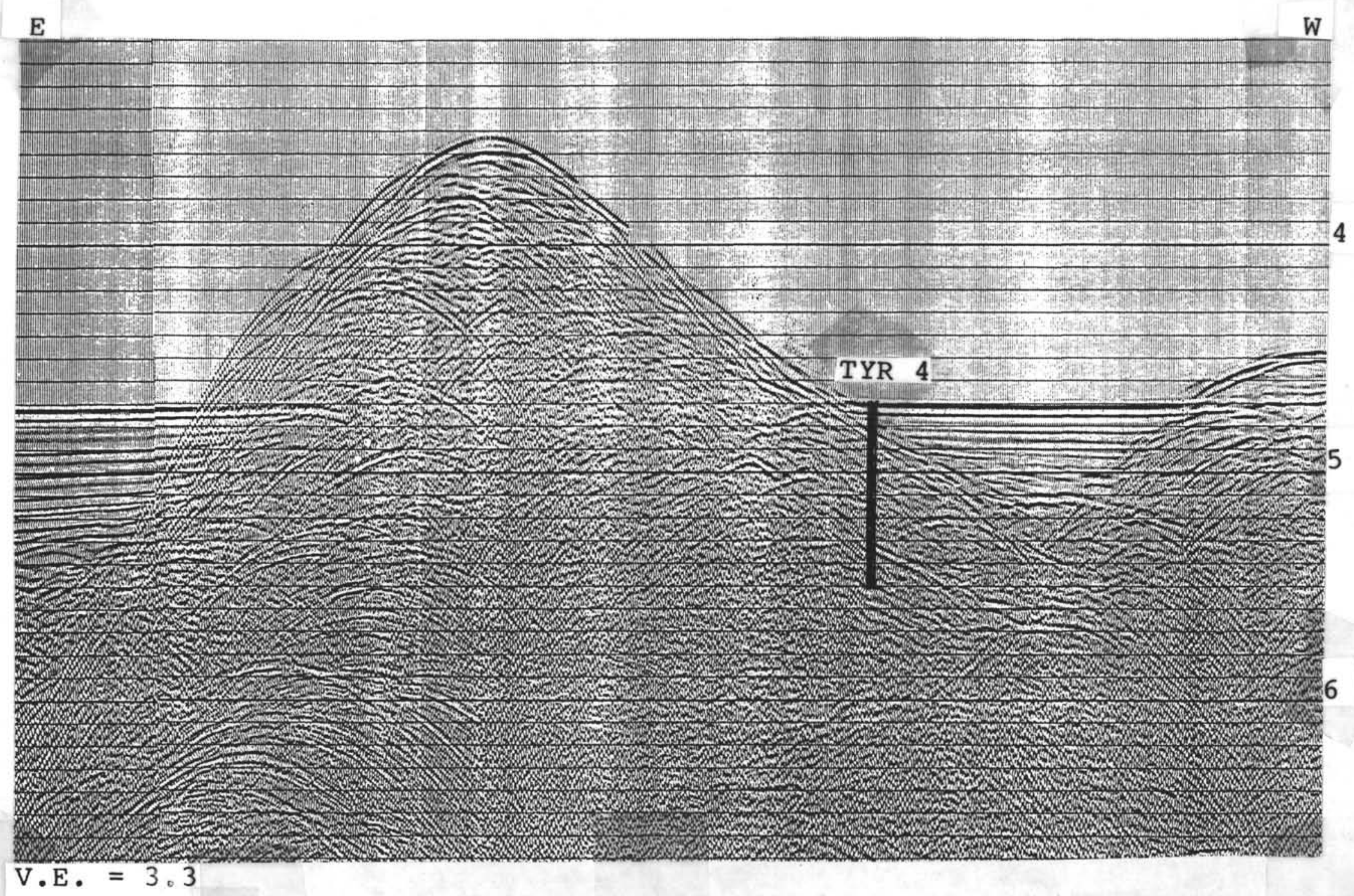

Figure 12: Detail of IFREMER-IFP-CNRS Seismic line ST 12 showing Site TYR 4.

SITE NUMBER: TYR 4 (Lower Sardinian Margin)

POSITION: 40°11'N 12°10'E

SEDIMENT THICKNESS: > 1000 m

WATER DEPTH: 3525 m

PRIORITY: 2

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 860 m.

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel line ST 12, (Shotpoint 2060).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To sample the prerift/synrift contact, if Site 3 fails this objective.

SEDIMENT TYPE:

- 0-160 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 160-280 m: Syn-rift sediments: Possibly turbidites, marls, calcarenite, clays,
- 280-810 m: Pre-rift series, age and lithology unknown. Possibly siltstone, sandstone, or shallow water carbonates including calcarenite, marble or dolomite,
- 810-860 m: "Basement", age and lithology unknown. Possibly gabbro, schist, phyllite, gneiss, granite, sandstone or conglomerate. Age may be Mesozoic.

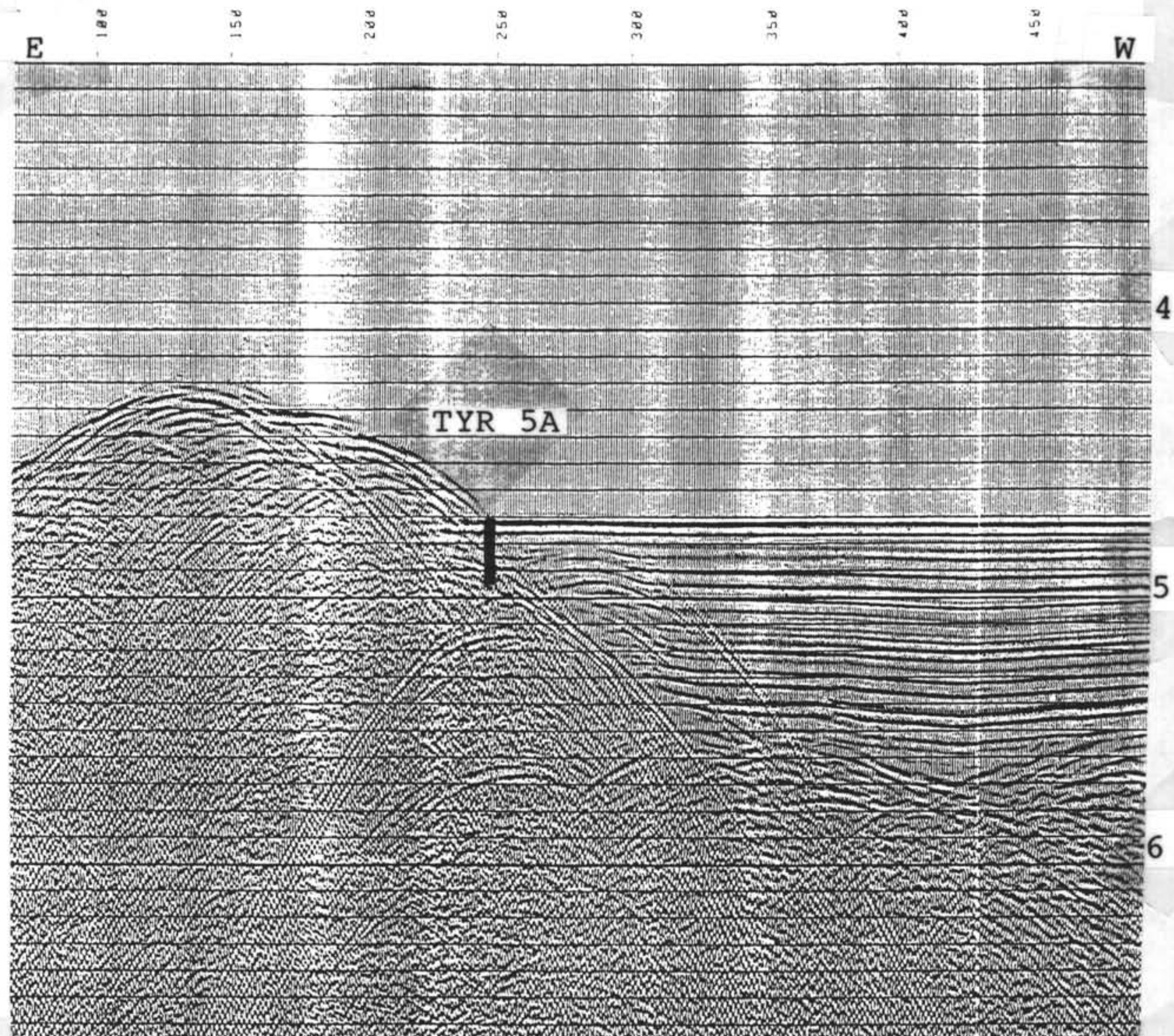

Figure 13: Detail of IFREMER-IFP-CNRS Seismic line ST 12 showing Site TYR 5A.

SITE NUMBER: TYR 5A (Central Vavilov Basin)

POSITION: 40°10'N 12°25'E

SEDIMENT THICKNESS: 50 m

WATER DEPTH: 3525 m

PRIORITY: 2

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 100 m.

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel Line ST 12 (Shotpoint 1250).

HEAT FLOW: No

LOGGING: No

OBJECTIVES:

To determine the nature of a highly magnetic N-S trending ridge which lies at the boundary between continental and supposed oceanic crust.

SEDIMENT TYPE:

- 0-50 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 50-100 m: Igneous basement: Basalt or serpentinized ultramafics.

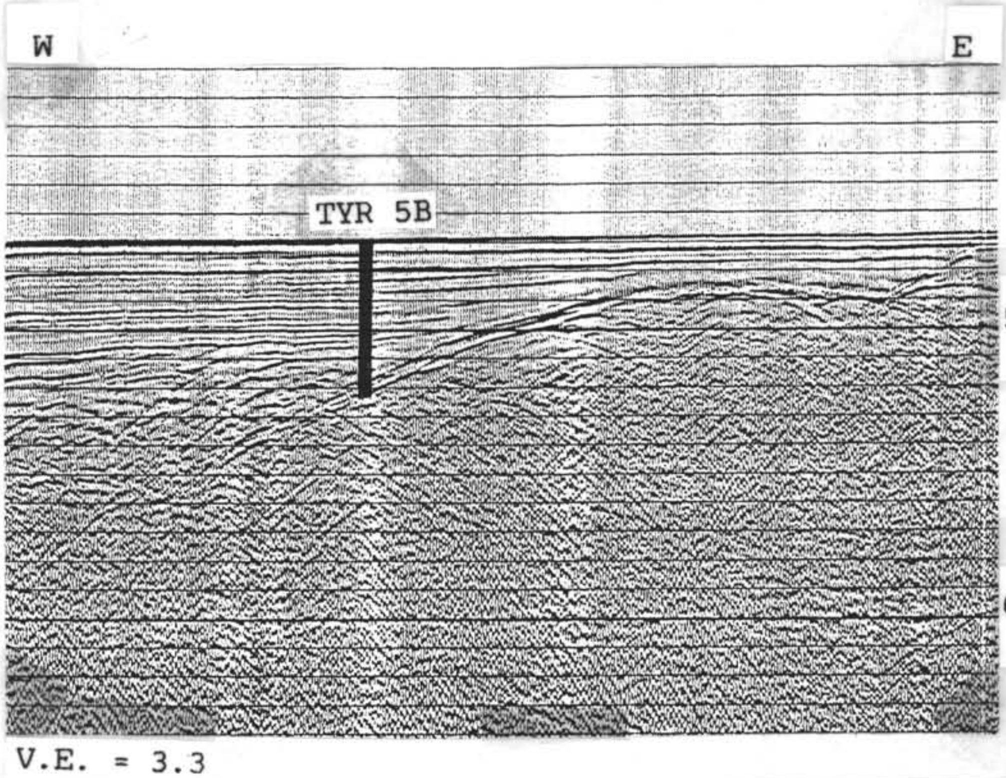

Figure 14: Detail of IFREMER-IFP-CNRS Seismic line ST 12 showing Site TYR 5B.

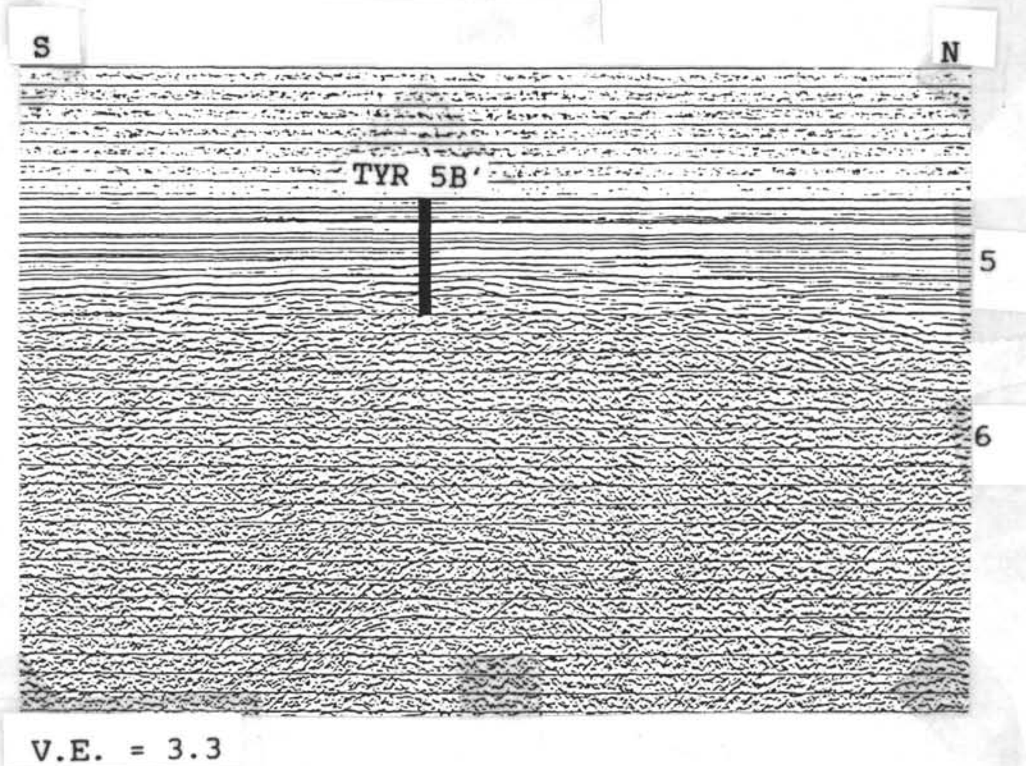

Figure 15: Detail of IFREMER-IFP-CNRS Seismic line ST 03 showing Site TYR 5B'.

SITE NUMBER: TYR 5B (Central Vavilov Basin)

POSITION: 40°10'N 12°44'E

SEDIMENT THICKNESS: 500 m

WATER DEPTH: 3510 m

PRIORITY: 1

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 550 m (including 50 m basement penetration).

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel line ST 12 (Shotpoint 168).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To determine the nature of "oceanic crust in the central part of the basin and to sample potential hydrothermal deposits at the sediment/basement contact. To determine the nature of the widely observed diffuse reflector which occurs at 400 msec subbottom.

SEDIMENT TYPE:

- 0-310 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 310-500 m: Unknown unit capped with diffuse seismic reflector. May be basalt breccia; may be a non-evaporitic Messinian facies,
- 500-550 m: Basalt.

SITE NUMBER: TYR 5B' (Central Vavilov Basin)

POSITION: 39°55'N 12°47'E

SEDIMENT THICKNESS: 450 m

WATER DEPTH: 3510 m

PRIORITY: 1 (alternate)

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous RCB coring to 500 m (including 50 m basement penetration).

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel line ST 03 (Shotpoint 1950).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

Same as TYR 5B.

SEDIMENT TYPE:

- 0-390 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 390-450 m: Unknown unit capped with diffuse seismic reflector. May be basalt breccia; may be a non-evaporitic Messinian facies,
- 450-500 m: Basalt.

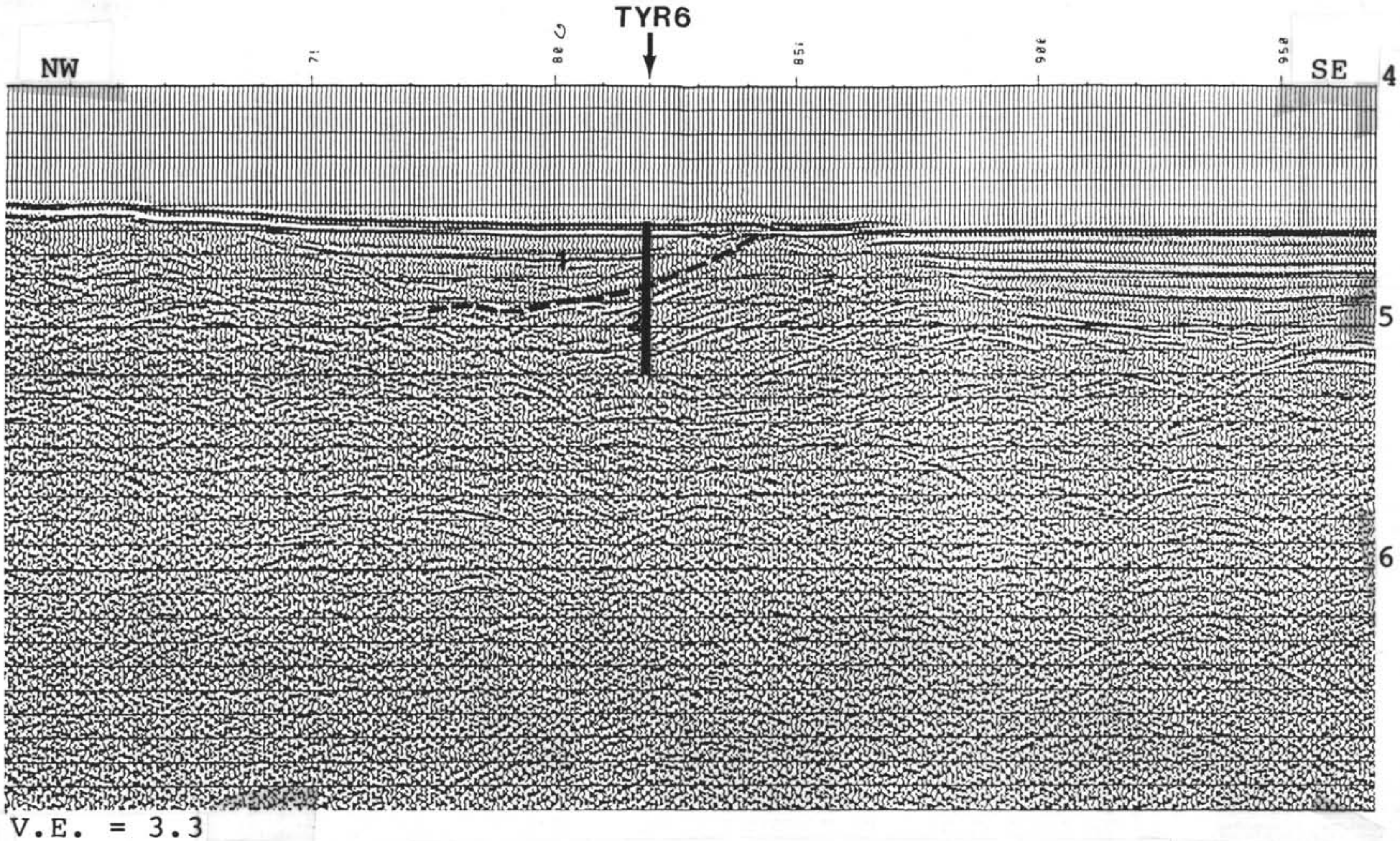

Figure 16: Detail of IFREMER-IFP-CNRS Seismic line ST 14 showing Site TYR 6.

SITE NUMBER: TYR 6 (Marsili Basin)

POSITION: 39°21'N 13°46'E SEDIMENT THICKNESS: > 1000 m

WATER DEPTH: 3420 m PRIORITY: 2

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous APC/XCB coring to 600 m.

SEISMIC RECORD:

Single channel line TY 41, TY 48 and TY 49,
IFREMER-IFP-CNRS multichannel Line ST 14 (Shotpoint 2820).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To document age of the contact between pre- and syn-rift sediments and the pre-rift series. to compare the timing of rifting in the Marsili Basin with that in the Vavilov Basin.

SEDIMENT TYPE:

- 0-150 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 150-600 m: Tilted reflectors, turbiditic sequences, age unknown.

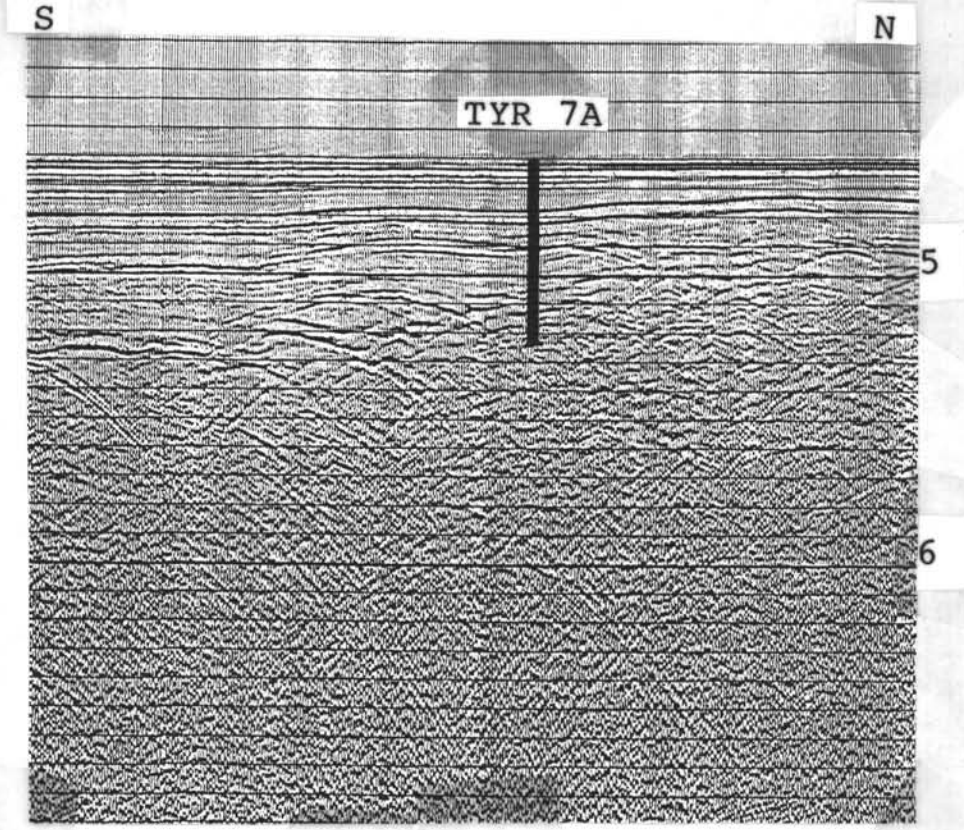

Figure 17: Detail of IFREMER-IFP-CNRS Seismic line ST 15 showing Site TYR 7A.

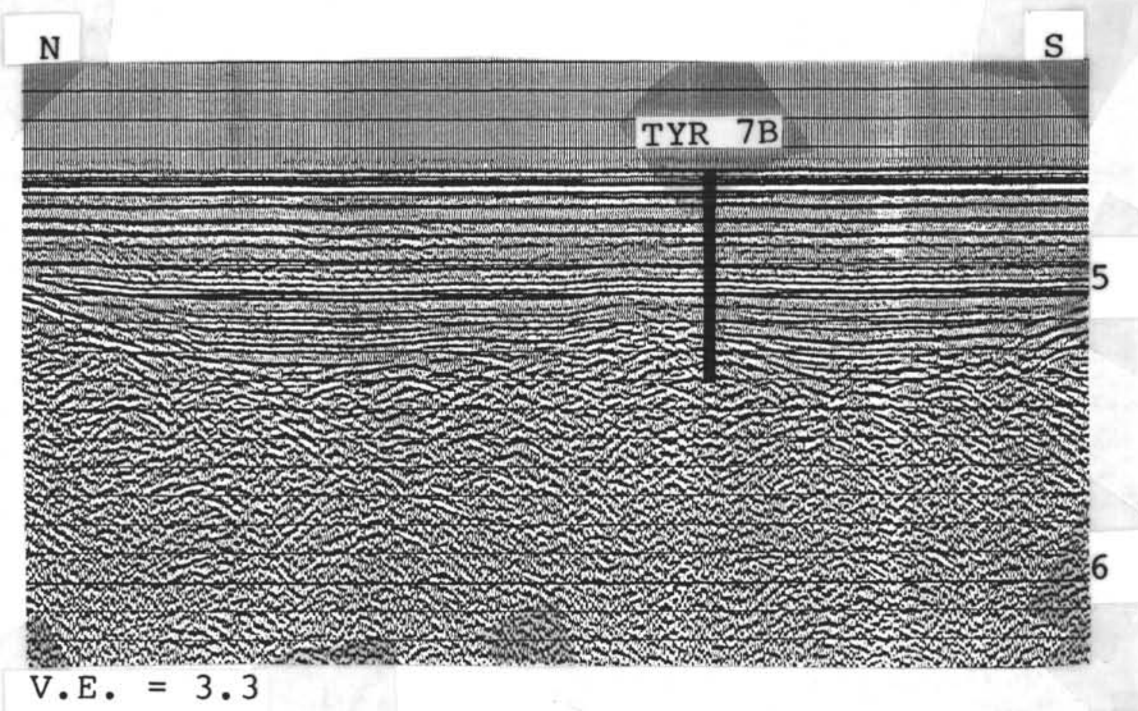

Figure 18: Detail of IFREMER-IFP-CNRS Seismic line ST 16 showing Site TYR 7B.

SITE NUMBER: TYR 7A (Central Marsili basin)

POSITION: 39°30'N 14°08'E

SEDIMENT THICKNESS: > 400 m

WATER DEPTH: 3450 m

PRIORITY: 1 (alternate)

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous APC/XCB coring to 520 m.

SEISMIC RECORD:

Single channel line TY 41, TY 48 and TY 49,
IFREMER-IFP-CNRS multichannel Line ST 15 (Shotpoint 1650).

HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:

To document the nature and age of the seismic sequences covering the whole central Marsili basin and to study the tephrachrnology of this area.

SEDIMENT TYPE:

- 0-370 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 370-470 m: Unknown unit capped with diffuse seismic reflector. May be basalt breccia; may be a non-evaporitic Messinian facies,
- 470-520 m: Basalt.

SITE NUMBER: TYR 7B (Central Marsili basin)

POSITION: 39°19'N 13°53'E

SEDIMENT THICKNESS: > 370 m

WATER DEPTH: 3435 m

PRIORITY: 1

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous APC/XCB coring to 420 m (including 50 m basement penetration).

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel Line ST 14 (Shotpoint 3020),
IFREMER-IFP-CNRS multichannel Line ST 16 (Shotpoint 1400).

HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:

Same as TYR 7A.

SEDIMENT TYPE:

- 0-370 m: Pelagic and hemipelagic marls, oozes, ashes and thin turbidites of Plio-Pleistocene age,
- 370-420 m: Basalt.

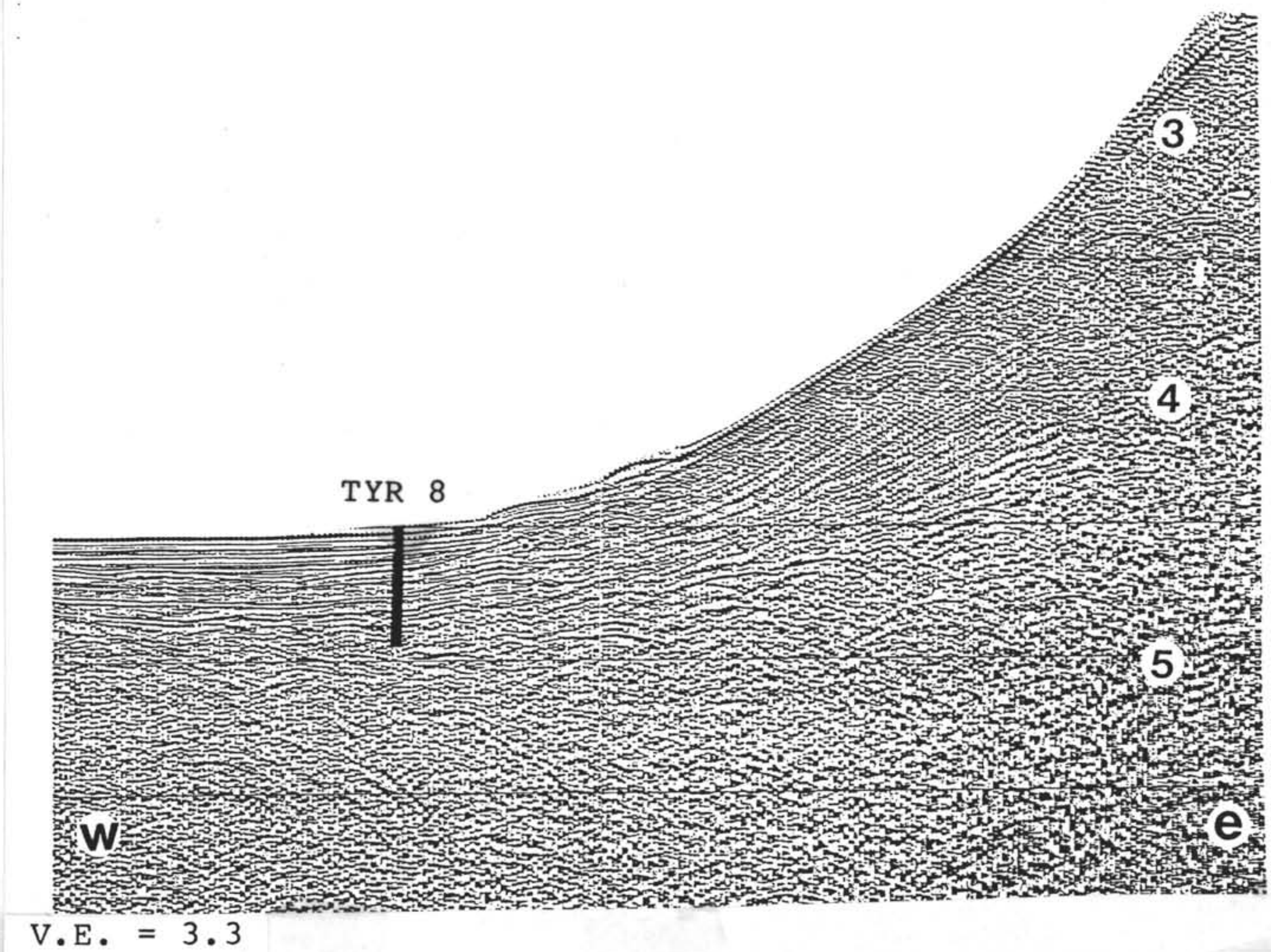

Figure 19: Detail of IFREMER-IFP-CNRS Seismic line ST 17 showing Site TYR 8.

SITE NUMBER: TYR 8 (Base of Marsili Seamount)

POSITION: 39°10'N 14°13'E

SEDIMENT THICKNESS: 800 m

WATER DEPTH: 3500 m

PRIORITY: 2

PROPOSED DRILLING PROGRAM:

Single-bit hole, continuous APC/XCB coring to 400 m.

SEISMIC RECORD:

IFREMER-IFP-CNRS multichannel Line ST 17 (Shotpoint 860).

HEAT FLOW: No

LOGGING: Yes

OBJECTIVES:

To record SE Tyrrhenian volcanic activity, to determine youngest Cenozoic paleomagnetic stratigraphy and tephra-chronology.

SEDIMENT TYPE:

- 0-400 m: Plio-Pleistocene pelagic marls, oozes, thin turbidites, abundant ashes, intercalated with basalt flows or sills.

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