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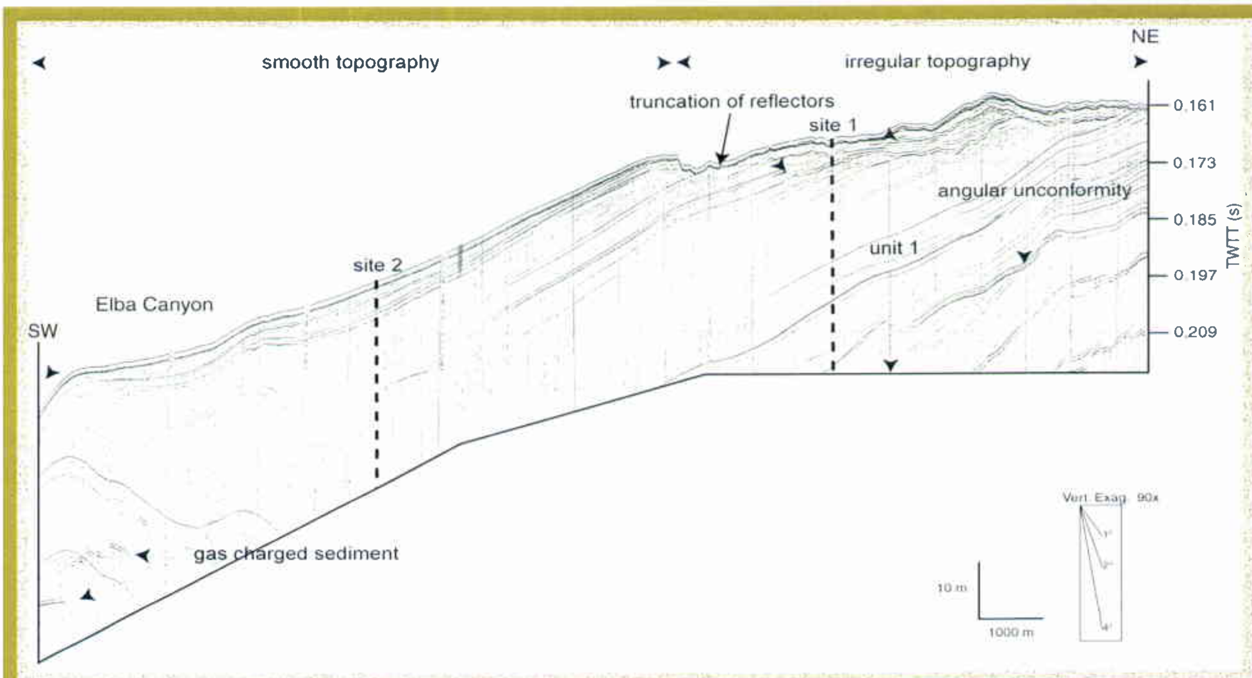
Seismic stratigraphy of the Capraia basin, Northern Tyrrhenian Sea



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July 2000

NORTH ATLANTIC TREATY ORGANIZATION   ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD

Seismic stratigraphy of the Capraia Basin, Northern Tyrrhenian Sea

D. Noseworthy

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Jan L. Spoelstra
Director

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Seismic stratigraphy of the Capraia Basin, Northern Tyrrhenian Sea

Noseworthy, D.

Executive summary: Acoustic propagation and reverberation in littoral regions is strongly influenced by the seafloor, which tends to be the controlling factor in the way that sound is reflected and scattered by the ocean environment. Thus, in order to advance the understanding of the effect of the environment on system performance data, fundamental measurements of the seafloor must be made. In the GEOSCAT '99 cruise a seismic reflection survey was conducted in the north Elba region (one of the two SACLANT Centre test-bed areas) to provide a qualitative basis for understanding the sub-seafloor layering structure. One of the common elements to shallow water regions, is the high spatial variability in both lateral and vertical extent. The north Elba region is not an exception to this and exhibits a wide variety of seafloor structures including rock outcrops, thickly sedimented regions with stochastic layering, buried dune features, surficial erosional channels, and gas pockets. The data and accompanying analysis presented here should be useful for analyses of a variety of data sets collected in this region, including but not limited to seafloor reflection, seafloor scattering, propagation, reverberation, geoacoustic inversion and focused field experiments.

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Seismic stratigraphy of the Capraia Basin, Northern Tyrrhenian Sea

Noseworthy, D.

Abstract: The distribution and thickness of sediments within the Capraia Basin, Northern Tyrrhenian Sea, have been mapped using high-resolution seismic reflection data. The data were studied within the geologic framework determined by previous works conducted in the Northern Tyrrhenian Sea. This study was especially influenced by the work of Brizzolari *et al* (1991). Collectively these studies show that sediment above the basement in the Capraia Basin consists of at least two seismic units, deposited since the Mid-Upper Pleistocene.

Unit 1 is correlated with Brizzolari's *et al.,* (1991) unit B, and unit 2 with his unit C. Unit 1 lies unconformably below unit 2, and covers a vast area within the Capraia Basin. As determined by Brizzolari *et al.,* (1991), the deposition of unit B and unit1 was strongly influenced by Mid-Upper Pleistocene glacio-eustatic fluctuation. Subsequent rise and fall of sea level within shallower regions of the basin, especially between 115-100 m water depth, resulted in the deposition of stacked sedimentary successions (of unit 2) which display strong erosional character and discontinuity. Basinward, unit 1 thickens drastically, from 10 – 80 ms twtt, into a package of aggregated to slightly progradational reflectors. Conversely, unit 2 thins basinward. It is limited geographically to the northwestern region of the Capraia Basin. As determined by Brizzolari *et al.,* (1991), the geometry of unit 2, is strongly influenced the depositional setting. Unit 2 is composed of a thin (1- 15 ms twtt) package of stratified reflectors, which taper westward. Studies have shown that successions correlating with unit 2 are predominantly composed of sediment transported into the basin by modern day feeding sources, with dominant influence coming from the Cecina River, located northeast of the study area. Brizzolari *et al.,* (1991) interpreted unit 2 to be the result of present-day highstand sedimentation in the Capraia Basin, deposited since the Holocene.

Acknowledgements: I would like to express my sincere thanks to my fabulous teacher and supervisor, Charles Holland. I would also like to thank Piero Boni, Ferda Turgutcan, Paola Nardini, John Osler, Arthur Green, the entire Acoustics Division at SACLANTCEN, and all staff involved in the GEOSCATT99 cruise.

Contents

1 Introduction

In September–October 1999, 192-line miles of high-resolution seismic-reflection profiles were collected between latitude 42°48'N and 43°22'N, and longitude 10°00'E and 10°25'E, in the northernmost extent of the Tyrrhenian Sea (Fig. 1). The survey was carried out with the intent to characterize and map the regional extent of subsurface reflectors, and establish the geologic history of the region.

2
Survey equipment and data acquisition

2.1 Equipment

In September-October 1999 the *RV Alliance* conducted the survey, which collected seismic reflection data used in the following report. The seismic source was a GeoAcoustics model 5813 Geopulse boomer with repeatable short pulse length and a broad bandwidth (approximately 500 to 15000Hz). The boomer contains an insulated round metal plate of radius 0.15m and a rubber diaphragm adjacent to a flat-wound electrical coil. A short duration high power electrical pulse discharges into the coil resulting in a magnetic field which, in turn repels the metal plate. As a result of plate motion in the water, a single broadband acoustic pressure pulse less than 0.2 ms in duration with a broadband source level of 227 dB re 1 μPa for an input of 280J was generated. The source was mounted on a catamaran with a source depth of 0.2 m and a tow speed of 4 – 5 knots. The pulse repetition rate was 1 pulse per second (approximately one pulse every 2.5m). Uniboomer pulses and data acquisition is controlled by GPS, to avoid any possible errors in clock synchronisation. The receiver array consisted of a single channel surface towed array of 10 hydrophones, with a 21m horizontal separation between source and receiver. To correct for this horizontal separation, a time correction, which is a function of water depth and a depth averaged sound speed, was applied to the reflector travel times in preparation of horizon interpretation.

2.2 Data acquisition

The signal is passed through three gain stages. The first stage is a Rockland high pass filter above 300Hz with 20dB gain, used to remove low frequency ship and mechanical noise. The second gain stage is a Stanford band pass from 100Hz to 30 000Hz with a gain of 26dB. The third gain stage is a low pass 15 kHz, 0dB gain frequency device, a stage which attempts to optimise bandwidth versus noise considerations. An analog copy of the reflection seismograms was printed on an EPC thermal paper chart recorder. Digital data, sampled at 40 kHz, were acquired as 2 byte integers in SEG-Y format on a HP Series 700i workstation.

2.3 Survey tracks

Approximately 192 line-miles of high-resolution seismic-reflection profiles were collected from the Capraia Basin, offshore northwestern Italy, during the cruise (Fig. 2). The seismic reflection profiles were typically divided into segments of 20 to 30 minutes of elapsed time, each with a 0.15 s time window, starting at a variable time after the trigger.

The tracks were designed to connect various sites where Holland and Osler (1998) analyzed wide-angle reflection data collected in previous cruises.

3
Procedures and techniques

3.1 Analytical procedure

The Seismic Unix software package (SU), version 3.2 (Stockwell and Cohen, June 1998), was used for visualisation and interactive interpretation of the seismic reflection data. SU is a "user friendly" program, which allows unrestricted use of codes for both processing and software development. SUXPICKER is a version of SU module, used to pick travel times along horizons chosen based on acoustic character (Holland and Osler, 1998). Travel time picks were made either every 30th or 60th seismogram (horizontally spaced 38 m or 75 m, respectively), depending on geologic complexity. The seabed, fourteen major seismic reflectors, and the acoustic basement were assigned unique identifiers and then interpreted within SUXPICKER.

The regional distribution and thickness of the units were visualised using isopach mapping[1]. Isopach mapping was done in IDL 5.2, Research Systems Incorporated, 1998. The IDL gridding algorithm, *trigrid*, uses Delauany triangulation of the geographic location of the travel time picks.

[1] An isopach map, is a map of areal extent and thickness variation of a stratigraphic unit, used in geological exploration and for structural analysis (Parker,1994).

4
Previous studies

Investigations of Quaternary Geology in the Mediterranean Sea have spanned for more than a century, and generally depict the dynamic concepts of global Quaternary history. Chiocci et al., (1996), Selli (1995) and Brizzolari et al., (1991) have done extensive seismic stratigraphic analysis within the Tyrrhenian Sea, where three major seismic units are typically defined above the basement. These authors have set the geological foundation used as the framework for this study. In particular, the work of Brizzolari et al., is heavily drawn on in as much as their study area is very close (southwest) to our area.

5
Bathymetry

The study area defines a NW-SE-elongate semi-enclosed basin, which is bounded on the east by the mainland of Italy, to the south by Elba Island and on the west by the Elba Ridge, Gorgona and Capraia Isles. This area encloses approximately1200 mi^2 along the Tuscan continental shelf where water depths rarely exceed 150m. In the westernmost region of the study area, the continental shelf is cut by the Elba Canyon, a submarine canyon which progressively deepens northwestward. As defined by Leoni, (*et al.*,1993), the basin can be divided into two sub-basins on the basis of structural height. A small sub-basin, *B*, which extends from Vada Shoals to Meloria Shoals off Livorno, ranges from 50 – 100m water depth. A second larger sub-basin, *A*, extending from Elba Island to Vada Shoals, reaches water depths between 100 and 150 m. For the purposes of this study, we will focus on sub-basin *A*, referred to herein as the *Capraia Basin*.

Sea floor morphology is variable within the Capraia Basin. The sea floor is relatively smooth from approximately 200 m water depth, in the Elba Canyon, up to 130 m water depth in the basin. Shallower than 130 m, the sea floor becomes more irregular as seen in Fig. 3 between Site 2 and Site 1. From 115-100 m water depth, the sea floor becomes smoother. This variation in morphology may be the result of modern day tidal processes within the basin. The only river on the plain, which provides a substantial amount of sediment into the basin is the Cecina River, located in the north west of the study area. Once the sediment is transposed from the river into the sea, it is transported southward mainly by currents and littoral drift. Currents from the southern region of the Tyrrhenian Sea converge with the northern current and deposit sediment in an area located south of San Vincenzo (Leoni, *et al.*, 1993).

6

Description of seismic units

For the purposes of this report, seismic reflectors will be discussed in terms of time, spatial distribution, and acoustic signature. Due to the dynamic processes associated with deposition in the shallower areas of the basin, units were sometimes irregularly shaped, discontinuous, and stacked units were often bound at their top and base by erosional unconformities. Because of this non-heterogeneity, mapping within shallow areas was challenging, and sometimes prevented the usage of standard seismic-stratigraphic methods typically used in such studies. Brizzolari *et al.,* (1990) also noted this problem.

6.1 Acoustic basement

An acoustic basement was defined in the Capraia Basin at the base of the sedimentary cover. Reflectivity of the basement ranges from weak to moderate throughout the mapped area. As illustrated in figure x, the region of the basement mapped defines a concave shaped, semi-enclosed basin opened to the west (Fig. 5). The basement rises toward land in the north, south and east, and is occasionally exposed at the sea floor, as illustrated in Fig. 3. The basement was too deep to be mapped in all but the easternmost fringes of the study area. Brizzolari *et al.,* characterised the basement as (1) transparent, and (2) stratified (Fig. 6). The basement in our study area could be similarly characterised. These characters were not mapped individually, however their presence may suggest two-fold deposition.

6.2. Unit 1

According to the time window used in this study to interpret seismic data, reflectors contained within unit 1 are the most geographically extensive throughout the Capraia Basin. Unit 1 encompasses seismic reflectors 4 – 15 (Fig. 4). Unit 1 is bound at its base by reflector 15, and at its top by an erosional unconformity[2], defined by Brizzolari (*et al.,* 1991), as the upper surface of his unit b. It ranges in thickness from 10 ms twtt in the eastern regions of the study area, plunging to 80 ms twtt basinward. Unit 1 possesses a variety of acoustic signatures, and can be classified as having variable reflectivity, which ranges between continuous and discontinuous throughout the study area.

[2] An unconformity is a break in the stratigraphic sequence between strata, which is the result of either non-deposition or erosion.

Reflector 15 spans from the centre to easternmost extents of the basin, and between lines QR in the south and KL in the north. In plan view it has a diamond shaped geometry, which covers 153 mi^2. In cross section reflector 15 is a planar surface, which steeply slopes from 5 ms twtt in the east, towards 80 ms twtt in the center of the basin (Fig. 8). Reflector 15 can be defined as an angular unconformity, which possesses a strong erosional character (downlap)[3] throughout the basin. It ranges from weak- to very high-amplitude reflectivity throughout its length.

Reflector 14 covers a 128 mi^2 rectangular shaped area in plan view, elongated NW-SE along line PQ in the west-central region of the basin. It ranges from 5 ms twtt along its edges, plunging to 80 ms twtt at the intersection between lines GH and PQ (Fig. 9), giving it a concave-up cross section. Reflector 14 has high-amplitude reflectivity throughout its length, and becomes truncated by overlying reflectors in the centre of the basin.

Reflector 13 has a rectangular shape in plan view, enclosing an area of 140 mi^2. It is elongated NW-SE along line MN in the centre of the basin, with an unsymmetrical concave-shaped cross section. Its amplitude ranges from weak in the south, to higher-amplitude reflectivity in the centre and northern regions of the basin. Reflector 13 is deepest near the intersection of lines GH and PQ, where it declines to 60 ms twtt (Fig. 10). The reflector climbs towards the sea surface in the north along line KL, but becomes truncated by overlying reflectors just below the sea floor.

Reflectors 11 and 12 cover a vast geographical area and time range within the basin, enclosing a circular shaped area of 198 mi^2, and180 mi^2 respectively, which range in depth between 1 – 50 ms twtt (Figs. 11 and 12). The greatest depths occur in the central region of the basin immediately west of line MN on line GH. The shallowest regions along reflectors 11 and 12 occur around the periphery of their boundaries, resulting in concave up cross sectional geometries. Both reflectors have an erosional character (onlap)[3] which display wide ranges of reflectivity across the study area (Figs. 3 and 6).

Reflector 10 covers a diamond shaped area of 63 mi^2, in the centre of the basin. It forms a planar surface, which dips from 1 ms twtt in the east towards 20 ms twtt along its western extent (Fig. 13). It has high- to moderate-amplitude reflectivity in the south, increasing in strength towards the centre of the basin. It shows evidence of erosion (onlap) with neighbouring horizons in the centre of the basin.

Reflector 9 covers a rectangular shaped area of 85 mi^2 in the central region of the basin. It has a concave shaped cross section, which reaches it maximum depth of 30 ms twtt at the intersection of GH and PQ (Fig. 14). It has high- to moderate-amplitude reflectivity

[3] Downlap is one of a suite of terms used in seismic stratigraphy defined by Vail and Mitchum (1977,p.51) as a geological approach to the seismic stratigraphic interpretation of data. *Downlap* occurs where dip of the older surface is less than the dip of the overlying strata. *Onlap* occurs where the dip of the older surface is greater. *Lapout* is the lateral termination of a reflector at its depositional limit (Mitchum *et al.,* 1977a,b).

in the south, decreasing in strength towards the centre of the basin where eventual lapout[3] occurs.

Seismic reflector 8 is locally confined to a 36 mi^2 rectangular shaped region in the west-central part of the basin. It has an unsymmetrical concave shaped cross section. The reflector ranges from 20 ms twtt, west of the intersection between lines GH and PQ, rising towards 1 ms twtt around its boundary (Fig. 15). Reflector 8 has moderate amplitude reflectivity, and moderate lateral continuity.

Reflector 7 is extensive throughout the central and northwestern regions of the Capraia Basin. It encompasses an area of 106 mi^2, and has a 'spear-head' geometry in plan view. Reflector 7 ranges from 15 ms twtt at the intersection between lines GH and PQ, decreasing to 2 ms twtt around its edges, giving it a concave shaped cross section (Fig. 16). It shows high- to moderate-amplitude reflectivity and is typically defined as an erosional event throughout the basin, as demonstrated by the truncation of reflector 8 in the basin centre. It shows evidence of lapout in the north and south of the study area.

Seismic reflectors 4, 5 and 6 are geographically restricted to the northwestern corner of the study area. They rise from the Elba Canyon toward line MN in the basin centre and to QR in the south. The reflectors are curved to planar in cross section, and encompass a diamond shaped geographical area of approximately 60 mi^2, 108 mi^2 and 75 mi^2, respectively. The greatest depth of the reflectors occurs in the NW at 10 ms twtt, decreasing in time as they approach the surface in the south (Figs. 17-19). Reflectors 4, 5 and 6 have high-amplitude reflectivity throughout their length, and are truncated at the sea floor. Reflector 4 shows evidence of mild onlap with reflector 5, near its termination at the sea surface. Lapout of reflector 6 occurs near the axis of a fold located in the south on segment qr01 (figx).

Variation in the amplitude of reflectors over localised regions and small pull downs of reflectors were identified throughout unit 1. These characteristics, as noted by Brizzolari (*et al.,* 1991), to be commonly located above basement highs, suggest the presence gas of gas in unit 1.

6.3 Unit 2

Seismic reflectors 1, 2 and 3 are contained within the sedimentary package defined by this report as unit 2. Unit 2 may be associated Brizzolari's (*et al.,* 1991) unit c.

The shape of reflector 1 (which is the sea floor) has been discussed in the *Bathymetry* section. The reflective character of the seafloor across the basin, was uniformly high-amplitude reflectivity. Unit 2 is thickest in the northeastern region of the study area, at 15 ms twtt, tapering out completely toward the southwest.

Reflector 3 defines the boundary between units 1 and 2, where unit 2 lies unconformably above unit1. In its entirety, unit 2 is a relatively thin unit (never exceeding 15 ms twtt) which consists of a regularly reflective package of acoustically strong reflectors, which show remarkable lateral continuity.

As illustrated in figures x, and y, reflectors 2 and 3 have a lobe-shaped geometry in plan view. In cross sectional view, the unit is wedge-shaped. The wedge is thickest at the northeast, thinning progressively towards the southwest. Reflector 2 barely exceeds 10 ms twtt depth in the northwest of the study area, tapering out completely toward the south, at 1 ms twtt below the seafloor (Fig. 20). The reflector has high- to moderate-amplitude reflectivity in northeast, which increases in strength towards the centre of the basin. Reflector 2 shows evidence of mild downlap with reflector 3 in the centre of the basin. Similar to reflector 2, reflector 3 reaches approximately 10 ms twtt depth in the northeast, thinning out completely in the southwest at 1 ms twtt below the sea floor (Fig. 21). It shows high- to moderate-amplitude reflectivity throughout its entirety.

There were no obvious indicators of gas within unit 2.

7 Discussion

The reflectors chosen in this study were picked on the basis of acoustic, rather than geologic character. Previous studies have verified the existence of three distinct geological units above the basement near the Capraia Basin (for a through review, see Brizzolari, *et al.,* 1991). The following section attempts to equate between the acoustic model created by Holland (1998), and geologic character of the Capraia Basin as interpreted by this study and previous works.

Reflector 15 occurs at the base of unit 1 as an angular unconformity[4], which covers a vast area within the Capraia Basin. It separates units which have distinct acoustic signatures and unique geometries. Unit 1 is composed of groups of irregular reflectors, comprising stacked depositional packages in the shallowest regions of the shelf, which gradually thickens basinward into a more continuous package of aggregated to slightly progradational reflectors. The package defined herein as unit 1, which encompasses reflectors 4-15, may be correlated with Brizzolari's (1991) unit B. As described by Brizzolari, the thickness of unit b is strongly controlled by post-depositional erosion, and only weakly related to the structural geometry of the basin. The strong variation of internal reflectivity and external geometry of acoustic reflectors within unit b in the eastern (shallowest) regions of the study area, suggest that it consists of packages of stacked depositional sequences of a coastal-shallow marine environment, deposited during a lowstand[5] (Brizzolari *et al.,* 1991). Dune type features located along the northern end of line AH and Hs5, and complex erosional patterns within unit 1, verify that periods of lowstand occurred within the Capraia Basin. Therefore, it can be postulated that unit 1 stratigraphically correlates with geologic formations related to sea-level oscillations of the Mid-Upper Pleistocene. As postulated by Brizzolari, (*et al.,* 1991), the origin of such formations is fluvio-continental up to coastal, and can be considered extensions of the coastal and marine sequences on the Tuscan shelf.

Unit 2 is different from underlying units in terms of geometry and geographical distribution. The lobate-shaped, seaward thinning wedge of unit 2 is indicative of a package of sediment deposited at the mouth of a river, by terrigenious processes.

Studies have shown that, materials deposited in the northern part of the Tyrrhenian Sea, were delivered by feeding sources which transported sediment originating from: (1)

[4] An angular unconformity occurs between older strata which dip at a different angle than younger strata

[5] *Lowstand* is one of four types of system tracts defined by Vail and Mitchum (1977). The base of a lowstand systems tract is characterized by subareial erosion with valley incision on the shelf, turbidite fan complexes and prograding complexes into the basin. Lowstand deposition often recognized in shallowing-upwards lowstand deltas, by prograding shorelines into the basin, and onlap landward with pinchout in the vicinity of the offlap break of the preceeding highstand.

sedimentary complexes involved in the Apennines orogenesis, and/or, (2) postorogenic sedimentary sequences. The Cecina river is the main transport mechanism for such terrigeneous sediment into sea (Leoni, *et al.*, 1993). The lobate geometry demonstrated by the isopach maps of reflectors 2 and 3, support a terrigeneous source supplied by the Cecina, however, no core analysis was done to verify provenance[6].

As apparent between Brizzolari's, (*et al.,* 1991) unit B and C, the differences in reflective character, and thickness distribution determined by isopach mapping of unit 2 and 1 suggests they were deposited during very different times of eustatic sea-level and in different depositional settings. These distinctions are also evident in the acoustic character of the seismic reflectors. The basal surface of unit 2 lies unconformably above unit1. This unconformity represents the last lowstand erosonial surface deposited in the basin (Brizzolari, *et al.,* 1991), which can be correlated with the Holocene deposits on the neighbouring Tuscan coast. Previous studies have determined that these deposits include beach sands, eolian dunes, lacustrine and fluvial deposits (Brizzolari, *et al.,* 1991, Chiocci, *et al.*, 1996). Because unit 2 lies above this erosional surface, and due to the cyclic nature of systems tracts, unit 2 is probably related to the most recent highstand[7] setting within the Capraia Basin.

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[6] Provenance is the location, topography, and composition of the source area for any sedimentary rock (Parker, 1994, p.223)

[7] Highstand is a type of systems tract defined Vail and Mitchum (1977,p.51). The physical boundary between the transgressive and highstand systems tract is called the maximum flooding surface. It is a submarine condensed section characterized by downlap above apparent truncation below.

8
Conclusions

The data analysed for this study show that unconsolidated sediments overlying the basement in the Capraia Basin, Northern Tyrrhenian Sea, are composed of numerous depositional sequences, which were strongly effected by glacio-eustatic sea level fluctuation since the Pleistocene. Analysis of seismic reflection data, isopach geometry and geographical distribution of the seismic units determined: (1) a.) unit 1 is composed of stacked depositional packages in the shallowest regions of the basin, which correlate with Brizzolari's (*et al.,* 1991) unit B. As postulated by Brizzolari, (*et al.,* 1991), the units are composed of several lowstand coastal sequences, which are bound by unconformities that formed during times of subaerial exposure and erosion during sea-level lowstands. b.) Towards the basin centre, reflectors within unit 1 are aggregated to slightly progradational, and comprise a package which thickens westward. (2) The basal surface of unit 1 is defined by the angular unconformity identified as seismic reflector 15. (3) Unit 2 was deposited during a similar timeframe and depositional environment to Brizzolari's (*et al.,* 1991) unit C. It can be postulated that unit 2 was deposited during the Holocene, and is the result of present-day highstand sedimentation in the Capraia Basin.

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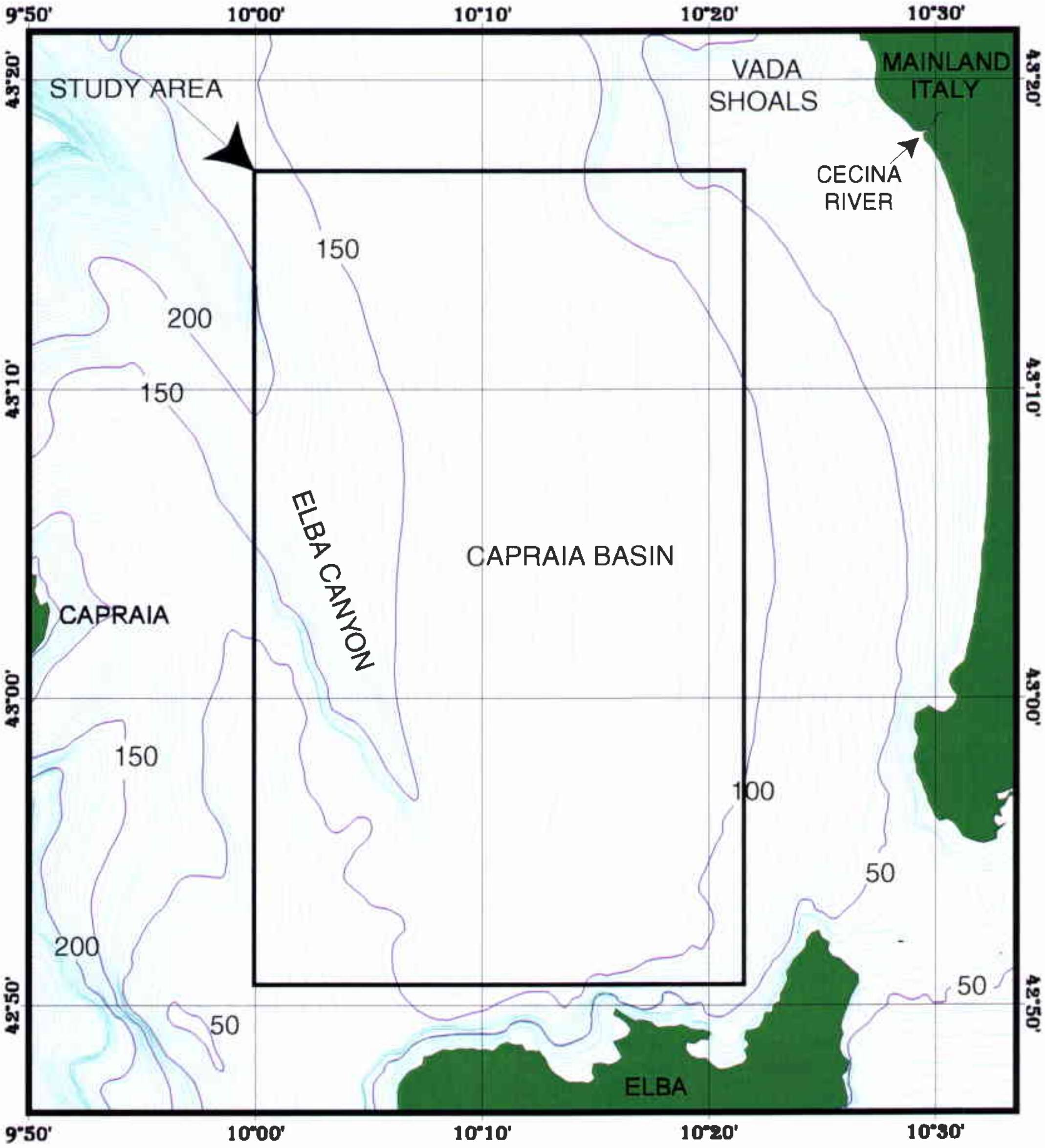

Figure 1 *Location of the study area; Capraia Basin, Northern Tyrrhenian Sea, showing major physiographic features.*

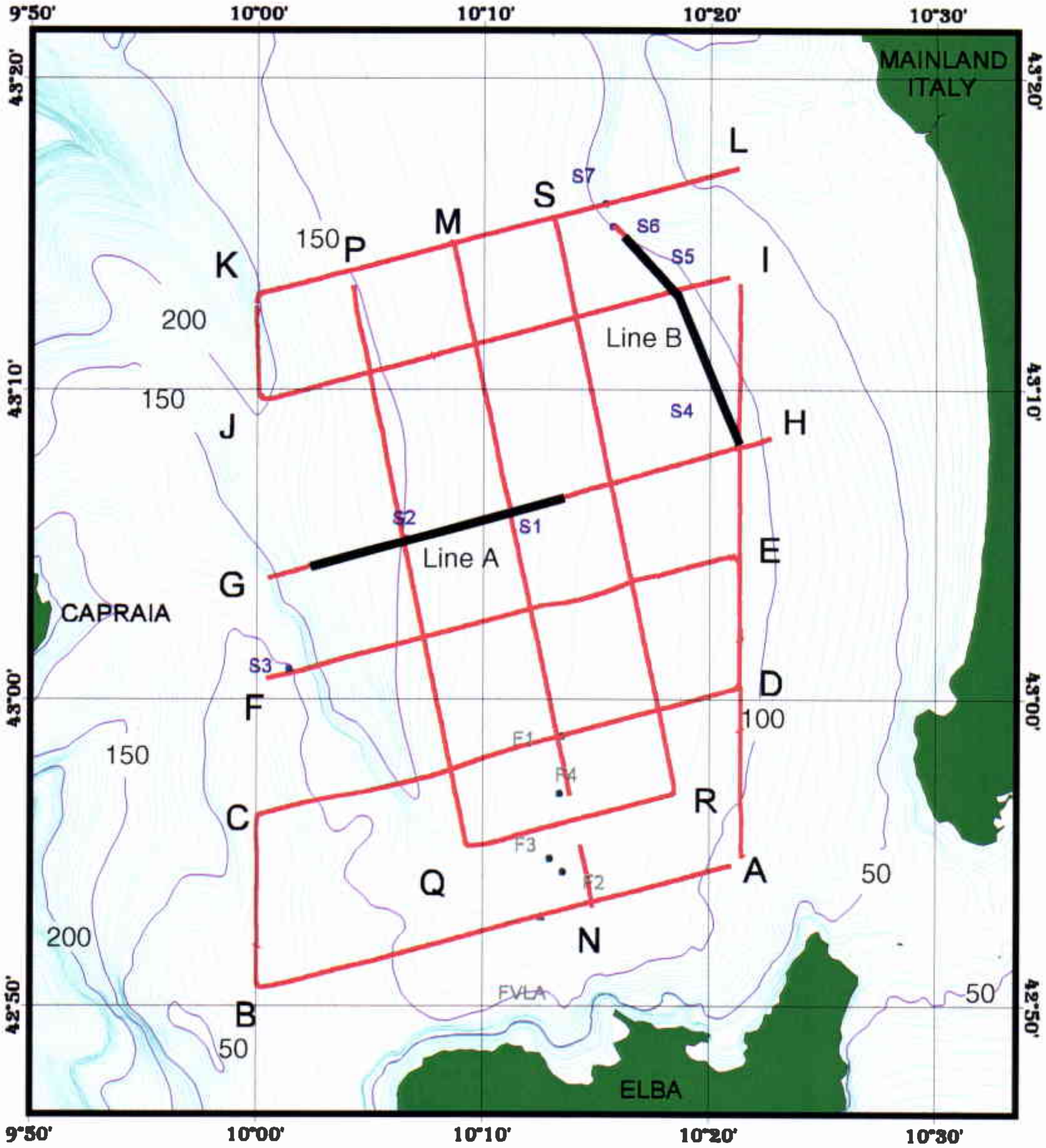

Figure 2 *Map showing location of seismic profiles, and site locations. Heavy black lines (A and B) are seismic profiles illustrated in Figures 3,4,6 and 7.*

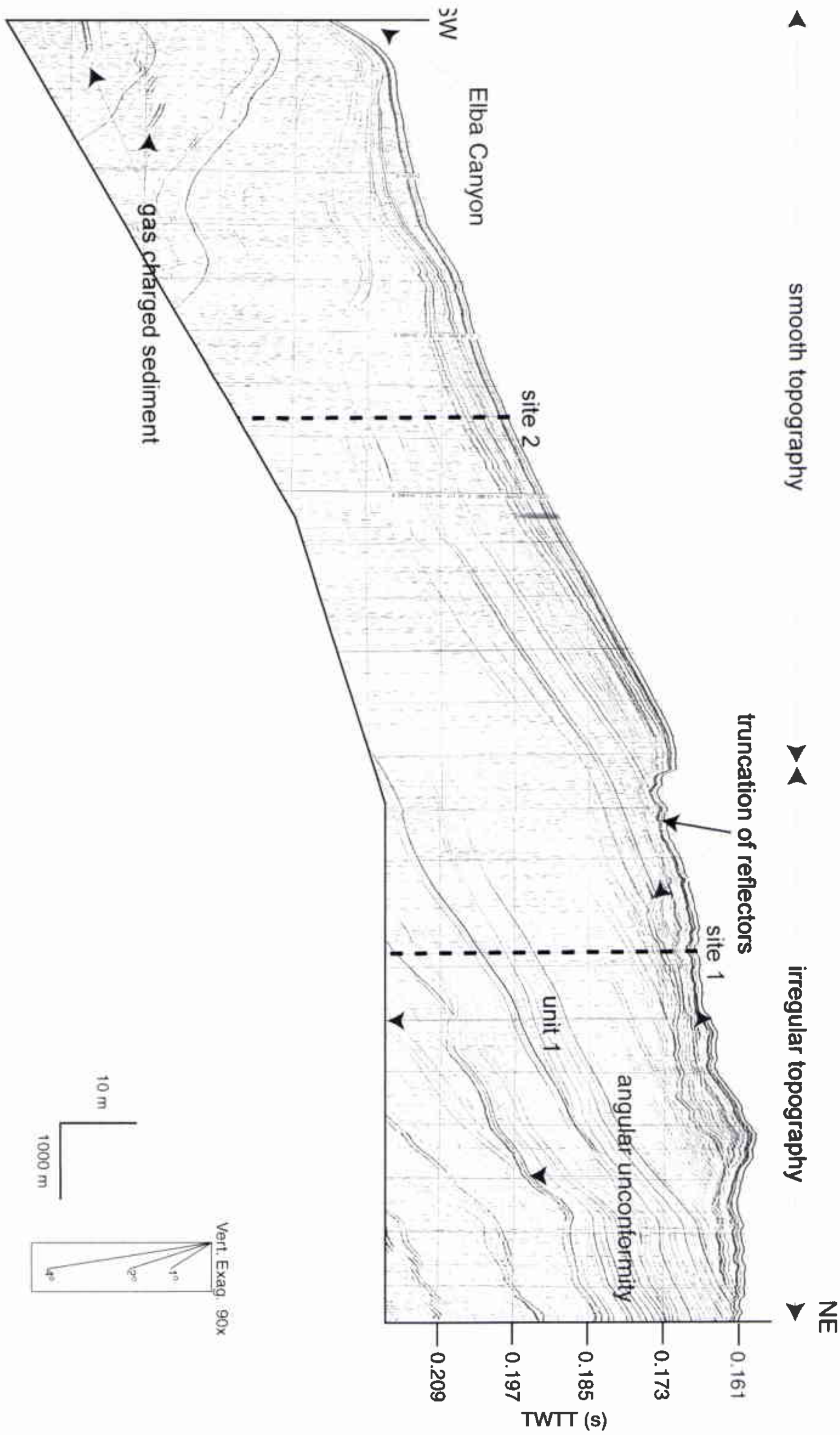

Figure 3 *Seismic reflection profile (Line A) showing sites 1 and 2, and various geological features within unit 1, and on the seafloor.*

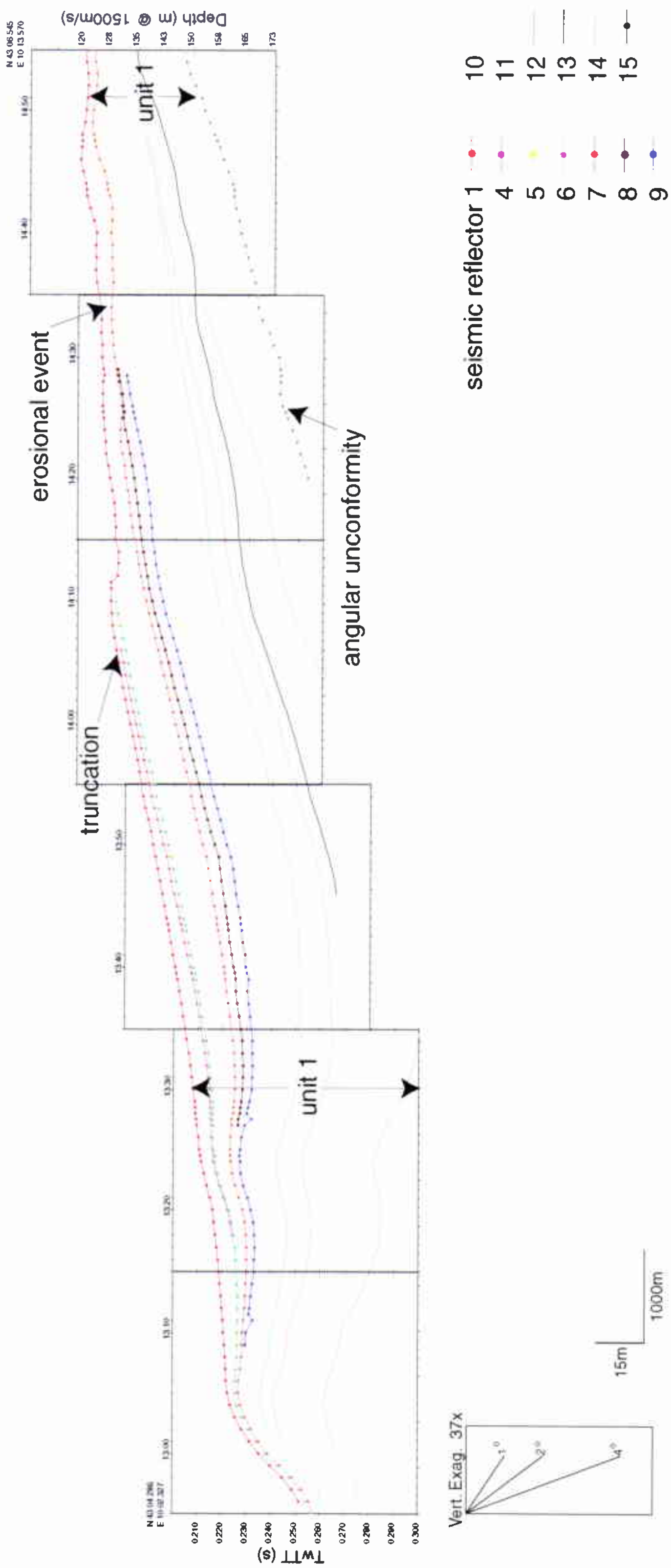

Figure 4 *Interpreted seismic reflection profile (Line A) showing the distribution of seismic unit 1 and reflectors 4-15 in the central region of the Capraia Basin.*

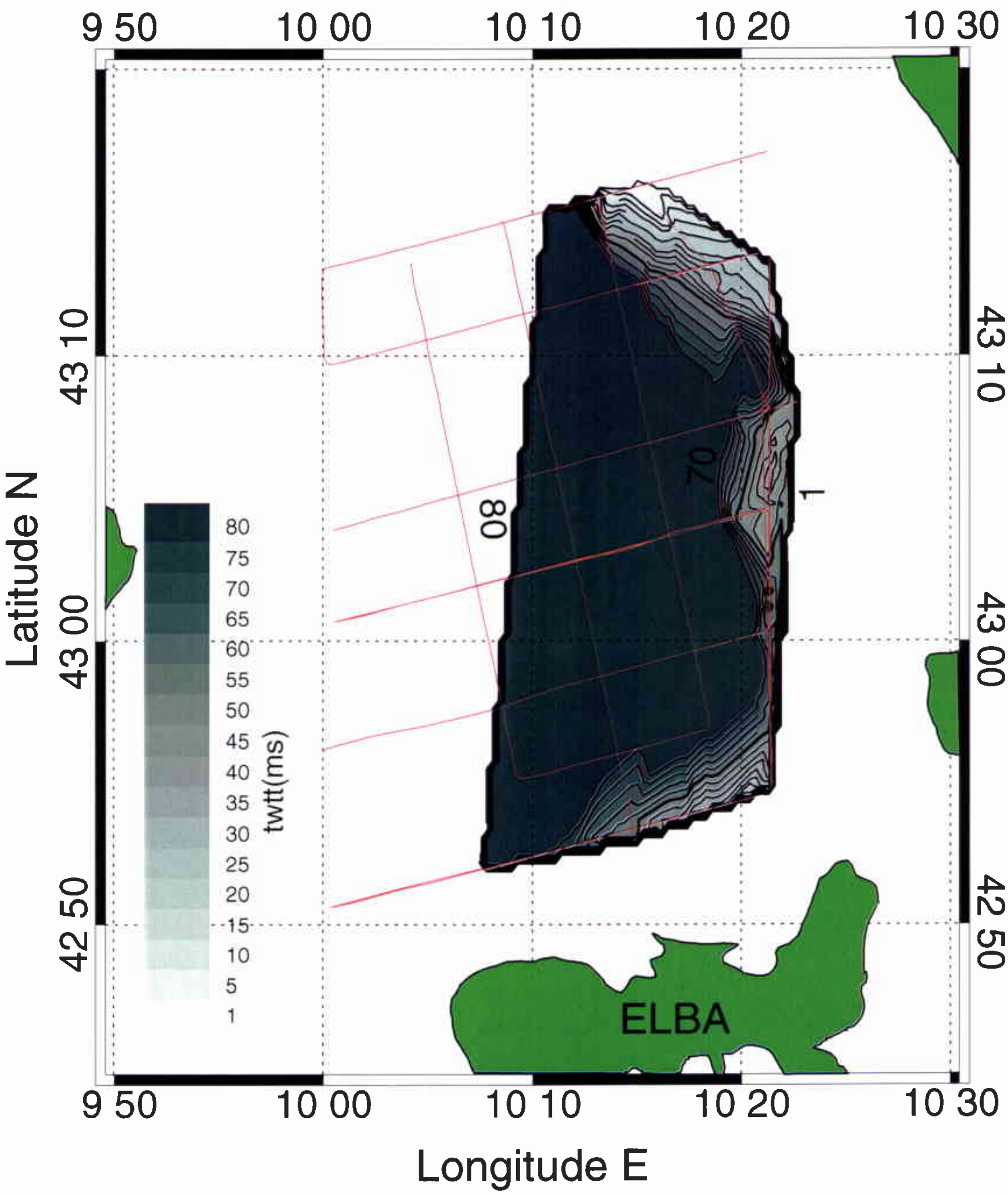

Figure 5 *Depth to basement isopach (using the seafloor as datum). Over most of the basin, the basement was too deep to be mapped. Thus the 80 ms contour is indicative only that the basement is deeper than 80 ms.*

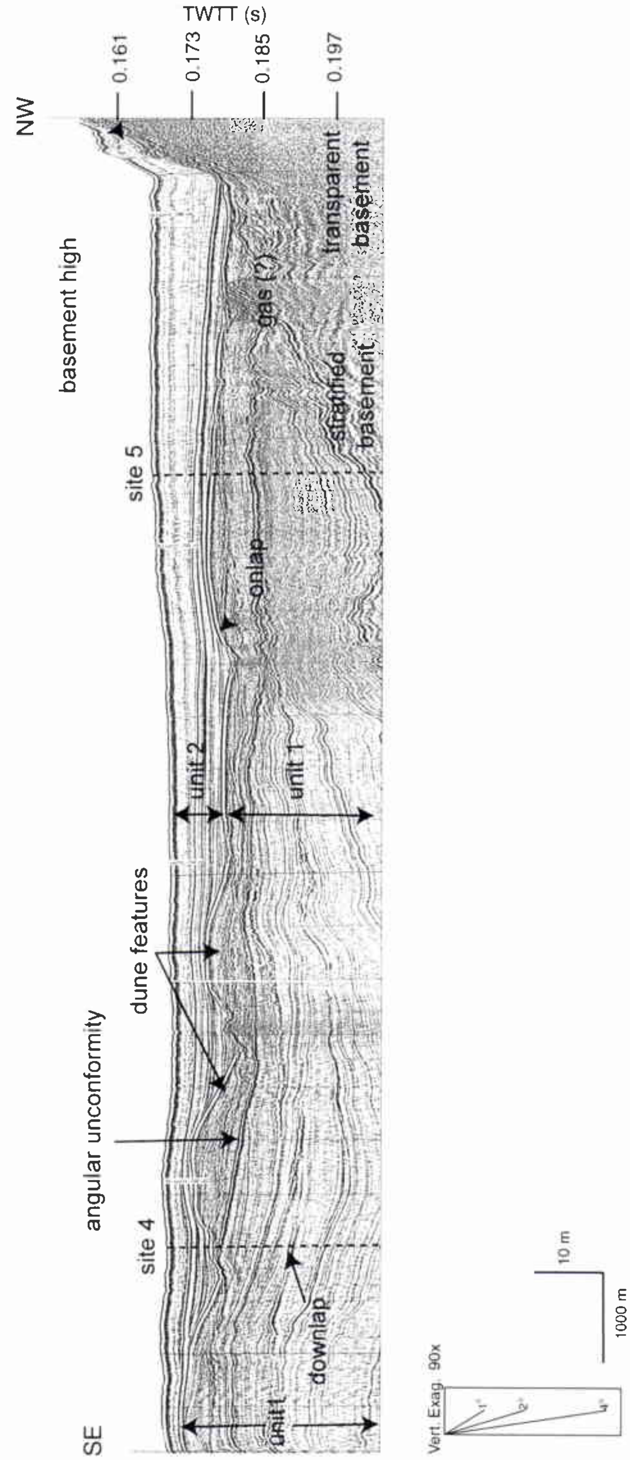

Figure 6 *Seismic reflection profile (Line B) showing sites 4 and 5, and various geologic features.*

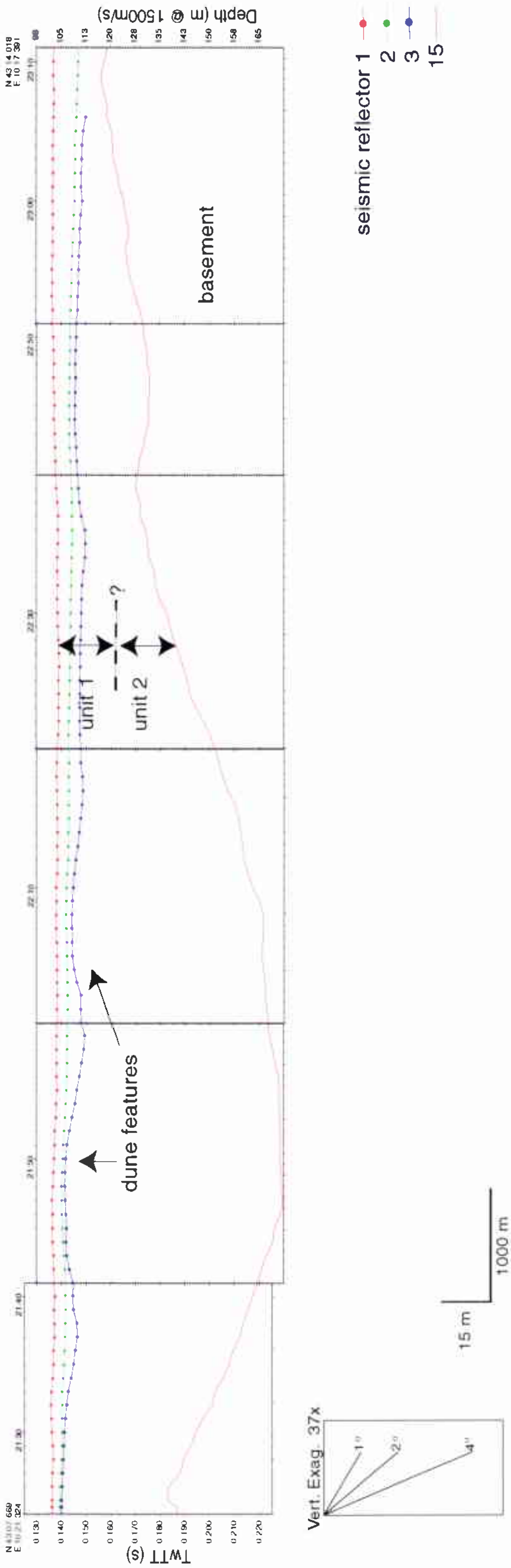

Figure 7 *Interpreted seismic reflection proifile (Line B) showing the distribution of units 1 and 2 along the eastern flank of the Capraia Basin. The reflector separating units 1 and 2 was not defined in this study. It is a regional marker defined by Brizzolari et al., (1991).*

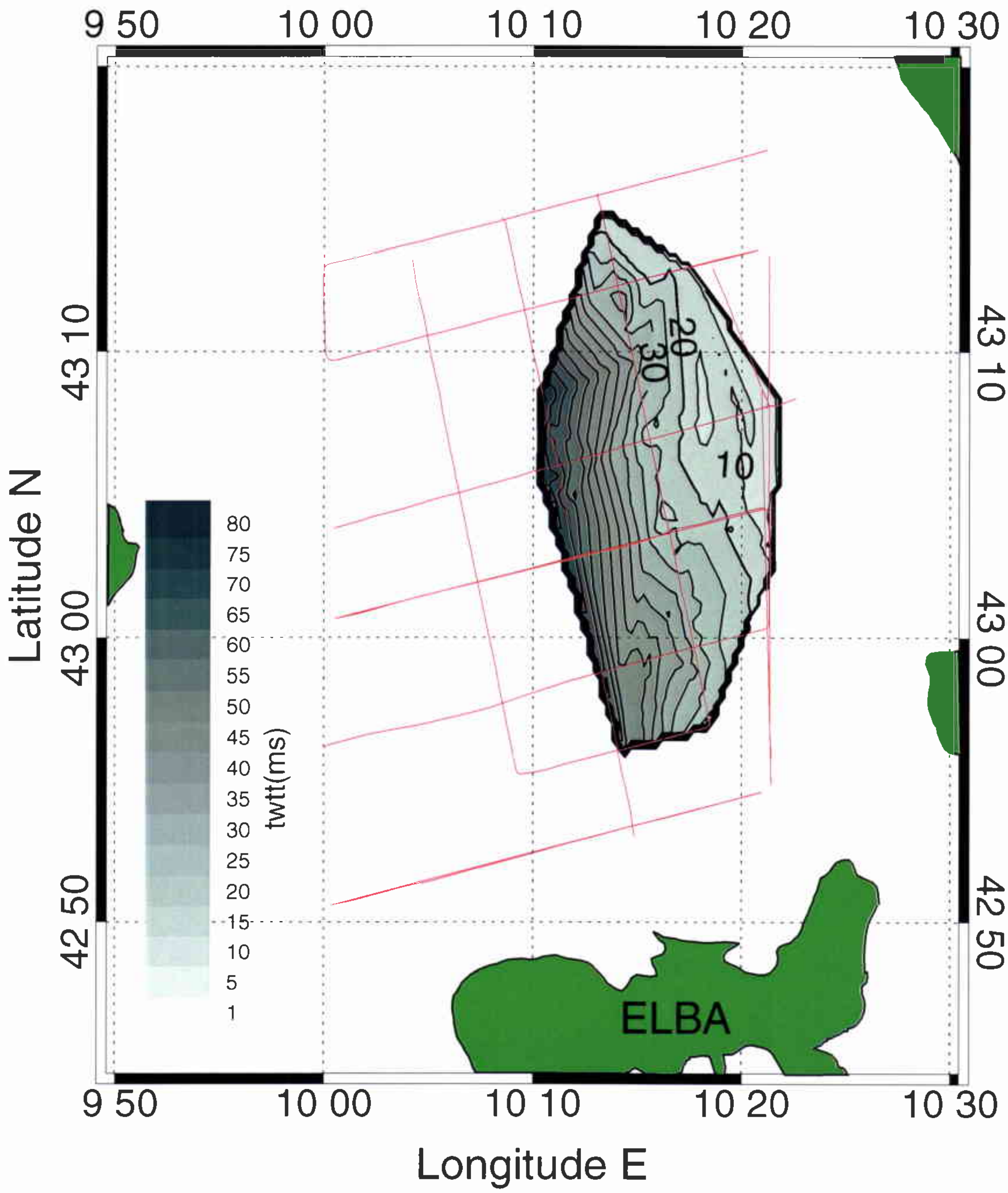

Figure 8 *Depth to reflector 15 isopach(sea floor as datum). Reflector 15 is an angular unconformity which is extensive throughout the basin, and marks the base of unit 1.*

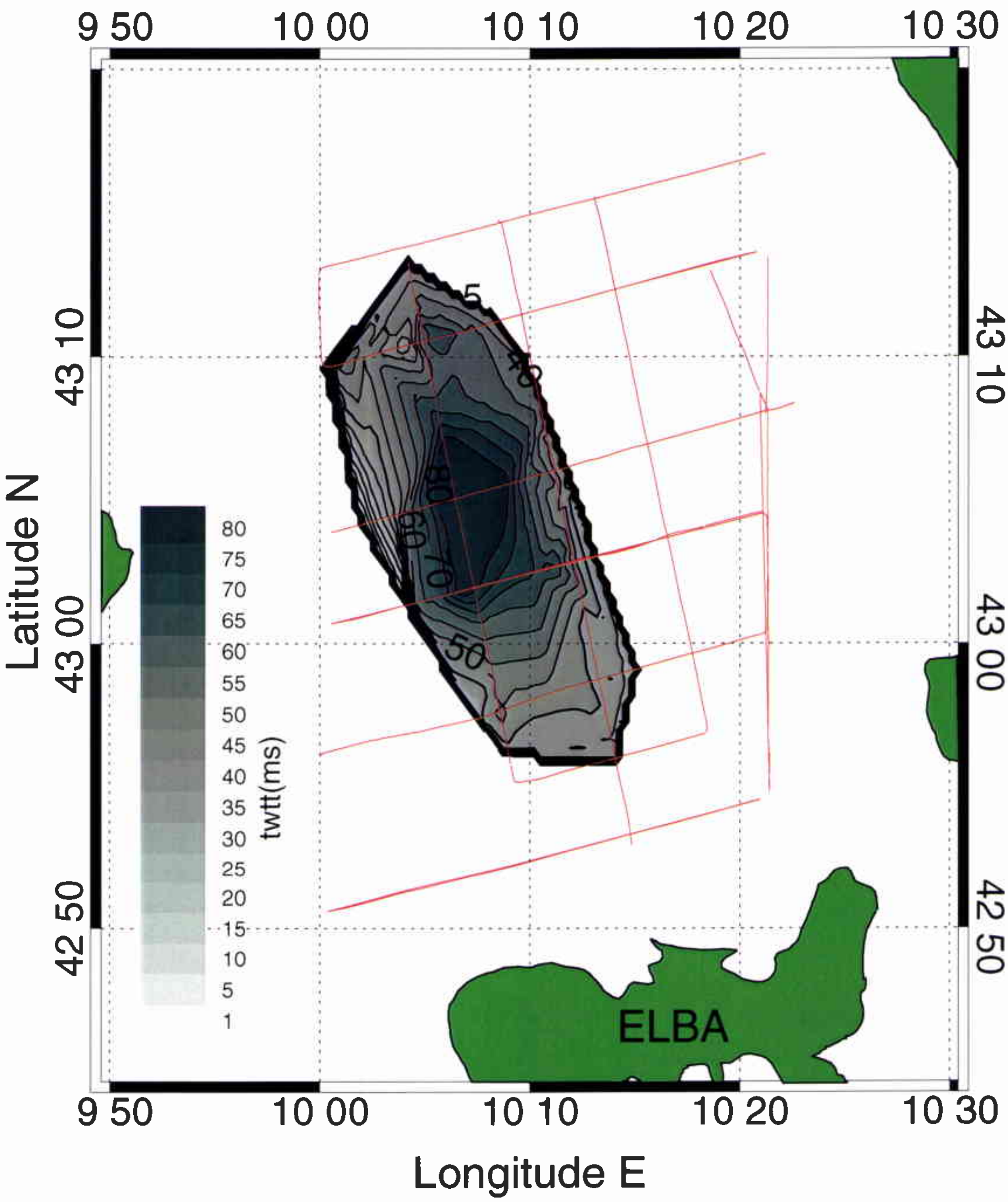

Figure 9 *Depth to seismic reflector 14 isopach (sea floor as datum).*

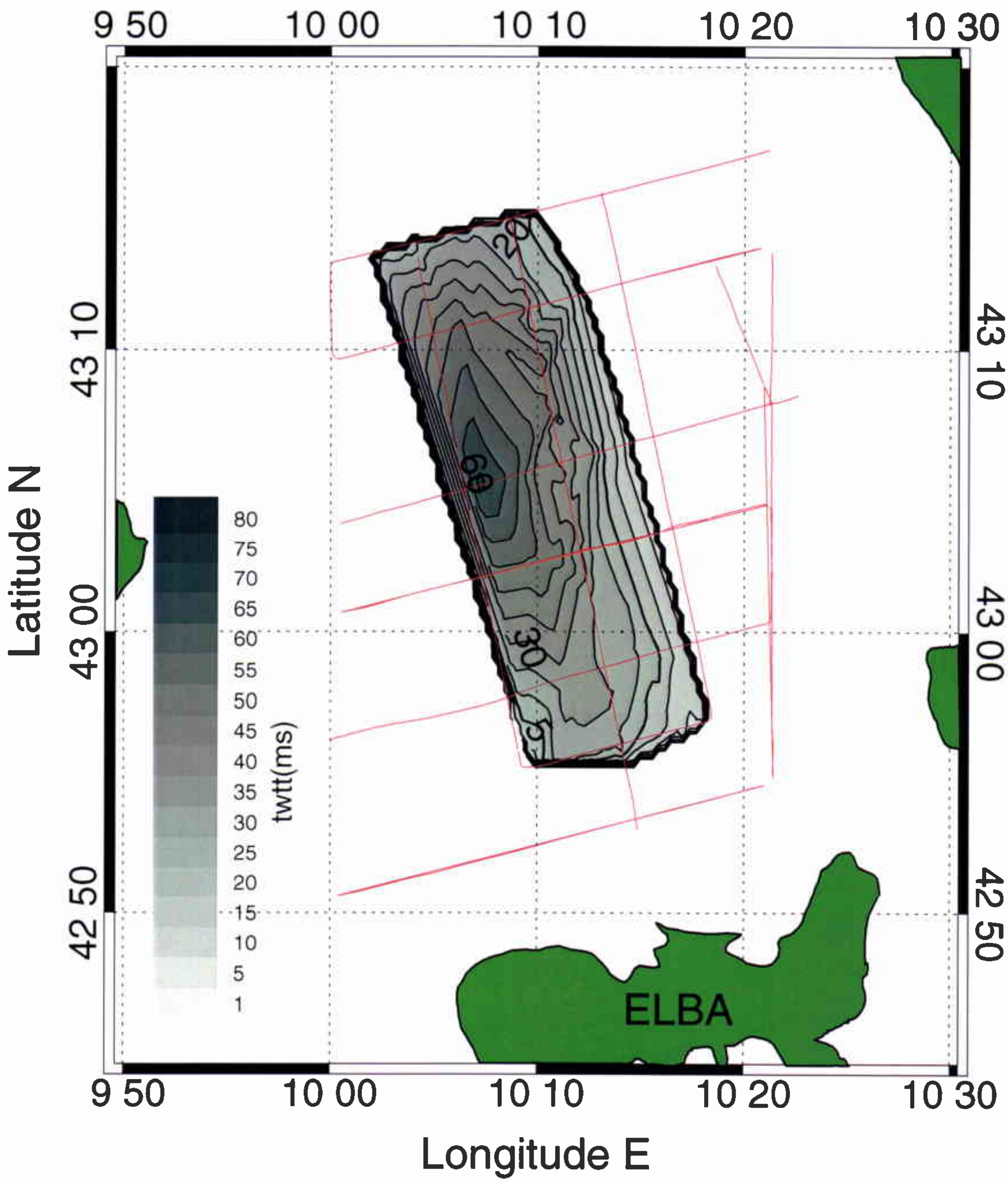

Figure 10 *Depth to seismic reflector 13 isopach (sea floor as datum).*

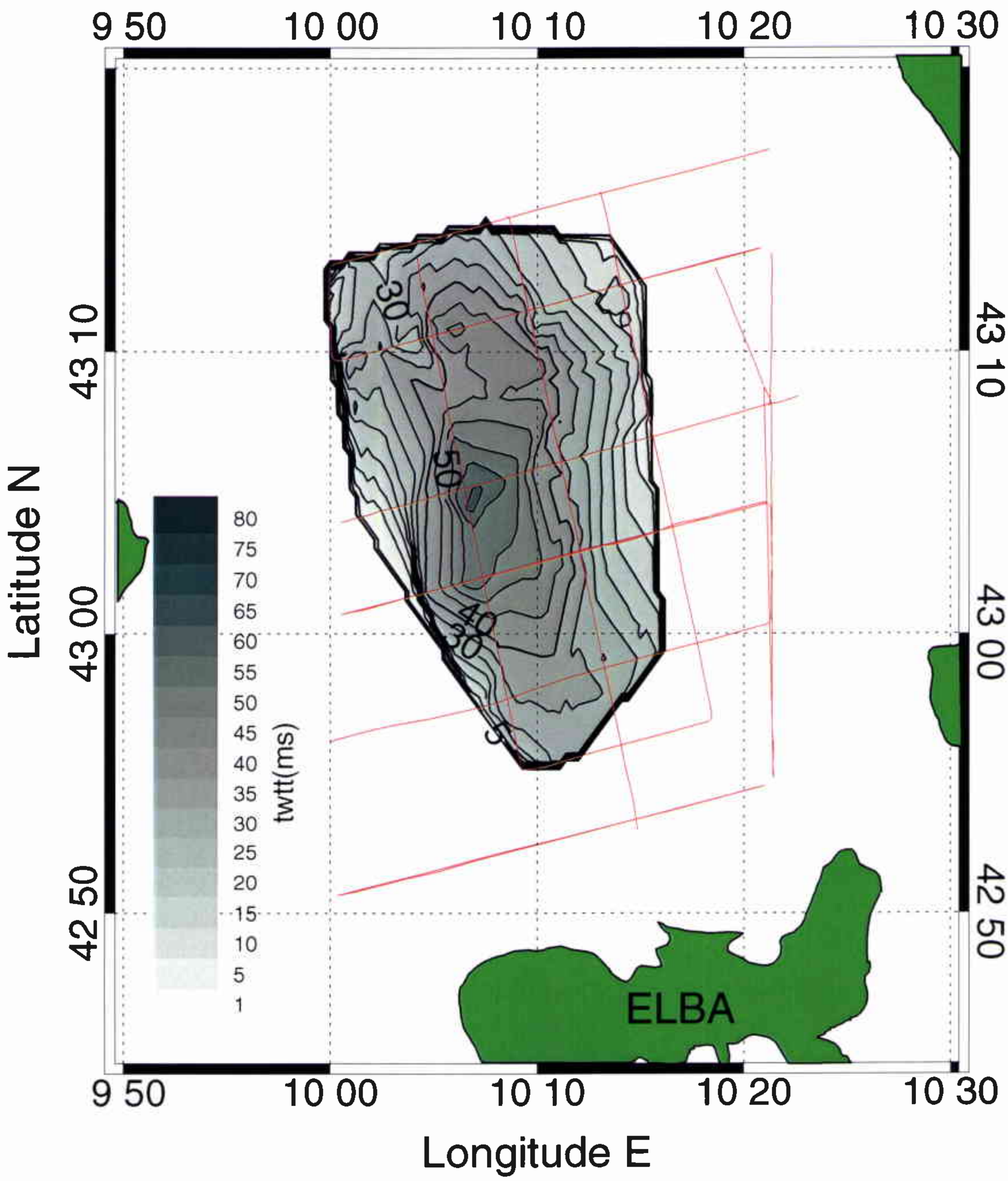

Figure 11 *Depth to seismic reflector 12 (sea floor as datum).*

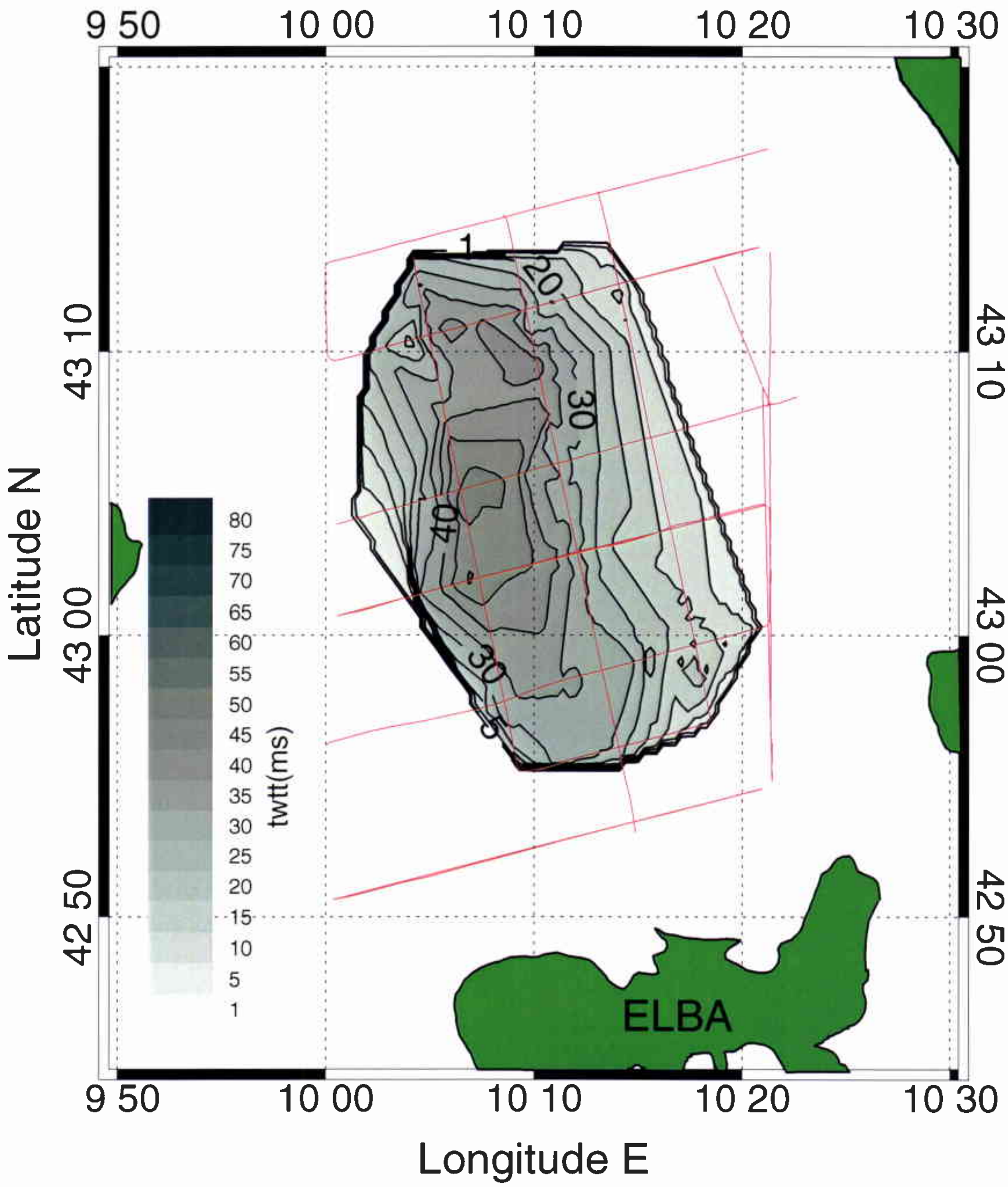

Figure 12 *Depth to seismic reflector 11 isopach (sea floor as datum).*

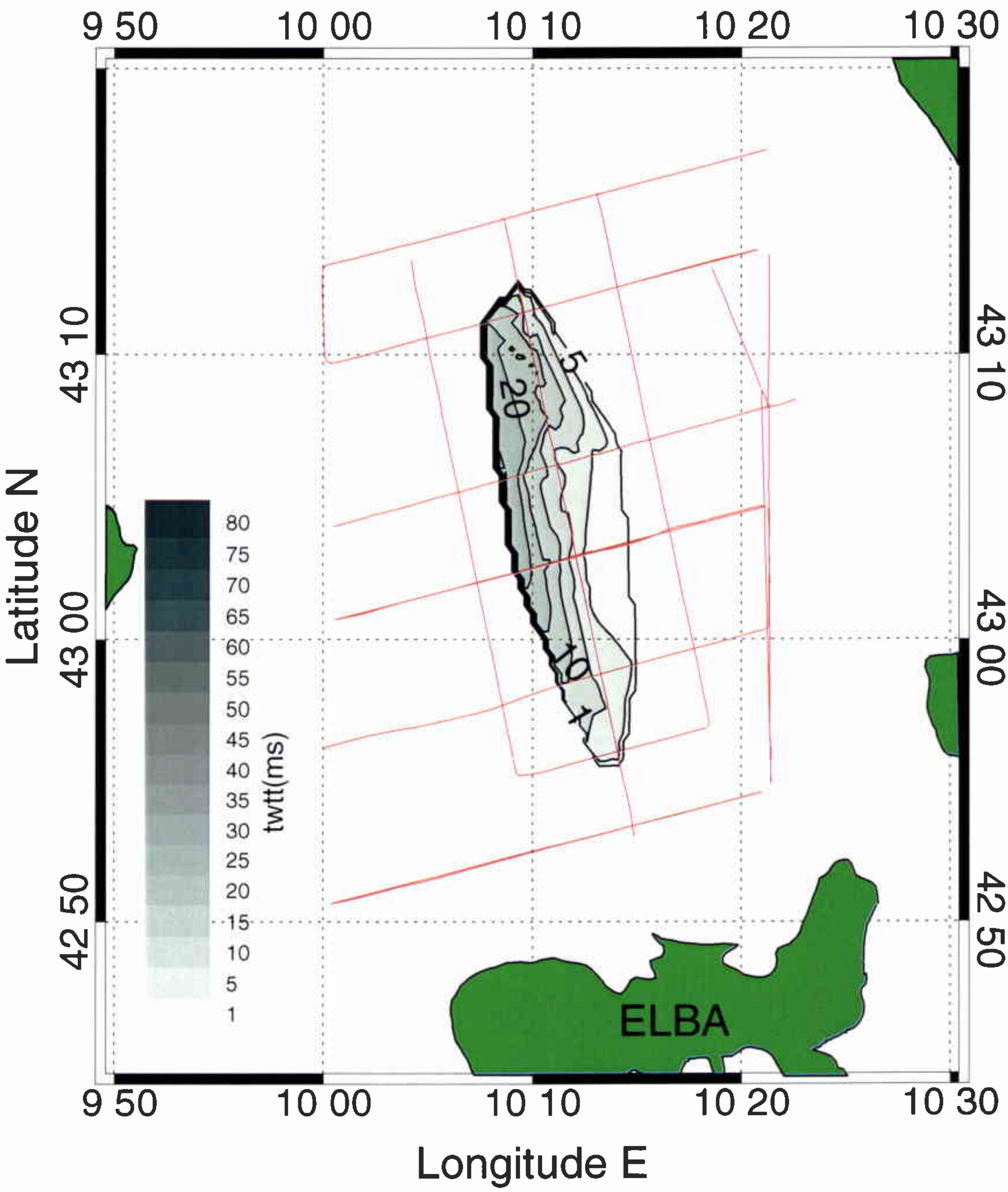

Figure 13 *Depth to reflector 10 isopach (sea floor as datum).*

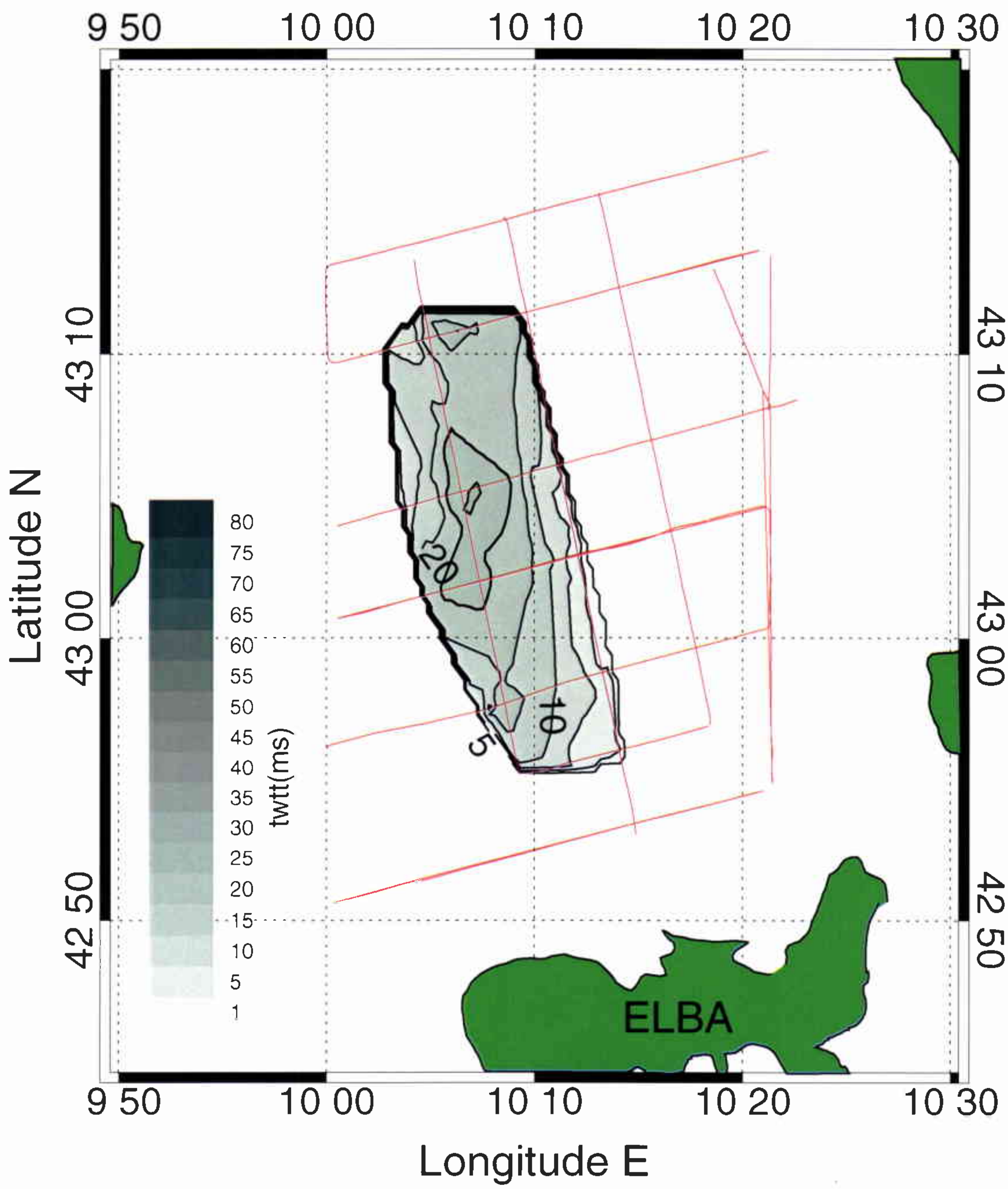

Figure 14 *Depth to seismic reflector 9 isopach (sea floor as datum).*

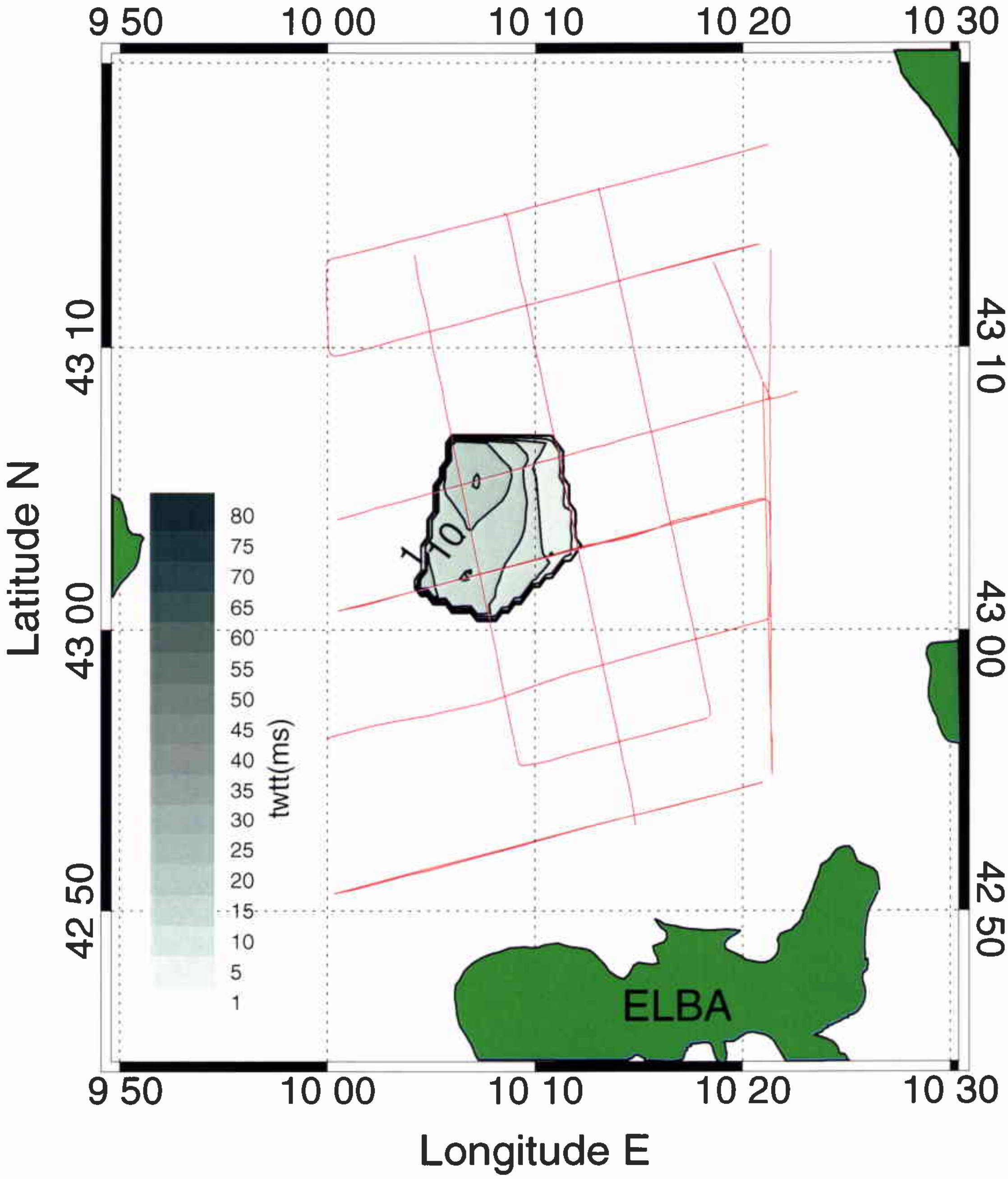

Figure 15 *Depth to seismic reflector 8 isopach (sea floor as datum).*

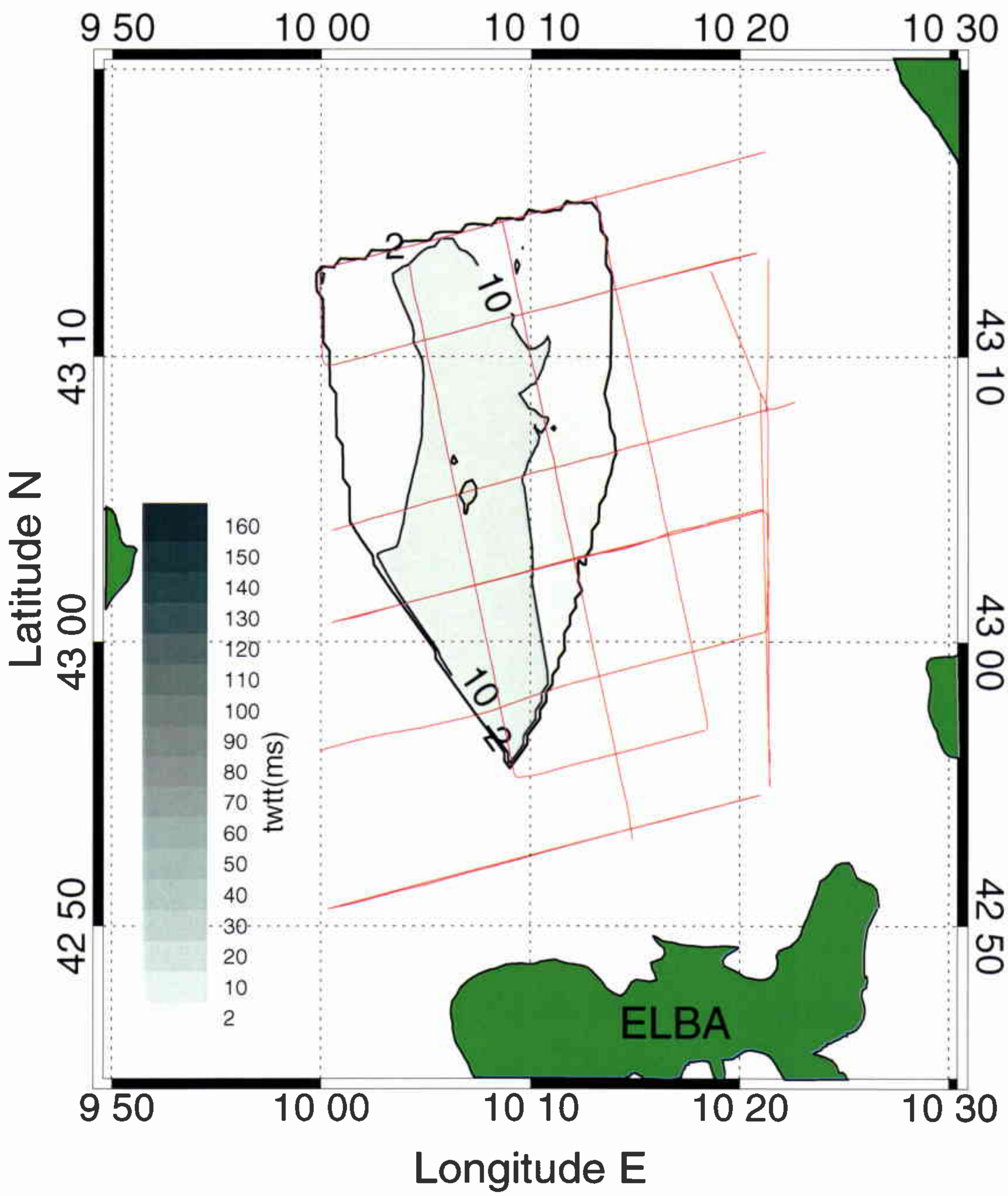

Figure 16 *Depth to seismic reflector 7 isopach (sea floor as datum).*

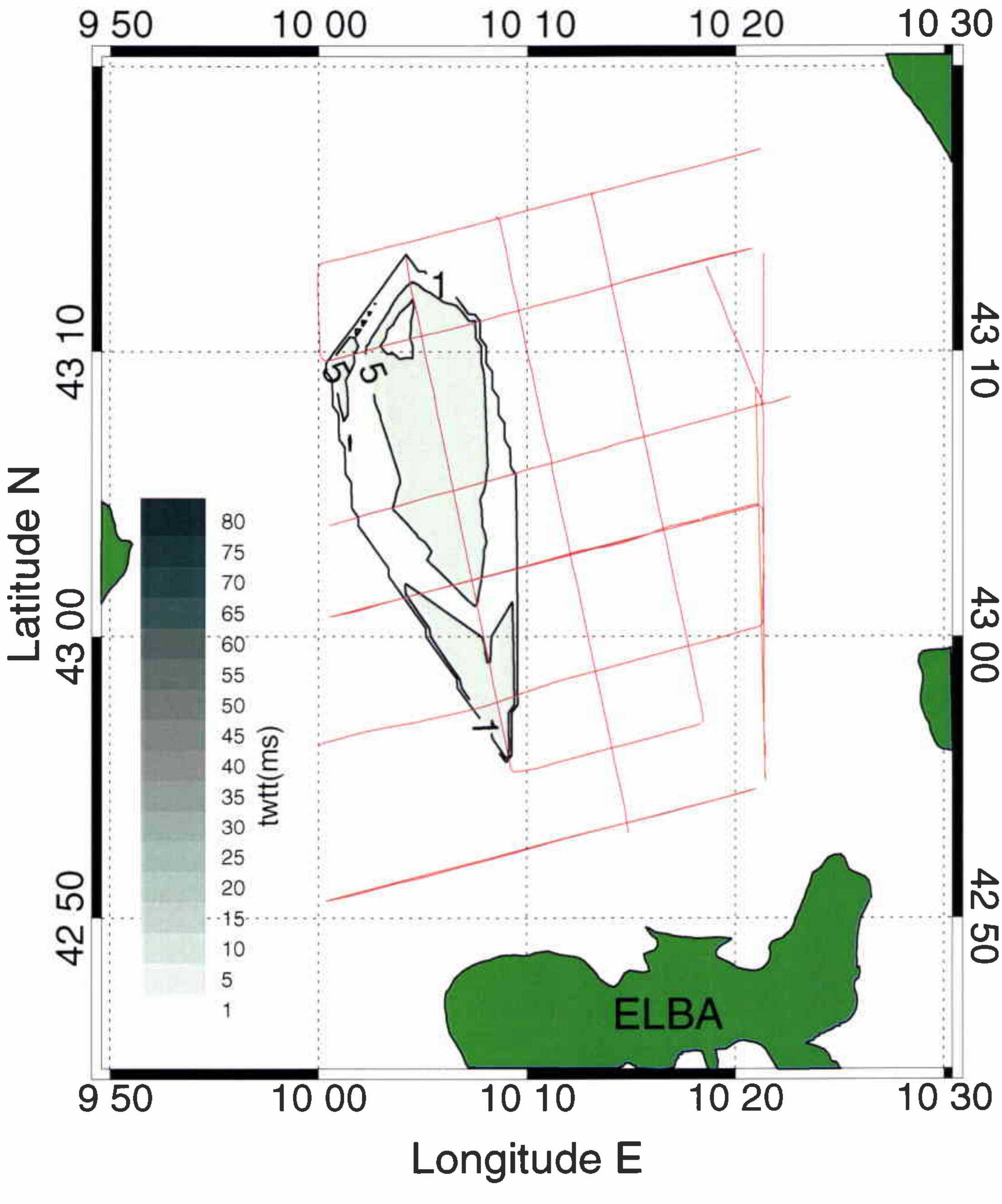

Figure 17 *Depth to seismic reflector 6 isopach (sea floor as datum).*

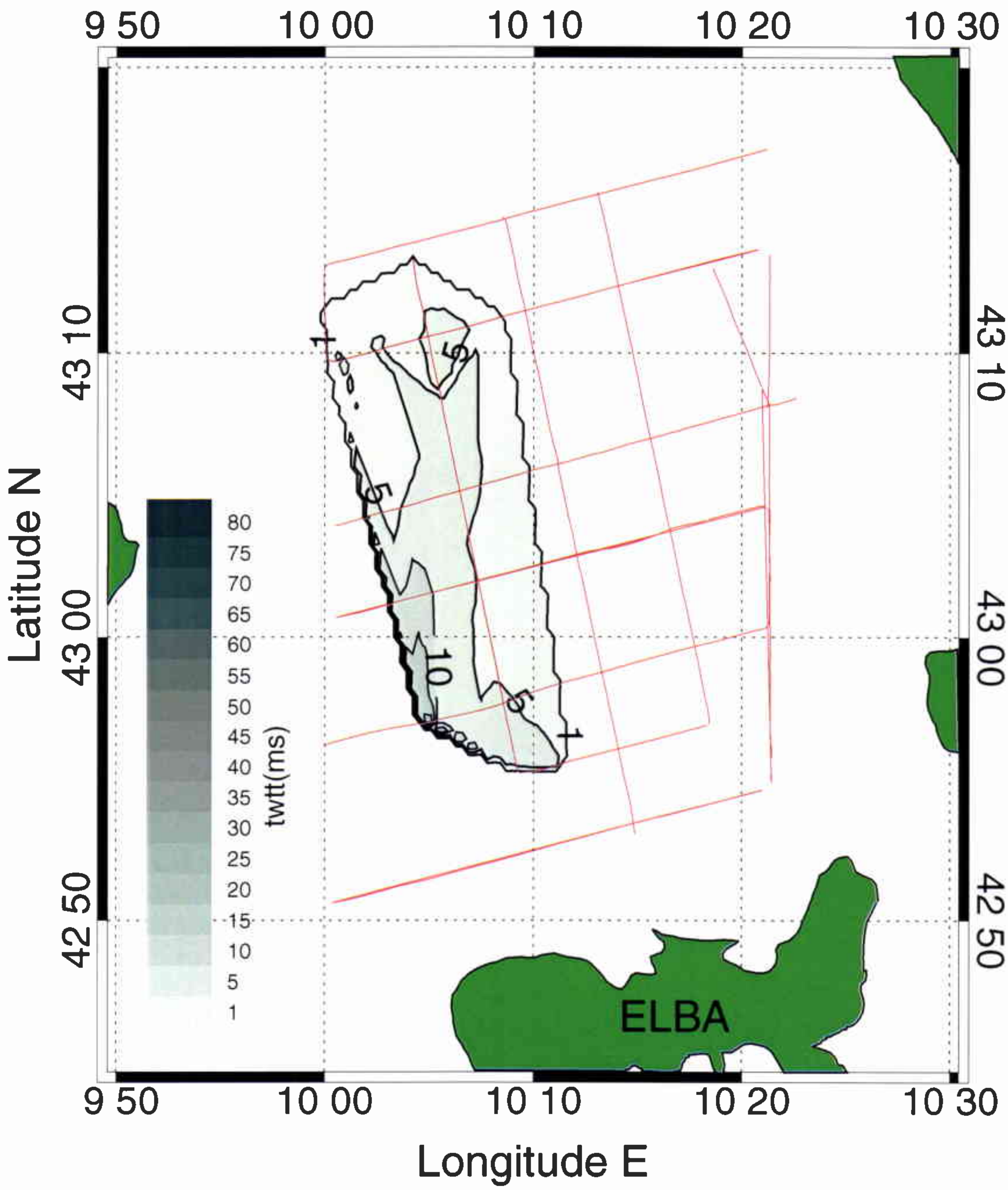

Figure 18 *Depth to seismic reflector 5 isopach (sea floor as datum).*

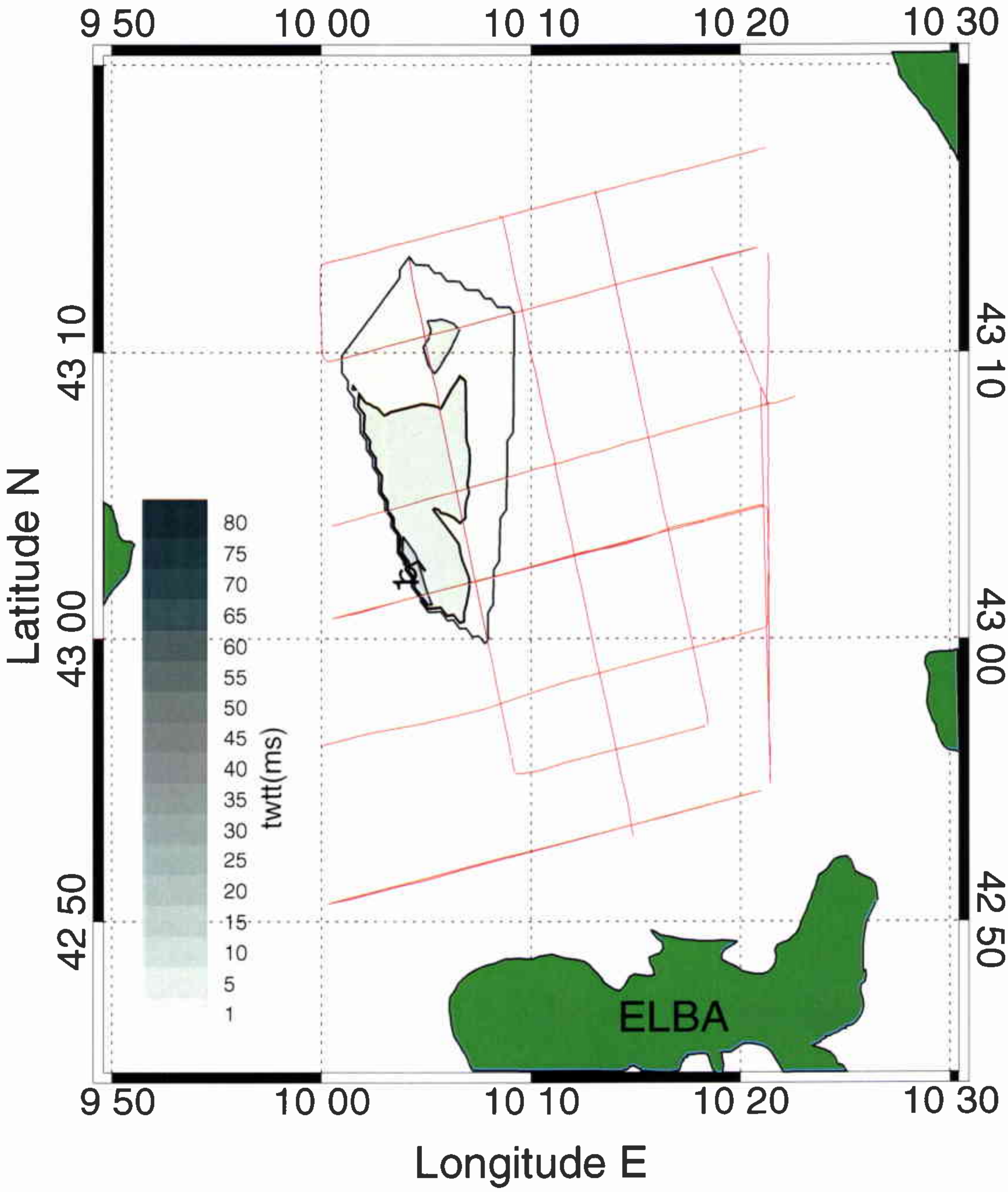

Figure 19 *Depth to seismic reflector 4 isopach (sea floor as datum).*

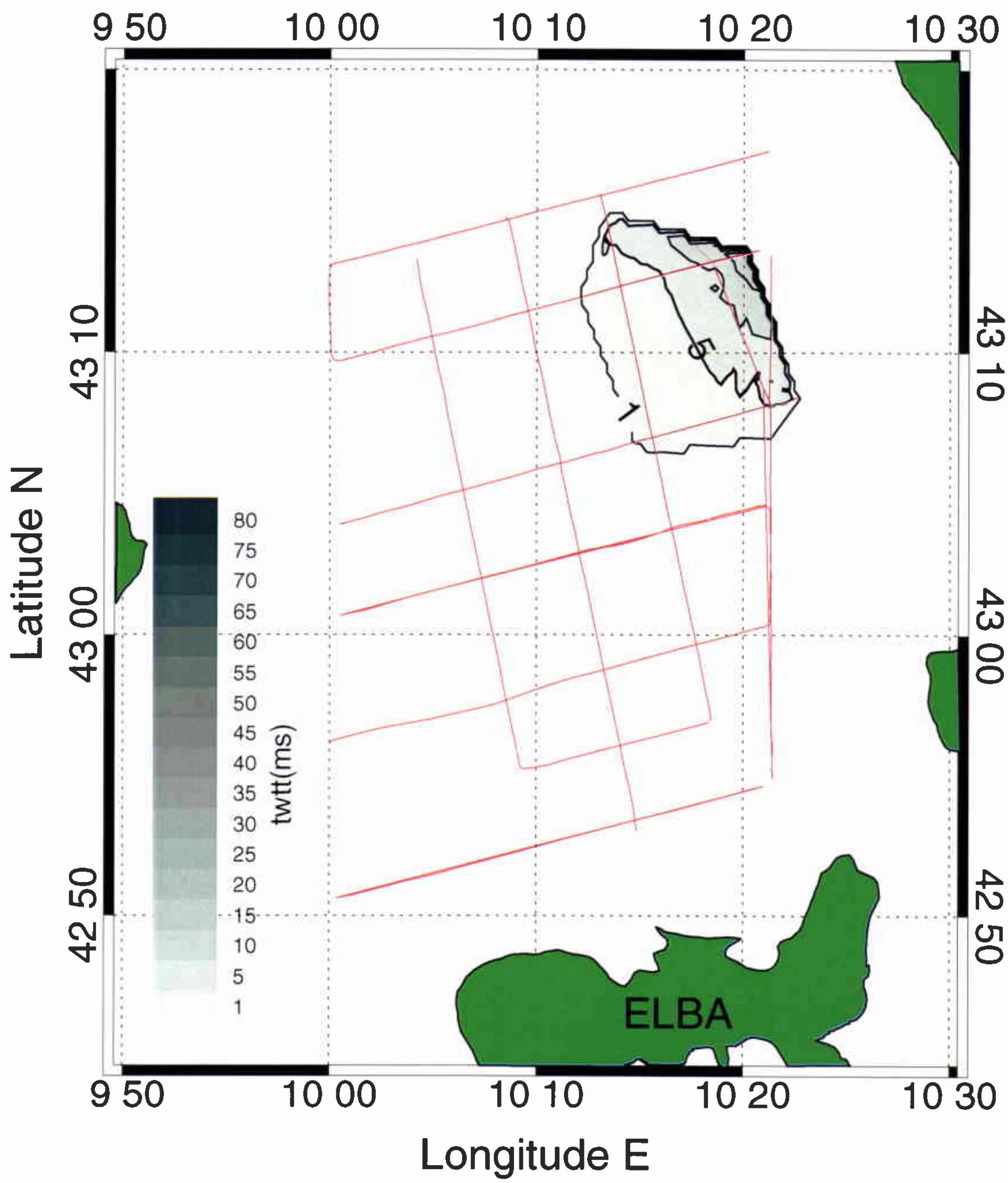

Figure 20 *Depth to seismic reflector 3 isopach (sea floor as datum).*

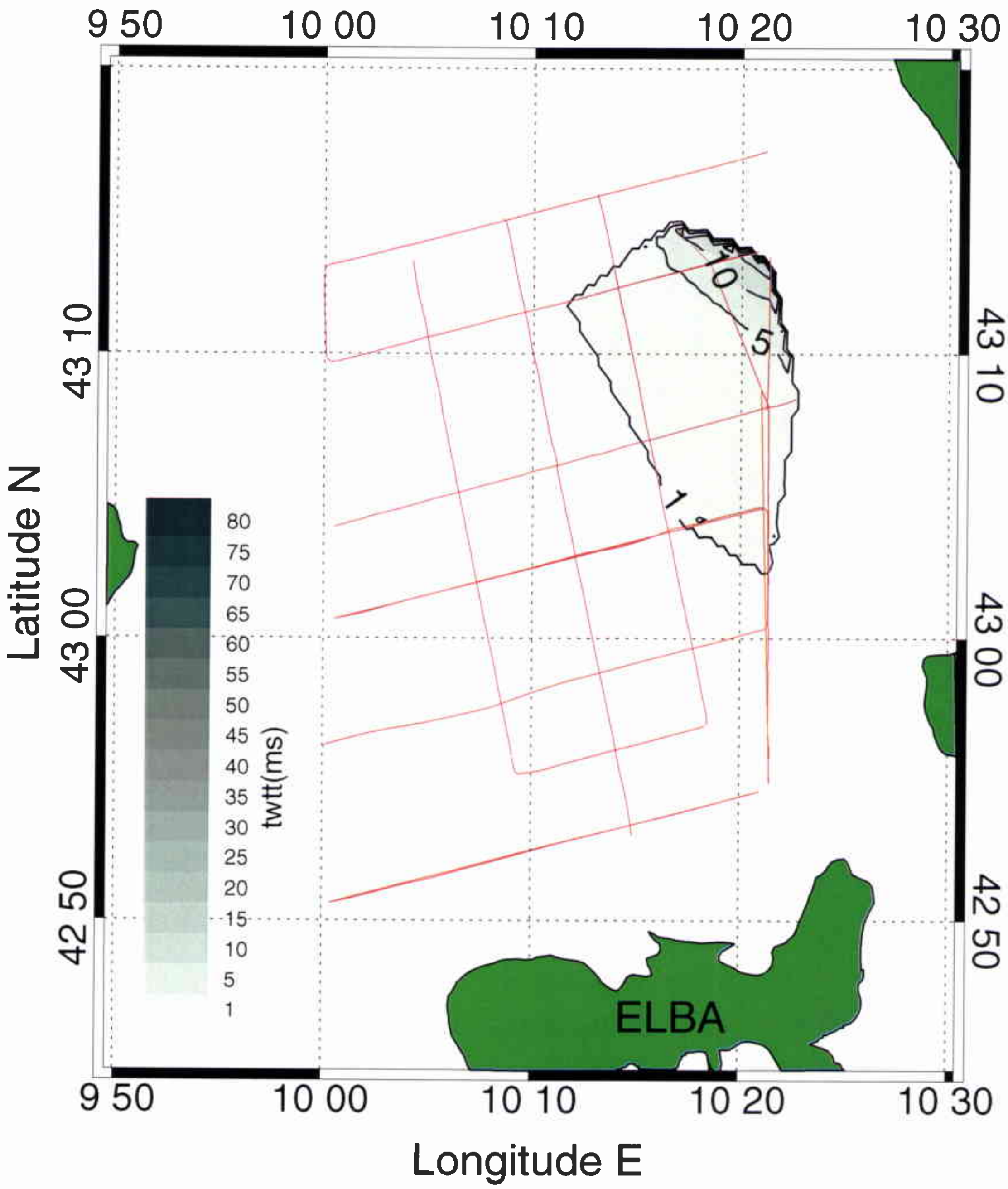

Figure 21 *Depth to seismic reflector 2 isopach (sea floor as datum).*

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Title

Sesmic stratigraphy of the Capraia Basin, Northern Tyrrhenian Sea

Abstract

The distribution and thickness of sediments within the Capraia Basin, Northern Tyrrhenian Sea, have been mapped using high-resolution seismic reflection data. The data were studied within the geologic framework determined by previous works conducted in the Northern Tyrrhenian Sea. This study was especially influenced by the work of Brizzolari *et al* (1991). Collectively these studies show that sediment above the basement in the Capraia Basin consists of at least two seismic units, deposited since the Mid-Upper Pleistocene.

Unit 1 is correlated with Brizzolari's *et al.*, (1991) unit B, and unit 2 with his unit C . Unit 1 lies unconformably below unit 2, and covers a vast area within the Capraia Basin. As determined by Brizzolari *et al.*, (1991), the deposition of unit B and unit1 was strongly influenced by Mid-Upper Pleistocene glacio-eustatic fluctuation. Subsequent rise and fall of sea level within shallower regions of the basin, especially between 115-100 m water depth, resulted in the deposition of stacked sedimentary successions (of unit 2) which display strong erosional character and discontinuity. Basinward, unit 1 thickens drastically, from 10 – 80 ms twtt, into a package of aggregated to slightly progradational reflectors. Conversely, unit 2 thins basinward. It is limited geographically to the northwestern region of the Capraia Basin. As determined by Brizzolari *et al.*, (1991), the geometry of unit 2, is strongly influenced the depositional setting. Unit 2 is composed of a thin (1- 15 ms twtt) package of stratified reflectors, which taper westward. Studies have shown that successions correlating with unit 2 are predominantly composed of sediment transported into the basin by modern day feeding sources, with dominant influence coming from the Cecina River, located northeast of the study area. Brizzolari *et al.*, (1991) interpreted unit 2 to be the result of present-day highstand sedimentation in the Capraia Basin, deposited since the Holocene.

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