37. DOMINANT STRUCTURAL TRENDS ON THE WESTERN CONTINENTAL MARGIN OF IBERIA: IMPLICATIONS ON INITIAL RIFTING[1]

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INTRODUCTION

Preparatory to IPOD site surveys for Leg 47B, a provisional bathymetric map was established (three sheets, scaled 1:500,000) for the area west of the Iberian peninsula. This report presents a new version of this bathymetric map (scaled 1:2,400,000 at 41°N) which incorporates data obtained since 1974.

ORIGIN OF DATA

Bathymetric contours on the continental shelf were drawn using numerous soundings of the Service Hydrographique et Océanographique de la Marine Française (map numbers 3388 [1959], 6088 [1963], 6133 [1956], 6229 [1963], and 6611 [1974]), and of the Instituto Hidrographico de Portugal (map numbers 1 [1970], 2 [1973], 4 [1970], 5 [1971], 6 [1972], and 7 [1973], compiled at a 1:150,000 mean scale). Complementary data from other sources concerning the continental shelf are scanty.

Several deep-ocean data sources were employed, as follows:

1) Unpublished bathymetric maps drawn by Berthois et al. (1965) from unpublished data of the Institut Scientifique des Pêches Maritimes, obtained by the R/V Président *Théodore Tissier* and *Thalassa* during their 1956 to 1964 cruises.

Sheet Number	Scale
13	1:231,500
14	1:236,600
15	1:242,100
16	1:247,000

2) Carte bathymétrique du golfe de Gascogne at a scale of 1:500,000 at 46°N, CNEXO Sheets 74-4 and 74-5 by Berthois (1974).

3) Bathymetric map of the Museum d'Histoire Naturelle, Laboratoire d'Océanographie Physique: Du Détroit de Gibraltar au Cap Saint-Vincent, unpublished map, 1971.

4) GEBCO bathymetric soundings at a 1:1,000,000 scale, plotting Sheets 42, 43, 59, and 60.

5) Bathymetry of the northeast Atlantic, Sheet 3: Mid-Atlantic Ridge to southwest Europe by Laughton et al. (1975) of the Institute of Oceanographic Sciences, United Kingdom, at a scale of 1:2,400,000 at 41°N.

6) Sounding sheets from the Service Hydrographique et Océanographique de la Marine Français F/V *d'Entrecasteaux* at a 1:1,000,000 scale at 46°N (1973).

Bathymetric soundings from campagne Noratlante, R/V *Jean Charcot*, 3 August-2 November 1969. Publication du Centre National pour l'Exploitation des Océans (CNEXO). Série Résultats des campagnes a la mer, number 1, 385 pages (1971).

8) Unpublished data from the following cruises: (a) R/V *Jean Charcot*, Cruist CH01, Centre Océanologique de Bretagne (1969); (b) R/V *Jean Charcot*, Cruise GIBRACO, CH 29 and CH 30, Centre Océanologique de Bretagne (1972); (c) R/V *Jean Charcot*, Cruise CINECA IV, CH 61 and CH 62, Centre Océanologique de Bretagne (1973); (d) R/V *Jean Charcot*, Cruise GEOBRESIL, CH 49, Centre Océanologique de Bretagne (1973); (e) R/V *Jean Charcot*, Cruise ALBATLANTE, CH 56 and 57, Centre Océanologique de Bretagne (1974); (f) R/V *Noroit*, Cruises N 11 and N 12, Centre Océanologique de Bretagne and Université Pierre et Marie Curie (1975); (g) R/V *Jean Charcot*, Cruise CH 80, Université Pierre et Marie Curie (1976); and (h) R/V *Jean Charcot*, transit using the Sea-Beam equipment (1977).

PRODUCTION OF MAPS

Soundings are expressed in corrected meters using Matthew's (1939) tables. Contours were drawn at a scale of 1:500,000 with an isobath spacing of 200 meters. Unpublished profiles listed above are shown in dashed lines with or without documented soundings. The nomenclature of submarine features is from Laughton et al. (1975). The three original maps (Figures 1, 2, and 3) have been photographically reduced to a 1:2,400,000 scale at 41°N (i.e., to the scale of Laughton et al. [1975]). Maps at a 1:500,000 scale are available from the Centre Océanologique de Bretagne.

TECTONIC SETTING OF THE WEST IBERIAN CONTINENTAL MARGIN

The main bathymetric features of the northeast Atlantic have been described by Laughton et al. (1975). Thus, we focus on the morphology of the continental margin west of Iberia in the area of Site 398. The western continental margin of Iberia is a rifted-type margin (e.g., Bott, 1976; Le Pichon et al., 1977) created during several tensional episodes since the Early Permian between Iberia and North America (Groupe

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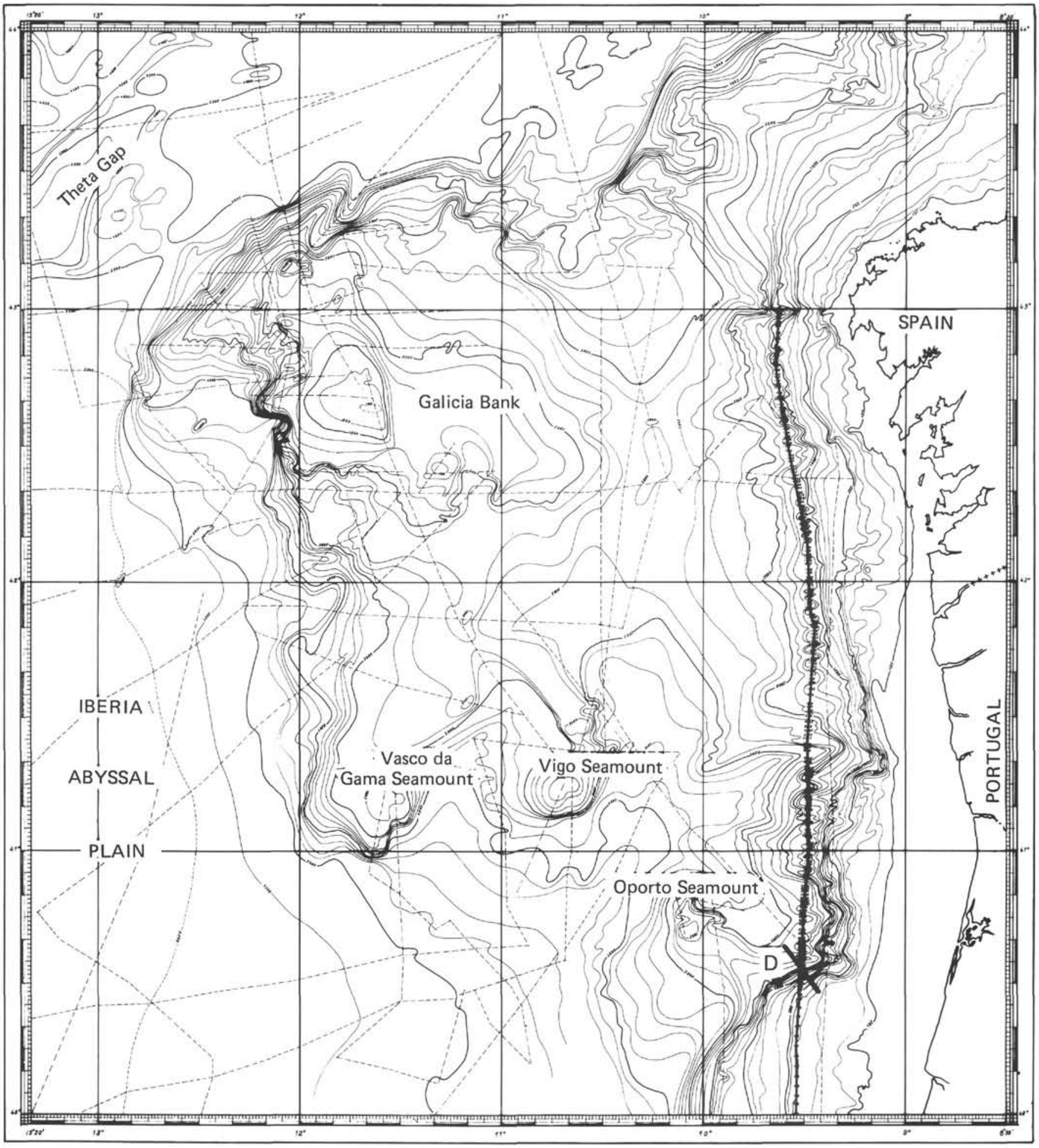

Figure 1. *Bathymetric map west of Iberia (Sheet 1) in corrected meters (Matthews, 1939). Scale of 1:2,400,000 at 41°N. Isobath spacing = 200 meters. Unpublished tracklines in dashed lines (see text). Nomenclature of submarine features from Laughton et al. (1975).*

Galice; Sibuet and Ryan; both, this volume). Nevertheless, the general morphology of this margin, at least in the vicinity of Site 398, was formed in Early Cretaceous time (late Barremian to latest Aptian) during a tensional episode responsible for the horst and half-graben structures (Sibuet and Ryan, this volume). Also, the regional morphology of this margin is largely controlled by the late Hercynian fracturing pattern. The São Vincente, Setubal, Lisboa, and Nazaré canyons roughly follow the late Hercynian shear directions

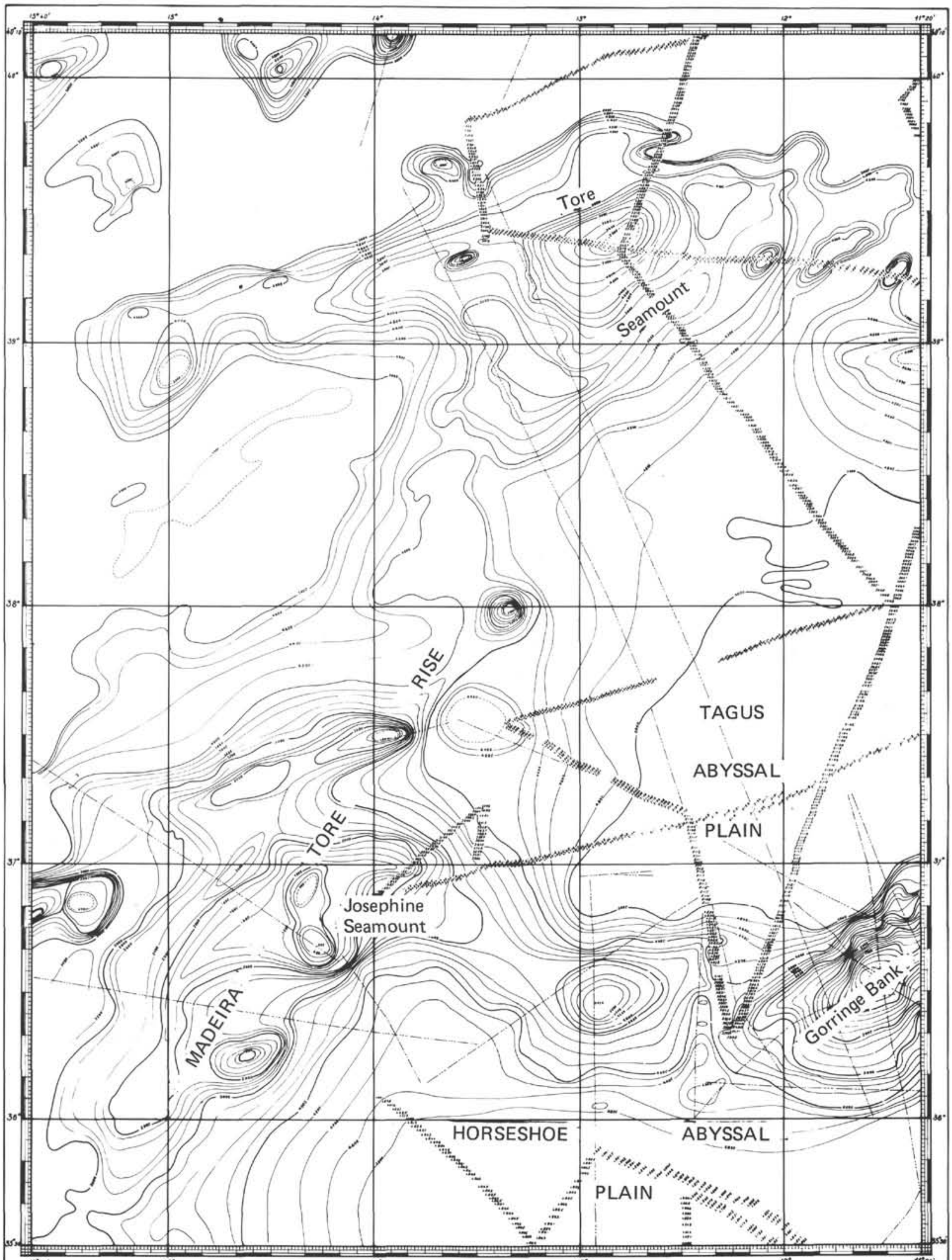

Figure 2. *Bathymetric map west of Iberia (Sheet 2).*

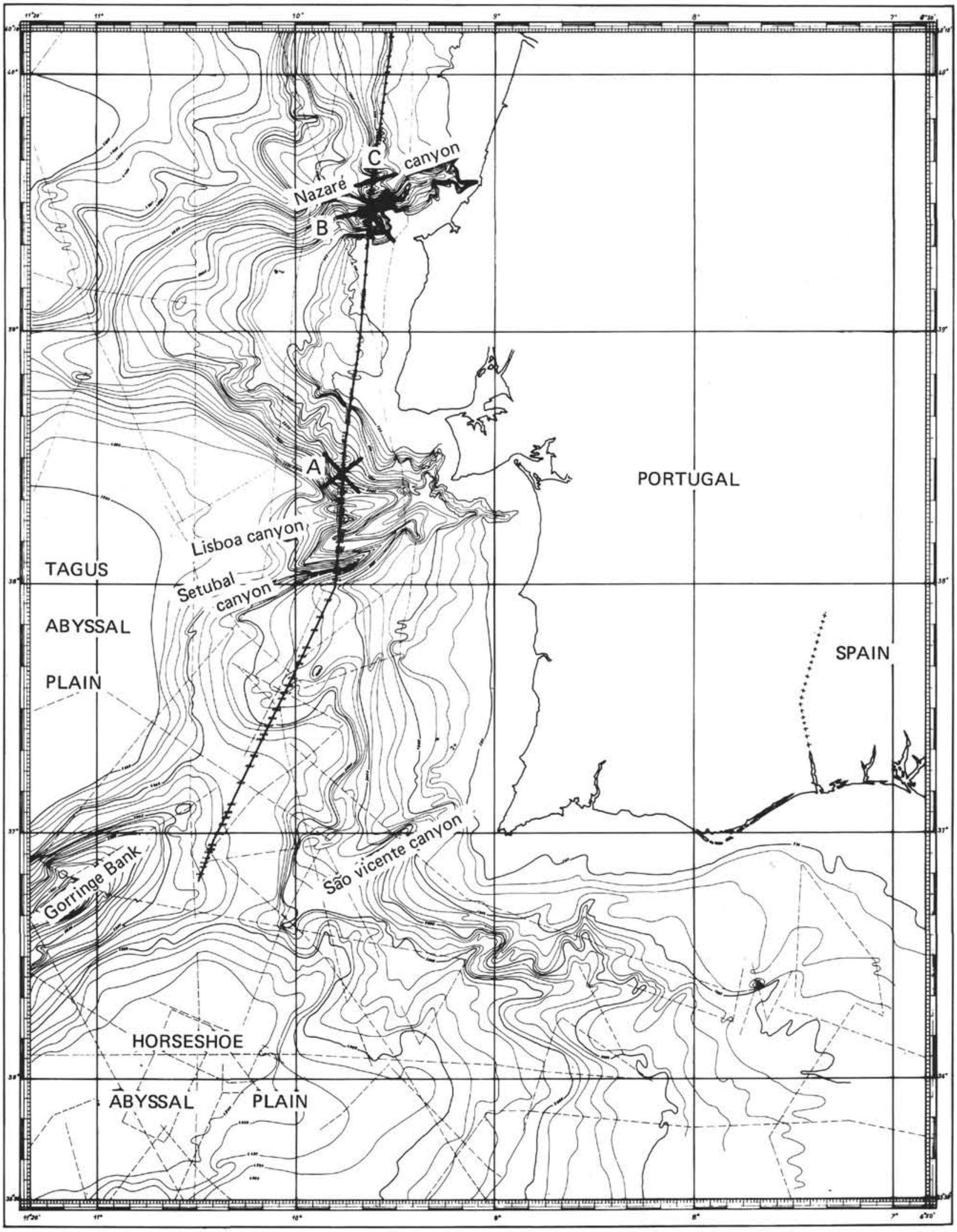

Figure 3. *Bathymetric map west of Iberia (Sheet 3).*

(E-ENE) as pointed out by several authors (Berthois et al., 1965; Boillot et al., 1974).

Previous studies suggest that Galicia Bank and the Vigo, Oporto, and Vasco da Gama seamounts are subsided continental blocks (Black et al., 1974; Pautot et al., 1970; Montadert et al., 1974) and were also affected by the late Hercynian pattern of faults (Groupe Galice, this volume). These features, approximately at the same depth (except for Galicia Bank), could have been affected by Late Cretaceous-early Tertiary compressive movements which affected the northern margin of Iberia (Sibuet and Le Pichon, 1971; Boillot et al., 1971; Le Pichon and Sibuet, 1971). These features probably have subsided continuously from the sea level since latest Aptian times, which marked the beginning of continuous sea-floor spreading west of Iberia (Sibuet and Ryan, this volume; Sibuet et al., in press).

A multibeam echo-sounder profile on the western Iberian continental margin was obtained in December of 1977 with depths generally between the 1000- and 2000-meter isobaths (Figures 1 and 3). The multibeam echo-sounder built by the General Instrument Corporation is sold under the name of "Sea-Beam." It consists of 15 narrow beams, the output of which is processed in real time. Contour maps are plotted at a chosen scale. The width of the real time contour plot is approximately ¾ of the water-depth (Renard; Renard and Allenou; Allenou and Renard; all in press). One of the most important advantages of this system is that morphological trends are directly outlined on records (Figure 4).

Several authors (Le Pichon and Hayes, 1971; Sibuet and Mascle, 1978) consider that the break-up of continents must have occurred along previous zones of weakness which had affected the whole lithosphere. To test this hypothesis, trend directions have been calculated on the sea-beam profile. Linear features used in this study are valleys of canyons when they are narrow and of constant width (Figures 4A and B), walls of canyons when valleys are widened out, and external limits of spurs. Sixty-two directions have been measured from 37.5° to 43°N (Figures 1 and 3). The frequency distribution of these directions has been obtained with averages over 10°. Two main peaks (45°N and 71°N) and three smaller ones (97°N, 314°N, and 335°N) appear in Figure 5. The error in the determinations, about 10°, results largely from the bathymetric profile having been run in very rough sea conditions (waves 7 to 8 m high).

Arthaud and Matte (1975) have demonstrated that late Hercynian strike-slip faulting in the Iberian peninsula, resulting from a north-south to northwest-southeast compression, occurred along three main directions, i.e., northeast-north-northeast, northwest-north-northwest, and east-east-northeast. These wrench faults with offsets of a few kilometers to several hundred kilometers, were active from middle Carboniferous (Westphalian, 300 ±10 m.y.) to Early Permian (280 m.y.). Their directions on the photogeologic map (IFP-CNEXO maps, 1976; Biju-Duval et al., 1976) correspond to a well-developed pattern of faults. In the western part of Iberia, the mean directions of these trends have been calculated using about 40 measurements for each type of fault. The directions obtained are 37°N, 73°N, and 311°N with a quadratic error of 5° to 6° (Figure 5).

The main implication of Figure 5 is that the northeast-north-northeast, northwest-north-northwest, and east-east-northeast maxima in directions over Iberia, which are respectively 37° ±6°, 311° ±6°, and 73° ±5° (determinations on the photogeologic map), overlap with the 45° ±10°, 314 ±10°, and 71° ±10° maxima in trend directions (Figure 5) measured on the margin which represent 70 per cent of the measured events. Consequently, the morphology of this margin seems to be controlled by the late Hercynian fracture pattern as pointed out by several authors (Berthois et al., 1965; Le Pichon et al., 1971; Boillot et al., 1974). This new well-defined correspondence between late Hercynian trends on land and on the continental margin westwards of Iberia clearly demonstrates that the initial break-up of continents between Iberia and North America has been guided by the previously acquired fault pattern. The initiation of the break-up of continents in this area is consequently post-late Hercynian (middle Carboniferous; Westphalian, 300 ± 10 m.y.) to Early Permian (280 m.y.) fracturing as recognized by most authors (e.g., Le Pichon et al., 1977; Groupe Galice, this volume). We suggest that the dominance of the 45°N and 71°N directions on the continental margin, which reflect a similar dominance on the continent, may indicate that the initial motion of North America with respect to Iberia could have followed this northeast-east-northeast strike slip direction, the conjugate direction being a direction of readjustment associated with rifted segments of the continental margin.

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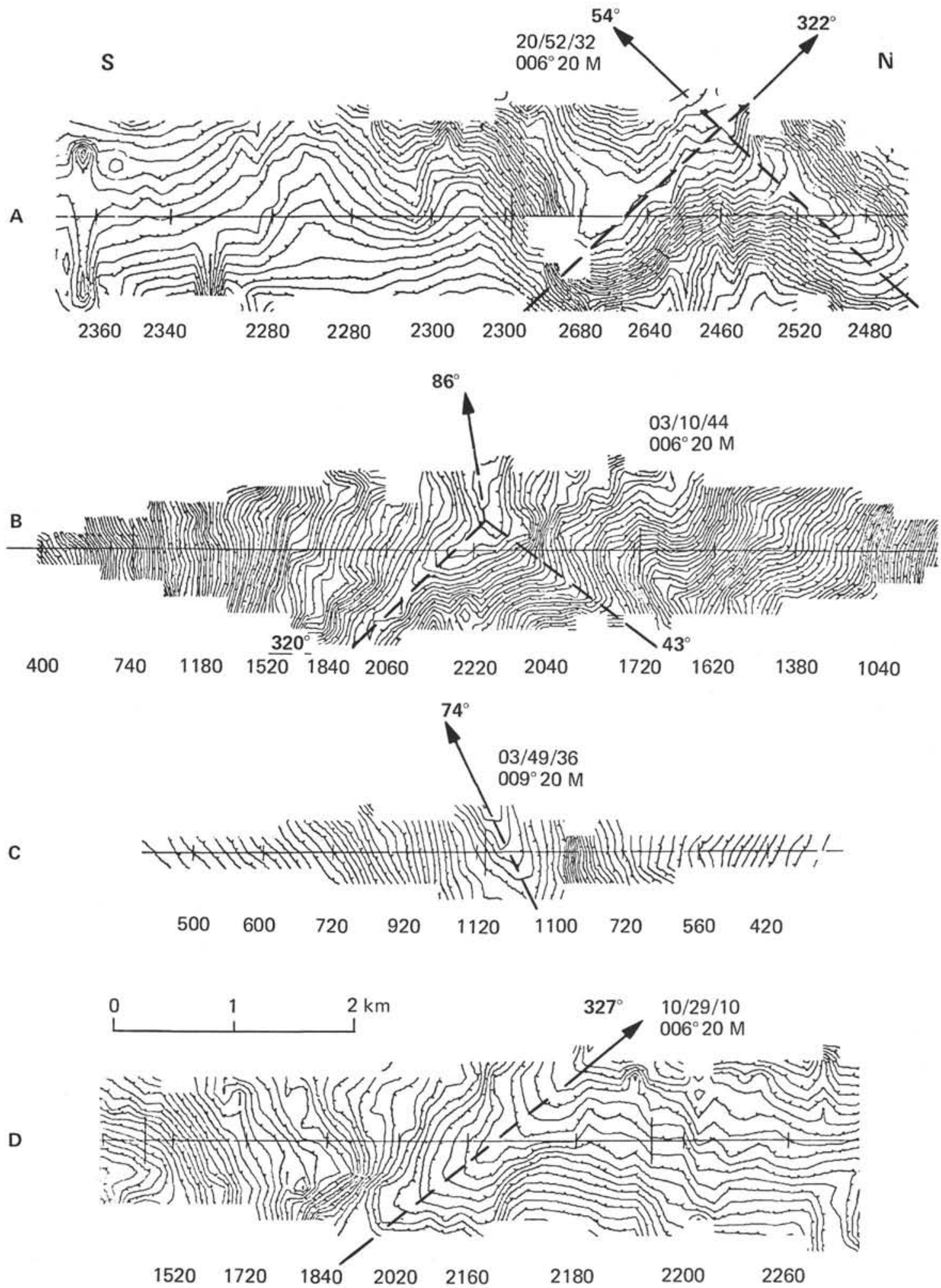

Figure 4. *Real-time bathymetric contour maps. The horizontal central lines represent the ship's track. Large lines cutting across this line correspond to the time (hour, minute, second), the course, and the contouring interval. Small lines cutting across both the main line and isobaths correspond to the depth written below. Small ticks along isobaths are on the deepest side. The original scale was 1:25,000; after reduction, the scale is 1:50,000. Four examples of canyons are shown and located in Figures 1 and 3. Orientations of canyons are indicated. Note that canyons follow conjugate structural directions (Figures 4A and B) and that a change in the trend of a canyon is shown in 4B.*

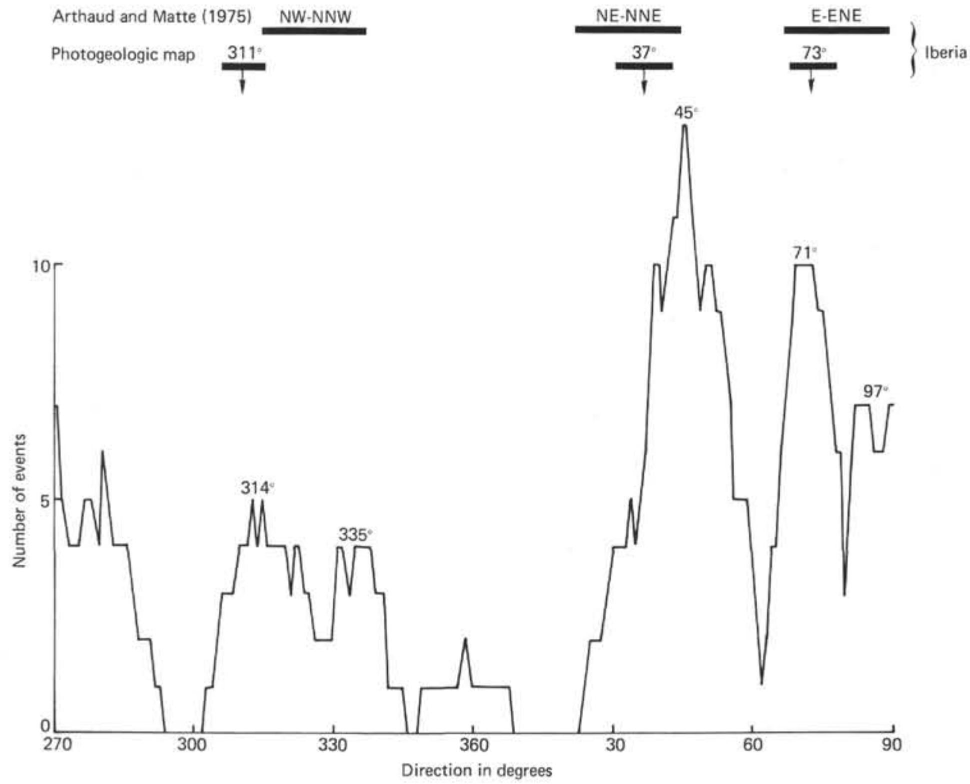

Figure 5. *Frequency distribution of trends on the western Iberian continental margin using averages over 10°. Late Hercynian fracture directions in Iberia from Arthaud and Matte (1975) and from the photogeologic map (IFP-CNEXO Sheet 1, 1976).*

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