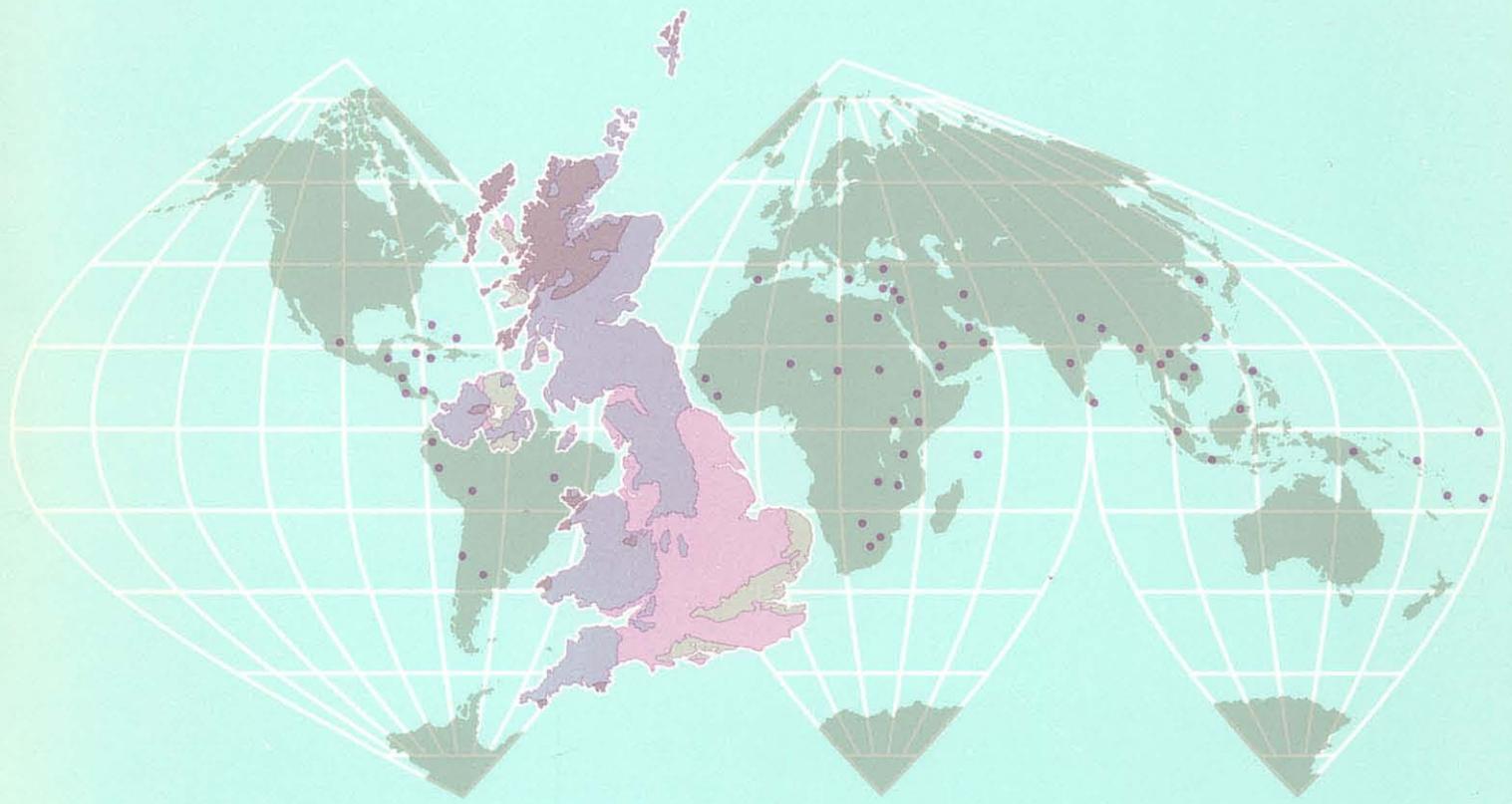




Geological and geophysical investigations in Lyme Bay



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SUMMARY

As part of a general research programme into geological mapping of coastal areas for engineering purposes, a geological and geophysical survey of the sea floor to the south-east of the coast between Lyme Regis and West Bay, Dorset, was carried out. The survey covered 90 km² and resulted in detailed mapping of two eastward plunging anticlines and their complementary synclines. The east-west and north-east-south-west trending faults, which produce major structural changes, occur within 1 mile of the coastline and demonstrate the problems of extrapolating coastal stratigraphy to any great distance offshore.

Un levé géologique et géophysique du fond de la mer, qui a été effectué entre Lyme Regis et West Bay, Dorset, faisait partie d'un programme de la recherche générale, pour des fins techniques, sur la cartographie géologique des zones cotières. Le levé, qui s'étendait jusqu'à 90 kilomètres carrés, a abouti au dressage des cartes détaillées de deux anticlinaux qui plongent vers l'est, et de leurs synclinaux complémentaires. Les failles, qui se dirigent de l'est à l'ouest et du nord-est au sud-ouest, produisent des changements structuraux majeures en deca de 1,6 km du littoral, et démontrent nettement les problèmes associés à l'extrapolation de la stratigraphie au littoral à une grande distance au large.

Als Teil eines allgemeinen Forschungsprogrammes für die geologische Kartierung der Küstengehiete für technische Anwendungen, machte man eine geologische und geophysische Untersuchung des Meeresbodens südöstlich der Küst zwischen Lyme Regis und West Bay, Dorset. Der Untersuchung eines Gebietes von 90 Quadratkilometern folgte die ausführliche Kartierung von zwei nach Osten führenden Antiklinen und ihren entsprechenden Synklinen. Die Ost-West und Nordost-Sindwest gerichteten Verwerfungsspalten, die grosse Strukturveränderungen verursachen, geschehen innerhalb einer Meile der Küste, und zeigen deutlich die

Probleme, die mit der Extrapolation der Küstenstratigraphie bis zu irgendeiner grossen Weite von der Küste weg verbunden sind.

INTRODUCTION

In recent years there has been increasing interest in the engineering properties of the sea floor and underlying geological structures in the nearshore environment. These coastal areas form an interface zone between land and marine activities and are under intense pressure from demands for oil and gas pipeline installations, deep water anchorages, sewage pipes, navigational installations and recreational facilities. Selection of a development area is controlled both by fundamental factors, such as geological structure and geomorphological history, and by social and ecological circumstances.

The first essential part of an investigation of any area where civil engineering developments are proposed is a geological survey of the sediment and rock types likely to be encountered during the subsequent site investigation of their engineering properties. In the shallow water coastal zone the sub-bottom geology can sometimes be determined by extrapolating information from the adjacent land; usually, however, marine geological surveys are carried out using geophysical techniques such as continuous seismic profiling and sideways looking sonar in conjunction with borehole and gravity core samples.

The work described here is part of a general research programme into geological mapping of coastal areas for engineering purposes. Particular attention is paid to the Dorset Coast in southern England, known throughout the world as a classic area for studying Jurassic rocks. The major part of the Jurassic system is observed in a series of coastal exposures stretching from Pinhay Bay in the west to Portland Bill in the south-east. Many important papers have been published on this area (Buckman, 1910, 1922; Lang, 1914, 1917, 1924, 1936, Howarth, 1957;

Dean et al, 1961). Recently, however, research has continued offshore into Weymouth Bay (Donovan and Stride, 1961) and the eastern English Channel (Dingwall, 1970).

In the area between Lyme Regis and West Bay, particularly in the area of Black Ven and Golden Cap, rapid recession of the coastal cliffs has occurred because of landslide activity. Landslide activity on Black Ven has seriously affected property and recreational facilities in Lyme Regis and Charmouth, and research studies have been carried out to examine the factors controlling the stability of this landslide (Denness, 1972; Denness and others, 1975; Conway, 1974). Current activity is related to the coastal geomorphology, which is controlled to a great extent by the geological history of the area, particularly in the immediate offshore zone.

The debris from these landslides has produced large mudflows on the beach and this material is continuously eroded away by the sea. Undoubtedly this process has been in progress for many thousands of years, as boulder arcs from old mudflows can be observed some distance from the beach in the nearshore zone. The bulk of the material is swept away eastwards by a strong inshore current but chert pebbles and some gravel and coarse sand can be found on the beach.

The Lyme Regis-West Bay area is ideal for a study of coastal engineering problems both on land and in the immediate nearshore zone, so the geological survey of the fore-shore area was extended offshore using marine geophysical surveying techniques (Figure 1). The sub-bottom structure and sea floor morphology were examined by continuous seismic profiling, side scan sonar and echo-sounding equipment. Sampling was carried out by scuba divers, Shipek grab, gravity coring and drilling.

The survey, which covering approximately 90 square kilometres, illustrates the high density of traverse lines necessary to allow reliable interpolation between adjacent data points in a highly complex area (Figure 2). The results highlight the danger of extrapolation of the land geology into the offshore zone and the problem of carrying out routine site investigations based solely on sample evidence.

SUMMARY OF FIELD WORK AND GEOPHYSICAL INSTRUMENTATION

The main geophysical survey work was carried out between 1970 to 1971 and the interpreted results were used to site sampling and drilling locations for the later cruises of 1972-1975.

SURVEYS FROM VESSELS

Ts 'Somerset', 29th July - 17th August 1970

The initial geophysical survey was carried out on a grid with a line separation of 500 m (Floyd and Hallam, 1970). A Decca Mark 12 navigation system was employed throughout and 5-minute fixes were plotted on photographically enlarged Decca lattice sheets (6 in to 1 mile). Decca reception was excellent throughout the survey and the lattice cut off angles were approximately 90°. A high standard of accuracy was therefore maintained.

Precautionary measures against Decca errors were, however, taken. Sixteen sounding markers were surveyed in along the coastline and four Dan buoys with radar reflectors moored in pre-selected positions. Both systems were used as cross checks to the Decca system. All traverse lines were run along the Decca lattice enabling a further cross check for accuracy.

In order to calibrate the various echo sounding surveys, a tide gauge was erected in Lyme Regis harbour. Observations were taken at half hourly intervals between 0800 and 2100 hrs during the period 4th-15th August 1970. This tide gauge was levelled into the bench mark on Lyme Regis quay, and echo sounding readings could then be reduced to the local OD.

Continuous seismic profiling was carried out with an I. F. P. multi-electrode sparkarray operating at 500J. Signals were received by an E. G. and G. Type 263B hydrophone and recorded on a Hunttec recorder.

Sonar records were obtained with an E. G. and G. towed side scan sonar fish operated by a modified E. G. and G. Type 254 recorder on which the results were recorded.

Bathymetric records were taken by a K. H. MS. 36 echo sounder mounted over the side of the ship.

Thirty-one bottom sediment samples were collected by Shipek grab.

'Dorset Lass', 20th September - 3rd October 1971

A shallow nearshore survey to obtain sonar coverage was carried out using the fishing vessel Dorset Lass. This completed the previous year's work and covered areas where Somerset was unable to operate. Sonar records were obtained from a KH MS. 47 transit sonar. Position fixing was achieved by operating the boat along fixed transit lines in a south-west-north-east direction, parallel to the Decca Lattice, and taking fixes with a sextant on ranging posts offset at right angles to the survey lines on the beach.

A preliminary interpretation of the records was carried out during the survey and these results used to determine sampling points for the scuba divers.

RRS John Murray and mv 'Whitethorn', 1974

Results of gravity coring carried out during a geochemical research cruise on the RRS John Murray were incorporated into this survey. Both continuous seismic profiling and transit sonar coverage were obtained on this cruise. The records, which covered a larger area than that in this paper, were used to cross-check the previous interpretation.

Core drilling, gravity coring and Shipek grab sampling were carried out by mv Whitethorn during routine surveying operations. The positions of the boreholes were fixed with the Alpine Precision Ranging system.

Both mv Whitethorn and RRS John Murray were fitted with Decca Mark 21 receivers operated in conjunction with an automatic track plotter.

Mv 'Whitethorn', 1975

A further 3 boreholes were drilled during routine surveying operations. Again their positions were fixed by the Alpine Precision Ranging system.

Onshore boreholes at Charmouth, 1973

Three boreholes, numbers 15, 16 and 16A, were drilled at Charmouth. Continuous core was obtained for geological logging and selected samples were retained for geophysical laboratory measurements. BH 15 was at 166.99 m above OD while 16

and 16A were at 3.43 m above OD and 3.39 m above OD respectively.

Sample identification and analysis

The positions of all sample and borehole locations are shown on Figure 3. Gravity core samples were divided into three portions, one for analysis, one for lithological studies and one for storage. Offshore cored boreholes were analysed in detail for both micro and macro-fauna. Samples collected by scuba divers were analysed for microfauna.

Velocity, density, and porosity determinations were carried out on samples from boreholes 15, 16 and 16A (Culshaw, 1973), borehole 74/48 and gravity core samples 330 and 331 (Darton, 1975) and additional samples collected on the foreshore.

INTERPRETATION OF GEOPHYSICAL DATA

The survey used three main geophysical surveying techniques: echo-sounding, sideways looking sonar, and continuous seismic profiling. All three sets of instrumentation were operated simultaneously so that recorded fix positions were identical for each. It is therefore possible to use the records to obtain a simultaneous interpretation of both the seabed morphology and sub-bottom geology. This has resulted in an improved geological interpretation (for example, possible faults on continuous seismic profiling records can be checked against outcrop patterns on the sonar records).

SURVEYING TECHNIQUES

Echo sounding

Continuous echo soundings were obtained and tidal corrections, based on readings from the tide gauge at Lyme Regis, were applied. As this gauge had been levelled into the bench mark on Lyme Regis quay all readings were reduced to the local OD and contoured at 2.0 m intervals (Figure 4).

Side scan sonar

These records were of variable quality due mainly to the difficulty of ensuring that the sonar fish was positioned at its optimum operating position of 10 m above the sea floor. However, it did prove possible to incorporate

the results of the more widely spaced 1974 John Murray survey.

No quantitative work was attempted on these records which were used, in conjunction with the echo-sounding data, to define outcrop patterns and cross check the structural styles shown on the continuous seismic profiling records. All the available sonar data are plotted on Figure 5.

Continuous seismic profiling

These records provide the most important structural information, since the major geological features are clearly recognisable and can be interpolated between survey lines. It is important to realise that the geological information is portrayed as a series of seismostratigraphic groups, whose lithologies and depths can be determined only by sampling of the sea bed outcrops or the collection of cores from boreholes.

Geological interpretations were traced from the seismic records with basic depth measurements expressed as two-way travel time in milliseconds (Sargent, 1966). Conversion of their value to true depths requires a knowledge of the compressional wave velocity in the various geological units and can be determined either by laboratory measurements on core samples or by sonic logging methods.

Considerable information is available on the compressional wave velocity in all the geological units offshore but for convenience the millisecond calibration is retained on the cross-section. Depth conversions can be made but it is found that, in particular, the alternating clay/limestone sequence within the Blue Lias and the different limestone types within the Inferior Oolite result in a wide range of values for the compressional wave velocity measured in these rocks.

In general the multiple reflections were clearly defined on the seismic records, although some masking of the sub-bottom reflectors did occur in the shallow nearshore area. Environmental noise did not prove a problem because of the calm sea and the fact that ts Somerset had a wooden hull.

STRATIGRAPHY

The units occurring onshore are shown in

Table 1 and a full description of them can be found in Wilson and others (1958) and Cope and others (1969).

The units mapped offshore, also shown in Table 1, are more broadly based than those recognised on land and the mapped boundaries do not always coincide with the accepted on-shore stage boundaries (e.g. the Callovian-Bathonian boundary). This lack of refinement can be attributed to the limitations of the offshore survey method, since the continuous seismic profiling equipment did not have sufficient resolution to differentiate among all the lithological units present, and the sampling programme supplied information on only the lithology and fauna of the strata at fixed localities. Therefore, the map shown in Figure 6 depicts only the seismostratigraphic groups which can be resolved by the equipment used in the continuous seismic profiling survey. Five main seismostratigraphic groups have been recognised offshore; each has its own range of physical characteristics and may be described in engineering terms following further, more detailed investigations. Each of these five groups is described below and a summary of their lithological properties is given in Table 1.

FIVE SEISMOSTRATIGRAPHIC GROUPS

Triassic (Rhaetic) (Group 1)

Although Rhaetic strata outcrop at Pinhay Bay, no samples of this unit have been obtained offshore. At Charmouth, borehole 16A passes into the White Lias at approximately 75 m below OD and terminates in the Westbury Beds at 87.87 m.

Lower Jurassic (Base of Blue Lias to Top Bridport Sands)

Within this sequence two distinct seismostratigraphic groups can be recognised, the Middle-Upper Lias sands and clays (Group 3) and the clay-limestone sequence of the Lower Lias below (Group 2).

The sparker records of the lower group (Group 2) (Figures 9 and 11) show characteristically closely spaced, strong reflecting horizons. These are probably associated with the clay-limestone sequence and the upper boundary of the group is therefore taken to be the base of the Three Tiers Bed (Table 1). The overlying Middle

Table 1 Stratigraphy.

Chronostratigraphy	Lithostratigraphic Unit	Chronostratigraphic Unit	Lithological Description	Group*	Map Boundaries and identifying nomenclature		
Upper Jurassic	ju	Oxford Clay Kellaway Beds	Callovian	Grey sandy shaly clay	6	(Refer to Fig. 6) jc-jo BOUNDARY	
				Grey sandy clay (more sandy than Oxford Clay)			
Middle Jurassic	jm	Upper Cornbrash	Bathonian	Cream coloured marl with sandy limestones	5	jn	
		Lower Forest Marble		Rubby yellow limestone with marly parting, in part massive blue centred limestone			
		Fullers Earth Clays		Generally massive central limestone between two clay divisions. In places central limestone thins out and limestone may develop at the top of the formation			
		Inferior Oolite (with several non-sequences)		Conchoidally fracturing marl weathering to stiff clay, some limestones developed in the middle of the formation			
		Bajocian	4	Massive and rubbly limestone. Pale grey to yellow with large pale ooliths	4	jb	
				Bluish or brownish limestone, coarsely ironshot. Generally hard and crystalline			
				Light grey brown limestone with fine pale green or yellow oolitic grains		MAP BOUNDARY	
Lower Jurassic	Upper Lias	Bridport Sands	Toarcian	Yellow micaceous sand with lenticular masses or bands of blue centred calcareous sandstone	3	jt	
				Downcliffe Clays			Grey sandy clay
				Junction Bed and Marlstone Rockbed			(Southern Area) Conglomeratic containing pebbles of marlstone and sandstone sometimes limonite coated, Marlstone matrix
	Middle Lias	Thorncombe Sands	Upper Pliensbachian	Grey silty sand becoming brown and sandy at top	je	MAP BOUNDARY	
				Downcliffe Sands			Yellow brown sand (often indurated to massive sandstone) and sandy marl
				Eype Clay			Blue micaceous marls and silt with impersistent calcareous sandstone bands
				Three Tiers Bed			Hard sandstone separated by marl. The boundary is not sharp
	Lower Lias	Green Ammonite Beds		Clay with irregular limestones at three horizons. Clay becomes sandy towards the top becoming a sandy loam	je	North of 50° 42'N only **	
				Belemnite Marls			Pale grey marl
		Black Ven Marls	Sinemurian	Dark marls and shales with occasional bands of thin limestone or limestone nodules	2	js	
Shales with Beef				Brownish paper shales with numerous seams of beef			
Blue Lias		Hettangian	Blue argillaceous limestone with subordinate clay and shale		jn	MAP BOUNDARY	
Upper Triassic	tu	Rhaetic	Rhaetian	Grey limestone and black shales	1	tr	

* Seismostratigraphic Group

** Only to the north of 50° 42'N are the lithostratigraphic units definable where they are approximately equivalent to the chronostratigraphic units

Lias - Bridport Sands sequence has been recognised from the sparker records by thick uniform layers divided by persistent but widely spaced stronger reflecting horizons. It is suggested that the strong reflecting horizons are probably the harder layers of cemented silty calcareous sands and limestone bands as seen in borehole 74/40. At outcrop the harder bands are very resistant to tidal scour and form prominent sea floor features. These features can be seen on the bathymetric map (Figure 4) and the sonar interpretation map (Figure 5). Sparker evidence also suggests that some of the horizons within the Middle Lias - Bridport Sands sequence thin southerwards (Figure 9, Line 17, Fixes 6-9).

Twenty-four gravity core samples and samples from boreholes 15, 16, 16A and 74/40 have been identified as coming from various horizons within these sequences. To the north of the westward continuation of the Eype Mouth Fault, sampling has been close enough to allow the sub-division of the Lias into lithological units approximating to stages. South of this fault line it is possible from sparker data to distinguish only the two major groups of the Middle-Upper Lias sands and clays and the clay-limestone sequence of the Lower Lias below. These divisions are shown on Figure 6.

Middle Jurassic (Inferior Oolite) (Group 4)

The Inferior Oolite gives rise to characteristic reflections on the sparker records. This oolitic, occasionally pisolitic, iron-shot argillaceous limestone also forms such distinctive seabed features that it has been possible to map it with some confidence throughout the area (Figures 4 and 5). Five gravity core samples have been identified as Bajocian. One cored borehole, 74/48, passes through a greatly expanded Inferior Oolite sequence which suggests that the unit thickens in a south-easterly direction (Dr I. Penn, pers. com.).

Middle Jurassic, Lower Fuller's Earth - Upper Cornbrash (Group 5)

The lithological boundary between the Inferior Oolite limestones and the Lower Fuller's Earth clays is distinctive on the

sparker records and can be best seen in the southern and eastern portion of the map (Figure 11 (Fixes 13-15) and 12).

Twelve gravity core samples of Bathonian age were collected. Along the southern edge of the area three cored boreholes penetrated a Bathonian age clay succession. Detailed studies of these logs are in progress and they will be included in a future publication.

Upper Jurassic (Kellaways - Oxford Clay) (Group 6)

No samples of a Callovian age have been obtained from the area under consideration but samples of this age have been found to the south and east (Dingwall, 1970). In the south-east corner of this area, a lithological change can be detected from sparker evidence. It is suggested that the clays of Callovian age found further east continue into the newly surveyed area here.

STRUCTURE

The geological structure in this area is described in detail by Arkell (1947), Wilson and others (1958), and Cope and others (1969). The major faults and structures are depicted on Figure 12, which shows a series of east-west trending folds plunging eastwards and cut by dip and strike faults. The earliest major period of folding that can be dated with certainty is the Pre Albian. It is suggested, however, that at least the initial structures may be as early as Toarcian (Buckman, 1922). The later Tertiary (Miocene) folding and faulting has affected the whole area, resulting in both the reactivation of previously formed fault lines and also the formation of new faults. It is difficult to distinguish the effects of these two periods of movement, especially in areas where no Cretaceous rocks are involved.

In Figure 12 the onshore regional structure is contoured into the newly surveyed area in which complex dip and strike faulted anticlines with their complementary synclines plunge eastwards (Figures 8-11). Some of the major onshore faults can be seen to extend offshore for considerable distances and play a major part in the structure of the area. These faults are

named and shown on Figures 6 and 12 and will be discussed later.

OFFSHORE ZONES

For descriptive purposes the off-shore area can be divided into three zones:

- i The coastal area from Pinhay Bay to Eype Mouth and southwards to the westward continuation of the Eype Mouth Fault.
- ii The wedge-shaped area between the Eype Mouth Fault and the westward continuation of the Bride Fault.
- iii The area to the south and east of the Bride Fault extension.

Zone 1

The strata within this zone are characterised by a series of tightly folded north-south and east-west trending anticlines and synclines which are cut by north-south trending faults. The complexity of the folding is shown on Figures 5, 7 and 9 and is especially noticeable between Pinhay Bay and Charmouth (Figure 6).

Zone 2

The structural outcrop pattern in this area is simpler than in Zone 1 and is well illustrated by Figures 6 and 10. A broad east-west trending anticline with the Middle-Upper Lias sands and clays flanking a core of the Lower Lias clay-limestone sequence occurs in the central part of this area. On the northern limb of the anticline the rocks dip steeply to the north bringing Bathonian strata to outcrop in West Cliff and Bridport Sands to outcrop at East Cliff (Wilson and others, 1958). The southern limb of the anticline dips gently towards the synclinal zone at about 50° 39'N where Bajocian strata (Inferior Oolite) crop out. A complex and intense fault zone, probably the south-westward extension of the Mangerton Tear Fault, separates this area from the next zone and displaces the outcrops on its southern side towards the north.

Zone 3

This area contains many anticlines and synclines and is bounded to the north by the westward continuation of the Bridge Fault and in the south by the westward continuation of

the Abbotsbury-Ridgeway Fault Zone (Figure 12). The dominant feature is the north-east – south-west trending anticline with a core of Bajocian age strata. This area is characterised by a series of east-west and north-east – south-west trending strike faults which affect strata of Bajocian and Bathonian ages (Figures 10 and 11). Dip faults appear to be rare. This fault system is similar in style to that found immediately to the south in the Weymouth Anticline (House, 1961).

MAJOR FAULTS

The major faults and the evidence for them are discussed briefly below, commencing in the west and proceeding from north to south.

Coastal faults

A series of small faults mapped on the fore-shore between Pinhay Bay and Eype Mouth can be traced offshore. Included in these are the Char Fault, the Ridge Faults and the Seatown Fault, the largest of which is the Seatown Fault with a throw of 30 m (Wilson and others, 1958). It is impossible to determine the throw of any of these faults offshore. The sonar pattern map shows that intense folding of the sediments accompanied the faulting (Figures 5 and 7), but despite this it is felt that the throws offshore are not markedly greater than onshore.

The westward extension of the Eype Mouth Fault

This is a major fault which extends westwards from Eype Mouth for approximately 12 500 m. Onshore it is the largest Pre Albian fault near Bridport. On the coast where Bathonian strata crop out at sea level it has a throw of approximately 180 m down to the south and it probably has a varying throw along its length though further details are not known. Onshore its easterly continuation is displaced approximately 1000 m northwards by the Mangerton Tear Fault.

The southwards extension of the Mangerton Tear Fault

This fault zone can be traced in a south-westwards direction for approximately 6000 m, the intensely folded and faulted zone being

clearly visible on the sonar outcrop pattern map (Figure 5) and the bathymetric map (Figure 4). It is a dextral tear with a displacement of about 1000 m affecting the clay-limestone sequence of the anticlinal area in Zone 2 (at 50° 41'30"N) the adjacent Bridport Sands outcrop (cropping out at East Cliff) and, onshore, the Eype Mouth, Symondsburry and Bridport Faults. The fault appears to have less effect on the strata farther to the south-west and eventually dies out at about 50° 40'30 "N 2° 50 'W. Onshore evidence shows that this fault can be assigned to the Miocene (Wilson and others, 1958).

The seaward extension of the Bride Fault

This fault can be traced to the south-west for 10 000 m where it appears to terminate against an east-west trending strike fault (at 50° 39'00 "N 2° 51'45 "W). Onshore the fault has a throw of 50 m to the south, and offshore an approximate throw of 30 m to the south is predicted.

The faults between the Bride Fault and the Abbotsbury Fault Belt

To the south of the Bride Fault lies an area of Bajocian and Bathonian strata which is cut by many east-west and north-east – south-west trending strike faults. No estimate of throws is possible on the present information. A similar zone occurs onshore where blocks of strata are separated by east-west step faults throwing down to the north, repeating successions over a wide area. No age determination of these onshore faults is possible.

The westward extension of the Abbotsbury Fault Belt

The fault belt limiting the Weymouth region on the north has been described in detail by Arkell (1947) with further details in Wilson and others (1958). It is a Pre Albian fault with a downthrow to the south of approximately 180 m onshore. Together with its complementary Abbotsbury Syncline it can be traced for approximately 7000 m along the southern edge of this survey. No estimate of throw is possible.

DISCUSSION AND CONCLUSIONS

The combination of sparker, transit sonar and sample evidence has resulted in the mapping of several plunging anticlines with their complementary synclines (Figure 12). These structures are cut by major east-west trending faults some of which can be shown to be extensions of onshore fault systems. North-south and north-east – south-west trending faults bisect and often displace these structures, these again being traceable onshore.

Offshore the age of these faults can only be inferred indirectly since the overlying Cretaceous rocks have been eroded. House (1961), however, suggests that Pre Albian faults downthrow to the south and are normal, while Tertiary faults throw down to the north and are reversed. In the absence of other evidence it is possible to assume that the same rule may be applied to this area in which case the Eype Mouth, Abbotsbury and other, smaller, southerly throwing faults are of Pre Albian age, while the smaller northerly throwing faults are of Tertiary age. As the Mangerton Tear Fault displaces all previously formed structures it is obviously Tertiary in age. Although this rule may therefore be applied in general, it is probable that the later Tertiary disturbances reactivated earlier fault lines and may even have reversed the original throw direction.

The directions of the various folds and faults are probably determined by buried Caledonoid and Armorican trends. Vertical movements and rotation of buried blocks resulted in the development of intense compressional stresses. Where the overlying sequences consisted of clays, a considerable amount of these stresses would be absorbed in the formation of tight anticlines and synclines but where limestones and more brittle strata occurred considerable faulting would take place. Such features could have resulted from a series of Armorican horst and graben structures which probably influenced not only the structure but also the sedimentary depositional history (Gattral and others, 1971).

The geological map produced by detailed geophysical surveying shows that, in this area, the basic seismostratigraphic groups can be related to lithostratigraphic and chronostratigraphic units or stages; hence a

structure and stratigraphic history can be outlined. This survey defined five basic lithological groups in the offshore area; and following more detailed examination, it will be possible to describe each in engineering terms. It is envisaged that this work will take the form of a detailed borehole investigation coupled with a further continuous seismic profiling survey using a system capable of a higher resolution in order to provide greater lithological detail. Sampling of the rock outcrops on the sea floor has revealed lithologies similar to those found on land and it is, therefore, not unreasonable to produce engineering data on the offshore lithological units by taking samples for analysis from appropriate boreholes on land.

Finally, it is immediately apparent from both the sonar and the continuous seismic profiling records that there is little superficial cover overlying the geological strata exposed on the sea floor. A thin layer of fine to medium sand appears to cover most of the area but this very rarely exceeds 0.5 m in thickness. As previously mentioned, evidence from regional sampling surveys suggests that material eroded from the coastal landslips is swept away eastwards by the strong nearshore current and very little of this material is actually retained or deposited in the survey area.

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REFERENCES

- ARKELL, W. J. 1947. The geology of the country around Weymouth, Swanage, Corfe and Lulworth. Mem. Geol. Surv. U.K.
- BUCKMAN, S. S. 1910. Certain Jurassic (Lias-Oolite) strata of South Dorset. Q. J. Geol. Soc. London, Vol. 66, pp. 52-89.
- 1922. Jurassic chronology II - Preliminary studies. Certain Jurassic strata near Eypemouth (Dorset). The Junction Bed of Watton Cliff and associated rocks. Q. J. Geol. Soc. London, Vol. 78, pp. 378-436.
- CONWAY, B. 1971. Geological structure of the Dorset coast foreshore from Pinhay Bay to West Bay, Bridport. Intern. Rep. IGS Eng. Geol. Unit, April 1971.
- 1974. The Black Ven landslip, Charmouth, Dorset. Rep. Inst. Geol. Sci., No. 74/3.
- COPE, J. C. W., HALLAM, A. and TORRENS, H. S. 1969. Guide for Dorset and South Somerset Excursion No. 1 International Symposium on the British Jurassic. Geology Dept. Keele University, April 1969.
- CULSHAW, M. G. and WHITTAKER, A. 1973. Logging, density, porosity and sonic velocity determinations on rock types from boreholes at Charmouth, Dorset. Intern. Rep. IGS Eng. Geol. Unit No. 39.
- DARTON, D. M. 1975. Sonic velocity, density and porosity determinations on rock samples from a borehole and gravity core samples from Lyme Bay, Dorset. Intern. Rep. IGS Eng. Geol. Unit No. 71.
- DEAN, W. T., DONOVAN, D. T. and HOWARTH, M. K. 1961. The Liassic Ammonite Zones and subzones of the N. W. European province. Bull. Br. Mus. Nat. Hist. (Geol.) Vol. 4, No. 10, pp. 437-505.

- DENNESS, B. 1972. The Reservoir Principle of Mass Movement. Rep. Inst. Geol. Sci., No. 72/7.
- CONWAY, B.W., McCANN, D.M. and GRAINGER, P. 1975. Investigation of a coastal landslide at Charmouth, Dorset. Q. J. Eng. Geol., Vol. 8, pp. 119-140.
- DINGWALL, R.G. 1970. The structural and stratigraphic geology of a portion of the eastern English Channel. PhD thesis, University of London.
- DONOVAN, D.T. and STRIDE, A.H. 1961. An acoustic survey of the sea floor south of Dorset and its geological interpretation. Phil. Trans. R. Soc. 244B, pp. 299-330.
- FLOYD, R.A. and HALLAM, J. 1970. Cruise report for ts Somerset, 29th July - 17th August. Intern. Rep. IGS Mar. Geophys. Unit, No. 12.
- GATTRALL, M., JENKYN, H.C. and PARSONS, C.F. 1971. Limonite concretions from the European Jurassic with particular reference to the 'snuff boxes' of S. England. Sedimentology, Vol. 18, pp. 79-103.
- HALLAM, A. 1958. The concept of the Jurassic axes of uplift. Sci. Prog. London, Vol. 46, pp. 441-488.
- HOUSE, M.R. 1961. The structure of the Weymouth anticline. Proc. Geol. Assoc. London, Vol. 72, pp. 221-238.
- HOWARTH, M.K. 1957. The Middle Lias of the Dorset coast. Q. J. Geol. Soc. London, Vol. 113, pp. 185-203.
- LANG, W.D. 1914. The geology of the Charmouth cliffs, beach and foreshore. Proc. Geol. Assoc. London, Vol. 25, pp. 293-330.
- 1917. The ibex Zone at Charmouth and its relation to the zones near it. Proc. Geol. Assoc. London, Vol. 28, pp. 31-36.
- 1924. The Blue Lias of the Devon and Dorset Coasts. Proc. Geol. Assoc. London, Vol. 35, pp. 169-185.
- 1936. The Green Ammonite Beds of the Dorset Lias. Q. J. Geol. Soc. London, Vol. 92, pp. 423-437, 485-487.
- SARGENT, G.E.G. 1966. A review of acoustic equipments for studying submarine sediments. Trans. Inst. Min. Met., Ser. B, pp. 113-118.
- WILSON, V., WELCH, F.B.A., ROBBIE, J.A. and GREEN, G.W. 1958. Geology of the country around Bridport and Yeovil. Mem. Geol. Surv. U.K., (1" sheets 327 and 312).

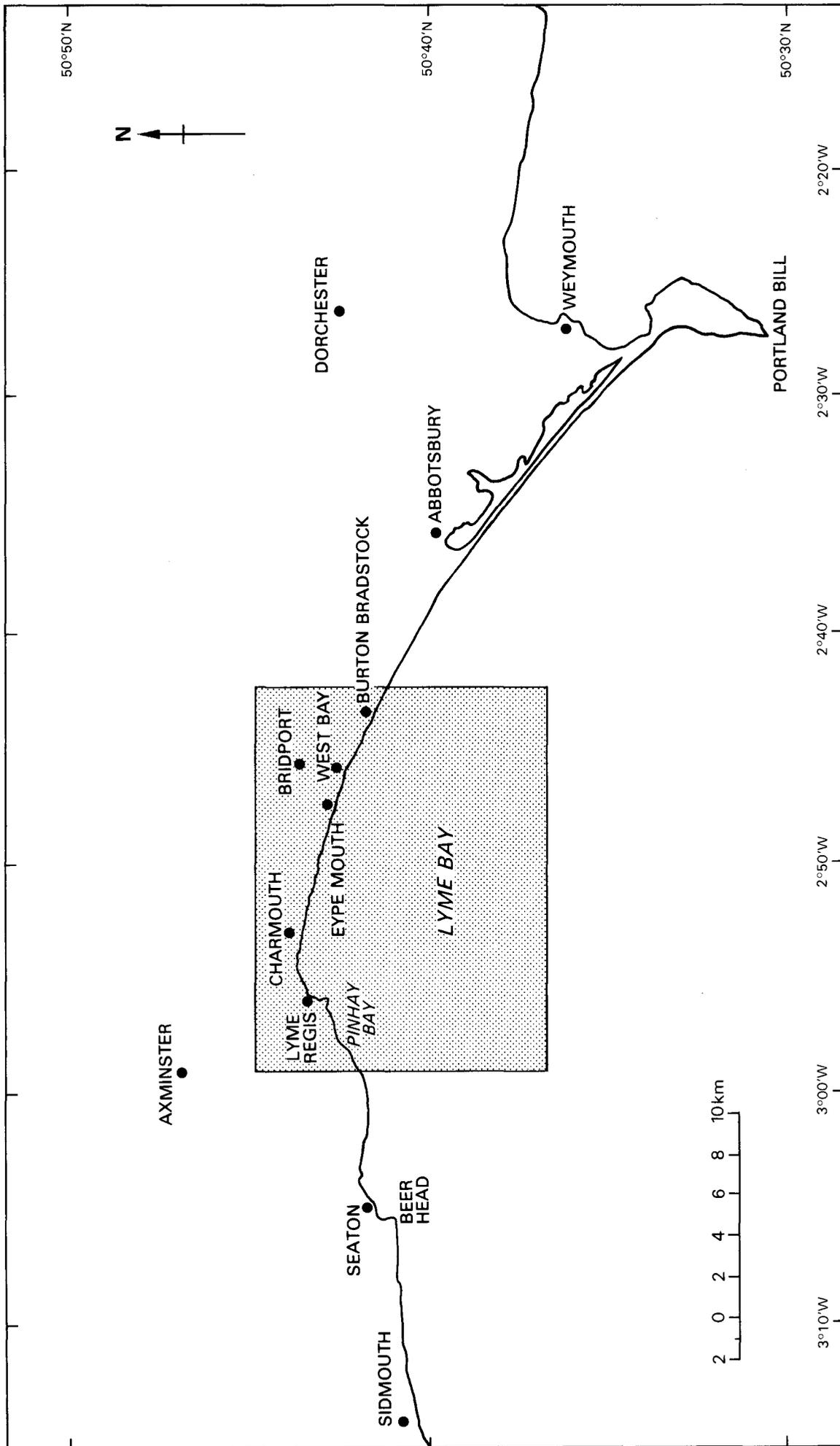


Figure 1 Survey Area.

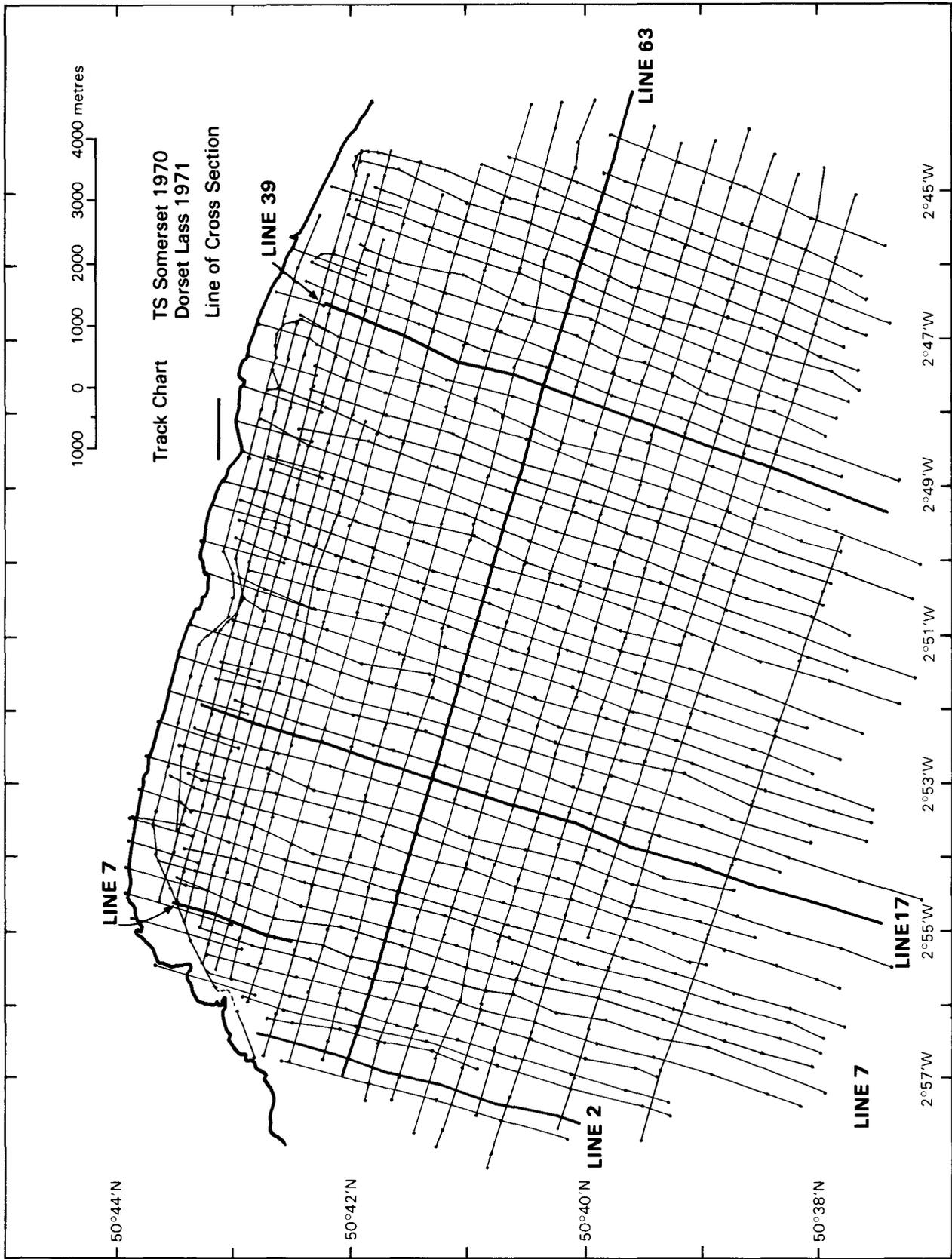


Figure 2 Track Chart.

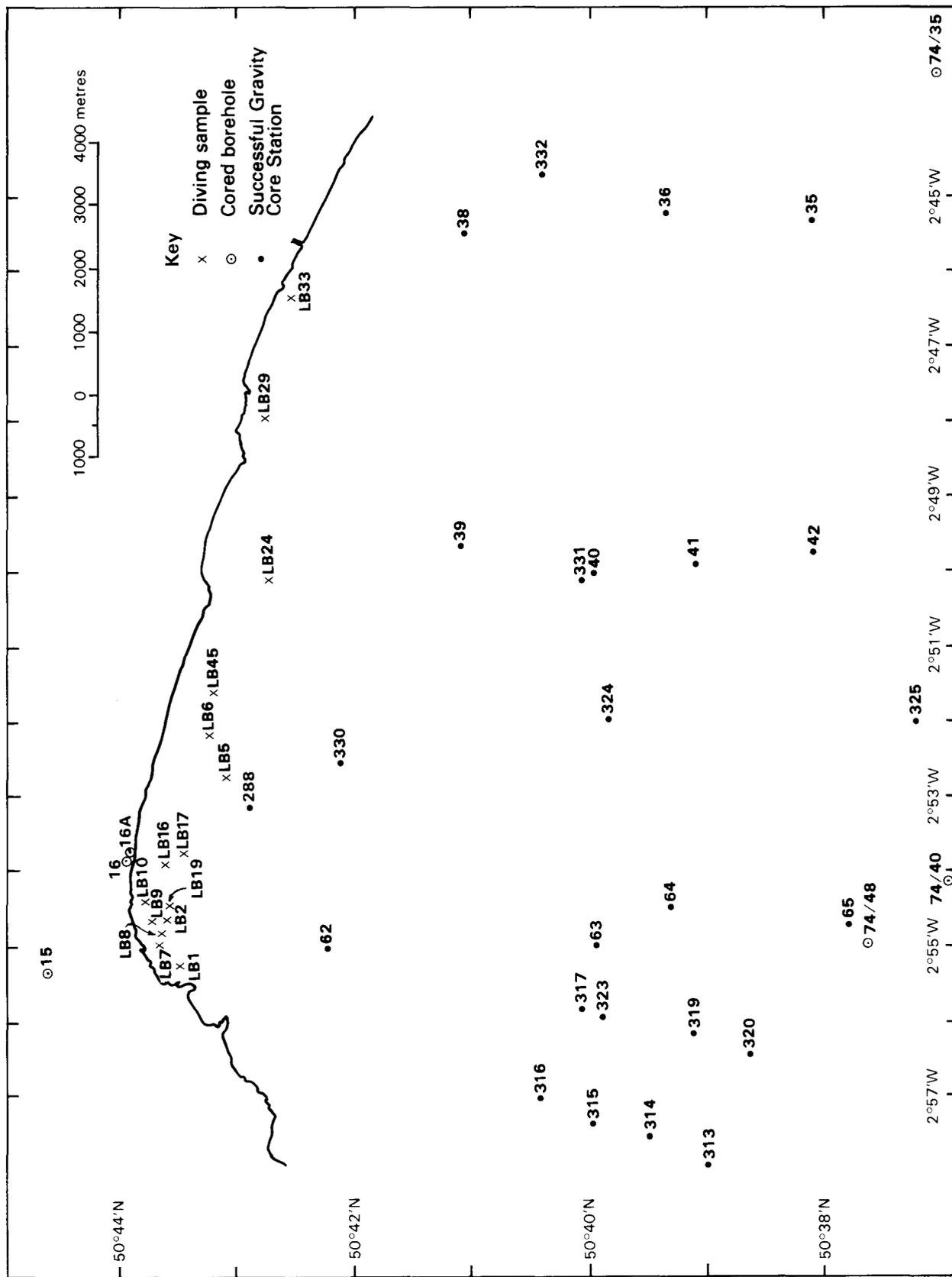


Figure 3 Sample locality Map.

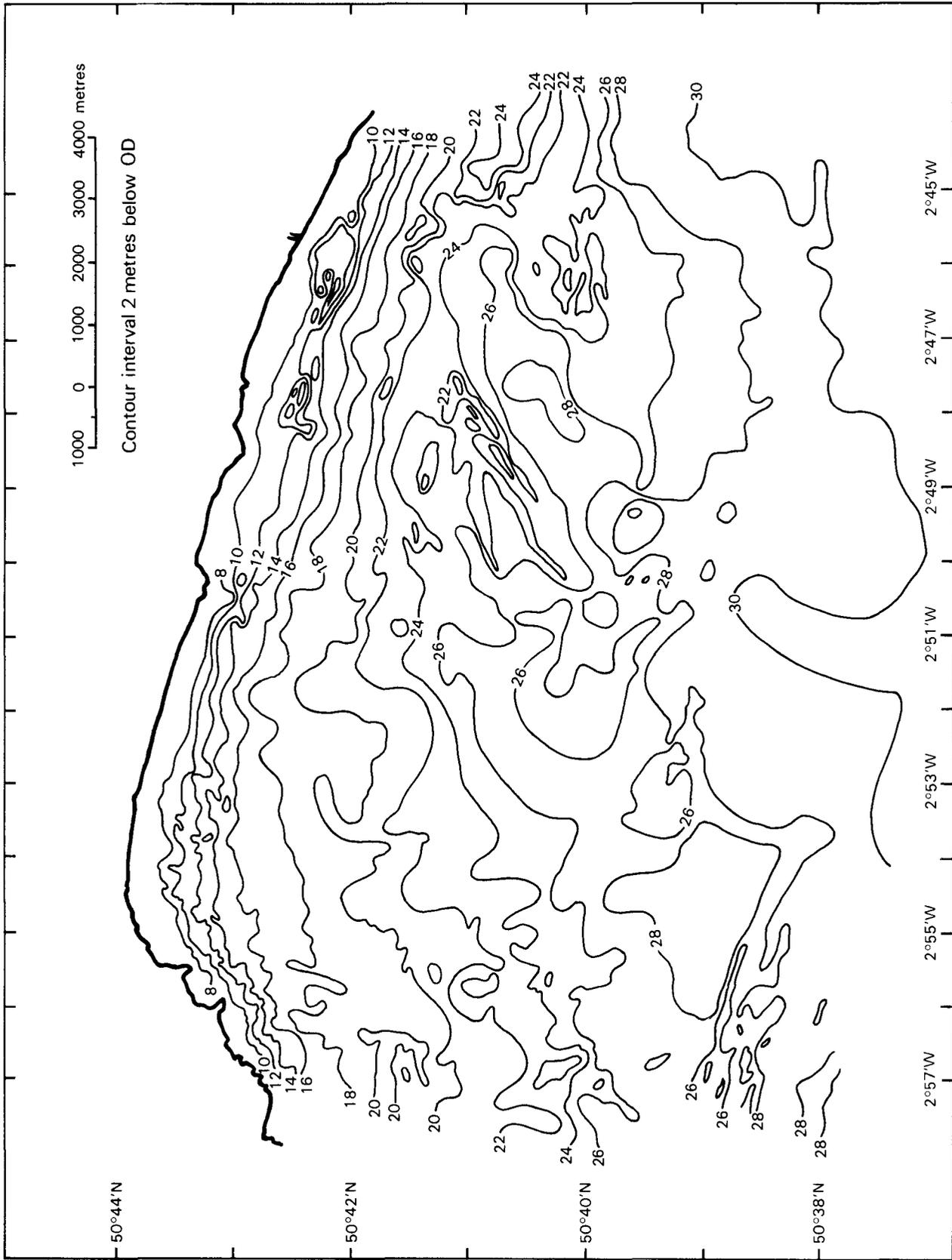


Figure 4 Bathymetric Map.

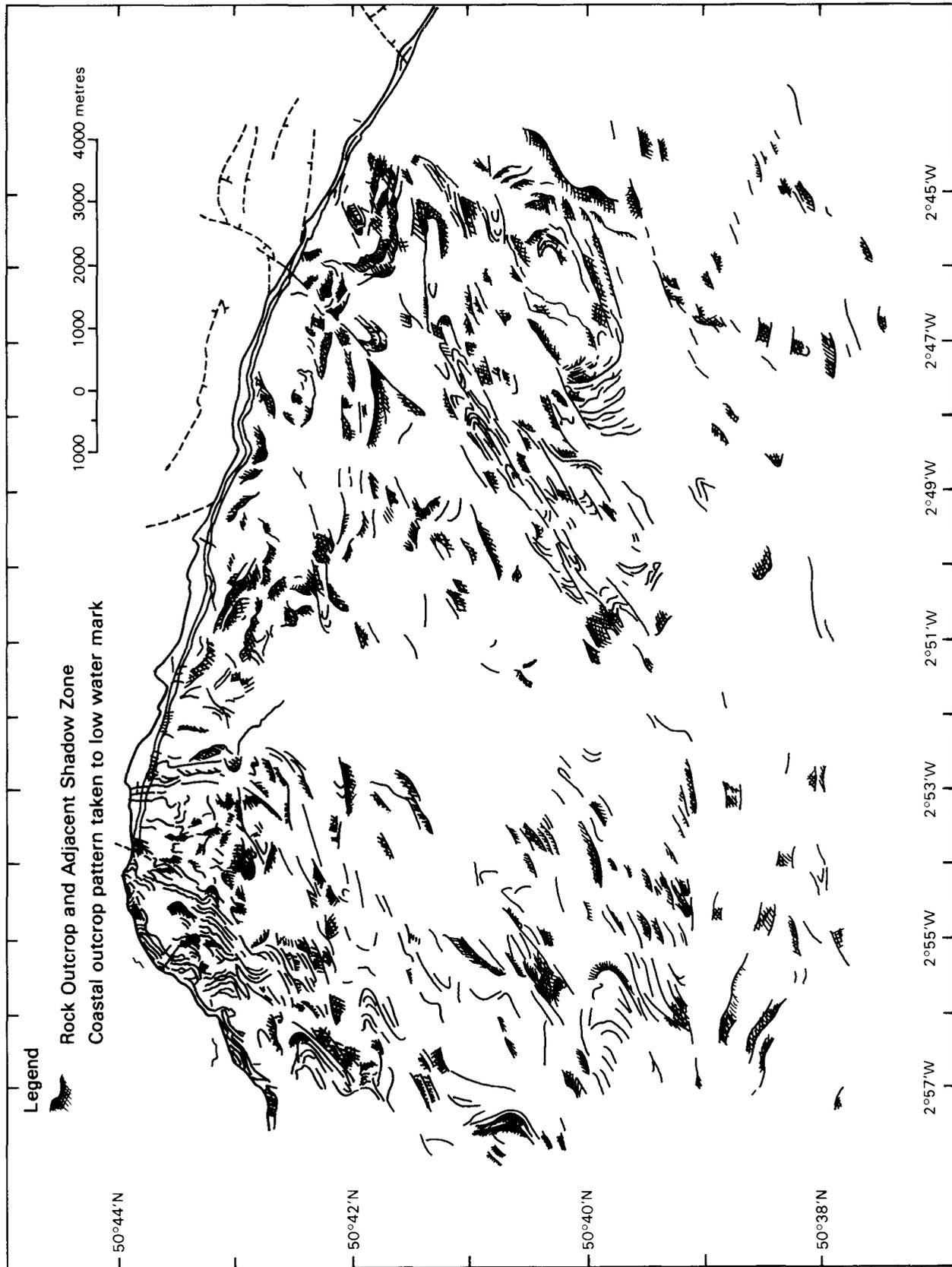


Figure 5 Side scan sonar and coastal outcrop pattern interpretation.

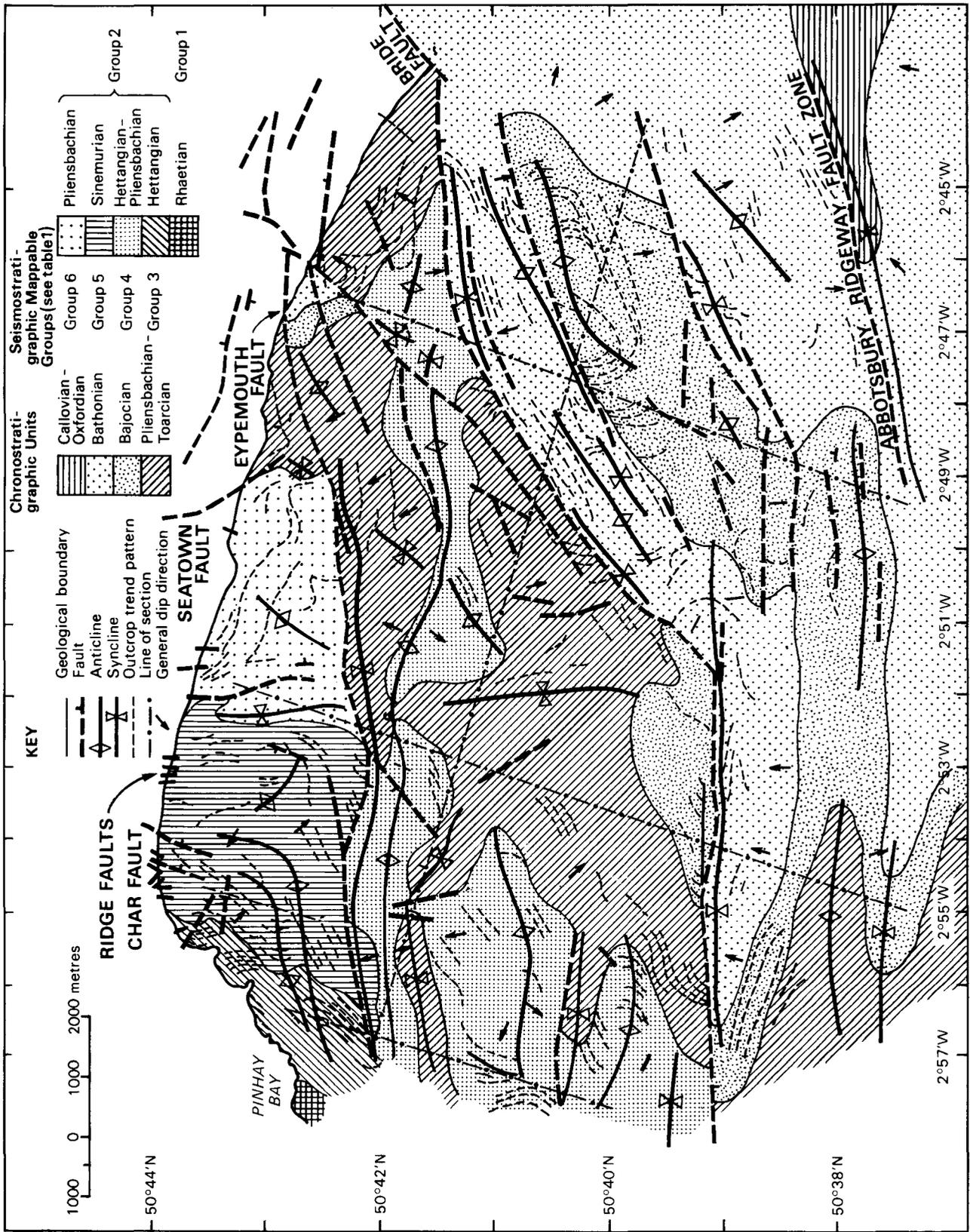
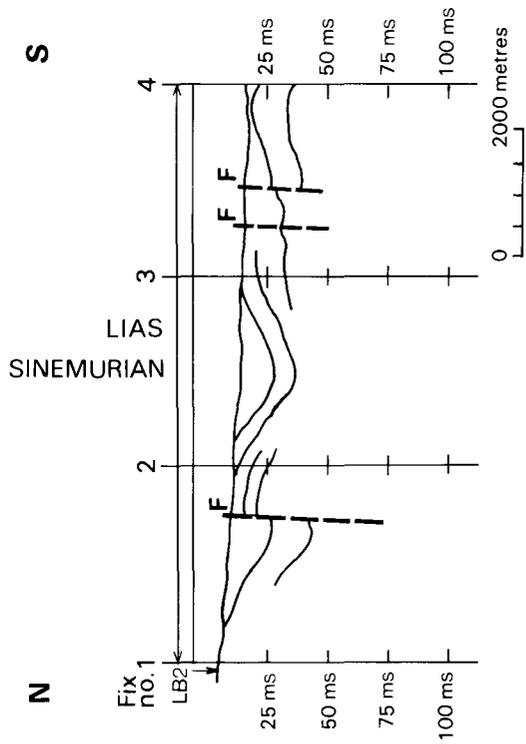
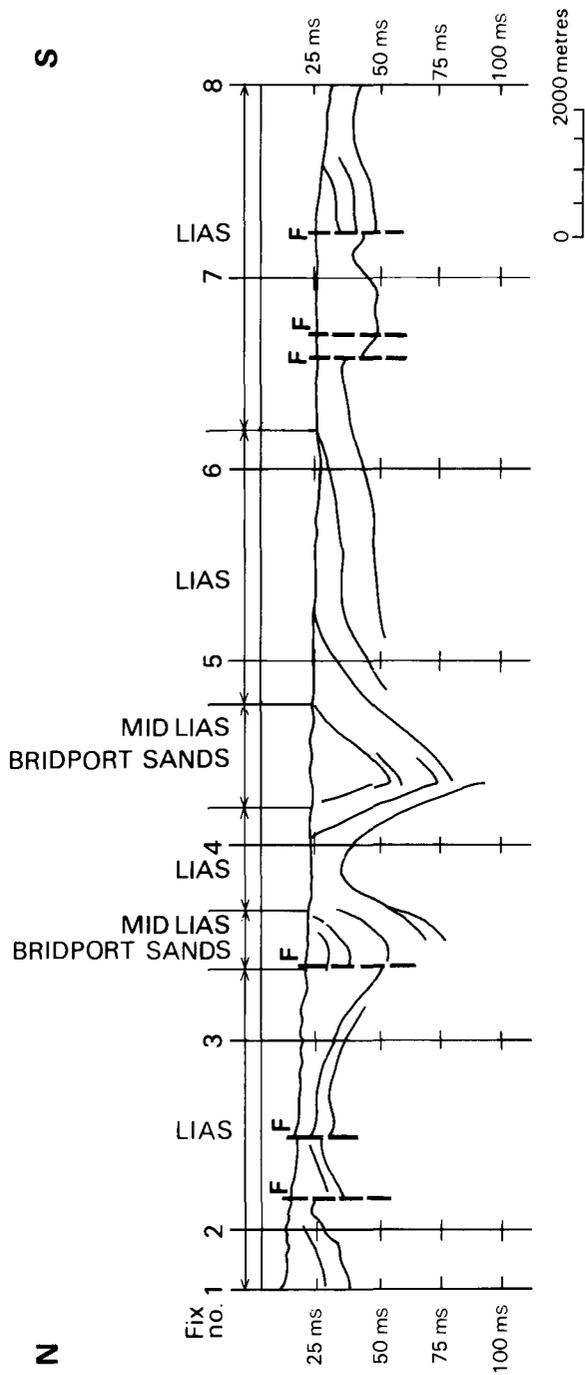
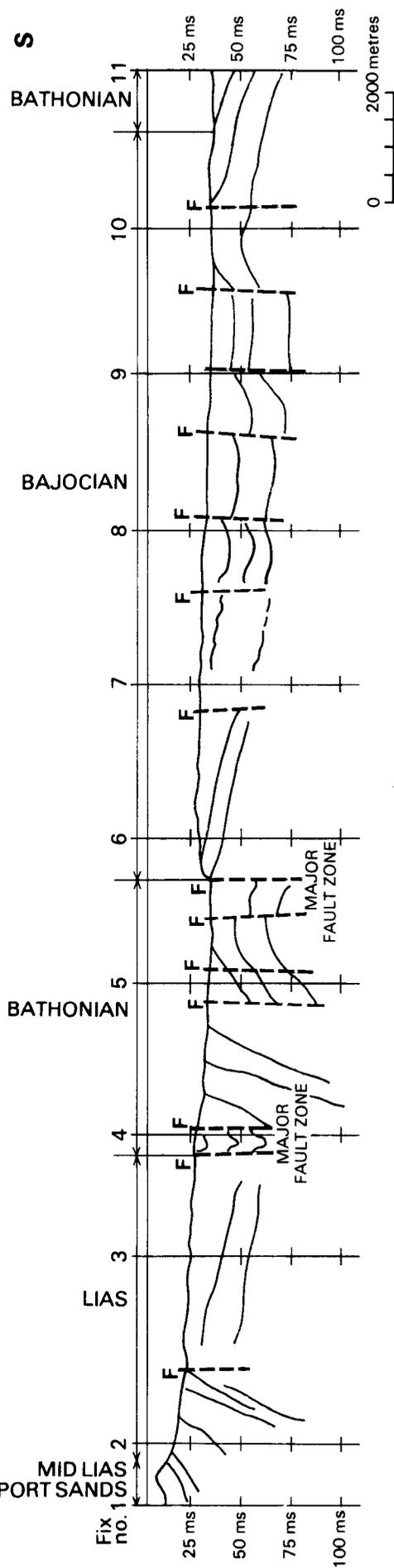
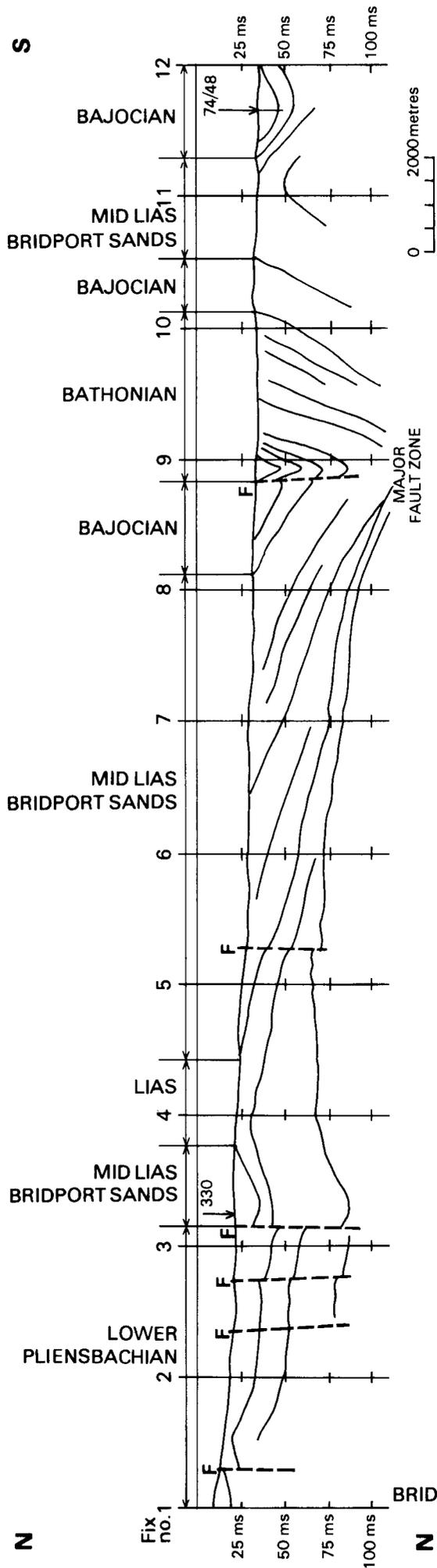


Figure 6 Structural and stratigraphic interpretation.



Figures 7 and 8 Geological interpretation of side scan and sparker record lines 2 and 7.



Figures 9 and 10 Geological interpretation of sparker record lines 17 and 39.

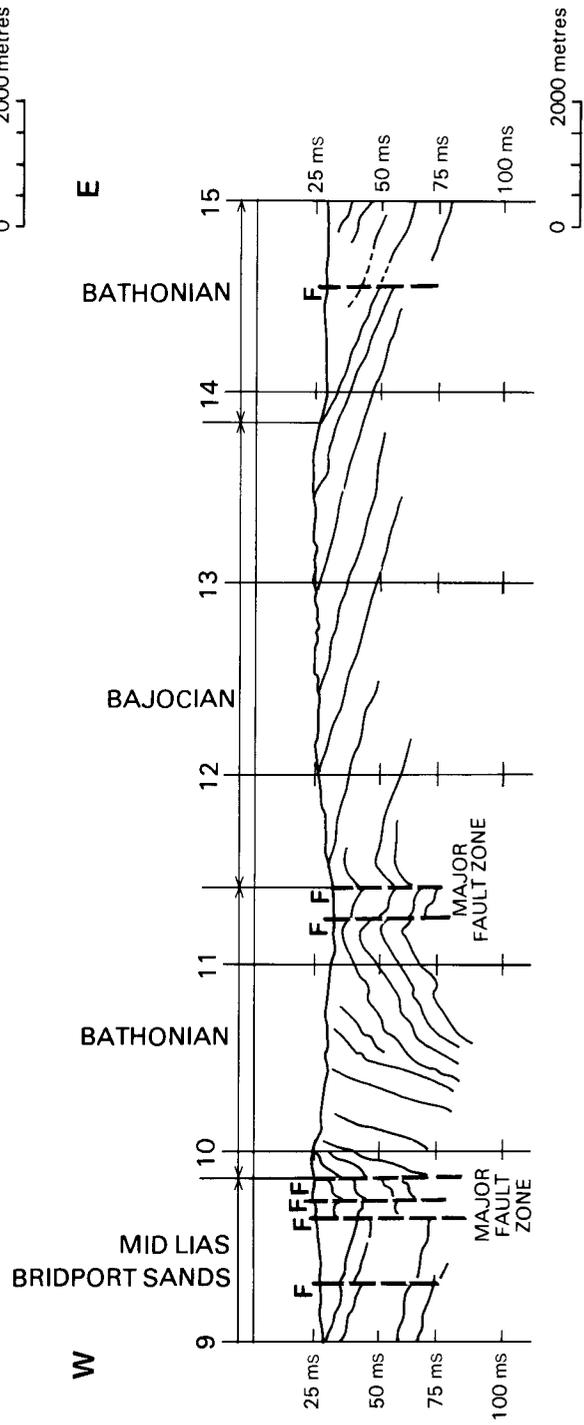
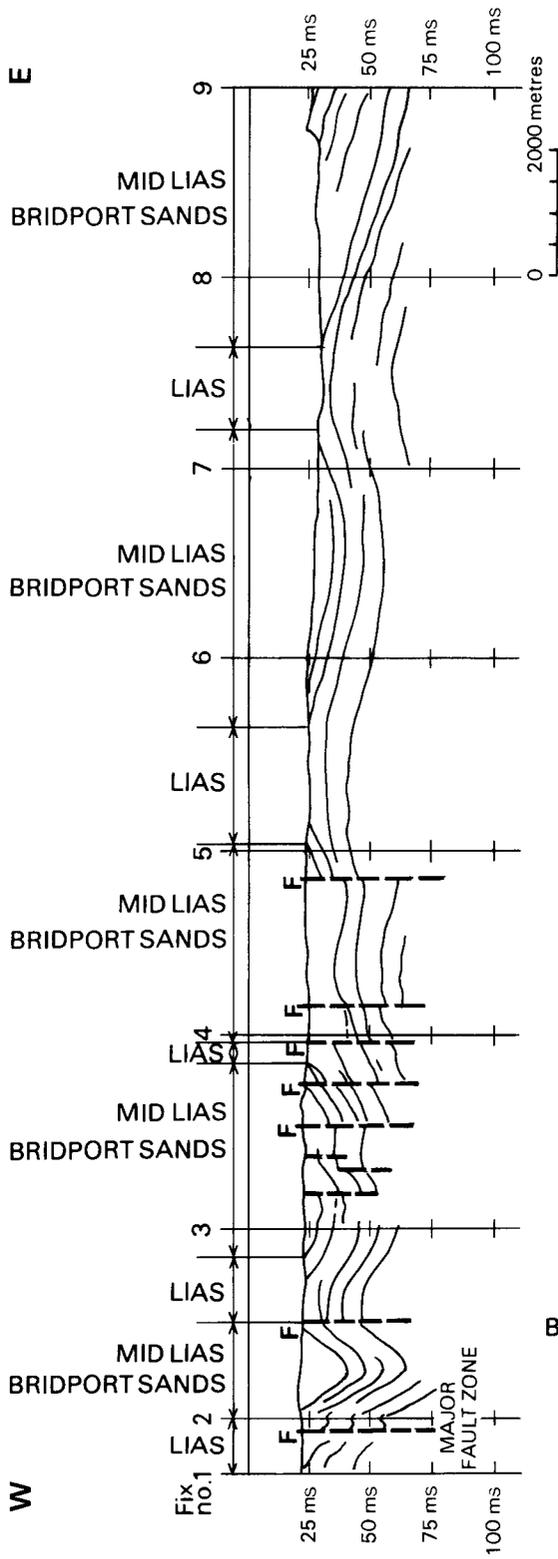
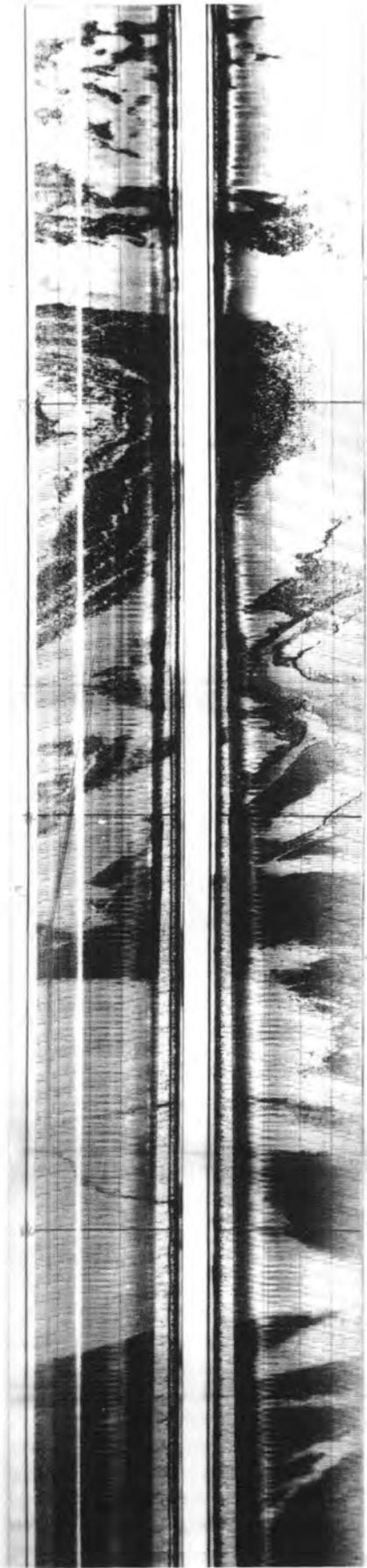


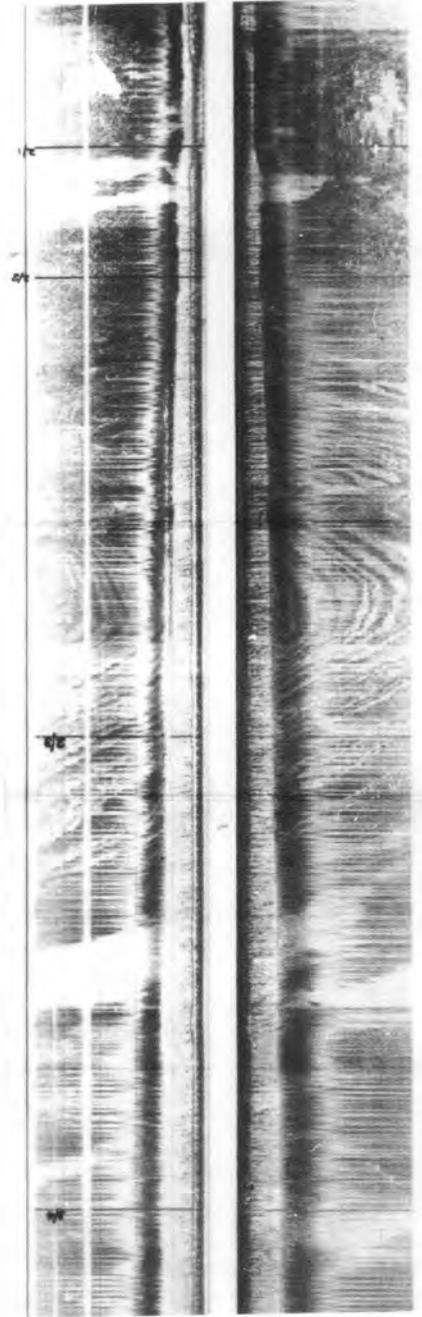
Figure 11 Geological interpretation of sparker record line 63.



SIDE SCAN
LINE 7

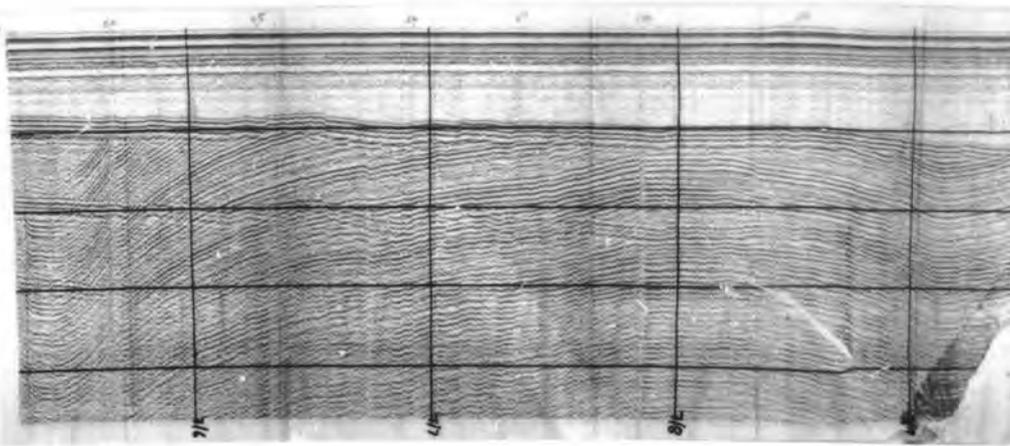
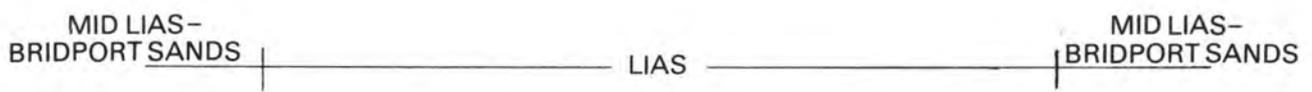
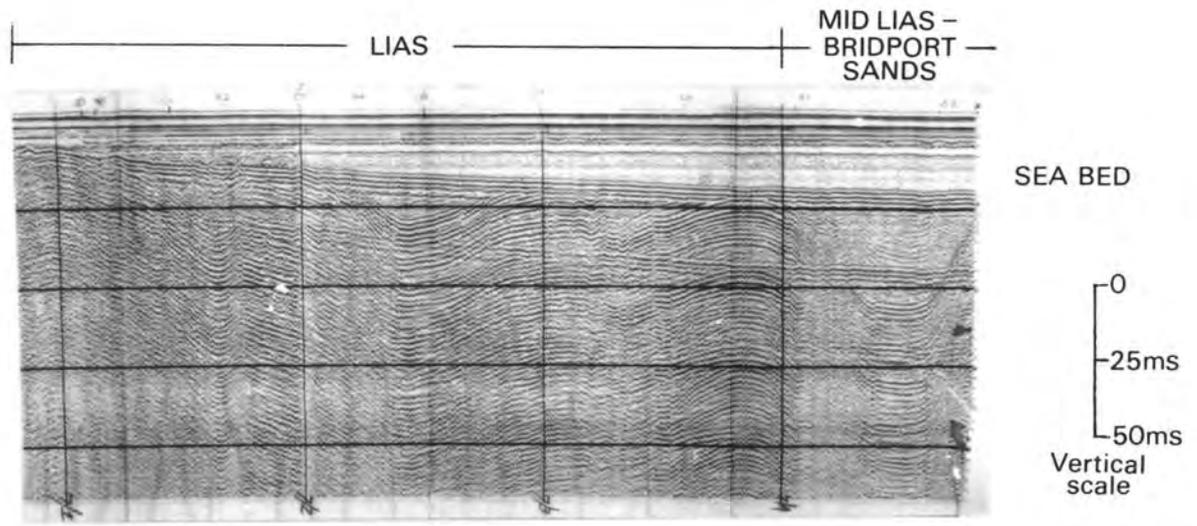
0 1 kilometre
Horizontal scale

0 50ms 100ms
Vertical scale



SIDE SCAN
LINE 2

Plate 1 Side scan lines 7 and 2.



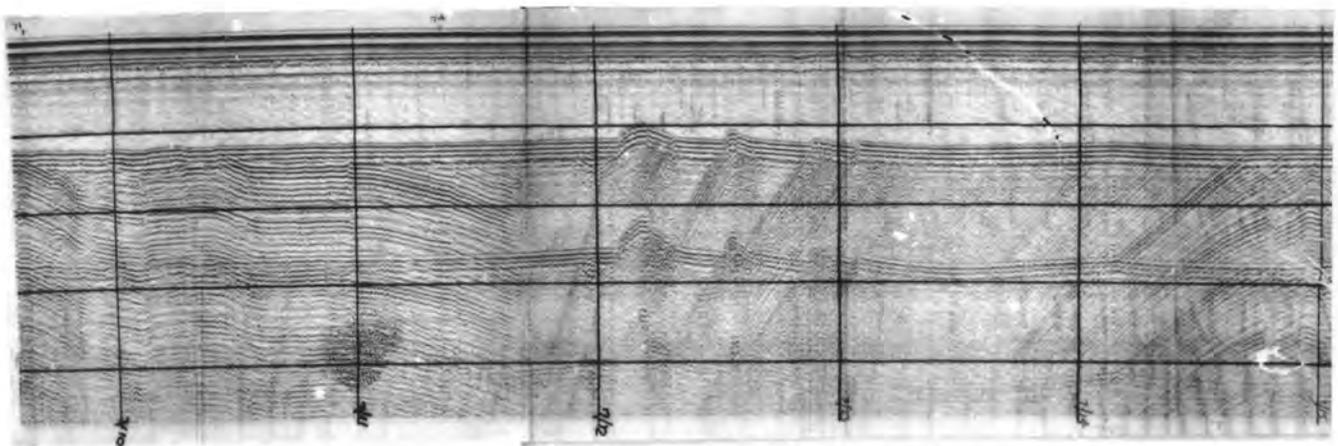
Horizontal scale 1 0 1 2 kilometres

MID LIAS - BRIDPORT SANDS

LIAS

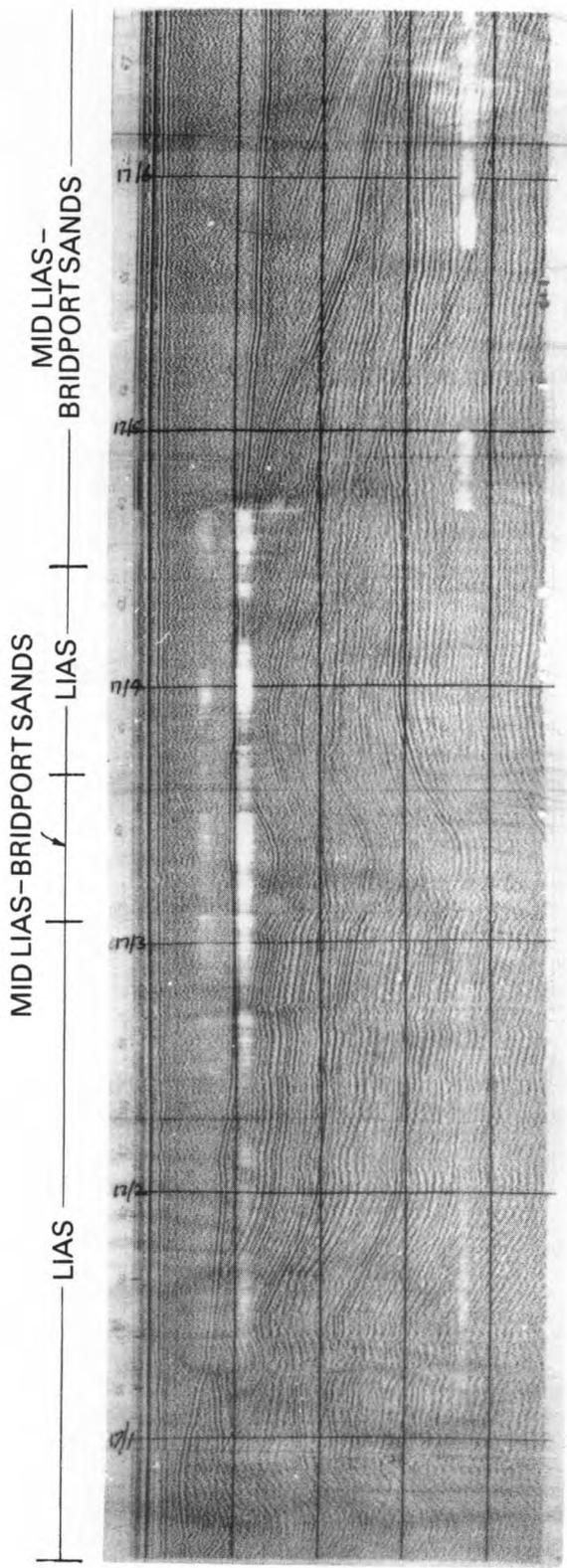
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MID LIAS - BRIDPORT SANDS



SPARKER LINE 7

Plate 2 Sparker line 7.



1 0 1 2 kilometres

Horizontal scale

0 25ms 50ms

Vertical scale

MID LIAS-BRIDPORT SANDS

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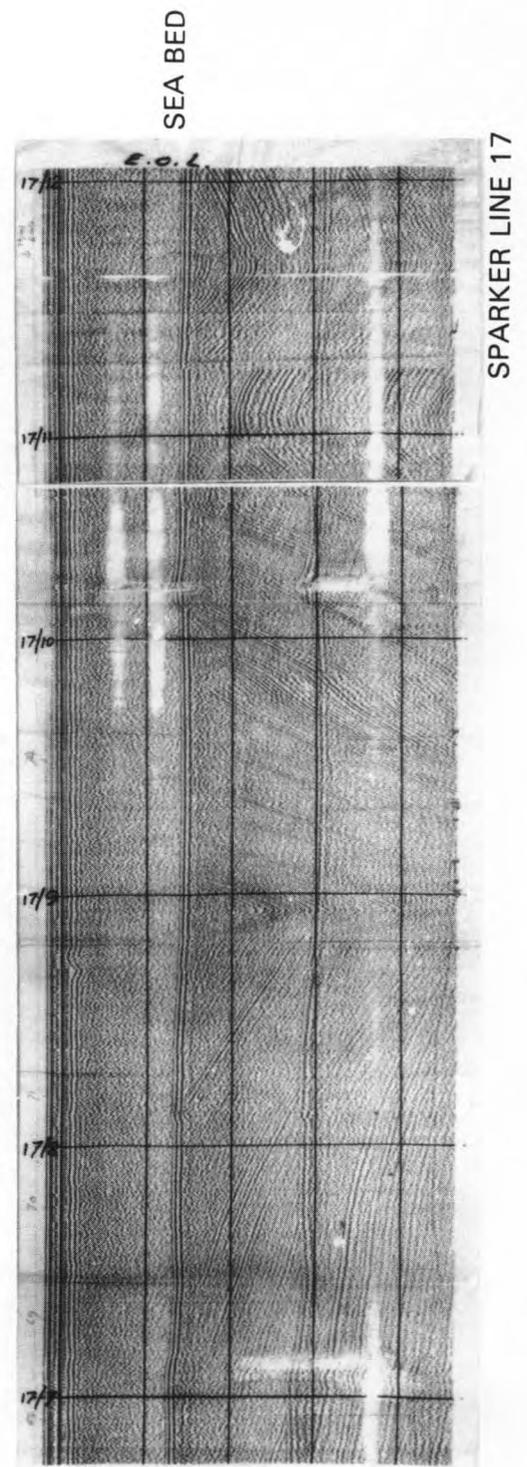


Plate 3 Sparker line 17.

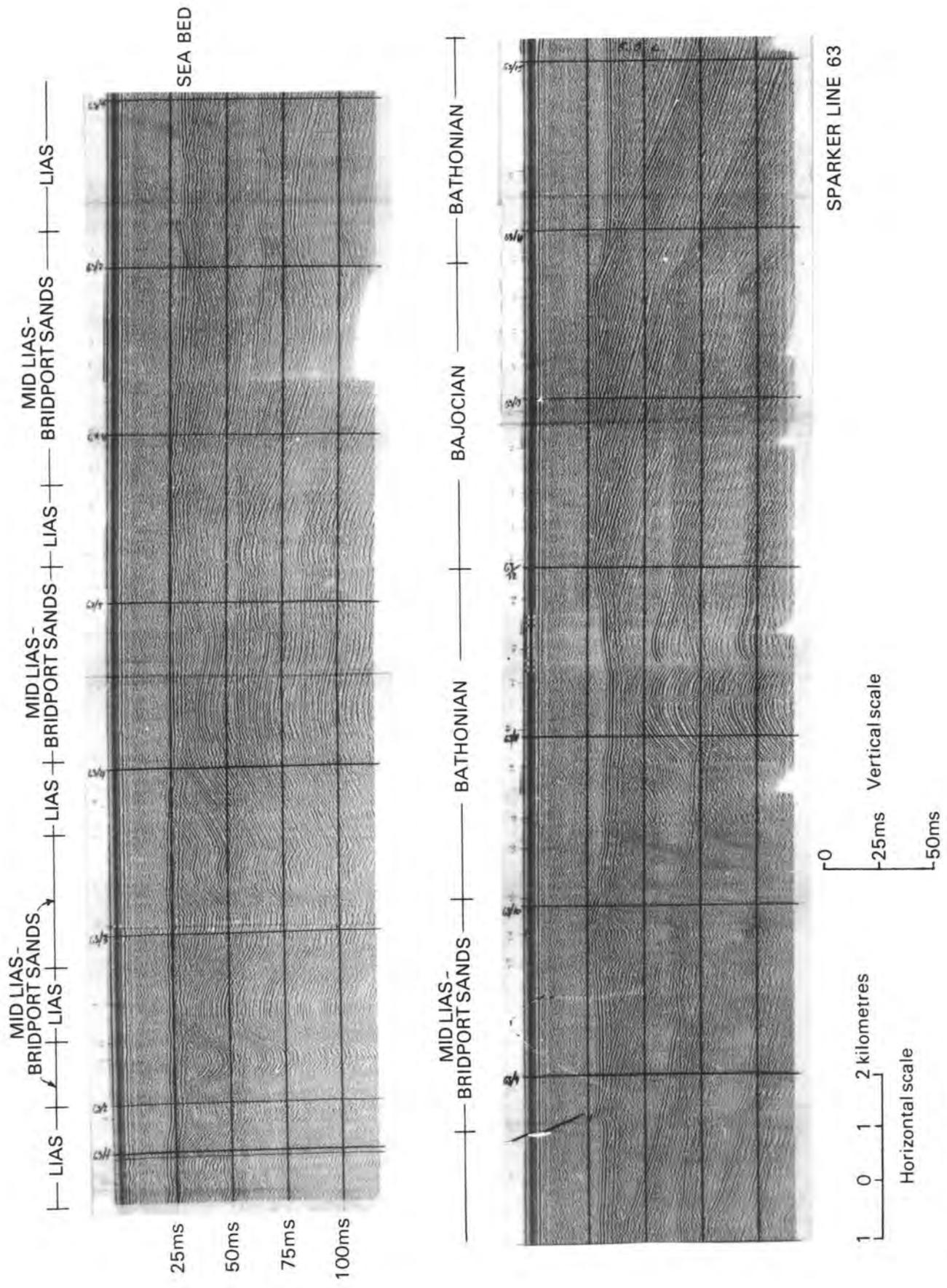


Plate 4 Sparker line 63.

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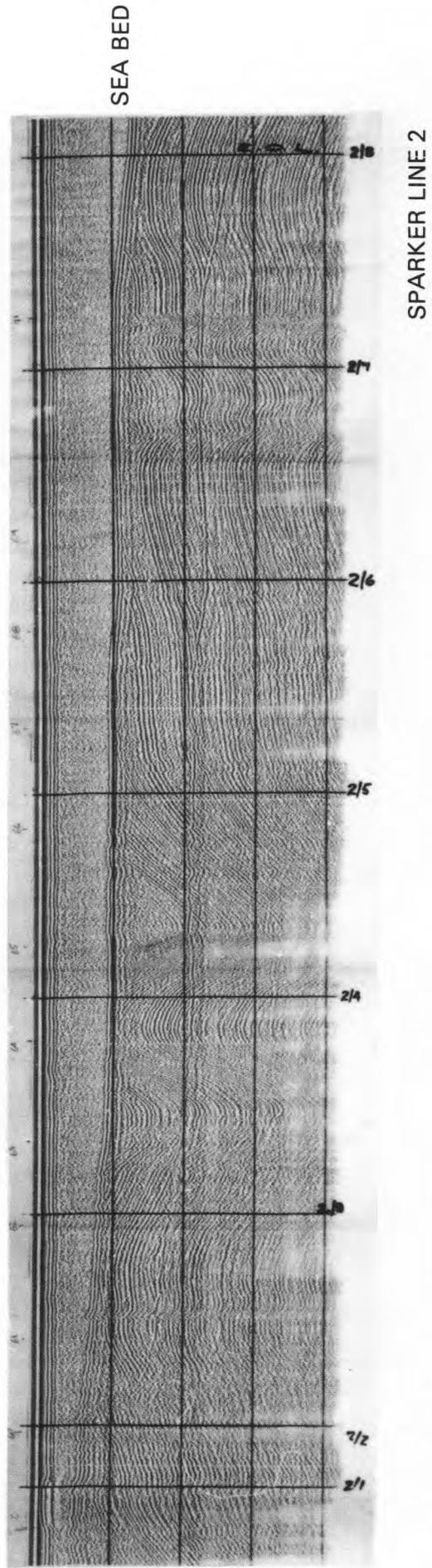
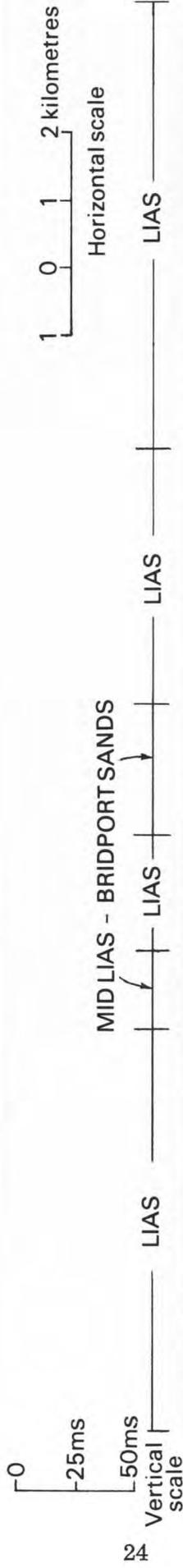
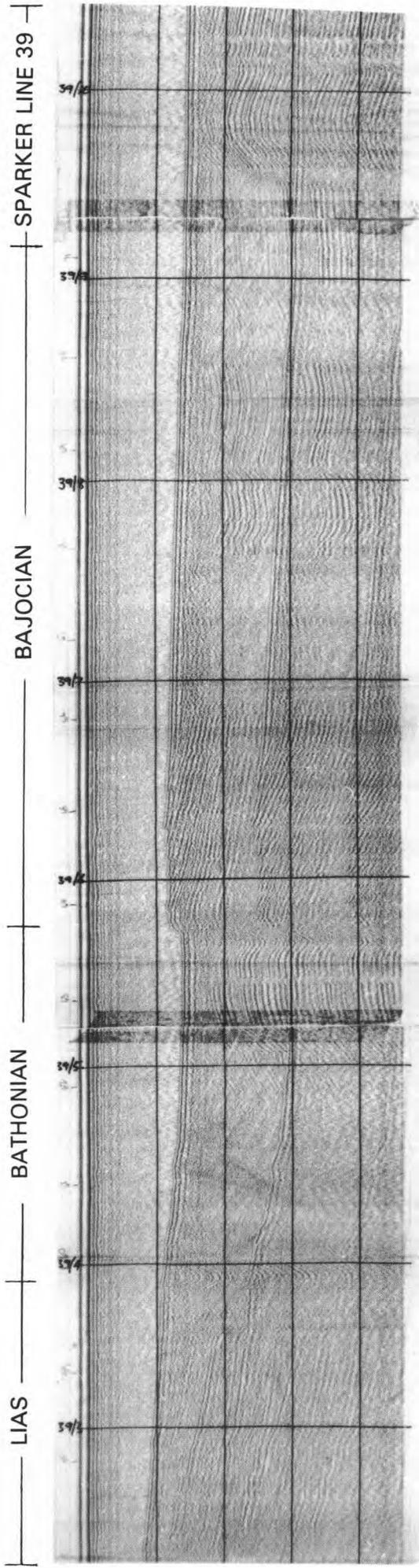


Plate 5 Sparker lines 39 and 2.

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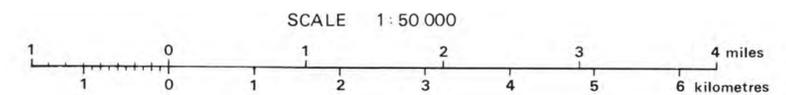
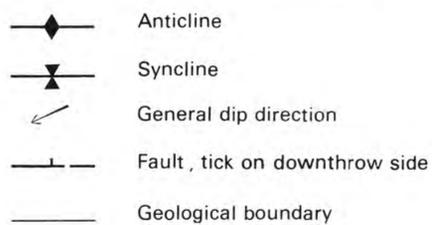
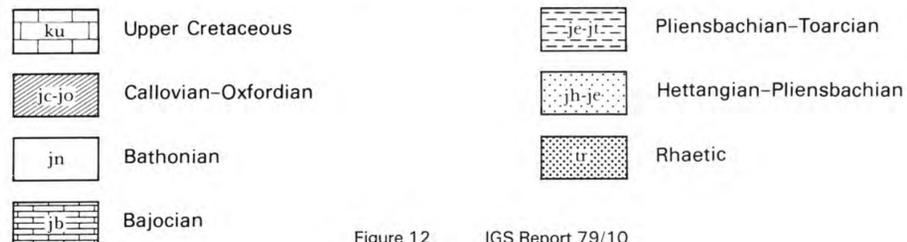
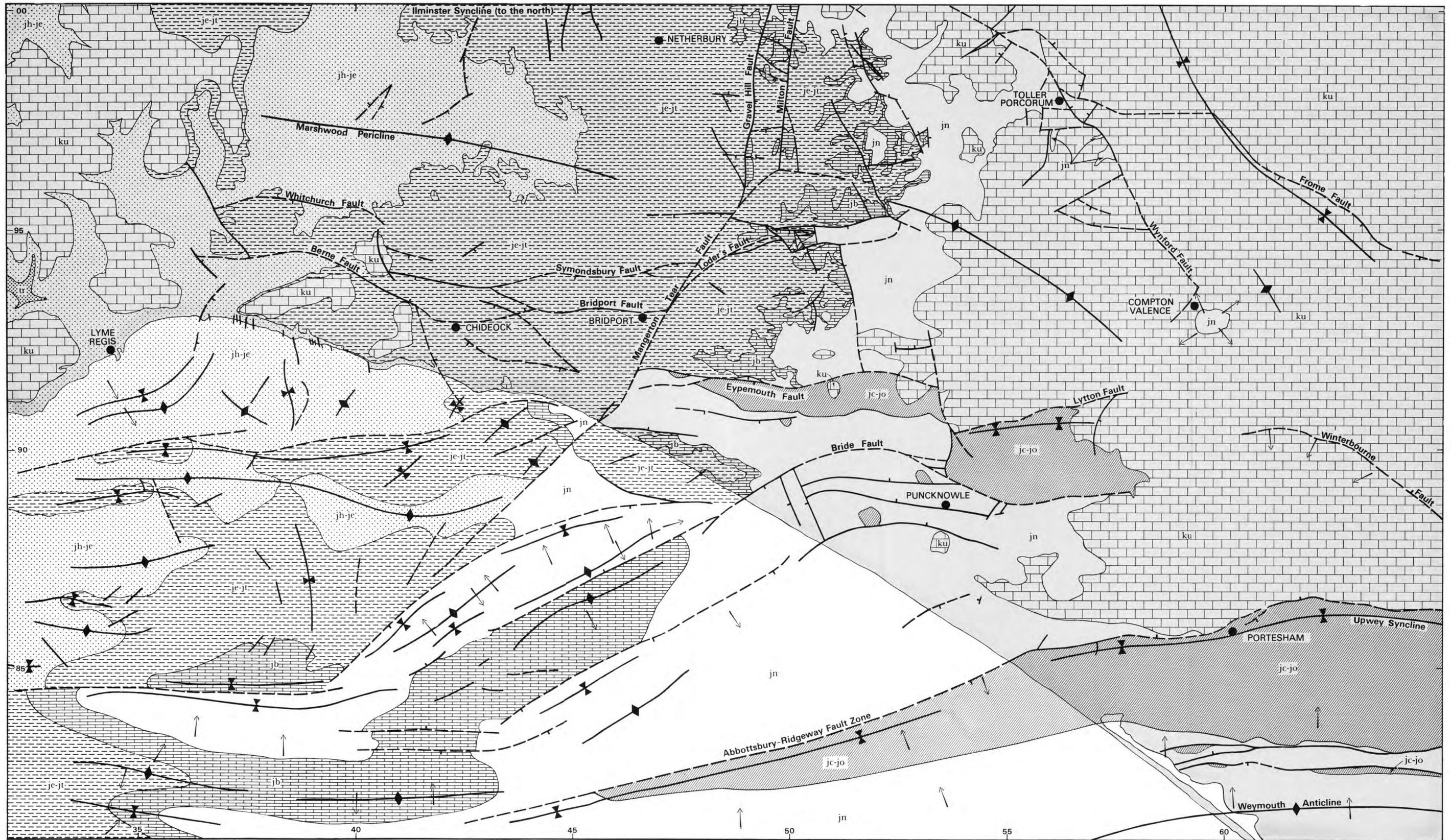


Figure 12 IGS Report 79/10