Geological and geophysical investigations in Lyme Bay
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D. M. Darton, R. G. Dingwall and D. M. McCann
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Geological and geophysical investigations in Lyme Bay

D. M. DARTON, R. G. DINGWALL and D. M. McCANN

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 southeast 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.

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 southeast. Many important papers have been published on this area (Buckman, 1910, 1922; Lang, 1914, 1917, 1924, 1936, Howarth, 1957;
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 500 J. Signals were received by an E, G, and G, Type 263B hydrophone and recorded on a Huntec 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 the 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.

My '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 the 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 seismo­
stratigraphic 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>
<thead>
<tr>
<th>Chronostratigraphy</th>
<th>Lithostratigraphic Unit</th>
<th>Chronostratigraphic Unit</th>
<th>Lithological Description</th>
<th>Group</th>
<th>Map Boundaries and identifying nomenclature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Jurassic</td>
<td>Oxford Clay</td>
<td>Callovian</td>
<td>Grey sandy shaly clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kellaway Beds</td>
<td></td>
<td>Grey sandy clay (more sandy than Oxford Clay)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle Jurassic</td>
<td>Upper Cornbrash</td>
<td>Lower</td>
<td>Cream coloured marl with sandy limestones</td>
<td></td>
<td>[Refer to Fig. 6]</td>
</tr>
<tr>
<td></td>
<td>Forest Marble</td>
<td>Bathonian</td>
<td>Rubbly yellow limestone with marly parting, in part massive blue centred limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fullers Earth Clays</td>
<td></td>
<td>Generally massive central limestone between two clay divisions. In places central limestone thins out and limestone may develop at the top of the formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inferior Oolite</td>
<td>Lower</td>
<td>Conchoidally fracturing marl weathering to stiff clay, some limestones developed in the middle of the formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(with several non-sequences)</td>
<td>Bajocian</td>
<td>Massive and rubbly limestone. Pale grey to yellow with large pale ooliths</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bluish or brownish limestone, coarsely ironshot. Generally hard and crystalline</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Light grey brown limestone with fine pale green or yellow oolitic grains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Lias</td>
<td>Bridport Sands</td>
<td>Toarcian</td>
<td>Yellow micaceous sand with lentilolous masses or bands of blue centred calcareous sandstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Downcliffe Clays</td>
<td></td>
<td>Grey sandy clay</td>
<td>jt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Junction Bed</td>
<td></td>
<td>(Southern Area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and Marlstone Rockbed</td>
<td></td>
<td>Conglomeratic containing pebbles of marlstone and sandstone sometimes limonite coated, Marlstone matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grey silty sand becoming brown and sandy at top</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yellow brown sand (often indurated to massive sandstone) and sandy marl</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>Blue micaceous marls and silt with imperisent calcareous sandstone bands</td>
<td>je</td>
<td>MAP BOUNDARY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plenusbachian</td>
<td>Hard sandstone separated by marl. The boundary is not sharp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Jurassic</td>
<td>Green Ammonite Beds</td>
<td></td>
<td>Clay with irregular limestones at three horizons. Clay becomes sandy towards the top becoming a sandy loam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Belemnite Marls</td>
<td></td>
<td>Pale grey marl</td>
<td>je</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black Ven Marls</td>
<td>Sinemurian</td>
<td>Dark marls and shales with occasional bands of thin limestone or limestone nodules</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shales with Beef</td>
<td></td>
<td>Brownish paper shales with numerous seams of beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blue Lias</td>
<td>Hettangian</td>
<td>Bluish conoidal marls with impure limestone bands</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blue argillaceous limestone with subordinate clay and shale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Triassic</td>
<td>Rhetic</td>
<td>Rhetic</td>
<td>Grey limestone and black shales</td>
<td>1</td>
<td>tr</td>
</tr>
</tbody>
</table>

* 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 pisolithic, 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 is 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, Symondsbury 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 10000 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 Caledonian and Armoricanoid 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 seismic stratigraphic 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


Figure 1 Survey Area.
Figure 2 Track Chart.
Figure 3 Sample locality Map.
Figure 4  Bathymetric Map.
Figure 5  Side scan transit 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.
Plate 2  Sparker line 7.
Plate 3  Sparker line 17.
Plate 5  Sparker lines 39 and 2.
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