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Marine Geology and Recent Sediments of Milne Bay, New Guinea

by

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RECORDS 1970/10

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Contents

Contents
(ii)

SUMMARY

Milne Bay is a graben structure which originated during the formation of the Owen Stanley fault lineament on shore and the Pocklington Shear zone which runs east to Guadalcanal. The bay floor has been sinking in Quaternary times and a thick succession of marine sediments has accumulated. A (?) Pleistocene unconformity observed in the sparker records indicates rapid submergence in the central southern part of the bay.

A trough running parallel to East Cape Peninsula shows a similar trend to structural features on the D'Entrecasteaux Islands to the north. This trend is postulated to have originated during the left-lateral shear of the region, which caused the offset of the Owen Stanley Metamorphic Belt.

Bottom sediments are dominantly fine-grained and poorly sorted. Deltaic progradation of terrigenous material takes place in the western part of the bay, and calcareous sediments derived from marginal reefs accumulate on the slope and shoals to the east. Owing to restricted bottom circulation, a reducing environment occurs in the central region resulting in the deposition of calcareous sediments with a high organic content.

INTRODUCTION

This report describes the results of a survey of Milne Bay undertaken early in 1968 by the Bureau of Mineral Resources; during the survey seven continuous seismic reflection profiles were run and thirty-two bottom sediment samples were collected. This investigation formed part of a marine geological reconnaissance by the B.M.R. of the Solomon Sea continental shelf bordering New Guinea and New Britain. The vessel chartered for the survey was the Kos II, an ex-whale chaser 38 m. overall length. It was built in 1929 and is powered by a triple expansion steam engine driving a single screw.

Physical setting:

Milne Bay lies between latitudes 10°15'S and 10°35'S, and longitudes 150°20'E., and 151°15'E. (Fig.1) The bay is bounded by two peninsulas which form the southeasternmost part of the mainland of New Guinea. It has an area of approximately 2,000 square Km and a maximum depth of just over 560 m. In form it is a steep-sided , flat-floored basin and connection with the open sea is impaired by a sill at 300 m. depth.

Milne Bay forms part of a region which was, and still is, subject to much tectonic activity; the relief on the mainland of New Guinea is extremely high, while the adjacent ocean basins are deep, with very steep sided slopes. Around New Guinea the continental shelf is either completely absent or in the very early stages of formation.

The extreme relief and the high precipitation in New Guinea results in rapid denudation and the supply of large amounts of sediment to the sea. Biogenic material, derived mainly from vigorous coral reef growths, also makes an important contribution to the sediments deposited in Milne Bay.

The rivers flowing into Milne Bay have a combined catchment area of about 30,000 square kilometers and drain the southern extremity and foothills of the Owen Stanley Range. The highest mountains in the catchment area rise to over 1500 m above sea level. Three major rivers, the Maiwara, the Guimin, and the Dawa Dawa carry most of the run-off of the area into Milne Bay. Several small coastal rivers of about 10 km in length occur on the East Cape Peninsula and the southern margin of the Bay.

The southern coastline of Milne Bay is remarkably straight while the northern coastline shows a more indented margin. Deltaic bulges occur off the mouths of the major rivers. Swampy foreshores are found on the northwestern margin of the bay.

The islands off the southern peninsula show indented irregular margins with bordering coral reefs. These islands reach elevation of 200 and 530 m. Some small islands, with coral reef surrounding them, occur on the northeastern margin of the bay. Nua Kata, the largest of these, reaches an elevation of 327 metres.

Climate

Milne Bay lies within the area affected by the southeast trade winds and the northwest monsoons. The southeast trade winds blow between May and October, but may start and blow intermittently from March onwards. By July and September they are steady and reach a wind force of 5 to 6 for several days.

From October to April the northwest monsoons affect the region of Milne Bay. Often the northwest monsoons bring squalls and heavy rain.

The climate in New Guinea is humid tropical. Temperatures range between 18°C and 35°C. Rainfall in the Milne Bay area is less than that for most parts of New Guinea, it is however, very high compared with other parts of the world. The average annual rainfall is about 274 cm, as compared with up to 500 cm for some other parts of New Guinea. Because of its position, Milne Bay which is surrounded by mountains in the north-west, receives most of its rainfall during the early part of the southeast trade winds season (Table 1).

January	17.8	cm	May	cm	30.5	September	cm	25.6
February	19.8	"	June	"	28.7	October	"	22.0
March	25.4	"	July	"	20.6	November	"	21.3
April	24.9	"	August	"	21.8	December	"	15.5

Table 1: Rainfall at Samarai (10°37'S, 150°40'E.)
Data from Pacific Islands Pilot, 1956.

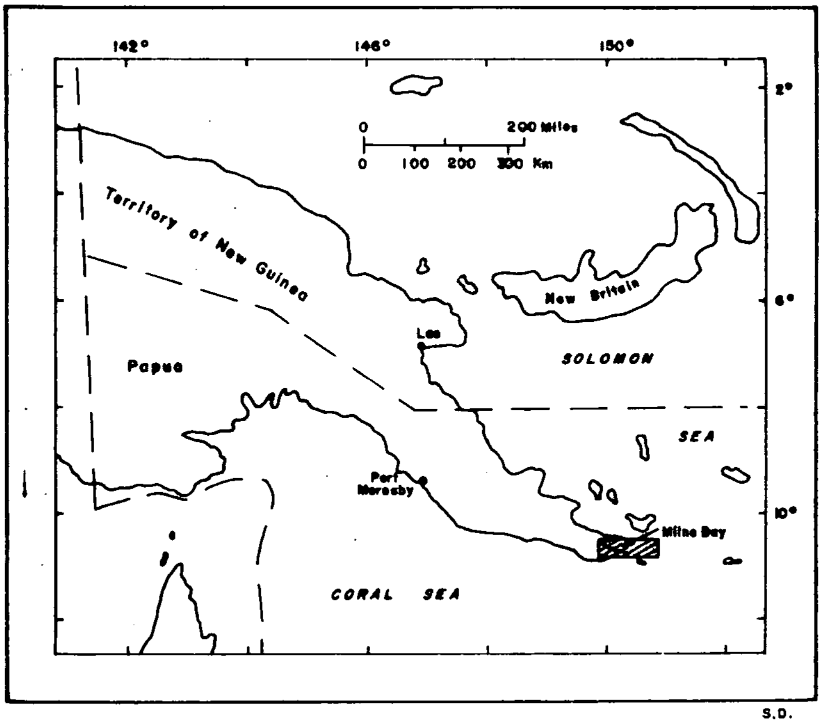


Fig. I — LOCALITY DIAGRAM

P/A/262

To accompany Record 1970/10

Previous Work:

Data on the marine geology of Milne Bay are scarce. The region to the south and east was the subject of a report by Krause (1965, 1967) in which the general tectonic framework of the north western Tasman Sea, the Coral Sea and the South Solomon Sea are discussed. Previous regional geological studies are documented in the appropriate places in the text. Gravity data collected by Milsom (in prep.) are discussed in the geophysical section. The marine geology of the Huon Gulf region, 400 km northwest of Milne Bay, has been described by von der Borch (1969) and Walraven (1968).

Oceanography

Little is known of oceanographic conditions in Milne Bay. Although the tidal range is only moderate within the bay, with a maximum rise above low water springs level of 2.7 m and an average rise of 1.5 m, strong tidal currents occur in some of the straits connecting the bay with open water. The Pacific Islands Pilot (1956) records, for example, currents of up to 6 knots in China Strait, south of Milne Bay. Tidal currents within the bay itself are weak.

Owing to the short fetch, wave amplitudes are low and periods short. The bay is protected from long period ocean swells.

The Pacific Islands Pilot notes that after heavy rain storms areas of turbid, sediment-laden water are encountered considerable distances offshore.

REGIONAL AND LOCAL GEOLOGY

The earliest account of the geology of the Papuan area is by Stanley (1923). A discussion of the geology of New Guinea with reference to the mineral deposits was given by Thompson & Fisher (1965), and Thompson (1967) has described the geological history of the region. Reconnaissance mapping by the Bureau of Mineral Resources in the last decade is the main source of information on the geology of the Milne Bay region (Davies 1967; Davies et al. 1968; Smith & Pieters, 1969).

Late Tertiary to Recent tectonic activity, associated with the circum-Pacific zone of island arcs and ocean trenches has profoundly affected the area (Weeks, 1959, Glaessner 1950). The structural provinces recognized in southeastern New Guinea by Thompson & Fisher (1965) are shown in Figure 2.

A zone of Cretaceous and possibly older metamorphic rocks in the Owen Stanley Metamorphic Belt, forms the sialic core of the mainland of southeastern New Guinea. This sialic core is separated from younger submarine basic volcanics and pelagic sediments by a discontinuous band of ultramafic rocks called the Papuan Ultramafic Belt. This belt of ultramafic rocks together with the Tertiary volcanics to the north is termed the Papuan Ophiolite Province. South of the Owen Stanley Metamorphic Belt similar volcanic rocks of oceanic origin occur, and it is postulated that they belong to the same province (Thompson & Fisher, 1965). The Cape Vogel Basin is a structurally depressed and topographically low-lying coastal zone, containing a thick succession of Miocene and Pliocene rocks.

Owen Stanley Metamorphic Belt.

The Owen Stanley Metamorphic Belt extends from Lae southwards almost to the Musa valley, where it is believed that faulting has caused it to be offset northwards (Smith & Green 1961, Thompson & Fisher, 1965). This offset portion of the belt forms the D'Entrecasteaux Islands and the Louisiade Archipelago.

The Owen Stanley Metamorphic Belt comprises greywackes and siltstones of Cretaceous or older age which have been regionally metamorphosed to schists and phyllites of the greenschist facies. (See Fig. 3). Locally they are intruded by granodiorites, granites and small lamprophyre dykes (Smith & Green 1961).

Since at least Middle Miocene times, the Owen Stanley Metamorphic Belt has been an emergent source of clastic sediments and now forms the Owen Stanley Range which rises over 4,000 m, above sea level.

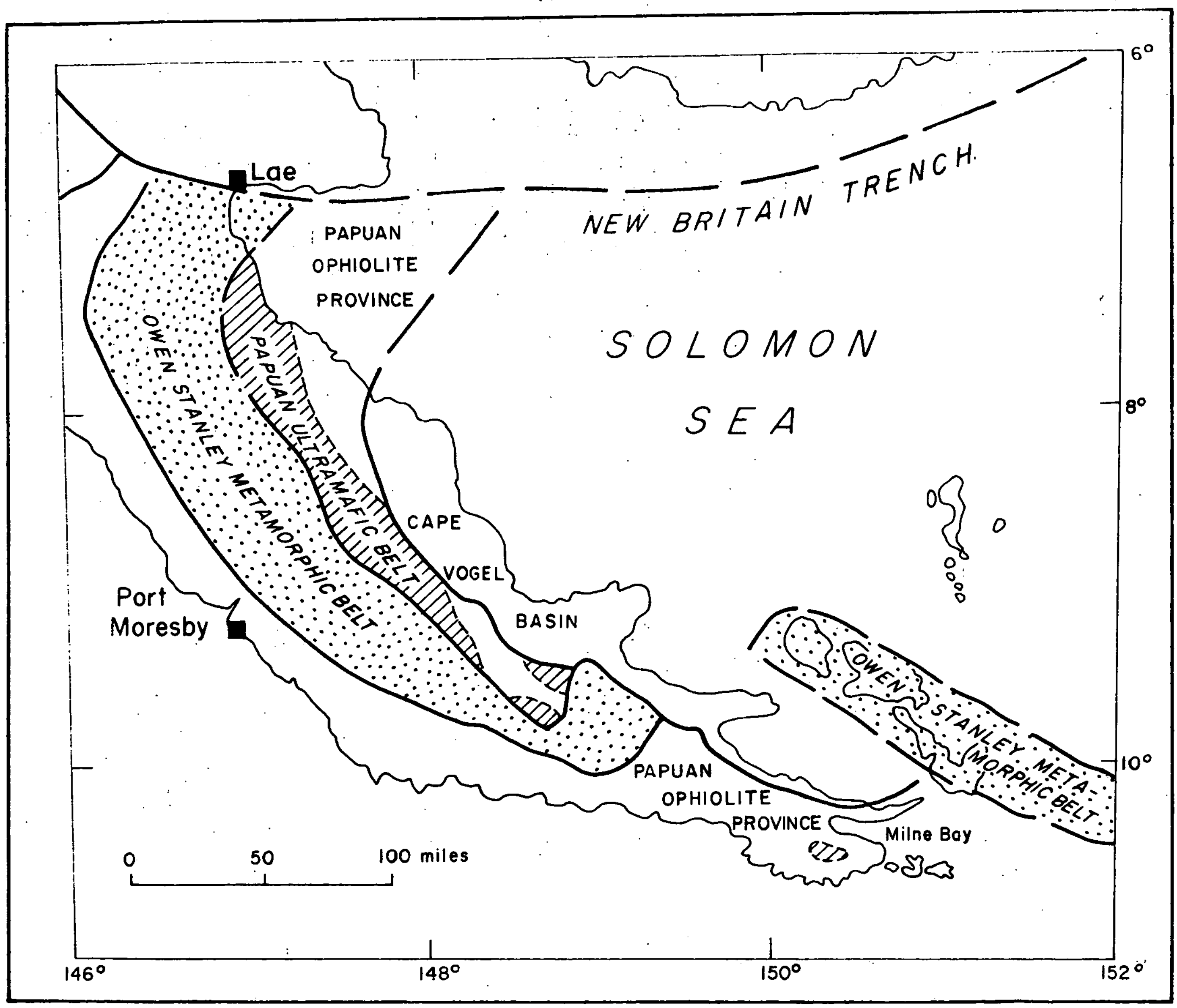
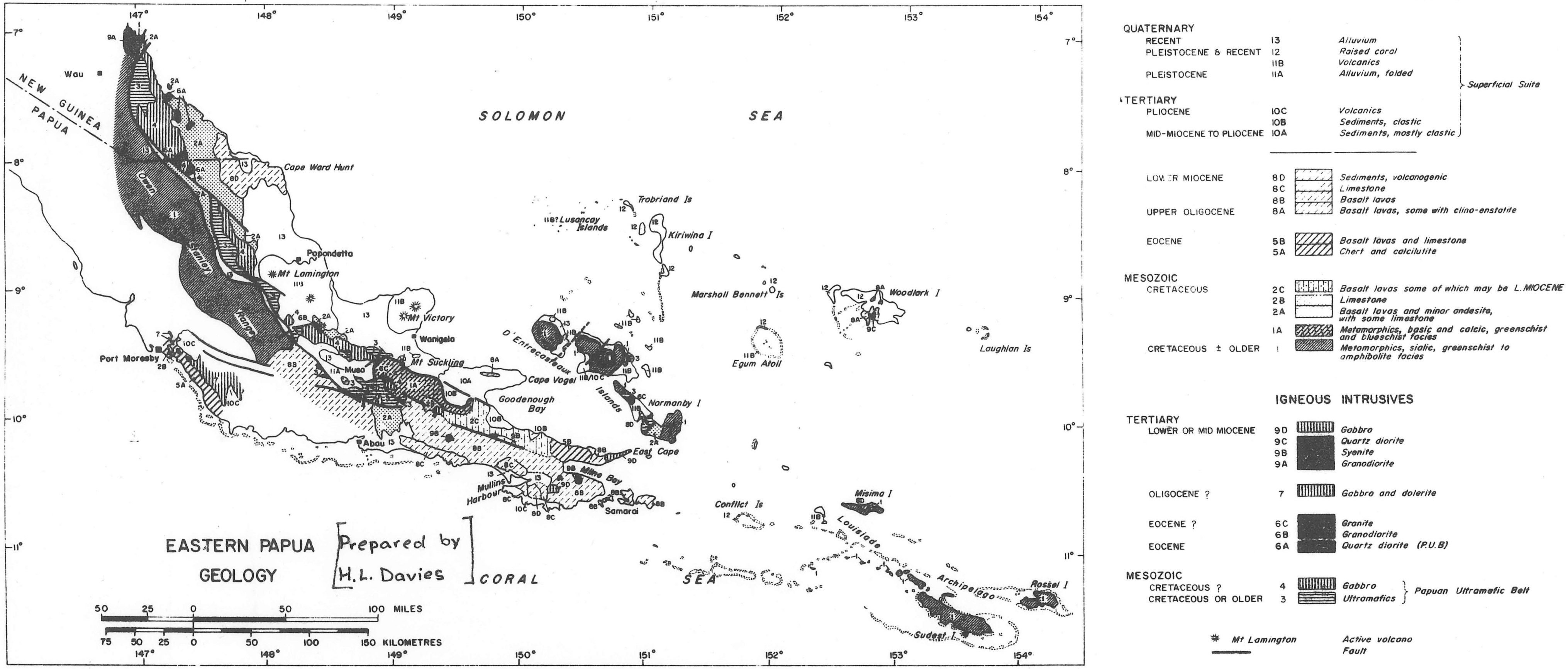


Fig. 2. Principal Structural Units in South Eastern New Guinea
(after Thompson & Fisher, 1964)

P/A/263

To accompany Record 1970/10

FIGURE 3



P/A/264

To accompany Record 1970/10

A major strike fault lineament forms the northern margin of the Owen Stanley Metamorphics. This fault, the Owen Stanley Fault, can be traced as a distinct topographic break for more than 300 km. Both vertical and lateral movement has occurred along this fault. Davies (1968) reports the fault to be in the nature of a low angle thrust dipping eastward at an angle of 20° to 30°. Krause (1967) has described a fault zone which is a regional shear probably coupled with folding and volcanism, called the Pocklington Fault. This fault zone can be traced on the bathymetric charts, from as far east as Guadalcanal Island, past Pocklington Reef and north of the Louisiade Archipelago, to join the Owen Stanley Fault somewhere in the region of Milne Bay (Fig. 6).

Papuan Ophiolite Province

The Papuan Ophiolite Province crops out on either side of the Owen Stanley Metamorphic Belt in southeastern New Guinea. The province is named from its association of ultrabasic and basic plutonic rocks, and basic submarine lavas. It includes grey, red-brown, and green siliceous claystones, inorganic calcilutite, and bedded chert. Thompson & Fisher (1965) recognized it as being a tectonic zone where there is no emergence and where there is no emergent continental mass nearby. It is thus typified by an assemblage of oceanic igneous rocks and ocean floor deposits. No implication of an early orogenic stage is made here.

Two distinct units, the Papuan Ultramafic Belt, and an oceanic province can be recognized as making up the Ophiolite Province.

The Papuan Ultramafic Belt is described by Davies (1968). It is comprised of peridotites and gabbros. Starting in the northwest part of southeastern New Guinea it runs southeastwards for 900 km. reaching widths of up to 40 km. The rocks show similarities in lithology to those of other such bodies occurring in orogenic zones on the Pacific margin, such as New Caledonia, Solomon Islands, Philippines, Celebes, Borneo, and Western United States. Thompson (1967) and Davies (1968) both suggest these ultramafic rocks to be part of the upper mantle which has moved westward since Cretaceous time. Collision with the sialic core of Papua has forced the mantle upward along the Owen Stanley Fault (Fig.4). It has been postulated (Davies 1968) that this exposed part of the mantle is slowly sinking at the present time.

The oceanic rocks of the Papuan Ophiolite Province are chiefly basic submarine lavas and associated limestones, marls and cherts of Cretaceous to Lower Miocene age. No terrigenous sediments occur within the stratigraphic succession of these oceanic sediments and volcanics. It is thought that these rocks are part of the mafic upper oceanic crust which has overridden the Papuan Ultramafic Belt and the sialic core of Papua (Davies, 1969; Thompson, 1967). Intrusions of leucocratic gabbro, diorite, trondhjemite, and rarely granodiorite occur in these oceanic rocks.

Topography within the Ophiolite Province is rugged with high steepsided mountain chains. The effects of Pleistocene glaciation can be seen on the highest parts of the Ophiolite Province, such as Mount Wilhelm and Mount Albert Edward.

Some parts of the coastline in southeastern New Guinea show evidence of Recent submergence and these sections fall within the Ophiolite Province (Thompson & Fisher 1965). Vertical displacements along the Owen Stanley Fault, and erosional remnants of a mature landscape on the crest of the Owen Stanley Range, indicate Pleistocene to Recent uplift of the Owen Stanley Metamorphics relative to the Ophiolite Province (von der Borch, 1969). Thus while the Ophiolite Province is being submerged the Owen Stanley metamorphic belt has been a positive structural element throughout Cainozoic time.

The Papuan Ophiolite Province probably extends under the sediments and volcanics of the Cape Vogel Basin.

Cape Vogel Basin

The Cape Vogel Basin can be regarded as either a sedimentary basin or a section of a volcanic arc. It is structurally depressed and forms a topographically low-lying coastal zone extending from Morobe in a southeasterly direction to Goodenough Bay.

A thick succession of Miocene and Pliocene sediments overlain by volcanics of Pleistocene to Recent age occur in the Cape Vogel Basin.

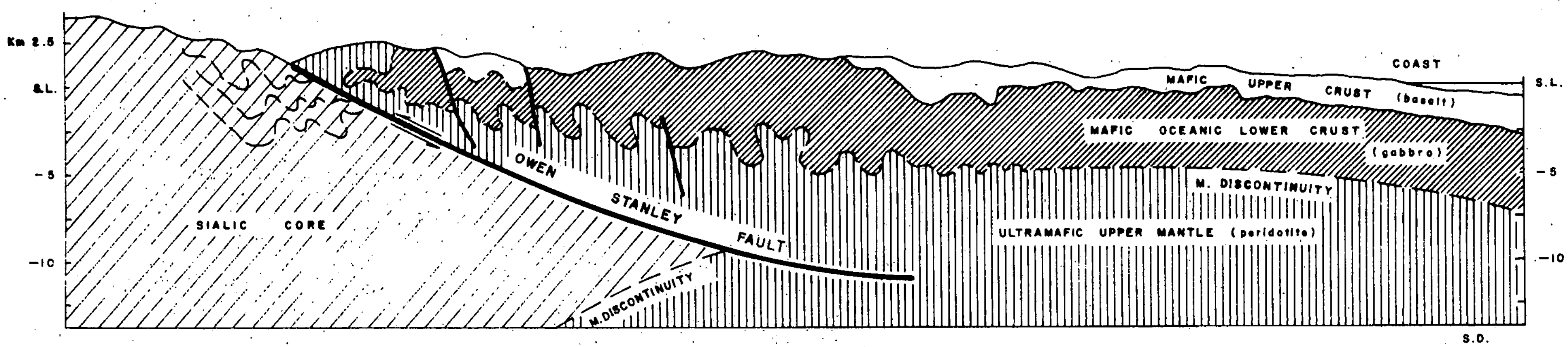
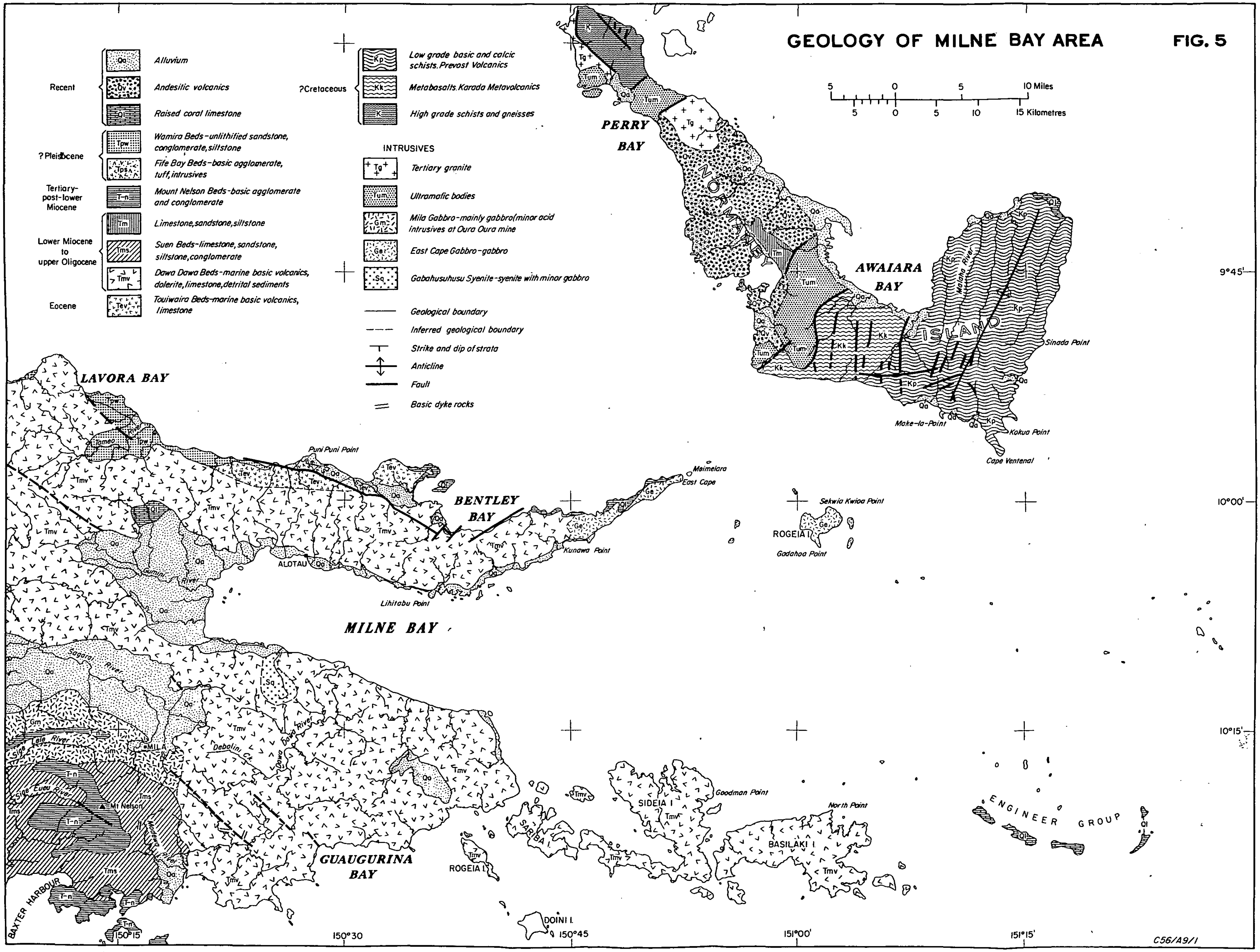


Fig. 4 — COLLISION OF UPPER MANTLE WITH SIALIC CORE RESULTING IN THE PAPUAN ULTRAMAFIC BELT (after Davies 1967)

P/A/265

To accompany Record 1970/10



C 56/A9/11

To accompany Record 1970/10

Local geology, Milne Bay.

The geology of the Milne Bay area has been described by Davies (1967) and Davies et al., (1968). The following summary is based on these reports. A geological map of the area after Davies et al (1968) is shown in Fig.5.

Dawa Dawa Beds.

On both sides of Milne Bay, and on the islands off the southern peninsula, basic volcanics, associated dolerite, basic detrital sediments, limestone, agglomerate and limey sediments crop out. These rocks termed the Dawa Dawa Beds (Davies 1967) are of Upper Oligocene to Lower Miocene age, and their total thickness probably exceeds 3000 m. They are intruded by ultramafic rocks, gabbro, and syenite.

Recent deposits.

Recent raised coral reefs occur in the northwestern part of Milne Bay, the headwaters of the Maiwara River, and the northern margin of East Cape. Flat-lying deposits of Recent alluvium occur at the head of Milne Bay. The old raised coral reef limestone deposit, situated at the westward margin of this deltaic unit, indicates the old shoreline of Milne Bay. Recent alluvial deposits in the form of deltaic mangrove swamps also occur along the north western margin of Milne Bay.

Geophysical data

Results of a regional gravity survey of Eastern Papua by the Bureau of Mineral Resources show some features which are significant in this study (Milsom in press). Figure 7 shows a preliminary gravity map of the area. South of Milne Bay around the Ulo Ulo area a gravitational high occurs, this high is probably due to some subsurface feature such as an ultramafic body. Another gravitational high occurs on the northern side of Milne Bay associated with the East Cape Gabbro. Directly eastward opposite the bay a gravitational low occurs over Dawson Island. It is likely that this low extends into Milne Bay itself (Milsom, manuscript).

The configuration of this gravity pattern suggests some movement of the bay relative to the land. The movement is probably a submergence of the bay floor in this region. A later discussion on the origin of Milne Bay deals with this theory in more detail.

BATHYMETRY

Regional Bathymetry

The regional bathymetry of the south Solomon Sea is shown in Figure 8. Krause (1967) has described the bathymetry and structure of this area. Woodlark Island which rests on Woodlark Ridge,has to the south of it a deep Basin, the Woodlark Basin (Krause 1967). This basin has an extremely irregular floor at about 3000 metres depth which is cut into a chaotic arrangement of hills, ridges, and irregular depressions. These hills have a general east-west alignment with escarpments cutting through the region in various directions.

To the south of the Woodlark Basin lies the Louisiade Archipelago which rests on the eastward extension of the Papuan Peninsula. It is a region of parallel structural ridges, throughs, and closed basins of which Milne Bay is one. Tagula Island, Rossell Island, and Pocklington Reef rests on a series of en-echelon ridges (Krause 1967).

South of the Louisiade Archipelago and the Pocklington ridge the sea-floor slopes down to the deep water of the Pocklington Trough which forms an extension of the Coral Sea Basin. The Pocklington Ridge is fault-bounded in the north. North of Milne Bay another closed basin with depth in excess of 1000 m occurs. This basin is bounded on the east by the D'Entreasteaux Ridge which extends northwards to join the Trobriand Platform (von der Borch, 1969), and southwards to join the southern extension of the Papuan Peninsula. On the northern margin of Goodenough Bay, Cape Vogel is joined to the D'Entrecasteaux Ridge by a sill whose southern margin slopes very steeply down to 1000 m. and is probably fault controlled. This fault may define the locus of dislocation which causes the offset of the continuation of the Owen Stanley Metamorphic Belt.

Bathymetry of Milne Bay

Milne Bay (Plate 1) is a restricted basin locked in on the west side by the Papuan Peninsula with coral reefs and islands on the east side. A sill at a depth of 300 m. forms the connections with the deeper ocean to the north and south, Near land, on the west side, a number of rivers enter Milne Bay after passing through a marginal swampy delta.

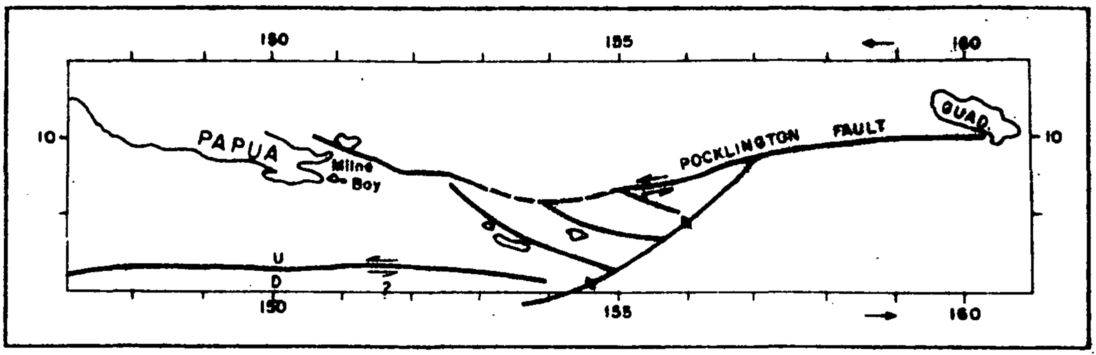


Fig. 6 POCKLINGTON FAULT

POSITION AS SHOWN BY KRAUSE, 1967

Strike-slip fault with sense

Normal Fault (U = up, D = down)

Postulated Rift

Postulated Regional Stress

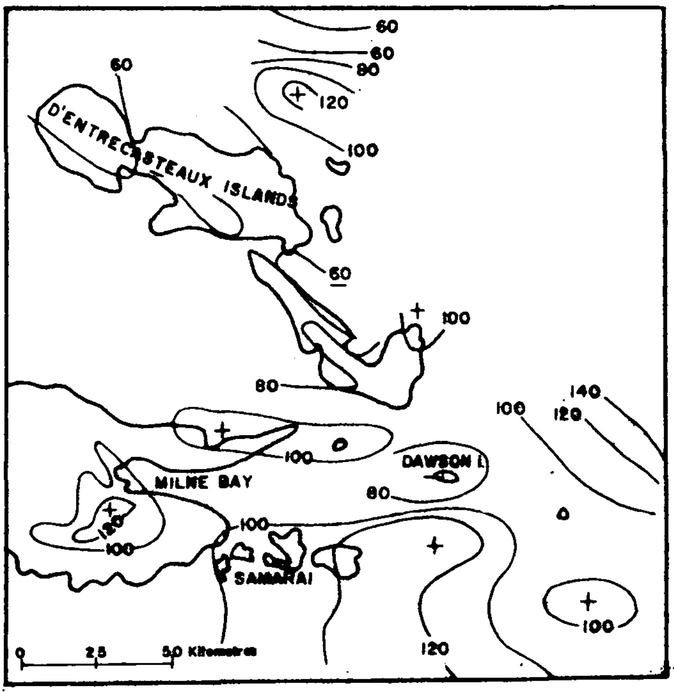


Fig.7 PRELIMINARY GRAVITY MAP OF MILNE BAY AREA

(From a Gravity Survey of East Papua and New Guinea, after Milsom manuscript)

Note: *Gravity highs on northern and southern margin of Milne Bay with a low near Dawson Island in line with trend of Milne Bay.*

P/A/266

To accompany Record 1970/10

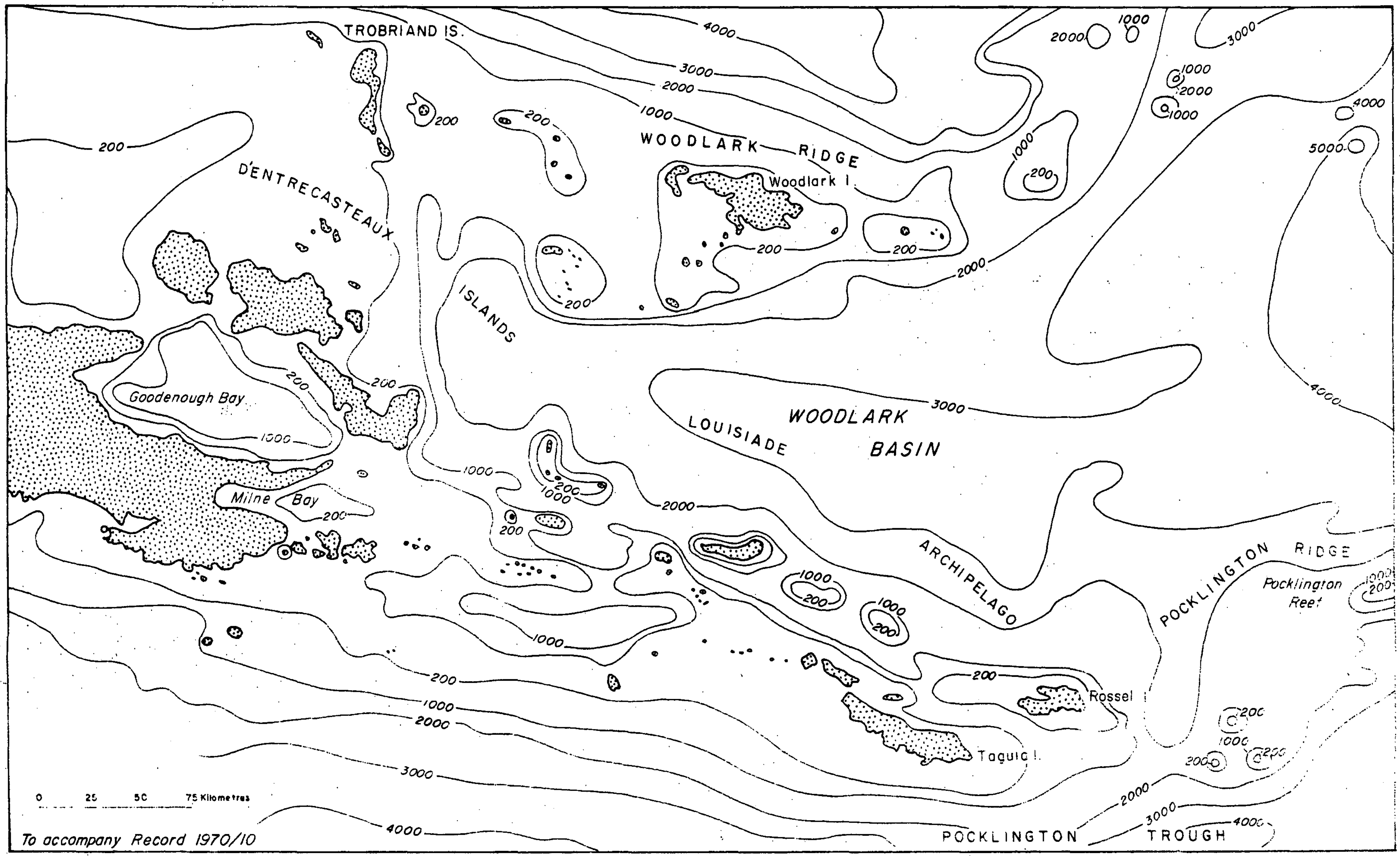


Fig.8. Regional Bathymetry of South Solomon Sea. Contours in Meters

P/A/267

On the western edge of the bay a shallow gently sloping irregular shelf occurs. The edge of this shelf occurs at about 80 m. Depth increases rapidly seaward of this narrow shelf and at the bay margin in the north and south. Steep slopes with gradients approaching 45° occur between 80 m and 250 m depth. Another break in slope occurs at about 250 m after which the gradient decreases to about 6°. This slope continues down to 500 m at which level the almost flat bottom of the bay is encountered.

In the north eastern part of the bay, south of Nua-Kata Island, the situation is slightly different. Here the initial very steep slope between 80 and 250 m is present seaward of the rudimentary shelf. However, below 250 m. the slope decreases to less than 1°. This gentle gradient continues for a distance of about 65 km. until the floor of the bay is met at a depth of 500 m.

Milne Bay is bordered on the eastern side by a number of shoals which support a few small islands. The southern end of these shoals is deeper and a channel with a minimum depth 300 m. forms the connection with other restricted basins on the submarine ridge off the Papuan Peninsula. To the south a number of shallow channels about 20 m. deep, such as China Strait and Fortescue Strait, connect Milne Bay with the Coral Sea Basin. Between East Cape and Nua-Kata Island a number of shallow channels communicate with Goodenough Bay.

In the northern part of the bay a narrow steep-sided trough runs from near the middle of the basin northeastwards parallel to East Cape peninsula. The bathymetric contours indicate a feature resembling a submarine canyon, but although no seismic data are available, it seems unlikely that this trough has been formed by erosion and a structural origin is postulated. The trough runs at a right angle to other structural trends in the bay and it is most likely connected with the structural features seen on Normanby Island to the north of East Cape where faults also trend northeast - southwest.

The straight southern margin of the Milne Bay basin and the steep slopes strongly suggest faulting. It seems likely that the northern side of the bay is also fault-controlled, although here the slopes are less steep and more indented.

SPARKER TRAVERSES

Seven sparker traverses were run across Milne Bay. The sparker traverses were obtained by a continuous profiling system comprising a 3-electrode Sparkarray and a 1000 watt-second power source, combined with a 7-element hydrophone and an Ocean Sonics GDR-T recorder. The recorder uses 190 inch wet paper and during these traverses was programmed at one sweep per second; this sweep speed gives a horizontal scale line interval of 36.7 m (20 fathoms) in water. Traverses were run at a speed of 4.5 to 5 knots.

The location of the traverses is as shown in Figure 9. Photographic reproductions of the traverses, accompanied by line drawn interpretations are shown in Plates 2 to 8. The vertical scale on the line drawing is in terms of two-way travel time quoted in seconds. Where sub-bottom thicknesses of strata or depths to reflectors are quoted in the descriptions of the profiles, a uniform velocity of 1700 m/sec has been assumed. Unless otherwise stated, the attitudes of reflectors mentioned refer to the apparent attitude along the line of section.

The term basement is used to indicate an irregular, strong reflector below which no obvious sedimentary bedding can be discerned. Note that due to bubble pulses all horizons are shown by a series of three or four lines on the original sparker records (see Sargent, 1969). The sparker records are described in order from east to west.

Traverse 1:

Traverse 1 runs from south to north at the eastern end of the bay. It represents an almost straight section between Shortland Reef and Cocked Hat Island. The quality of this record is excellent showing many prominent sub-bottom features (Plate 2).

The start of the traverse shows a shallow irregular bottom with a coral reef or basement outcrop at 2* in a depth of 40 m. At 3 the bottom has an almost vertical slope which becomes less steep at 150 m (4) and gradually flattens out into a deep channel at 340 m (15).

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* Numbers refer to features indicated on the line drawn interpretation of the profile.

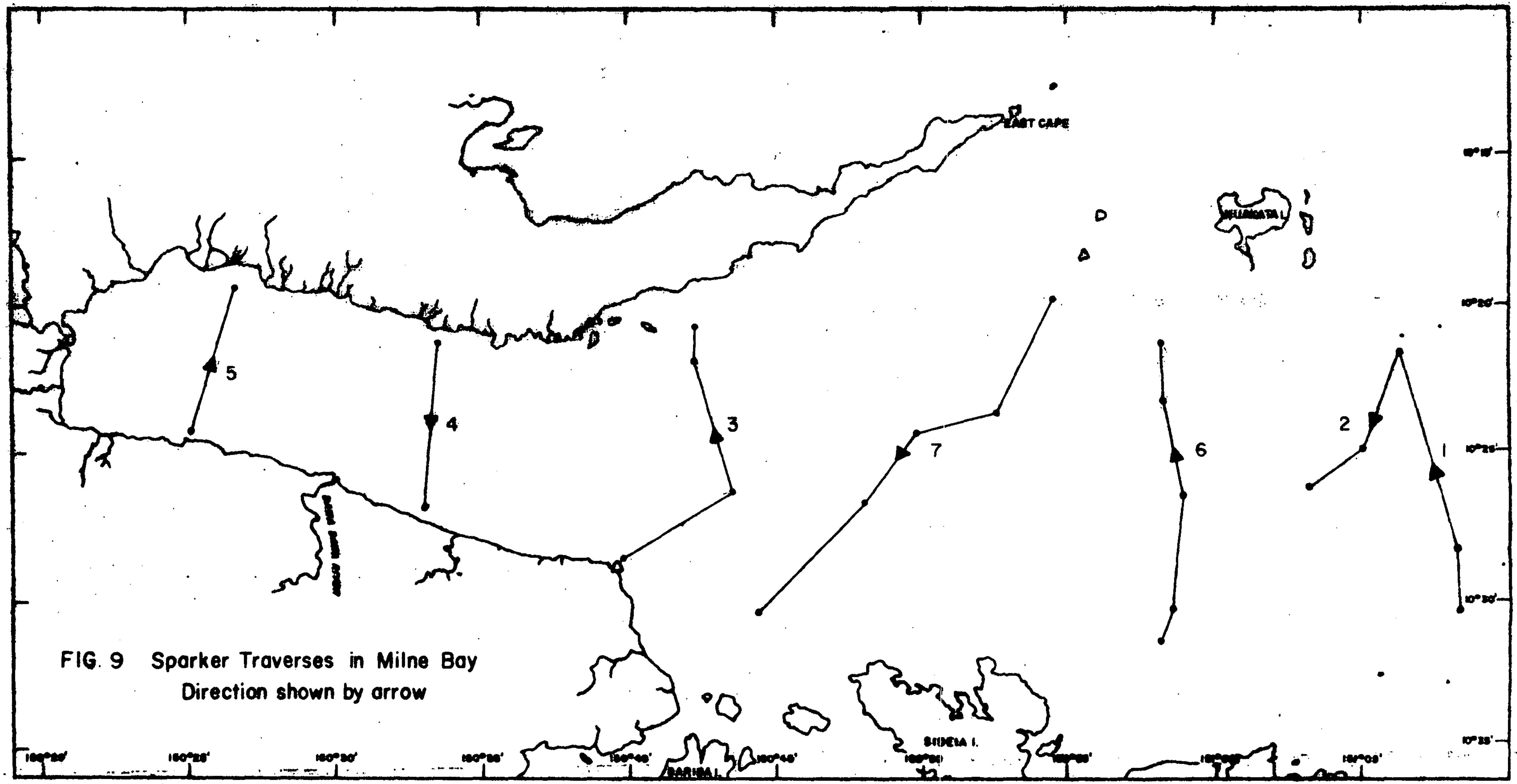

FIG. 9 Sparker Traverses in Milne Bay
Direction shown by arrow

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To accompany Record 1970/10

At 13, three acoustically impenetrable hummocks appear which represent basement rock forming the shoals around Nua Kata Island. Another basement high crops out at 17. Sub-horizontal bedding of the sediments fill between these basement highs can be seen at 10 and 11.

An almost vertical slope at 18 marks the northern edge of the deeper basin, and at 14 coral reefs can be seen on the edge of shallow shelf which is underlain by basement rock.

A strong reflector at 6 marks an unconformity which is well displayed in this and later profiles. Onlap of the overlying sediments is evident at 7. The unconformity probably represents a low sealevel stand during the Pleistocene. However since the maximum depth of the unconformity is 425 m. some submergence of the bay must have taken place to account for this depth. Maximum eustatic sealevel lowering is in the order of 120 to 125 m. (Curray 1961). The amount of subsidence in the section of the bay must thus be in the region of 300 m.

Conformity at 19 indicates the presence of a channel at the time when the unconformity originated.

A very faint unconformity below the one described occurs at 8 and since no penetration (9) can be observed below this reflecting horizon it is suggested that this is basement rock.

Multiple relfections are indicated at 16.

Traverse 2:

Traverse 2 is a short profile from Cocked Hat Island going south-west. The traverse begins in shallow water the seafloor being at 1 (Pl.3). At the start the bottom is irregular (2) owing to growth of coral reef on this shallow shelf. Little penetration below this shelf indicates that it is underlain by basement (6). The edge of the shelf is marked by a hummock (3) which is probably a reef structure.

Terraces occur around the margin of the shelf at 4. The shelf edge is deeply indented in this area, and the platform at A is in fact continuous with the rest of the shelf. Slopes at the edge of the shelf are steep (5) and may be fault controlled. Sediments can be seen to occupy the embayments (7) of the indented margin. The floor of the basin slopes gently southwards away from the edge of the shelf, and sub-horizontal stratification of the sediments underlying the bottom can be seen at 8 and 10.

The strong reflector at 12 marks the Pleistocene unconformity seen in traverse 1 just to the east of this traverse. A normal fault with a throw of about 30 metres occurs at 11. Multiple relfections are indicated at 13.

Traverse 6.

Traverse 6 runs from south to north about 12 km. west of Traverse 1. The start of the traverse is in shallow water with a somewhat irregular aeafloor (Pl.4). A coral reef on the edge of the shelf at 2, a small channel at 3, and a terrace at 4 are followed by a steep slope at 5 which is fault-controlled. The slope of the floor of the bay decreases (6) and continues to do so smoothly until at 8 a fault scarp is encountered; thereafter the floor slopes upwards gently to the end of the traverse.

In the deepest part of the traverse, apparently, conformable sediments are penetrated for 0.4 seconds (340 metres) at 7. As in Traverse 2, a normal fault downthrowing to the south occurs near the axis of the basin. North of the fault an irregular reflector at 12 indicates the unconformity noted in Traverses 1 and 2. The presence of this unconformity at a shallow depth beneath the bottom at 12, and the fact that it cannot be detected to the limit of penetration at 7, indicate that the throw of the fault considerably exceeds its expression on the sea floor. The unconformity may be followed for the major part of the record, although it becomes less obvious in the latter part. However, a change in the reflecting behaviour of the horizons at 14 marks the presence of this unconformity in that part of the record.

Multiple relfections are indicated at 15.

Traverse 7:

Traverse 7 runs from near Lelei-gana Island southwestwards towards the southern peninsula of the mainland. Excellent penetration on this record shows very clearly the relations of the subbottom strata in the middle of Milne Bay (Pl.5.).

A marked unconformity is observed in this record at 2, and can be traced in the deepest part of the basin to a depth of 425 m. beneath the sea bottom in a water depth of 560 m. , This maximum depth of 985 m, is very much lower than the maximum low-level seastand, which is reported to be about 125 m (Curray 1961, 1965; Van Andel, & Veevers, 1967). Thus in this part of the bay, submergence of about 760 m. must have occurred. This is much more than that postulated for the eastern part of Milne Bay and it is suggested that submergence here was at its highest due to a fault connected with the formation of the trough south of the East Cape Peninsula.

Below the unconformity the bedding is slightly distorted (8), and some of these reflecting horizons are truncated near the unconformity surface (9).

Since Pleistocene times sinking concommittent with sedimentation has gone on. Continuous horizontal reflecting horizons are present at (3), and a thickness of at least 425 m. is present in some of this section (13). Onlap of the sedimenta at the margins of the areas of active subsidence and maximum sedimentation is evident at 6, and small notches in the slope of the bottom (5) above these onlaps suggest down-faulting of the deeper parts of the basin, as at 7. Uniform closely spaced reflecting horizons indicate a well bedded sequence of sediments at 4.

At the end of the section the bottom rises again towards China Strait. Discontinuous, slightly wavy, reflecting horizons occur at 10; these may indicate slumping. Further south, at 11, undisturbed, closely spaced reflectors are present.

Multiple reflections are indicated at 12.

Traverse 3.

Traverse 3 runs from near Saraoni Island north-eastwards to the middle of the bay, and thence north north-west to East Cape Peninsula. The quality of the record is poor but gross features are still discernable (Pl.6). Near the start of the traverse the bottom shows undulations on a shallow narrow shelf (2, 4) probably due to presence of coral reefs. At 3 a very steep slope occurs between the two humps of 2 and 4. The floor of the bay at a depth of 525 m. is remarkably flat over a distance of 13 km, until the slope on the northern side of the bay is encountered.

Below the flat floor of the bay is a succession of horizontal reflectors to a depth below bottom of 125 m. Basement rock occurs on the bottom of the steep slope at (6), and undulating reflectors in this area are possibly due to slumping.

The upper slope at 7 is fairly uniform some slight penetration (9) seems to indicate some bedding below this slope. At 10 the edge of the shelf is reached again and the bottom shows uneven topography. A very indistinct horizon at 8, which subparallels the bottom slope at 7, occurs in the latter part of the record. This is possibly the unconformity noted in the traverses to the east.

Traverse 4:

Traverse 4 runs from north to south, covering the middle of the landlocked part of the bay. The bottom descends steeply, with irregularities until it flattens out at a depth of 480 m (Pl.7). Irregular and wavy reflecting horizons indicate basement rock at 2. Slump structures occur at 3 and 4 on the steep slope of the bay's margin.

The Recent sedimentary fill in the central part of the traverse displays numerous closely spaced horizontal reflectors which were penetrated to a depth of 85 m. Some onlapping occurs at 5.

At the end of the traverse near the southern margin of the bay, a straight steep slope occurs which is obviously fault controlled (7). Some irregular bedding can be seen on the upper part of this slope and under the narrow shelf (8). Multiple reflections are observed at (9).

Traverse 5.

Traverse 5 is the westernmost profile and covers the inner reaches of the shallow part of Milne Bay. The traverse runs from south to north.

Both the bottom and the underlying reflectors are somewhat irregular throughout this profile. The traverse was run more or less parallel to the foreset slope of a delta or series of deltas out-building from the rivers flowing into the head of the bay to the west. Irregularities of sub-bottom reflectors (3) are due to slumping down the foreset slope. Underlying basement probably appears at 2. Multiple reflectors are indicated at 4.

Structure and Sedimentation.

Milne Bay is situated in a region which has been and still is tectonically very active. It is a graben structure and subsidence has continued actively since the Pleistocene. The unconformity revealed in the seismic profiles is postulated to be the erosion surface developed during the low stand of sea level late in the Pleistocene. Curray (1961, 1965) postulates this low stand to have occurred 18,000 years ago. Since that time there has been a eustatic rise of the order of 125 m. (Curray 1961, 1965; From Figure 10 it may be seen that the maximum depth of the unconformity is now about 900 m., indicating about 775 m. of subsidence since the late Pleistocene transgression.

This subsidence has been accompanied by rapid sedimentation; the profiles show that a maximum thickness of 450 m. of Recent sediment overlies the unconformity (Fig.11). Assuming the transgression to have occurred 18,000 years ago, this gives a sedimentation rate of 2 cm. per year. Isopachs and structure contours in Figures 10 and 11 suggest that the locus of sedimentation is in the middle of the basin north of the outlet of China Strait.

A structural interpretation of the bay is shown in Figure 12. Faults can be inferred from both the bathymetry and the sparker records. The main trend of faulting controlling the margin of the bay is in line with the prominent Owen Stanley fault lineament to the north, and it is suggested that the same movement as the one which caused the Owen Stanley fault also formed Milne Bay. The probability arises that Milne

Bay is underlain by ultramafic material which formed part of the mantle and is sinking again after having been pushed up due to a movement of oceanic crust against the sialic core of Papua (Davies, 1968; Thompson, 1965).

The presence of the trough parallel to the East Cape peninsula is linked with the D'Entrecasteaux Islands to the north. The movement responsible for the offset of the Owen Stanley Metamorphic Belt on the D'Entrecasteaux Islands is also responsible for this feature.

SEDIMENTS

Thirty-two surface sediment samples were collected in Milne Bay during this survey. The location of the sample stations is shown in Figure 12; most samples were taken along traverses close to the seismic profiling runs. Station data are summarized in Appendix 1.

Grainsize

Grainsize analysis of the sand-size fraction, (coarser than 4 phi), was carried out by sieving or by sedimentation tube; where insufficient coarse material was present for these techniques, as often happened, direct grainsize measurement under the microscope was carried out. The silt and clay fraction was analysed by the standard pipette method.

The results of the grainsize analyses are summarized in Figure 14 in which the samples are plotted on a triangular diagram using the textural classification of Shepard (1954). Most of the samples fall in the silt, clayey silt, and sandy silt grades, and there are no clays, sandy clays, silty clays, or clayey sands. The areal distribution of the various textural types is shown in Figure 15. The central region of the bay is floored mostly by clayey silts. The clay content in the samples decreases near shore and towards the eastern extremity of the bay. South of Nua-Kata Island, a shallow shelf is covered with sand which further south and with increasing depth grades into silty sand, sandy silt, and silt.

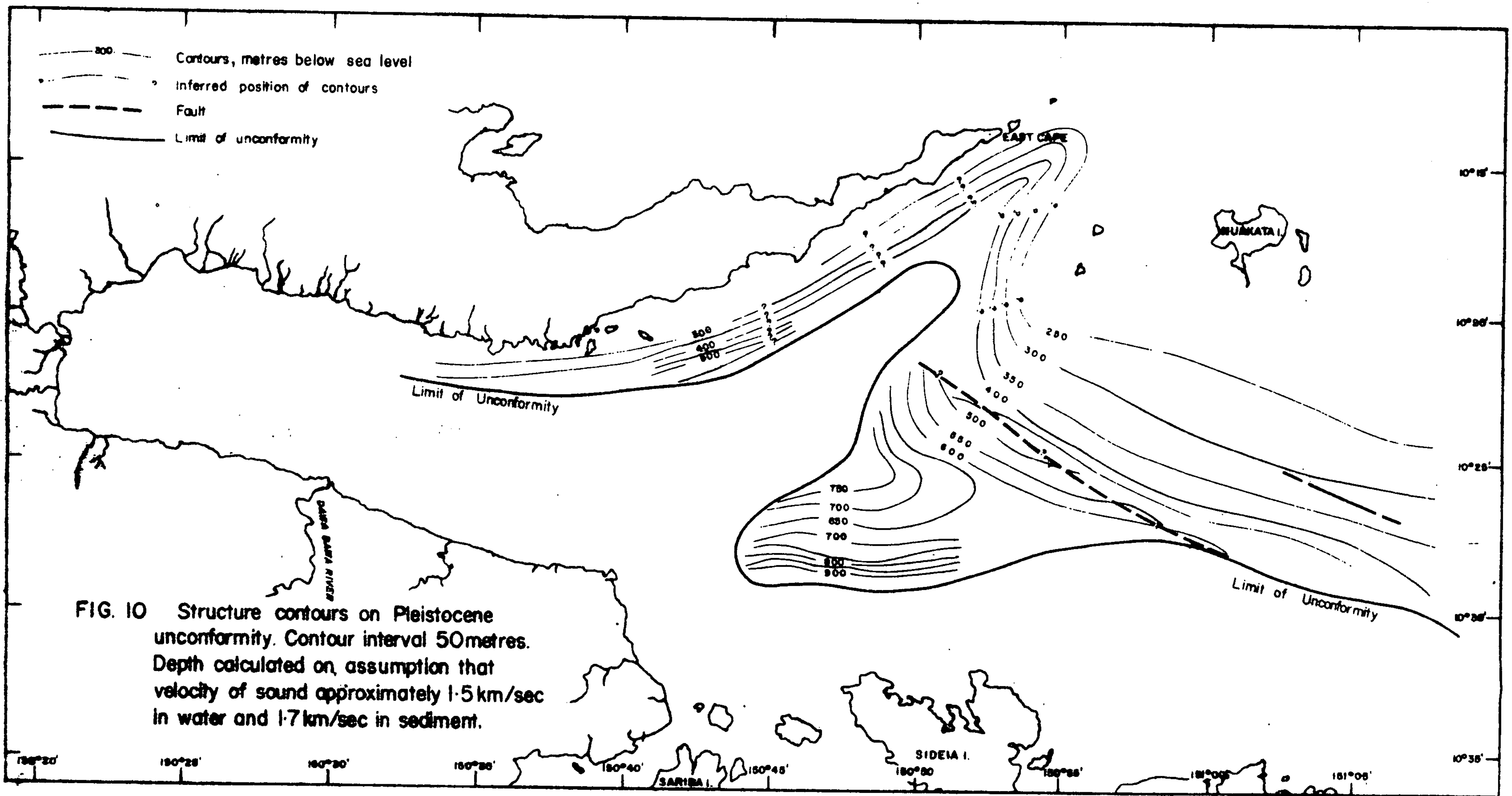

FIG. 10 Structure contours on Pleistocene unconformity. Contour interval 50 metres. Depth calculated on assumption that velocity of sound approximately 1·5 km/sec in water and 1·7 km/sec in sediment.

To accompany Record 1970/10

C56/A9/21

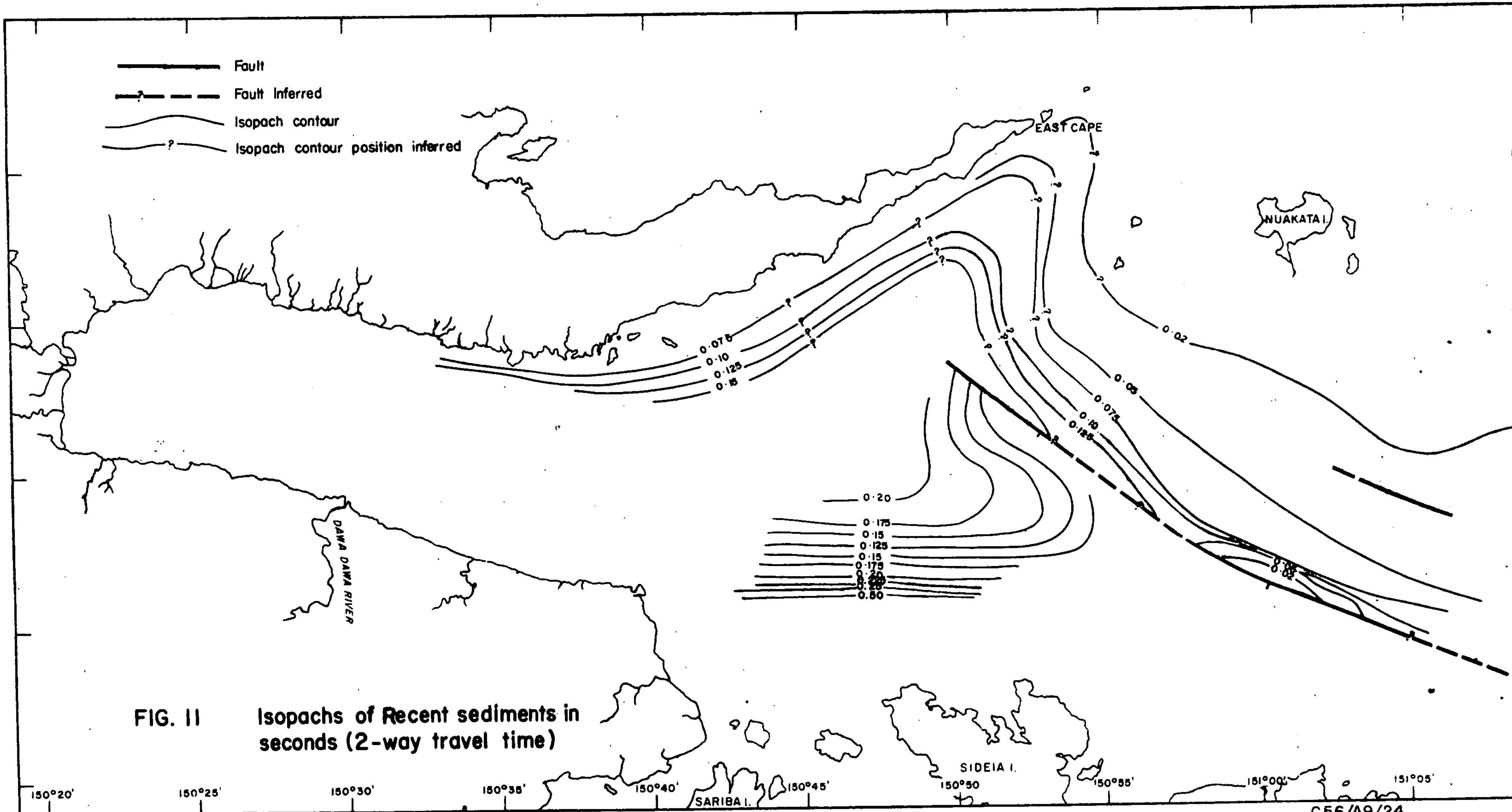

FIG. 11 Isopachs of Recent sediments in seconds (2-way travel time)

To accompany Record 1970/10

C56/A9/24

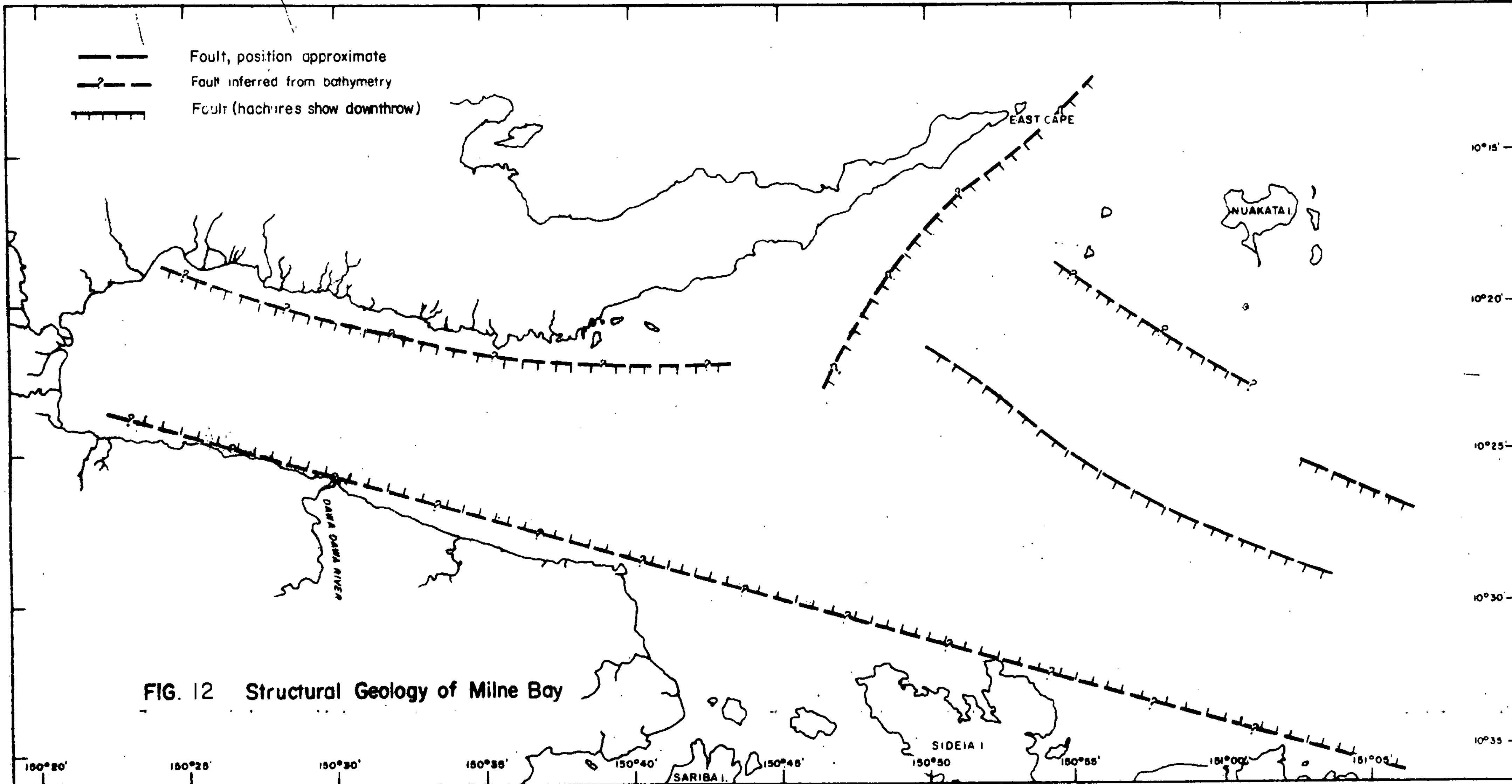

FIG. 12 Structural Geology of Milne Bay

To accompany Record 1970/10

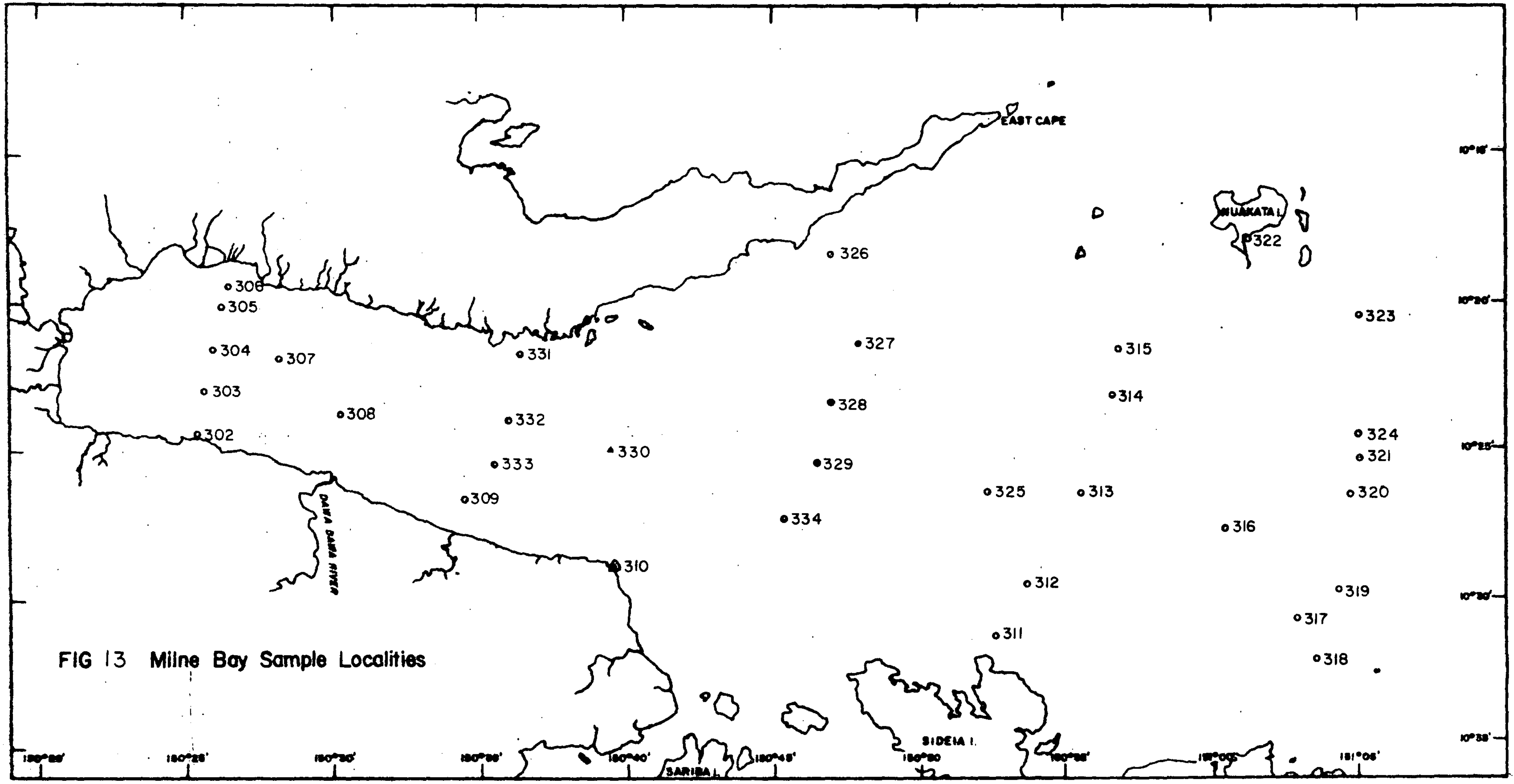

FIG 13 Milne Bay Sample Localities

To accompany Record 1970/10

C56/A9/25

In the western part of the bay two samples are in the sand, silt clay range. These samples occur on the edge of the prograding delta which is a product of the discharge of the rivers entering the bay in the West.

The deposits of Milne Bay are similar to the silty clays found generally deeper and at further distances from shore in other parts of the world, for example the Peru-Chile Trench (Trask, 1961), the Californian offshore basins., (Emery, 1960), the Gulf of California (Van Andel, 1964), and the Timor Sea, (Van Andel & Veevers, 1967). This is possibly due to the loss of ooarser material in the sediment load of the contributing rivers soon after entering the bay. Furthermore since the energy of the environment of Milne Bay is low there is little reworking by currents to carry clastic material coarser than silt away from the nearshore deltas.

Stastical analysis of the grainsize data (Appendix 1) shows that most samples are polymodal, indicating multisource origin of the sediment. Examination of the cumulative curves also commonly reveals gaps, usually in the region of the 5 phi (coarse silt) grade; this feature cannot be wholly explained by faulty analytical technique, and it seems likely that the source sediments are deficient in this size grade. The reason for this is obscure.

Sorting of the sediments is universally poor or very poor; the inclusive graphic standard deviation values (Folk & Ward, 1957) range from 1.10 phi to 3.32 phi. A plot of the distribution of sorting values shows a slight improvement in sorting towards the eastern end of the bay, which possibly results from the lesser influence of polymodal terrigenous sediment in this region.

Poor sorting must be ascribed to the low energy environment and lack of reworking, and to the multisource origin of the sediment, particularly the presence of an important biogenic component of which the particle size may be unrelated to the conditions controlling the deposition of allogenic material. It is also relevant to note that the samples consist of a mixture of the top 8 to 10 cm. of the sediment, and although they are taken to be representative of a single horizon, in fact they may consist of two or more litholgocially different laminations.

Calcimetry.

Determination of the total carbonate was carried out using apparatus similar to that descrobed by Hülseman (1967) which measures manometrically the volume of CO_2 evolved from a known quantity of sample. Results of the analyses are given in Appendix 1.

The distribution of the carbonate content in the Milne Bay samples is shown in Figure 16. Extreme values range from 5 percent to 98 percent and there is an increase in carbonate content going from west to east in the bay. In the western part of the bay near rivermouths the sediments contain little calcium carbonate owing to the dominance of terrigenous non-calcareous material. Fringing reefs are present but their contribution is not enough to drown the effects of sedimentation from the rivers.

In the central and deeper part of the bay carbonate content increases due to a decrease in terrigenous sediment and an increase in the organic component. The eastern margin is enclosed by coral reefs and the sediments in this area contain up to 98 percent carbonate which is mainly derived from the reefs.

Oxidisable Matter.

Oxidisable material was determined by prolonged digestion in hydrogen peroxide. The results of the analyses are given in Appendix 1. Values range from 0.8 percent to 12.7 percent by weight, and the areal distribution pattern reveals maximima in the central part of the basin, where circulation is restricted and euxinic conditions obtain, and in the extreme western end of the bay. In the latter case it seems likely that rapid sedimentation results in the burial of organic material, particularly plant remains, before oxidation can take place.

Mineralogy.

X-ray diffraction. Semi-quantitative mineral determinations were made by X-ray diffraction. The analyses were carried out using a P.W.1051 X-ray Diffractometer. The results in order of relative intensities of the minerals identified are shown in Appendix 2.

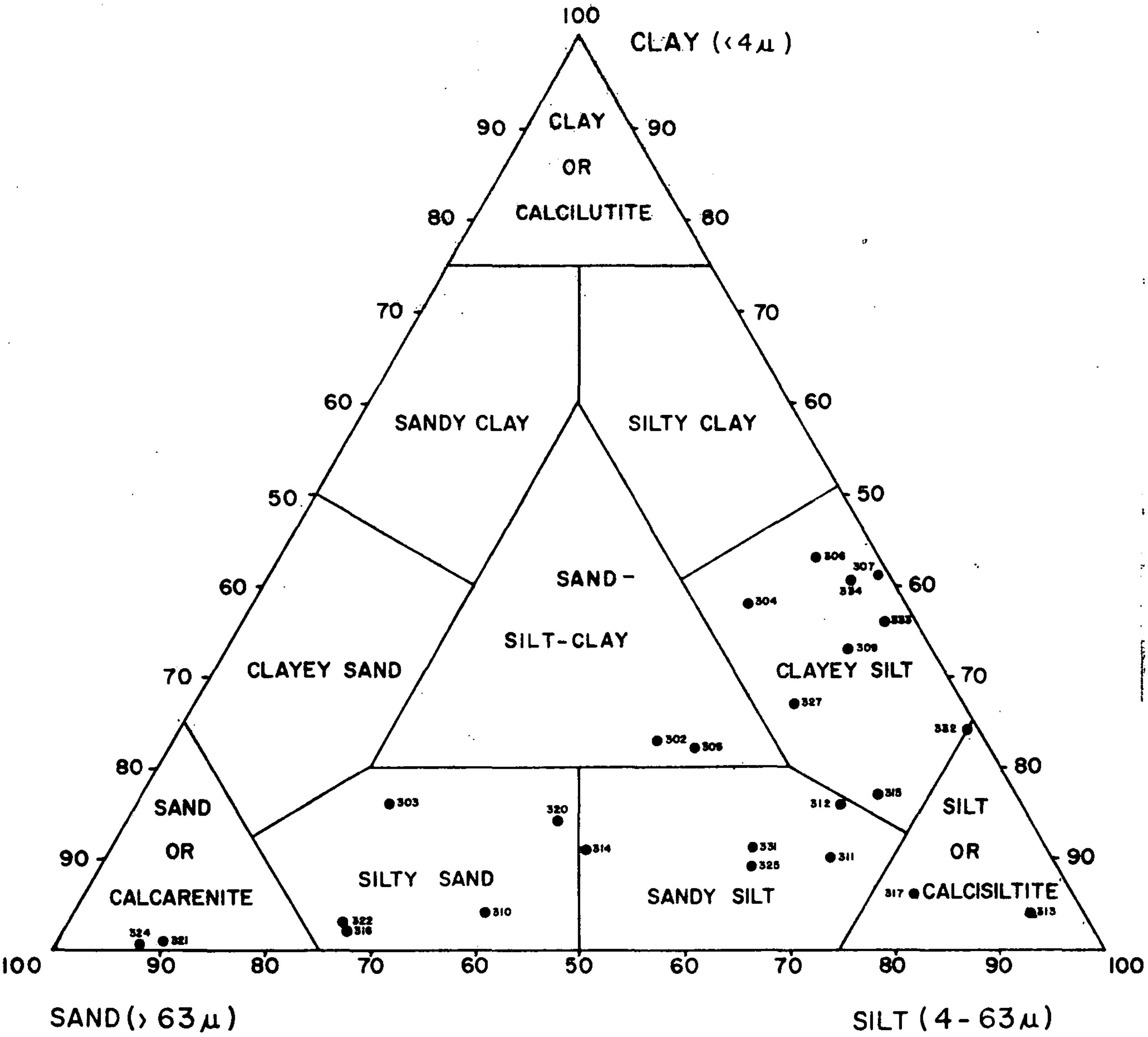

FIG 14 MILNE BAY SAMPLES Shepard (1954) TEXTURAL CLASSIFICATION

C56/A9/26

To accompany Record 1970/10

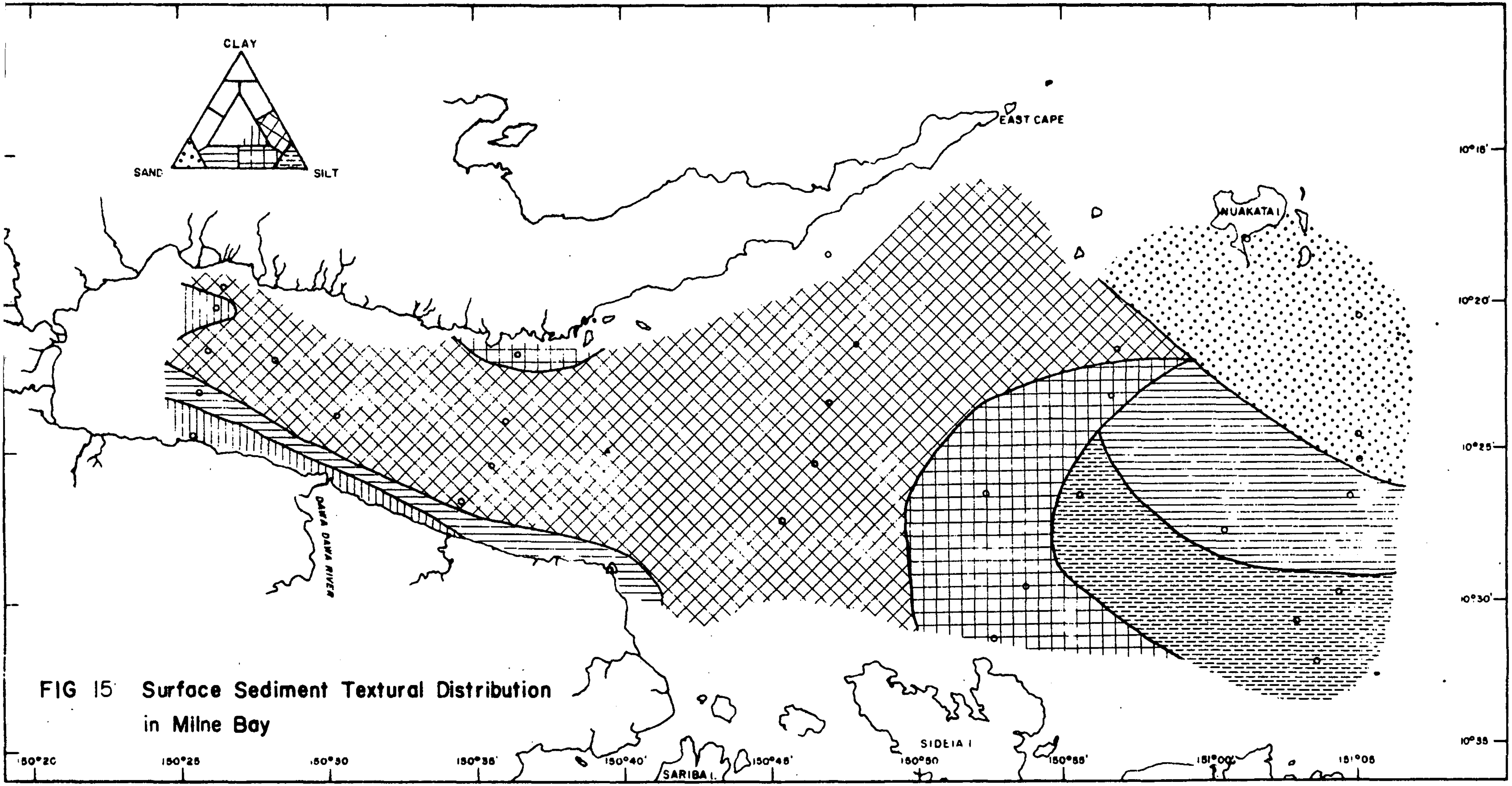

FIG 15 Surface Sediment Textural Distribution in Milne Bay

To accompany Record 1970/10

C56/A9/23

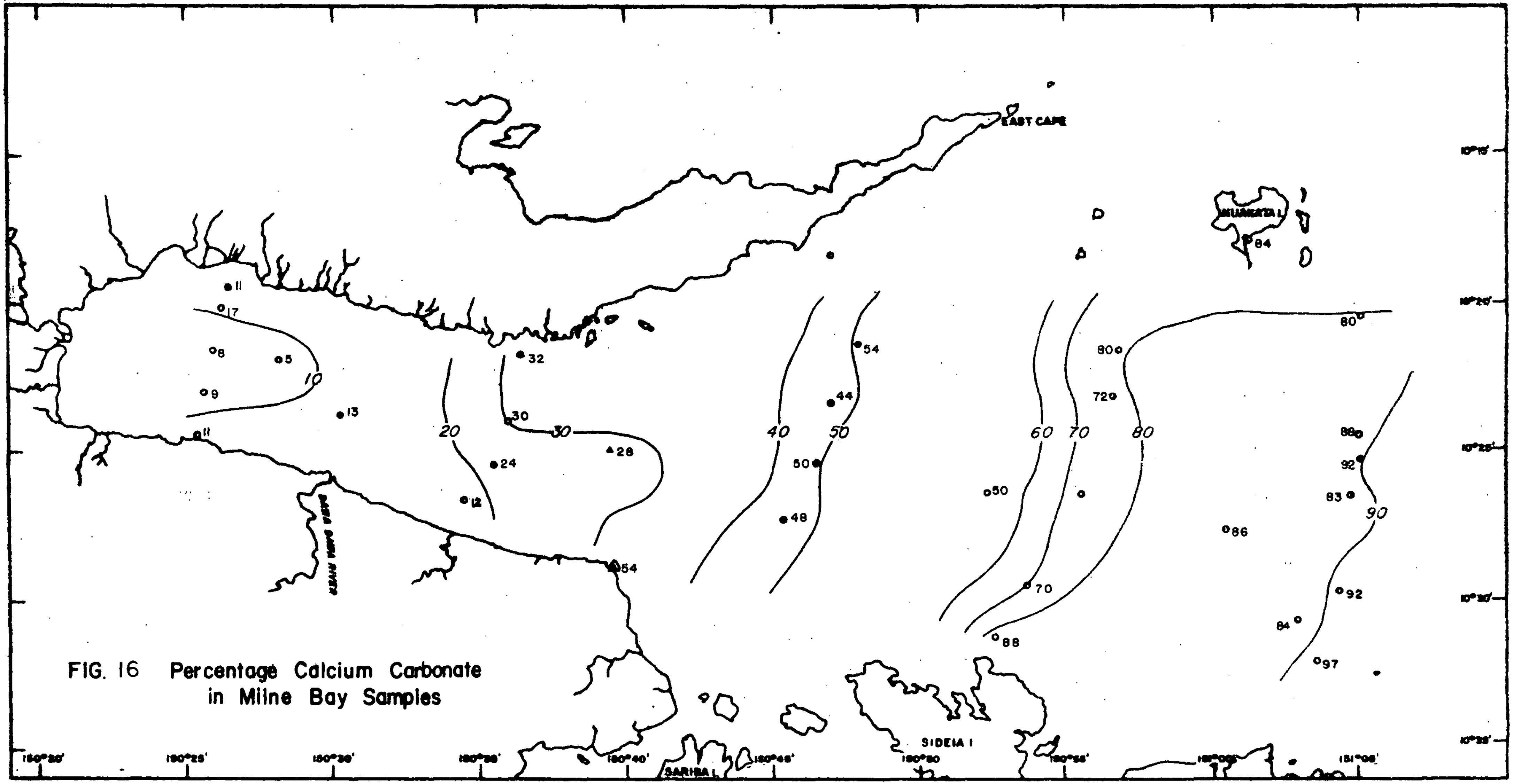

FIG. 16 Percentage Calcium Carbonate in Milne Bay Samples

To accompany Record 1970/10

C56/A9/17

Most samples contain calcite, albite, chlorite, aragonite, quartz and halite. In addition, near shore samples contain some muscovite. Albite is the most abundant mineral in three samples taken near shore. The rest of the samples have calcite or aragonite as the most abundant mineral in the sample.

Biogenic material: The fraction coarser than 4 phi was examined under a binocular microscope for remains of organisms. Tests of foraminifera dominate the skeletal fraction. Both planktonic and benthonic forms are present. Benthonic forms are most abundant in the samples taken at a depth of less than 200 m. Samples taken from a greater depth than 200 m. chiefly contain planktonic forms.

Some samples contain an abundance of siliceous sponge spicules especially those taken in the vicinity of reefs. Shells of gasteropods and pelecypods occur in the samples near the outer eastern margin of the bay in the back reef environment, and in the forereef environment of the near shore fringing reefs. Coral fragments are abundant in the samples on the shoals south of Nua-Kata Island. Other remains of organisms are present in the form of chitinous material probably from crustaceans. Echinoid spines and fragments are sporadically encountered in some shallow water samples.

In the central portion of the bay faecal pellets (0.1 to 0.2 mm) in diameter) are abundant. The faecal pellets are composed of reworked very fine-grained greenish sediment. It is notable that no tests of benthonic formainifera are found where faecal pellets are common. This may be due to the destruction of the foraminifera by the organism which produces the faecal pellets.

Heavy minerals: Separation of the heavy mineral fraction was carried out by centrifuging in bromoform. The sample was first treated with concentrated hydrochloric acid to remove carbonates and sieved to remove the -44 micron fraction. After centrifuging, the lower portion of the test tube was frozen and the upper unsolidified bromoform and light mineral fraction poured and collected on filter paper. The lower portion was allowed to melt and the bromoform containing the heavy minerals was likewise collected on filter paper. Both the light and heavy fraction were mounted. Optical determination of the minerals was done by use of a petrological microscope.

The heavy minerals present in the samples consist of pyroxenes, (augite and aegerine augite), hornblende, olivine, and opaques (hematite, magnetite, pyrite, and leucoxene).

The pyroxenes vary in colour from bright green (aegerine augite), to brown, to almost colourless varieties (augite). They are the most abundant heavy mineral in these samples and some heavy fractions contain up to 80 percent pyroxenes. Hornblende is also abundant locally, forming up to 50 percent of some samples, but is rare or absent in most cases.

The olivine is typically bleached yellowish green in colour and occurs only in a few nearshore samples, notably in the south-western extremity off the bay, where it consitutes up to 60% of the heavy mineral fraction. Opaque minerals in Milne Bay usually form about 10 percent of the heavy mineral fraction. Hematite occurs in powdery aggregates and magnetite in grains. Pyrite has been observed in some samples where it fills tests of foraminifera and is obviously of authigenic origin. The presence of this authigenic pyrite supports the view that reducing conditions prevail in some parts of Milne Bay (Krumbein and Garrels, 1952).

<u>Light minerals</u>: Almost all the samples from Milne Bay contain feldspar, mica, quartz, volcanic rock fragments, (in cluding glass) together with some authigenic glauconite. The proportion of light minerals varies for different samples, there being an increase in content inshore especially near river mouths.

Albite is the dominant feldspar while in some samples, notably in the southwestern margin of the bay, orthoclase is present. Quartz is only a very minor constituent in the Milne Bay samples. Mica is found in the near shore samples.

The potash feldspar in the southwestern part of the bay is probably derived from the Gabahusuhusu syenite which crops out to the south of Milne Bay. (Davies et al., 1968).

Clay Minerals: Orientated slides of clays from eighteen samples were analysed by X-ray diffraction. Untreated slides, glycolated slides, and slides heated to 400°C of each sample were run. The dominant clay mineral in the samples is a chlorite-smectite mixed layer type. The chlorite in the samples has partially lost the brucite sheets and forms the greatest portion of the mixed layered mineral. Illite and kaolinite are present in sample 332, but were not detected in the other samples.

The clay minerals normally occurring in Recent marine sediments are illite, chlorite and smectite (Millot, 1949). The absence of kaolinite in the Milne Bay samples is thus to be expected, but the lack of illite in all but one sample is unusual. Almost every author who has studied clays in a marine environment reports the presence of illite and in most marine sediments illite appears to be the dominant clay mineral. In addition to illite of allogeric origin, the mineral is also believed to form from diagenesis of other clays, particularly smectite.

It has long been noted that smectite occurs mainly in nearshore sediments and is particularly common in sediments derived from basic volcanic areas (Grim, 1953; Correns, 1937). The region surrounding Milne Bay is largely composed of basic volcanic rocks (Davies et al., 1968). These basic volcanic rocks weather produce mainly smectite and chlorite (Grim 1953) and it is these two clay minerals which are transported to Milne Bay. It would seem firstly that illite is not present in the source areas, and secondly that sedimentation is too rapid to permit diagenetic alteration of other clays to illite.

Chemistry.

A direct reading optical emission spectrograph was employed to determine the concentration of elements manganese, nickel, scandium, strontium, titanium, vanadium, yttrium, zirconium, barium, calcium, cobalt, chromium, copper, iron, and magnesium in the Milne Bay samples. The results are shown in Appendix 3. The elements Mg, Fe, Ti, are high in the samples in the western part of the bay where terrigenous material is deposited. The values are much higher than those quoted by Leith & Mead (1915), Clark (1924), and Poldevaart (1955) for "average sediment", and this is clearly a result of the source rocks being of basic composition.

In the eastern part of the bay the average value of Ti and Fe is very much lower than average sediment but higher than Clarke's average limestone. Magnesium is only slightly higher than the average sediment but much lower than the average limestone. It is notable that the values for Fe are higher in the western part and lower in the eastern part of the bay than the average of Leith & Mead (1915) and Poldervaart (1955), but the overall average in the bay is close to their average.

The elements Mn, Ni, Sc, V, Y, Zr, Cr, Co, Ba, and Cu, also reflect the same type of distribution as that of Fe, Ti, and Mg. Thus the influence of terrestrial material is seen to be most marked in the western half of the bay. The values of Cu, Cr, Co, Ni, V, Zr, and up to a point Sc suggest a basic source rock for these sediments.

Calcium and strontium are most abundant in the eastern part of the bay, reflecting the decrease in terrigenous material and increasing influence of biogenic carbonates.

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APPENDIX 1

SUMMARY OF SAMPLE STATION DATA, SAMPLE COLOUR, CARBONATE CONTENT, OXIDISABLE MATERIAL CONTENT, AND GRAINSIZE STATISTICS

Sample Number	Date	Time	Latitude S	Longitude E	Colour*	Depth metres	Carbonate Percent	Oxidisable Material Percent	Graphic Mean	Incl.Gr. Standard Dev.	Incl. Gr. Skewness	Kurtosis	Sand Percent	Silt Percent	Clay Percent
302	19.1.68	0047 Z	10°24.5'	150°25.9'	5 GY 6/1	80	11	3.8	6.06	2.91	0.36	0.75	31	46	23
303	"	0113 Z	10°23.0'	150°25.7'	5 GY 6/1	250	9	7.2	5.17	2.91	0.72	0.99	60	24	16
304	"	0134 Z	10°21.5'	150°26'	5 Y 6/1	225	8	12.4	7.90	2.12	-0.25	0.88	15	47	38
305	"	0165 Z	10°20.2'	150°26.3'	5 GY 6/1	130	17	6.00	6.08	2.67	0.18	0.59	28	50	22
306	"	0245 Z	10°19.5'	150°26.5'	10 Y 4/2	180	11	7.4	8.32	2.74	0-0.16	1.36	6	51	43
307	"	0315 Z	10°21.9'	150°28.2'	5 GY 6/1	400	5	7.7	8.13	2.82	-0.13	0.58	1	57	42
308	"	0404 Z	10°23.8'	150°30.3'	-	450	13	-	-	-	-	-	-	-	-
309	"	-	10°26.7'	150°34.6'	5 Y 6/1	540	12	11	7.93	2.39	0.07	0.91	8	59	33
310	"	-	10°29.0'	150°39.4'	5 Y 4/1	60	54	1.8	3.60	2.35	-00.13	1.77	57	39	4
311	"	2300 Z	10°31.3'	150°52.7'	5 GY 6/1	340	88	3.1	5.63	2.24	0.51	0.80	21	69	10
312	"	2330 Z	10°29.6'	150°53.8'	5 Y 7/2	520	70	2.5	6.48	2.42	0.06	0.90	17	67	16
313	20.1.68	0015 Z	10°26.5'	150°55.6'	5 GY 6/1	420	-	-	5.57	1.45	0.44	1.40	5	91	4
314	"	0102 Z	10°23.3'	150°56.6	5 Y 7/2	310	72	0.3	5.20	2.35	0.56	0.68	44	45	11
315	"	0137 Z	10°21.7'	150°56.8'	5 Y 7/2	270	80	2.1	6.47	2.42	0.38	1.10	13	70	17
316	"	0227 Z	10°27.7'	151°0.4'	5 GY 6/1	430	86	2.0	3.15	1.50	-0.31	1.50	71	27	2
317	"	0310 Z	10°30.9'	151°3.0'	5 GY 6/1	320	84	3.3	4.97	1.46	0.55	1.60	15	79	6
318	"	0410 Z	10°32.2'	151°3.5'	5 Y 6/1	200	97	-	-	-	-	-	-	-	-
319	"	0455 Z	10°29.8'	151°4.3'	5 Y 7/2	400	92	2.1	-	-	-	-	-	-	-
320	"	0532 Z	10°26.6'	151°4.7'	5 GY 6/1	320	83	2.1	5.32	2.74	0.50	0.93	45	41	14
321	"	0605 Z	10°25.3'	151°5.0'	5 GY 6/1	100	92	0.8	2.47	1.10	0.29	1.08	89	10	1
322	"	1100 Z	10°17.9'	151°1.2'	5 Y 6/1	30	84	0.8	3.56	1.42	0.14	0.84	71	26	3
323	"	2222 Z	10°20.5'	151°5.0'	-	50	-	-	-	-	-	-	-	-	-
324	"	2301 Z	10°24.5'	151°5.0'	5 GY 6/1	160	88	1.8	3.26	1.17	-0.06	1.10	92	8.3	2.1
325	21.1.68	0150 Z	10°26.5'	151°52.5'	5 Y 6/1	520	50	-	5.28	2.32	0.12	0.89	29	62	9
326	"	0404 Z	10°18.5'	151°47'	5 GY 6/1	40	98	1.4	-	-	-	-	-	-	-
327	"	0435 Z	10°21.5'	151°48'	5 GY 6/1	530	54	5.7	7.10	2.83	0.01	0.86	16	57	27
328	"	0460 Z	10°23.5'	151°47'	5 Y 7/2	540	44	12.7	-	-	-	-	-	-	-
329	"	0614 Z	10°25.5'	151°46.5'	5 Y 7/2	530	50	5.7	-	-	-	-	-	-	-
330	"	-	10°25.5'	151°46.5'	5 Y 7/2	530	50	5.7	-	-	-	-	-	-	-
331	"	-	10°25'	151°39.5'	5 Y 6/1	100	32	3.1	5.98	2.45	0.06	0.89	28	61	11
332	"	-	10°24.5'	151°36'	5 GY 6/1	550	30	7.2	6.80	2.91	0.73	0.74	1	75	24
333	"	0425 Z	10°25.5'	151°35.5'	5 GY 6/1	550	24	6.9	7.63	2.22	-0.05	0.76	3	61	36
334	"	2130 Z	10°27.4'	151°45.4'	5 GY 6/1	530	48	8.0	7.67	1.99	0.21	0.68	-	-	-

* Symbols refer to Rock Color Chart, <u>Geol. Soc. Am.</u>, 1959 . Comparison with the chart was made after the samples had been washed and dried.

APPENDIX 2

X-RAY DIFFRACTION RESULTS

The analyses were carried out using a Philips P.W. 1051 X-Ray Diffractometer, with the operating conditions as follows.

kV 40	mA 24	Geigner Tube Cu.K. alpha
R.M. 2 & 4	Mult 1.	T.C. 4
Chartspeed 1° - 20/min.		Disc. Ch. 12
Slits $\frac{1}{4}^{\circ}$ & 1°	Div.$\frac{1}{4}^{\circ}$ & 1°	rec-filter Ni

Chart range 5° - 80°

The determinations were made by comparing the unknown patterns with standard A: S.T.M. index patterns and standard mineral patterns.

The order of relative intensities of the minerals identified follows.

Sample Number	1	2	3	4	5	6(tr)
302	Albite	Chlorite	Quartz	Calcite	Muscovite	
303	Albite	Calcite	Quartz	Muscovite		
304	Calcite	Albite	Quartz			
305	Calcite	Albite	Quartz			Argonite
306	Calcite	Albite	Quartz			
307	Calcite	Albite	Quartz	Chlorite		
309	Calcite	Albite	Quartz	Aragonite		
310	Albite	Aragonite				Quartz
311	Aragonite	Calcite				Quartz Albite
312	Calcite	Aragonite	Quartz			Albite
313	Calcite	Aragonite	Albite			Quartz
314	Calcite	Aragonite				Quartz Albite
315	Calcite	Aragonite				Albite
316	Calcite	Aragonite				Albite
318	Calcite	Aragonite				Quartz Chlorite
319	Calcite	Aragonite				
320	Calcite	Aragonite				Quartz
321	Calcite	Aragonite				
322	Aragonite	Calcite	Quartz			Albite
324	Calcite	Aragonite				Albite
326	Aragonite	Calcite				
327	Calcite	Aragonite		Quartz	Albite	
328	Calcite	Albite	Quartz	Aragonite		
329	Calcite	Aragonite	Quartz	Albite		
331	Calcite	Albite	Quartz	Aragonite		Muscovite
						Chlorite
332	Calcite	Albite	Quartz	Aragonite		Chlorite
333	Calcite	Quartz	Aragonite	Albite		

Analyst: G. Berryman, Bureau of Mineral Resources

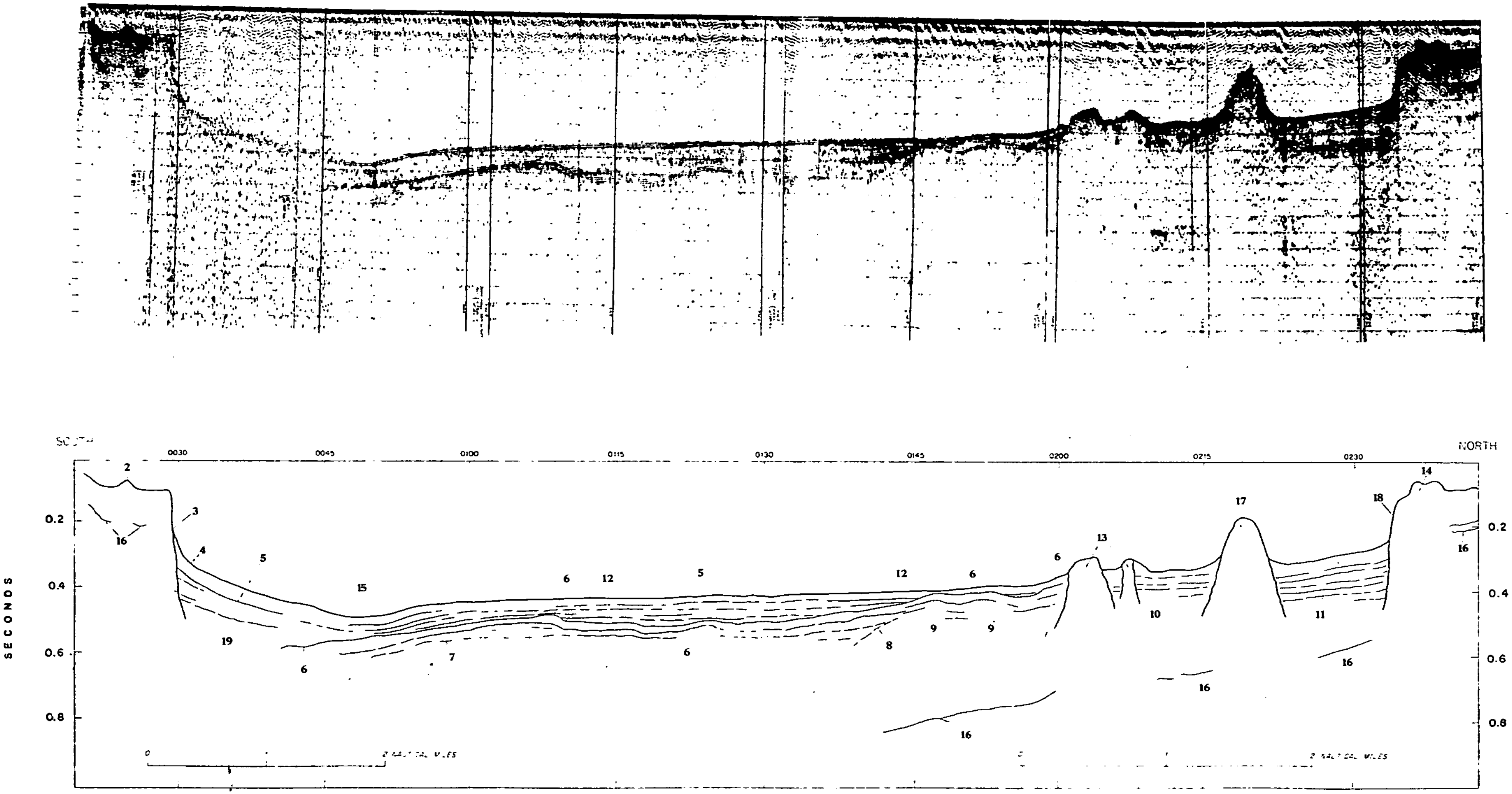
APPENDIX 3

DIRECT READING OPTICAL EMISSION SPECTROGRAPH RESULTS

Sample Number	% Mn	ppm Ni	ppm Sc	ppm Sr	% Ti	ppm V	ppm Y	ppm Zr	ppm Ba	% Ca	ppm Co	ppm Cr	ppm Cu	% Fe	% Mg
302	0.08	235	36	300	0.56	130	43	140	225	4.5	45	320	88	6.8	2.3
303	0.11	140	40	180	0.58	150	48	180	120	4.0	50	200	110	8.2	2.1
304	0.10	200	54	290	0.60	170	100	220	110	5.8	100	230	115	9.7	2.0
305	0.10	100	44	320	0.55	180	250	160	60	7.6	55	155	95	7.0	2.5
306	0.12	90	40	190	0.54	220	31	200	[illegible]	4.1	40	170	100	8.2	2.2
307	0.12	145	56	280	0.60	215	44	280	120	5.6	80	190	95	7.3	2.1
309	0.33	120	37	400	0.44	160	60	260	100	6.8	50	180	80	5.9	2.0
310	0.05	33	37	1150	0.42	96	50	130	160	>10	28	170	24	3.3	2.5
311	0.03	19	17	1300	0.14	46	31	-100	<40	>10	15	56	14	1.1	2.2
312	0.07	33	16	1100	0.18	52	22	-100	<40	>10	12	62	21	1.6	1.9
313	0.07	33	19	1250	0.19	54	30	-100	80	>10	17	77	60	2.1	2.1
314	0.05	34	20	1300	0.19	52	33	-100	100	>10	13	64	26	1.7	1.9
315	0.05	31	18	1200	0.17	52	31	-100	52	>10	16	62	16	1.5	1.7
316	0.05	30	17	1200	0.13	48	37	-100	150	>10	18	60	21	1.4	1.3
318	0.05	23	20	1650	0.07	42	48	-100	<40	>10	20	50	34	1.0	2.0
319	0.04	29	20	1500	0.12	46	43	-100	140	>10	25	54	30	1.0	2.1
320	0.03	34	21	1400	0.13	51	34	-100	110	>10	27	50	16	0.8	1.9
321	0.05	26	18	1220	0.08	39	34	-100	<40	>10	19	55	15	1.7	1.7
322	0.03	25	21	1500	0.13	54	35	-100	<40	>10	13	100	12	1.0	2.3
324	0.05	27	20	1200	0.08	42	43	-100	100	>10	25	60	14	2.4	2.2
326	0.02	10	15	1500	0.05	29	25	-100	<40	>10	11	35	8	0.3	2.3
327	0.27	70	23	900	0.37	120	25	100	120	>10	32	130	50	4.3	2.2
328	0.25	110	39	640	0.43	160	84	210	180	9.0	58	165	90	7.1	2.2
329	0.12	56	23	800	0.32	85	28	100	120	>10	25	97	37	3.7	2.1
331	0.14	64	16	600	0.30	78	33	280	210	>10	16	86	40	3.5	1.9
332	0.20	100	35	540	0.46	160	40	130	110	9.0	43	150	75	5.8	1.9
333	0.22	120	41	520	0.43	160	120	220	240	9.0	57	170	78	3.0	1.8

Analyst: S.E. Smith, Bureau of Mineral Resources.


PLATE 1
MILNE BAY
BATHYMETRY
CONTOURS IN METRES
0 1 2 3 4 5 MILES
To accompany Record 1970/10
C56/A9/13
MILNE BAY
BENTLEY BAY
EAST CAPE
NUAKATA I
CHINA STRAIT
FORTESCUE STRAIT
SIDEIA I
SARIBA I
DAWA DAWA RIVER
HAUMO RIVER
WEHURIA CREEK
Netuli I
Mahabarima I
Hana Wani I
Iabama I
Lelei-gana I
Boirama I
Daiwari I
Huli I
Blakeney I
Bright I
Slade I
Samarai I
Gorahi I
W. Iguari I
E. Iguari I
Ito I
Dinan I
Sopani I
150°20'
150°25'
150°30'
150°35'
150°40'
150°45'
150°50'
150°55'
151°00'
151°05'
151°10'
10°15'
10°20'
10°25'
10°30'
10°35'



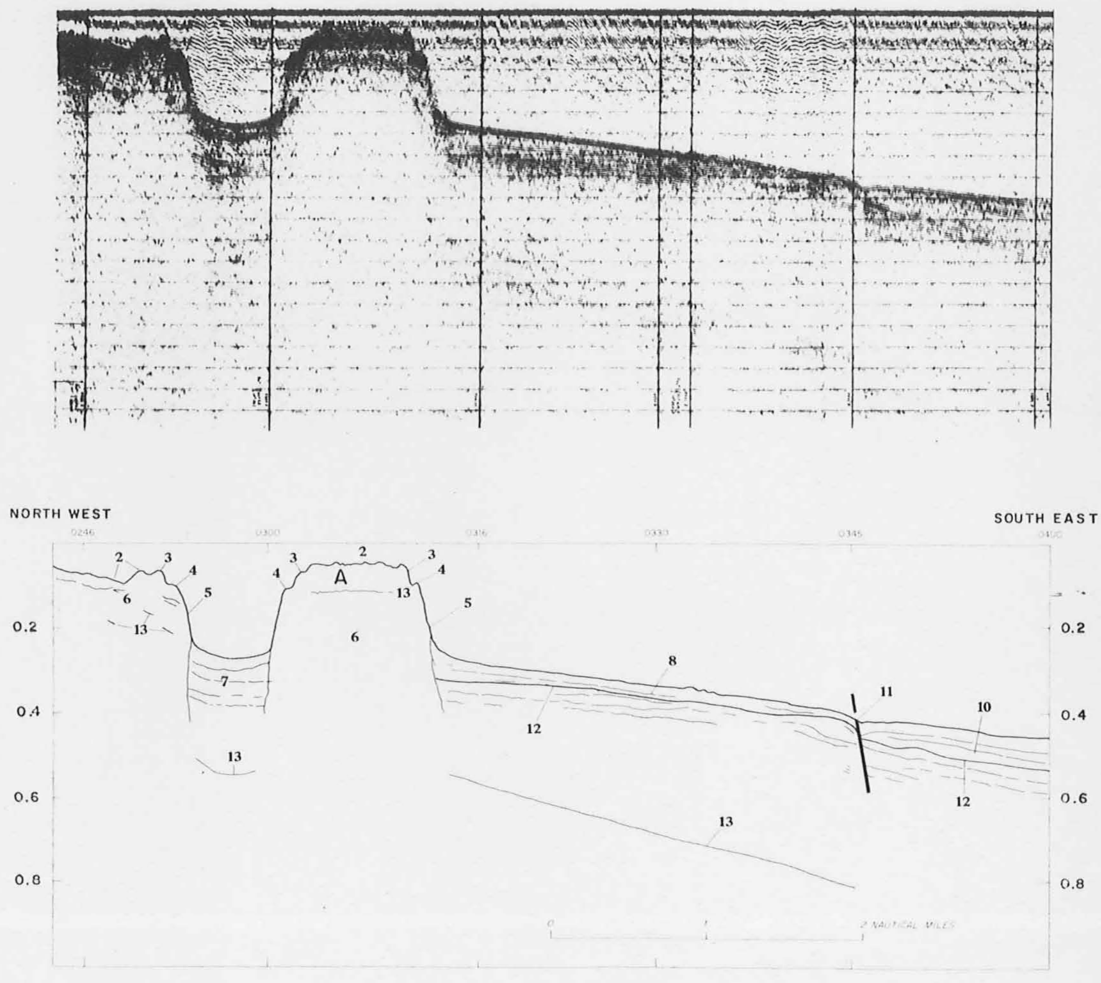
TRAVERSE 1

PLATE 2

To accompany Record 1970/10

C56/A9/18

PLATE 3

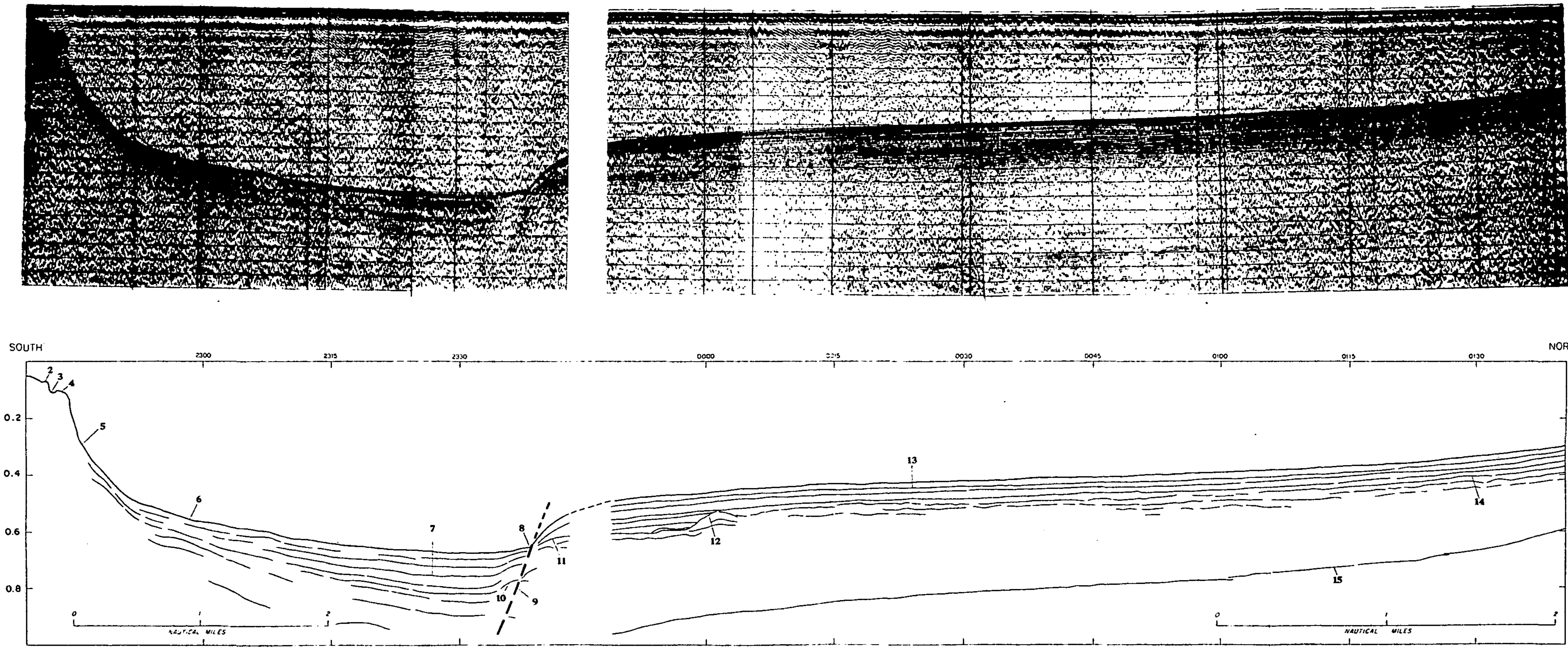


TRAVERSE 2

To accompany Record 1970/10

C56/A9/19

PLATE 4

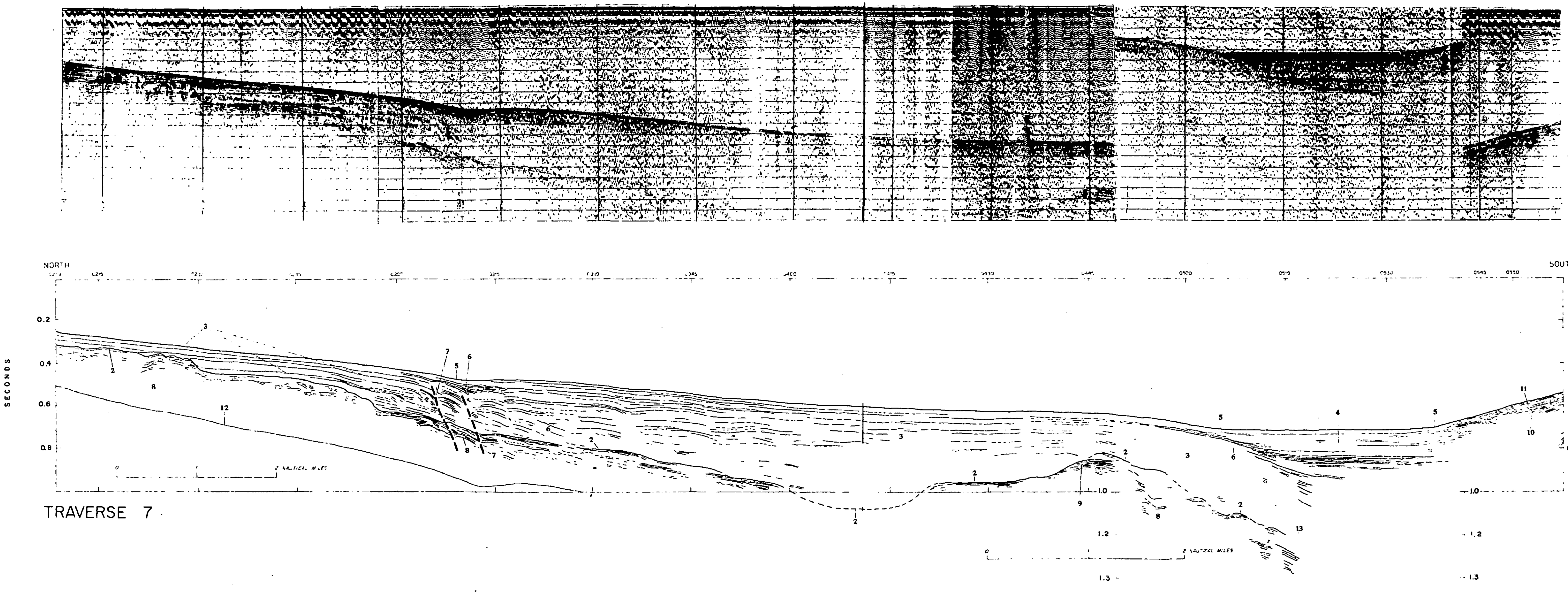


TRAVERSE 6

To accompany Record 1970/10

C56/A9/14

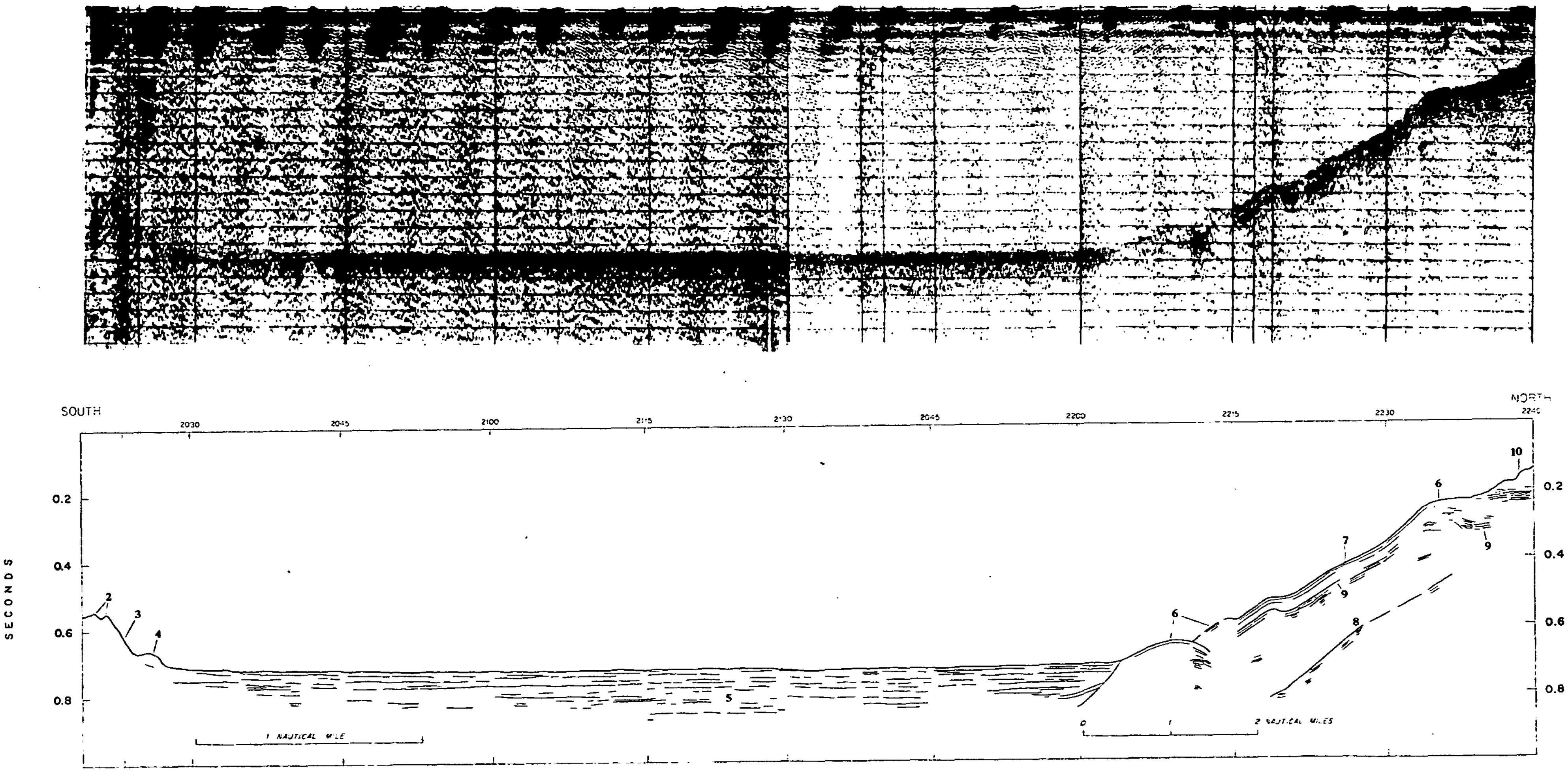
PLATE 5



TRAVERSE 7

To accompany Record 1970/10

C56/A9/15



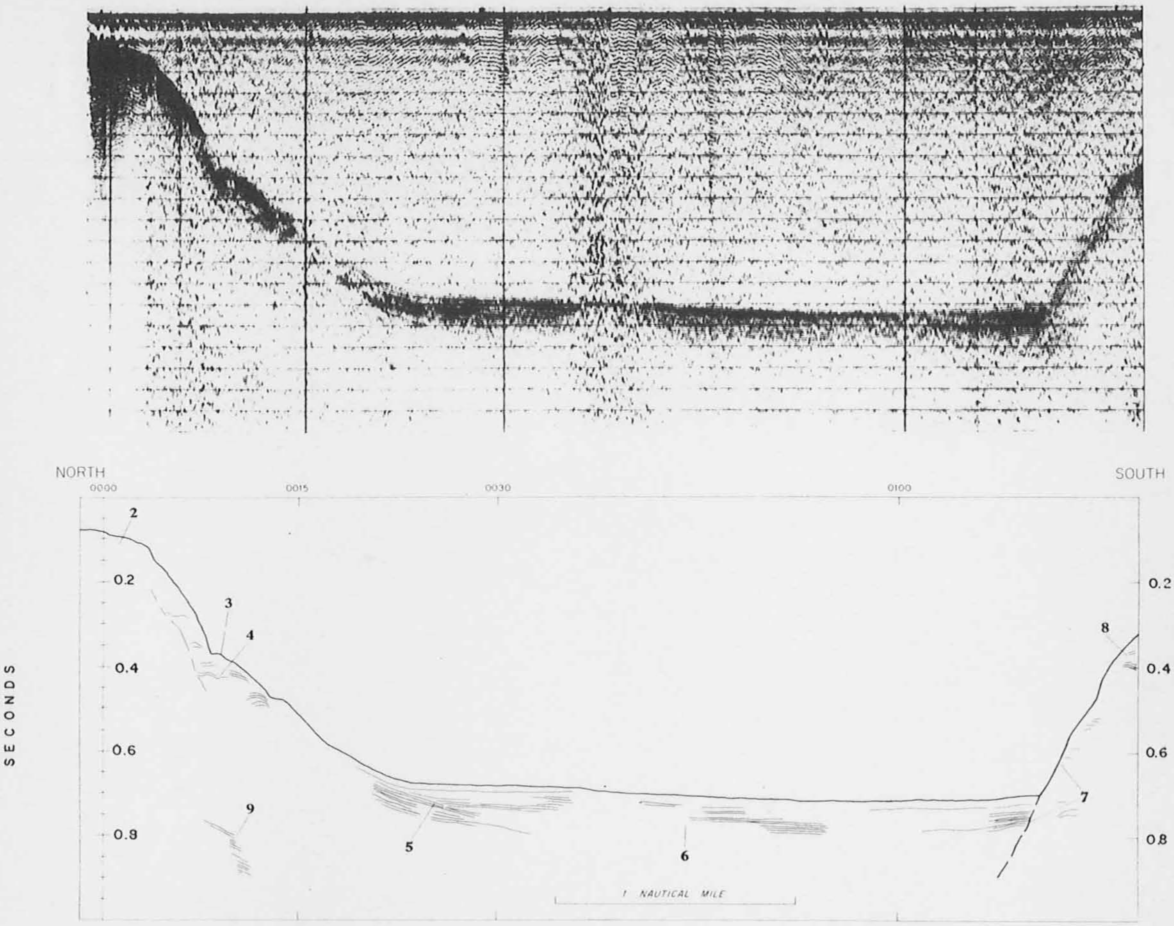
TRAVERSE 3

PLATE 6

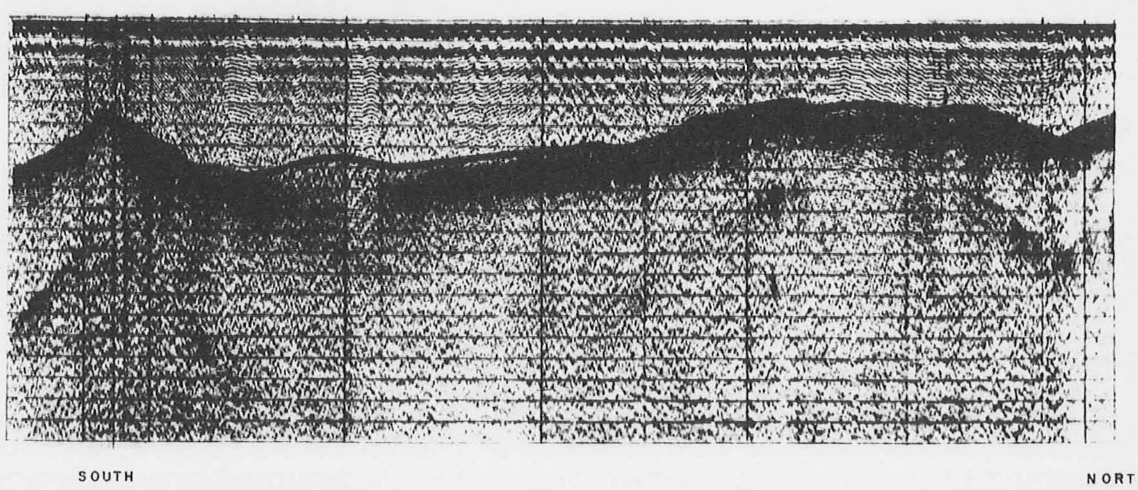
To accompany Record 1970/10

C56/A9/20

PLATE 7



TRAVERSE 4



TRAVERSE 5

To accompany Record 1970/10

C56/A9/16