THE SEAFLOOR ENVIRONMENT OFF SIMON'S TOWN IN FALSE BAY, REVEALED BY SIDE-SCAN SONAR, BOTTOM SAMPLIMG, DIVER OBSERVATIONS AND UNDERWATER PHOTOGRAPHY.

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ABSTRACT

A 12 km^2 area off Simon's Town in False Bay, South Africa, was surveyed by side-scan sonar and echosounder. The sonograph data were correlated with sediment samples and information from in-situ diver-inspections.

Six patterns of reflectivity (sonograph facies) were recognised in this study: Facies 1 - Lineaments within an irregular blocky pattern of light and dark tones define outcrops of Cape Peninsula Granite. Facies 2 - Alternating bands of light and dark tones, orientated WSW-ENE and spaced about a metre apart, characterise stationary, long-crested, trochoidal wave-ripples. These occur in a calcareous gravelly sediment at depths ranging from 20m to 35m. They probably develop during southeasterly gales in summer. Facies 3 - An uneven featureless medium-grey tone defines a patchy veneer of calcareous gravel and sand overlying a quartzose, fine to medium sand. Facies 4- "Cloud-like" and "tongue-like" patches of light tone represent windows of underlying rippled, quartzose, fine to medium sand that show through an overlying veneer of calcareous sand and gravel (Facies 3). Facies 5 - A slightly speckled, featureless, light-grey tone defines a blanket of rippled, quartzose, fine to medium sand in the deeper eastern part of the study area. Facies 6 - Patches of medium-grey tone within Facies 5 possibly indicate outcropping weathered granite (saprolite) or calcareous sediment.

The epifaunal assemblage indicates that the present-day subtidal environment in the study area is calm except during prolonged southeasterly gales in summer, when high-energy conditions prevail. Analysis of the sediment samples shows that the calcareous and quartzose sediments mix according to the Folk and Ward (1957) sediment-mixing model. The quartzose sand is probably derived from Late Pleistocene regressive dunes that were reworked during the Flandrian transgression, whereas the modern calcareous sediment is derived in-situ from carbonate-secreting organisms living either attached to granite outcrops or unattached on the seafloor surface.

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1. INTRODUCTION

1.1 Scope of thesis

This thesis reports on the surficial geology of a small area off Simon's Town which was mapped by means of side-scan-sonar and echosounding. Sediment samples and information from diver-inspections were used to aid the interpretation of the side-scan-sonar imagery (sonographs).

1.2 Study motivation

The Institute for Maritime Technology (IMT) wanted an area off Simon's Town to be mapped for an engineering project. This prompted them to undertake a high-resolution side-scan-sonar and bathymetric survey of the area in collaboration with Underwater Surveys (Pty.) Ltd. (Underwater Surveys (Pty.) Ltd., 1985). The writer was given the opportunity to use the side-scan-sonar and bathymetric data as the basis for this study.

1.3 Study area

The study area lies in False Bay, which is a large and square-shaped bay (almost 1000 square kilometres in area) at the southwestern tip of Africa (Fig. 1.1). The bay is the southward extension of a broad sandy valley known as the "Cape Flats" situated between the mountainous Cape Peninsula to the west and the Hottentots-Holland Mountains to the east. It opens to the south between Cape Point in the west and Cape Hangklip in the east. The bottom has a slope of about 1:370 towards the south, reaching a depth of over 100m between Cape Point and Cape Hangklip (Fig. 1.2). Apart from rock pinnacles and reefs around Roman Rock, Seal Island, York Shoal, East Shoal, and Whittle

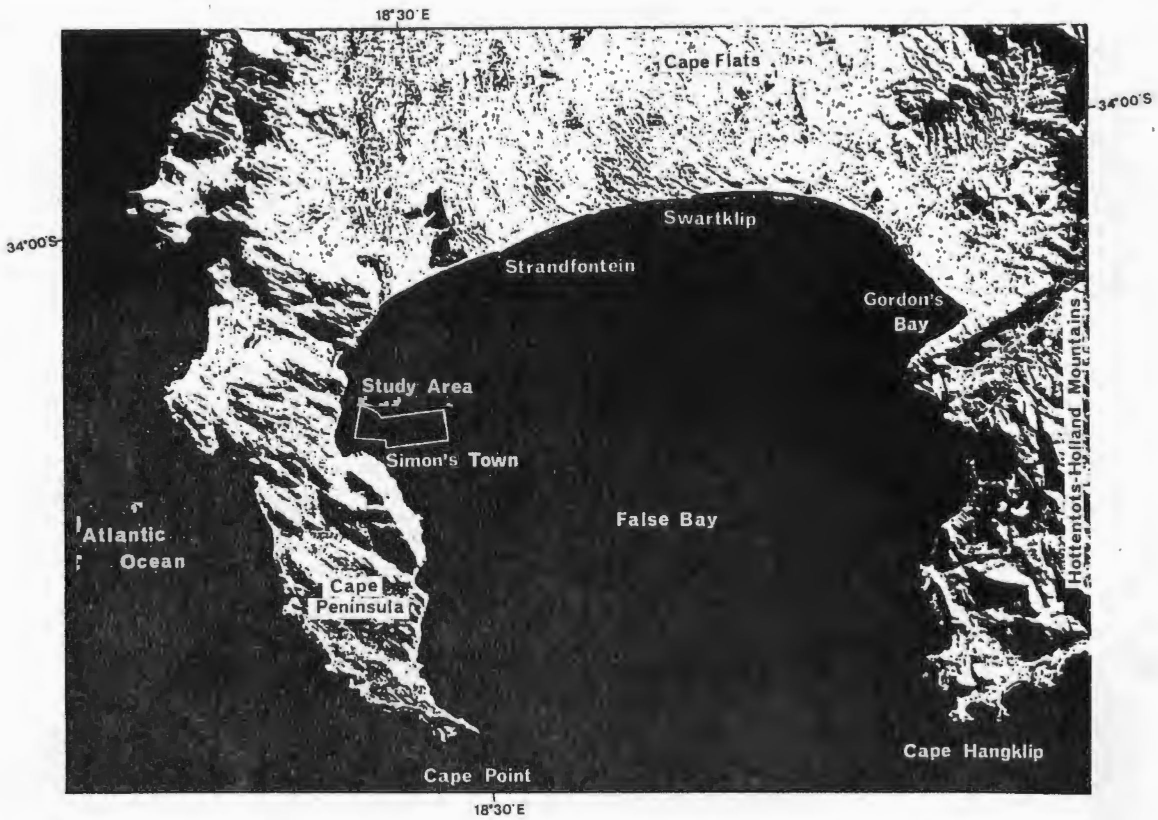
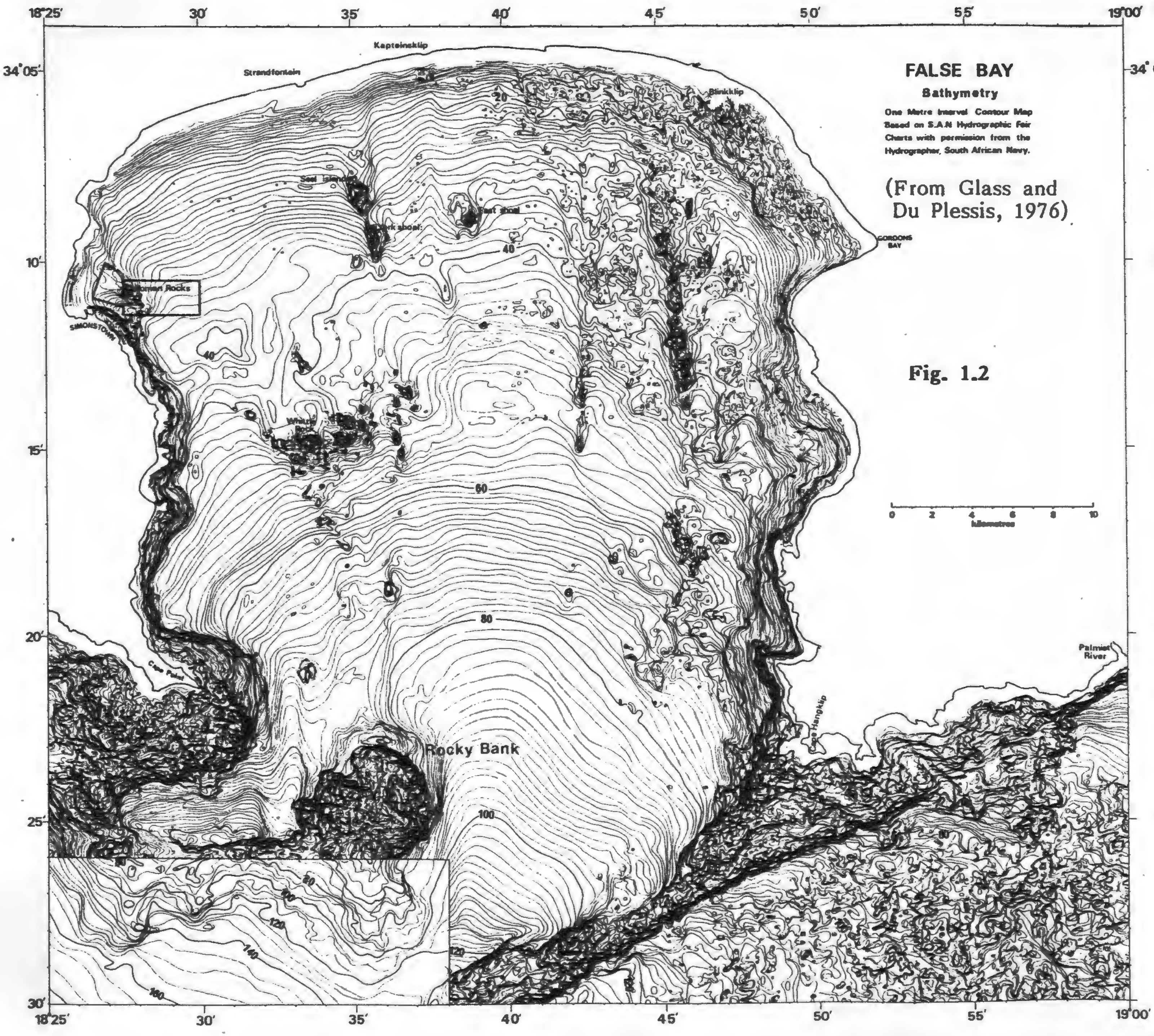


Fig. 1.1 LANDSAT Band-7 satellite image of False Bay showing the location of the study area. Note the rugged mountainous terrain along the western and eastern coasts of the bay. The bayhead is flanked by a low relief sandy area known as the "Cape Flats". Also note the relict Late Pleistocene NW-SE orientated longitudinal aeolian dunes between Strandfontein and Gordon's Bay.



(From Glass and Du Plessis, 1976)

Fig. 1.2

Rock, the seafloor in the western and southern part of the bay is relatively smooth, whereas the seafloor in the eastern part is highly irregular (Fig. 1.2) (Glass, 1976; Glass and Du Plessis, 1976).

The study area is located just beyond Simon's Town harbour, in the northwestern corner of False Bay, at the foot of the Swartberge (678m, Fig. 1.3). It lies in 20 to 40 metres water-depth, and has Roman Rock lighthouse in its centre (Fig. 1.2 and Plate 1.1). The study area covers an area of 12 square kilometres and has an unusual shape, best described as a circle-segment attached to a rectangle.

1.4 Aims

The aims of this study are: (a) to identify the different patterns of reflectivity (sonograph facies) that appear on the sonographs, (b) to correlate the sonograph facies with sediment samples, diver-observations and underwater photography, and (c) to use this information to advance the understanding of the seafloor environment within the study area.

1.5 Organisation of thesis

This thesis consists of six chapters. Chapter 2 reviews what is already known about the geology and physical oceanography of the study area. The methods used in this study are explained in Chapter 3. The writer's observations are presented in Chapter 4 and discussed in Chapter 5. Chapter 6 lists the conclusions drawn from this study. A list of references followed by appendices are found at the back of the thesis.

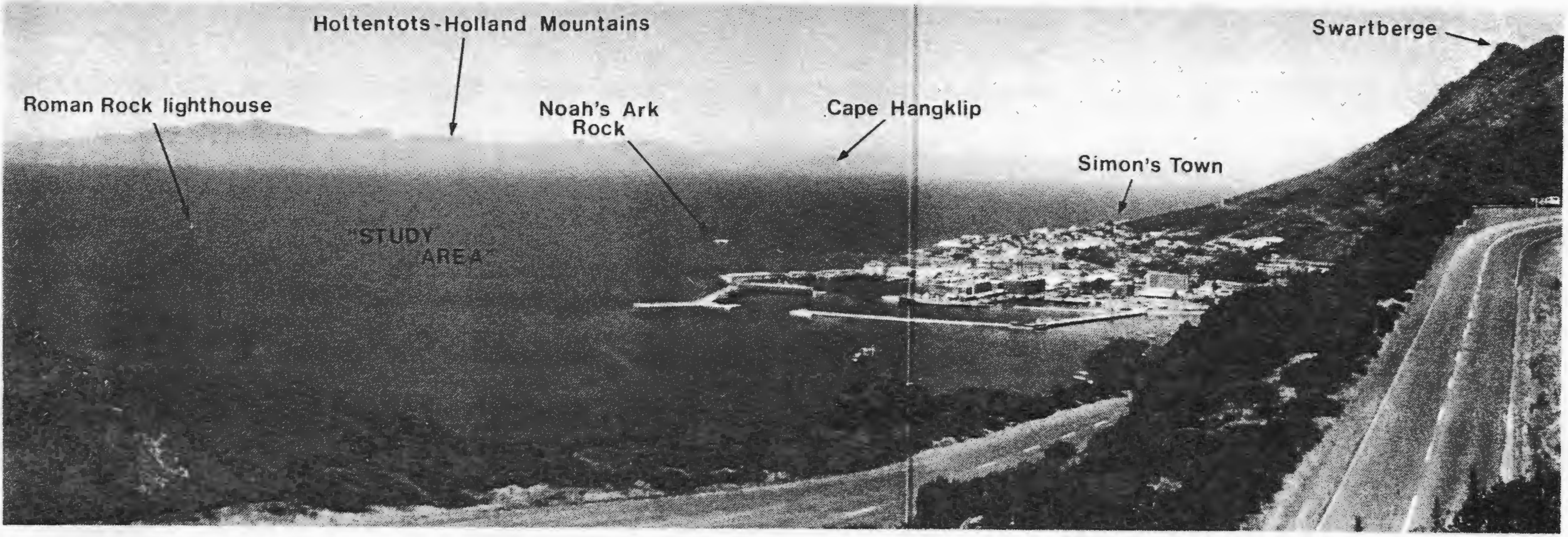


Plate 1.1 Panoramic view from Red Hill, looking southeast of Simon's Town, of the study area with Roman Rock lighthouse at its centre and the Hottentots Holland Mountains in the distance. The lower slopes of the Swartberge consist of Cape Peninsula Granite, whereas the upper slopes are formed of subhorizontally bedded Table Mountain Group sandstones. Note the granite islet of Noah's Ark Rock.

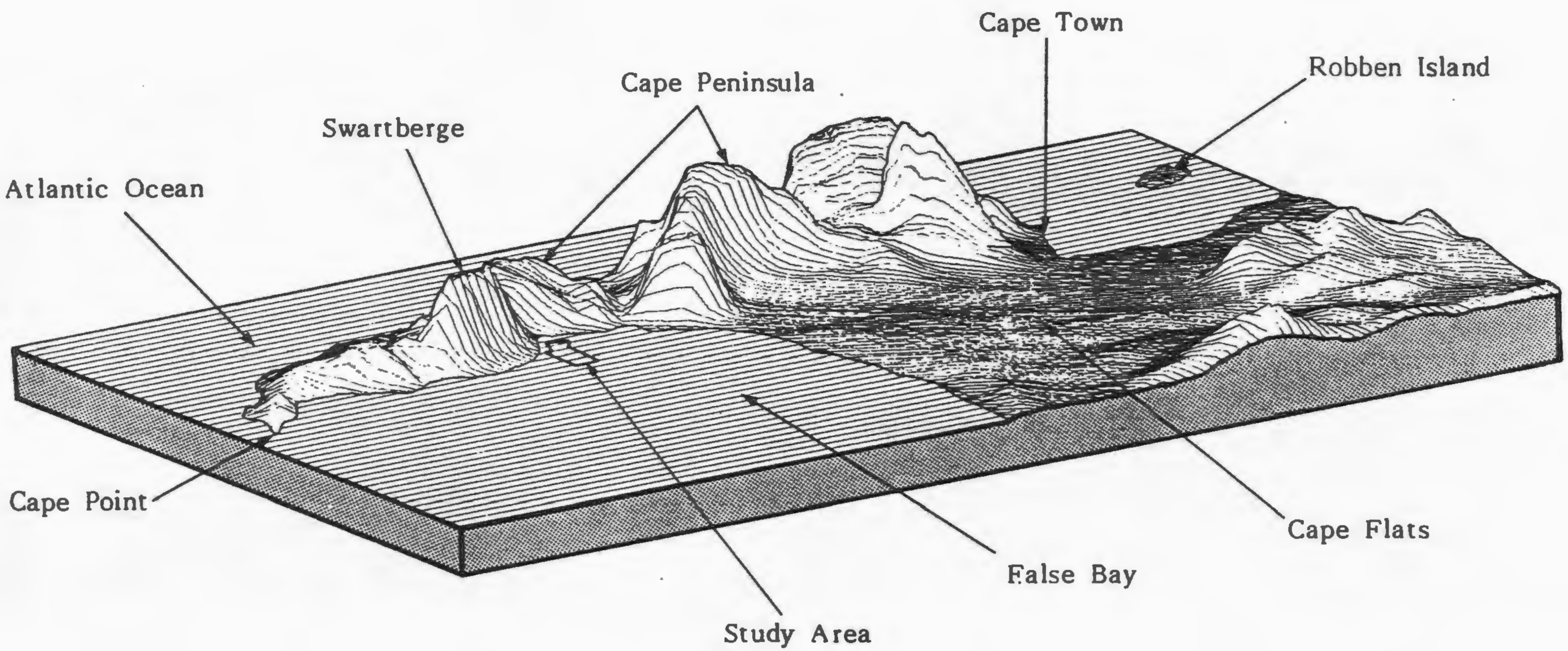


Fig. 1.3 Three-dimensional view showing the location of the study area (reproduced with the permission of Dr C.S. Keen).

2. LITERATURE REVIEW

2.1 Introduction

At the start of this project, the writer conducted an in-depth literature search on the principles and applications of side-scan-sonar (Terhorst, 1986), and on the marine geology and physical oceanography of False Bay. This short chapter reviews what is known about the marine geology and physical oceanography of the study area and its environs.

2.2 Geology

2.2.1 Previous research

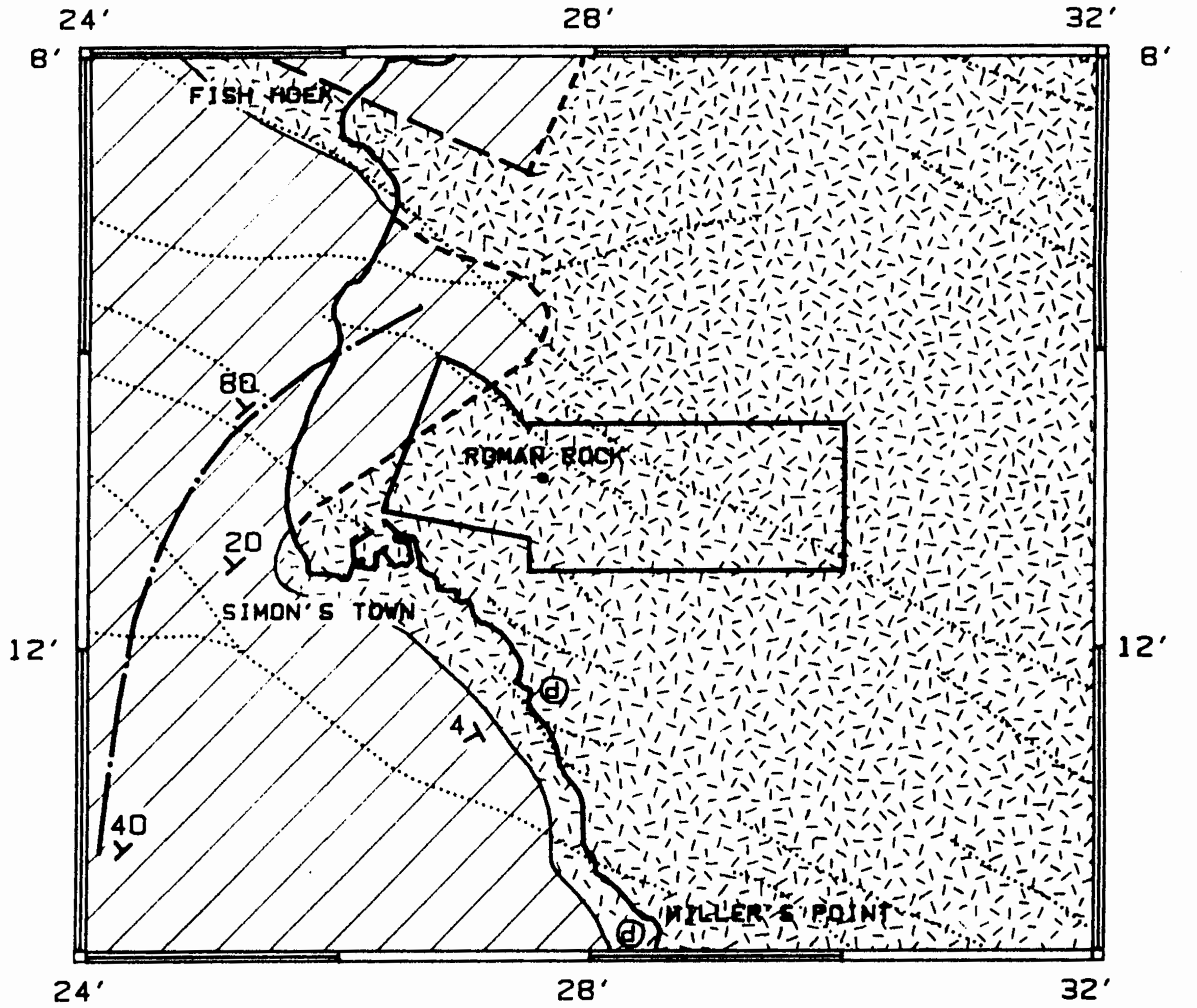
Table 2.1 lists all the previous geological research undertaken in False Bay. It shows that most of the previous research has been done on a scale covering the entire bay. The only studies dealing with specific areas within False Bay, were conducted in Gordon's Bay (Retief, 1970), on Rocky Bank (Flemming, 1976a), and off Strandfontein (Schoonees et al, 1983). The studies in Gordon's Bay and off Strandfontein dealt with sediment-transport patterns, whereas the study on Rocky Bank dealt with sealevel fluctuations. The writer is unaware of any other study in False Bay, where the geology of a small area has been studied in as much detail, as in this particular study.

2.2.2 Bedrock geology

The only geological map of False Bay was compiled by Gentle (1971). Figure 2.1, based on this map, shows that the study area is mostly underlain by the Late Precambrian Cape Peninsula Granite. An outlier of Ordovician Table Mountain Group sandstone underlies the NW corner of the

TABLE 2.1: Previous geological research in False Bay

Researcher(s)	Year	Nature of research
Murray and Renard	1891	Include a description of a single sediment sample collected off Simon's Town in their report on marine sediment samples collected during the 1873 to 1876 "Challenger" expedition.
Morgans	1956	Studied the relationship between sediment type and and benthic fauna in False Bay.
Fuller	1961 and 1962	Examined the textural properties of sediment samples collected from nearshore and beach environments around False Bay.
Bowie	1966	Undertook the first geological study of False Bay.
Bowie et al	1970	Describe the sediments in False Bay.
Mallory	1970	Outlines the bathymetry and microrelief of False Bay.
Retief	1970	Reports on sediment-transport patterns in Gordon's Bay.
Simpson et al	1970	Describe the results of a bathymetric and magnetic survey conducted to the west of the Cape Peninsula and in False Bay.
Gentle	1971	Maps the bedrock geology of False Bay from seismic and side-scan-sonar data.
Flemming	1976a	Describes Rocky Bank as a relict wave-cut terrace.
Glass	1976	Describes the 5m-contour-interval bathymetry of False Bay.
Glass and Du Plessis	1976	Describe the bathymetry of False Bay in relation to its geology.
Glass	1977	Discusses deep weathering in the Cape Peninsula Granite beneath the False Bay seafloor.
Glass	1980	Presents an overview of the geology of False Bay.
Russell-Cargill	1982	Undertook a side-scan-sonar survey off Simon's Town as an exercise to test equipment (No geological interpretation of the side-scan-sonar records was undertaken).
Flemming	1982	Reports on the geology of False Bay with particular emphasis on its modern sediments.
Schoonees et al	1983	Study sediment dynamics off Strandfontein.
Day	1986	Using magnetic data, mapped dolerite-dykes beneath the False Bay seafloor.



BEDROCK GEOLOGY
(From Browne 1963,
Gentle 1971 and Day 1986)

- Dolerite Dykes
- Table Mountain Group
- Cape Peninsula Granite
- Magnetic Anomaly
- Inferred Contact
- Fault
- Monocline Fold Axis
- Dip & Strike of Bedding

Fig. 2.1

Plate 2.1 Exposed granite at "Boulders Beach" just to the south of Simon's Town. Note the large, well-jointed granite boulders. The white base of the navigational beacon, seen a little to the left and above the middle of the photograph, is just under a metre high. Cape Hangklip can be seen on the horizon in the top left-hand corner.

study area.

The granite crops out as isolated rounded masses in the middle of the study area, around Roman Rock (Simpson et al, 1970; Glass and Du Plessis, 1976; Glass, 1980; Theron, 1984). Where the granite crops out along the coast to the south of Simon's Town, it is well jointed and appears very blocky (Plate 2.1). The principal joint-direction in the Cape Peninsula Granite is WNW-ENE (Boocock, 1952; Van der Merwe, 1963).

Plate 2.2 depicts a seismic profile across the study area. This is from a continuous-seismic-reflection survey carried out in False Bay by the Geological Survey of South Africa, and it shows that the granite beneath the study area is deeply weathered in places (Glass, 1977). The depth of weathering in the granite is probably greater where joints are closely spaced, and the granite crops out where joints are more widely spaced (Linton, 1955; Glass, 1977).

The Cape Peninsula Granite is overlain by the Table Mountain Group (TMG) sandstones. Although Figure 2.1 shows that the TMG underlies the northwestern corner of the study area (Gentle, 1971), there is no solid evidence to prove that it crops out. South of Simon's Town, the unconformity between the granite and TMG lies at 100m above sealevel. The erosion-resistant sandstones of the TMG have given rise to the mountainous terrain of the Cape Peninsula to the west of the study area (Fig. 1.3 and Plate 1.1) (Haughton, 1933; Browne, 1963; Theron, 1984).

The Cape Peninsula Granite and lower parts of the TMG have been intruded by a swarm of dolerite dykes (Haughton, 1933; Browne, 1963; Theron, 1984). Figure 2.1 shows the location of the dolerite dykes on the coast to the south of

Simon's Town, as well as a number of magnetic anomalies off Simon's Town. The predominantly NW-SE-orientated magnetic anomalies indicate where dolerite dykes have intruded the granite beneath the False Bay seafloor (Simpson et al, 1970; Day, 1986).

2.2.3 Unconsolidated sediments

The surficial sediments of False Bay have been studied by Morgans (1956), Fuller (1961, 1962), Bowie (1966), Bowie et al (1970), Retief (1970), Glass (1980), Schoonees et al (1983), and Flemming (1982). However, only Bowie (1966) and Glass (1980) mapped the regional surficial sediment distribution in the bay. Figure 2.2 shows that a number of samples were recovered off Simon's Town, but only four were within the study area (Flemming, 1982). Glass (1980) shows that off Simon's Town, the surficial sand fines seawards from coarse to fine sand (Fig. 2.3). He also shows that the sediments around the granite outcrops are very calcareous (Fig. 2.4). The various modes of sediment transport in False Bay were determined by Flemming (1982). He shows that the sediments are transported by bottom-traction in the western part of the study area, and by lower-bottom and upper-bottom suspension to the east (Fig. 2.5).

2.3 Physical oceanography

2.3.1 Wind-patterns

The weather-patterns at the SW tip of Africa are influenced by the interaction between the South Atlantic Anticyclone (SAA), situated in the subtropical high-pressure belt, and westerly (Rossby) waves in the circum-polar low-pressure belt. The position of the SAA fluctuates seasonally. It oscillates between a summer mean of 32°S and

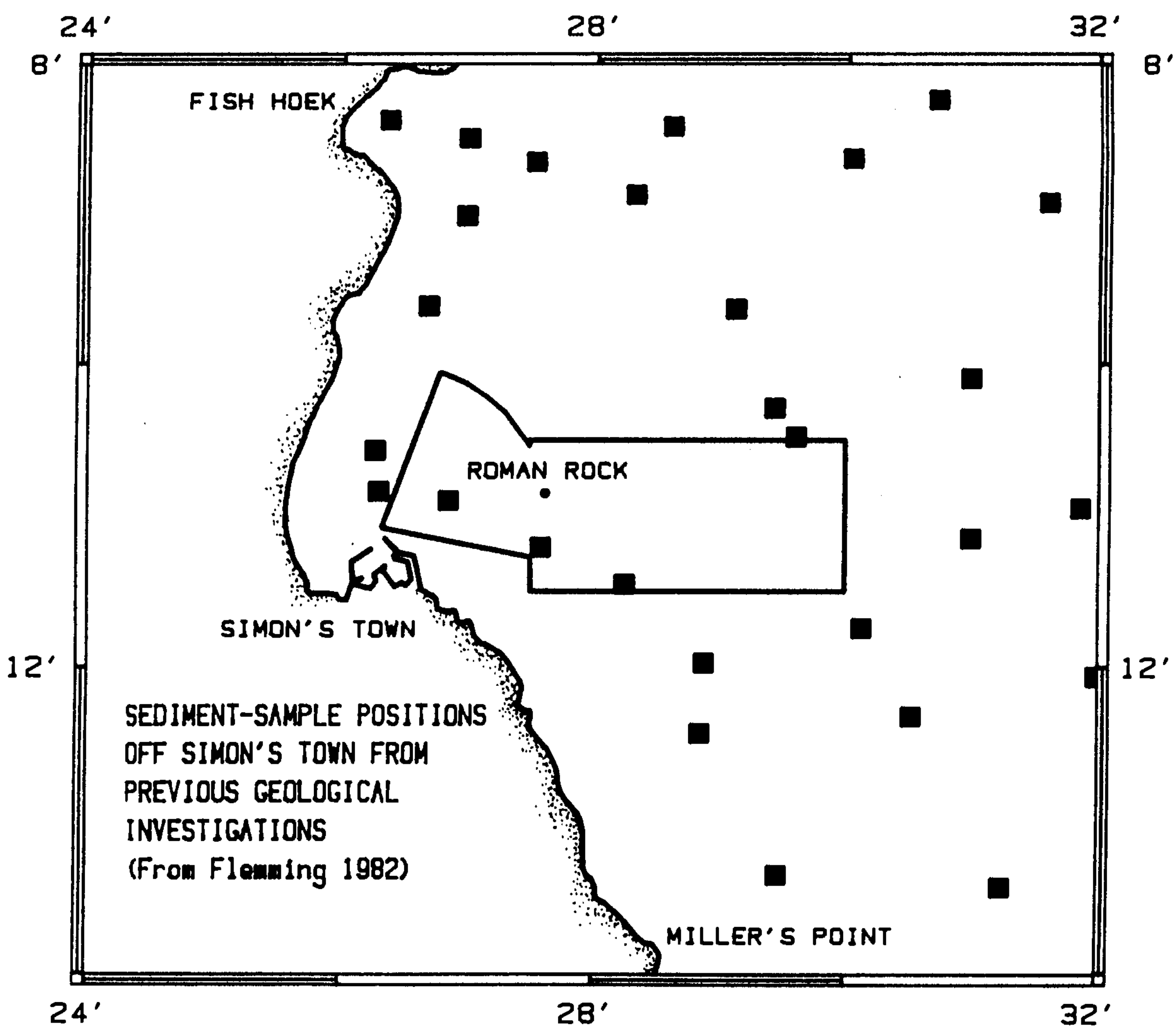
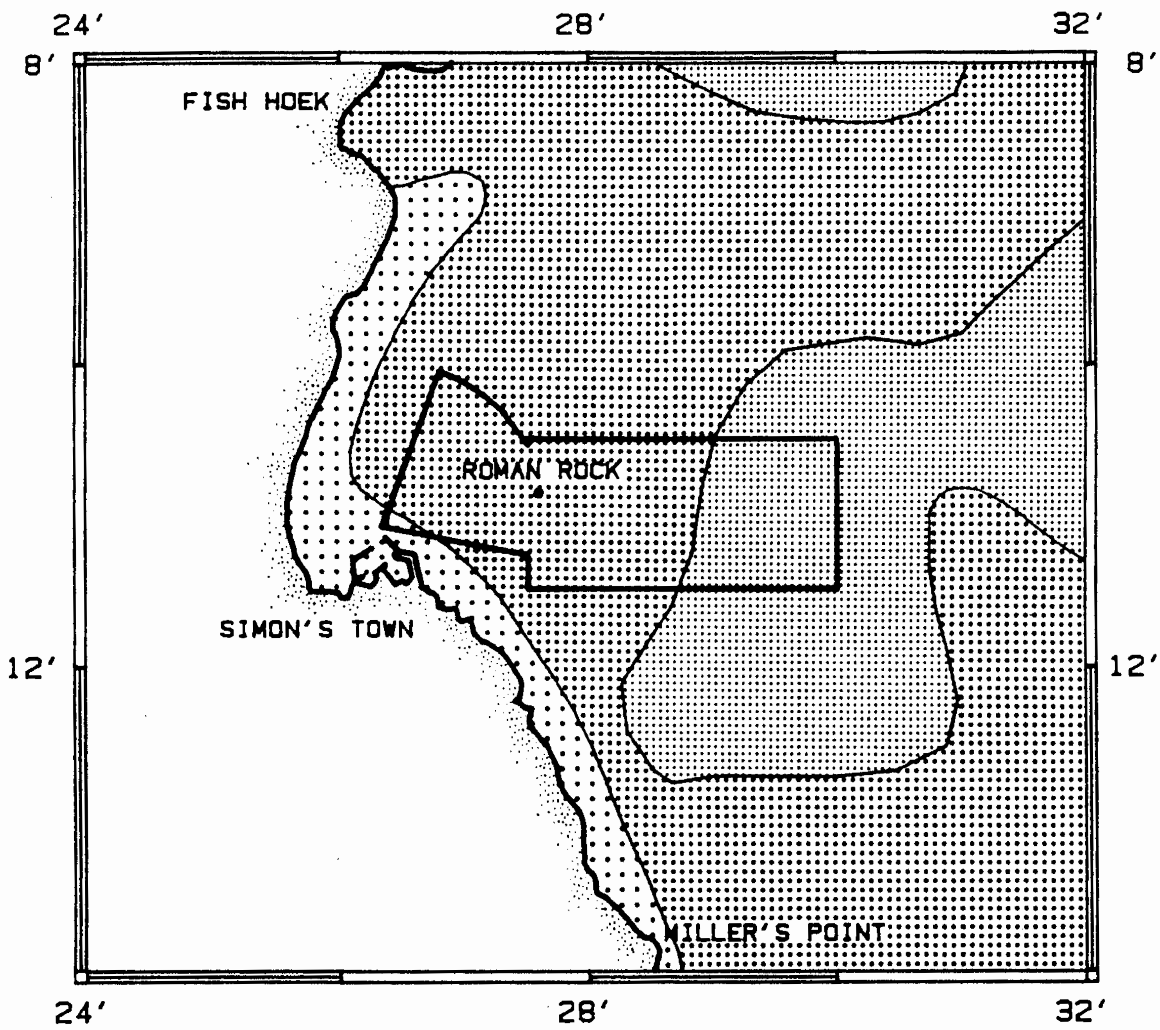

24′
28′
32′
8′
8′
FISH HOEK
ROMAN ROCK
SIMON'S TOWN
12′
12′
SEDIMENT-SAMPLE POSITIONS
OFF SIMON'S TOWN FROM
PREVIOUS GEOLOGICAL
INVESTIGATIONS
(From Flemming 1982)
MILLER'S POINT
24′
28′
32′

Fig. 2.2



MEAN SAND SIZE
(From Glass 1980)

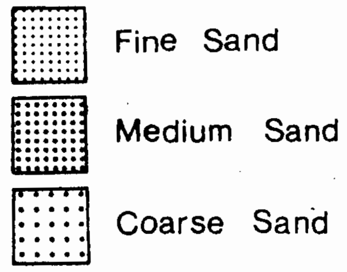
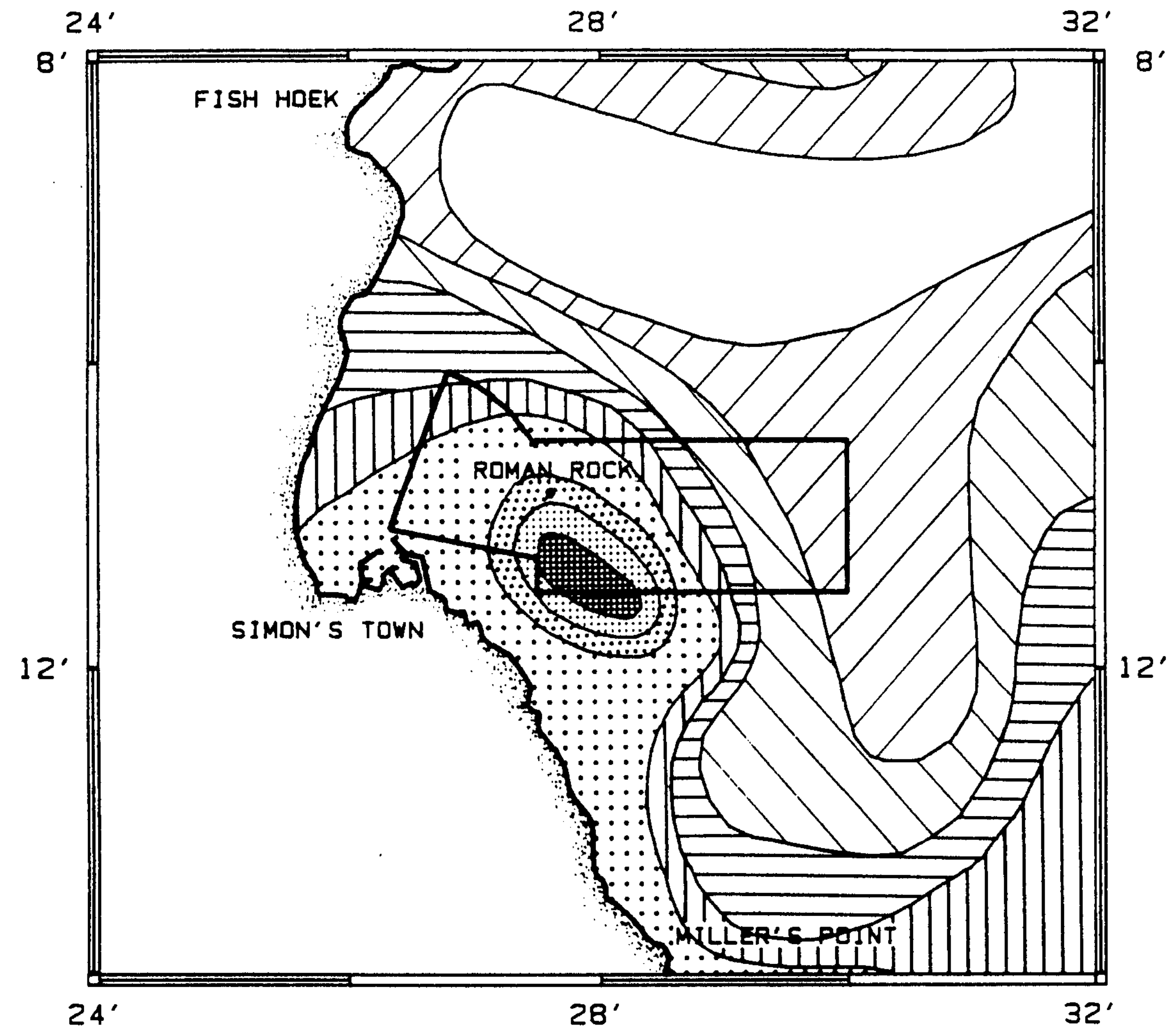


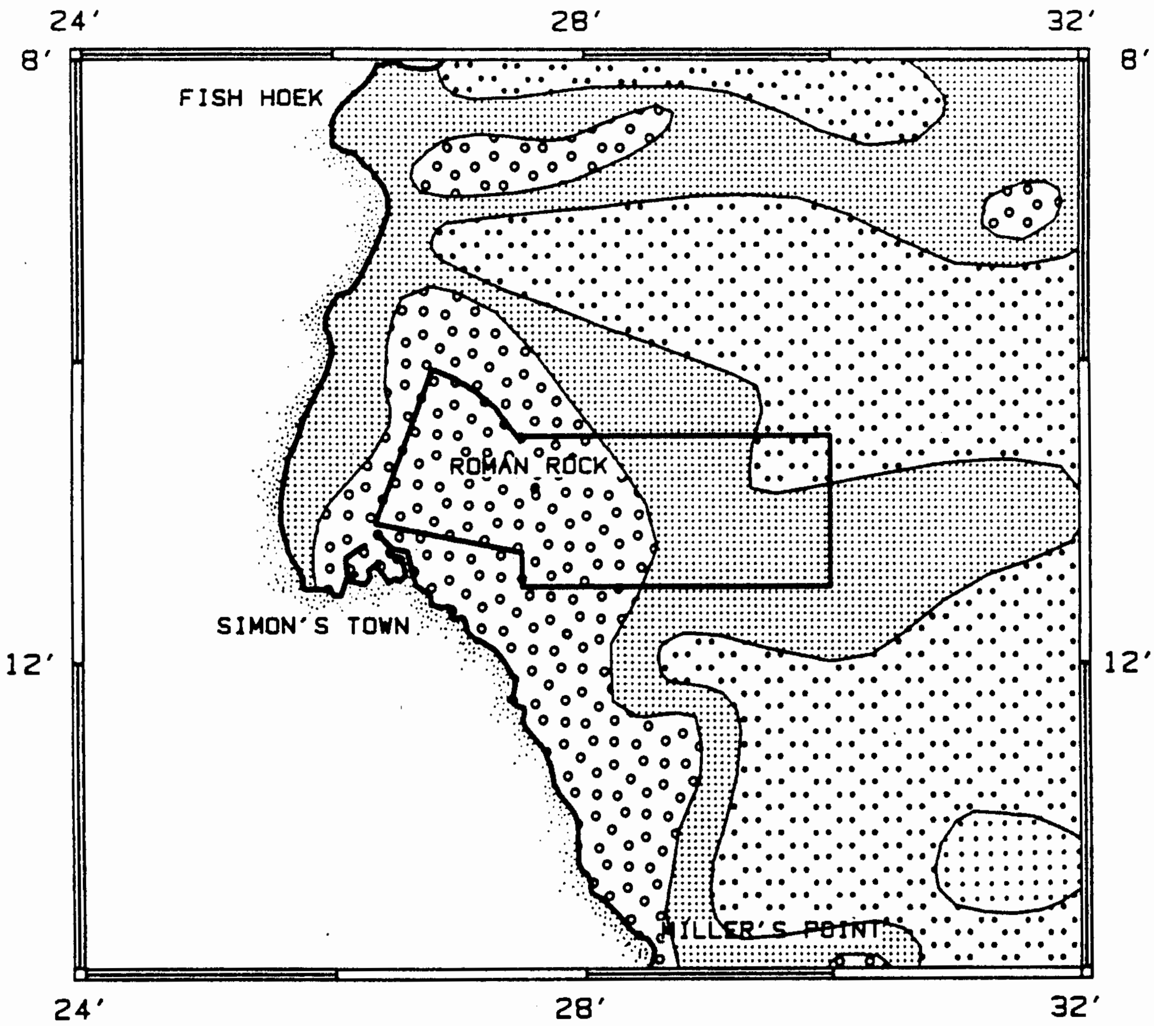
Fig. 2.3



%$CaCO_3$

(From Glass 1980)

Fig. 2.4



SEDIMENT TRANSPORT MODES

(From Flemming 1982)

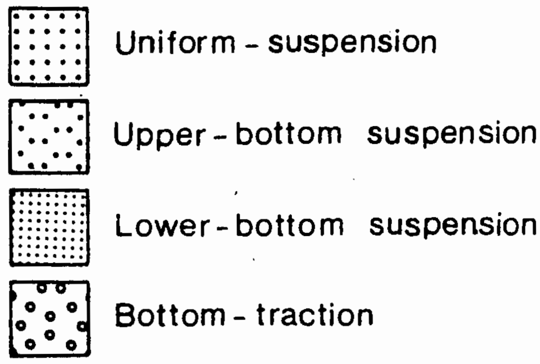


Fig. 2.5

a winter mean of 28°S (Schulze, 1965). False Bay, at about 34°S, is dominated by anticyclonic conditions in summer, and by cyclonic conditions in winter.

As a result, the physical oceanography of False Bay is dominated by a bidirectional wind-regime, with winds blowing seasonally from opposing quarters; from the SE in summer, and from the NW in winter (Atkins, 1970a and 1970b; Cram, 1970; Jury, 1980; Keen, 1980; Van Foreest, 1984; Van Foreest and Brundrit, 1985; Van Foreest and Jury, 1985).

The monthly distribution of wind-speed and wind-direction at Simon's Town for 1986 is shown in Figure 2.6. The winds were measured in Simon's Town harbour using a "Munro" anemometer (Potgieter, 1986). It shows that Simon's Town is dominated by SE winds from October to April, and by NW winds from May to July. August and September are characterised by winds blowing from both the SE and NW.

2.3.2 Wave-regime

Little is known about the wave-regime in False Bay. Wave parameters have been measured at only two locations in the bay, just beyond the surf-zone at Strandfontein (Schoonees et al, 1983), and in Gordon's Bay (Retief, 1970). These measurements are perhaps somewhat localised to be relevant to other parts of the bay (Fig. 1.1).

False Bay is exposed to swells from the southwest, south, and south-southeast (Darbyshire and Darbyshire, 1964; Shipley, 1964; Darbyshire and Pritchard, 1966; Bang, 1967; Rossouw, 1984). Figures 2.7 and 2.8 depict wave-refraction patterns for SW and SSE swells entering False Bay. These show that the study area is sheltered by the Cape Peninsula from the full onslaught of the southwest

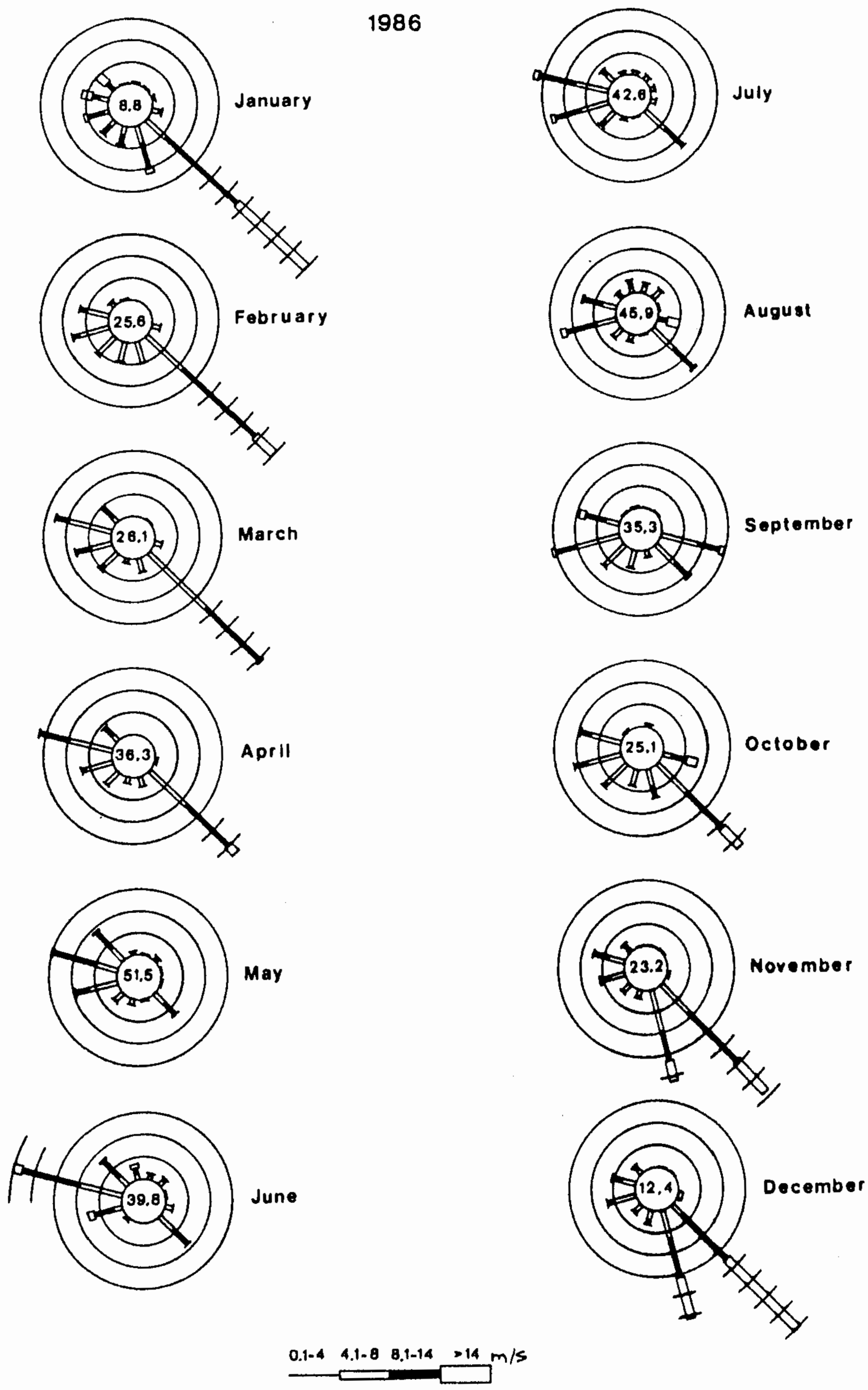


Fig. 2.6 Monthly frequency-distribution of wind speed and direction at Simon's Town for 1986. The circles represent five-percent intervals (Reproduced with the permission of Mr. E. Potgieter).

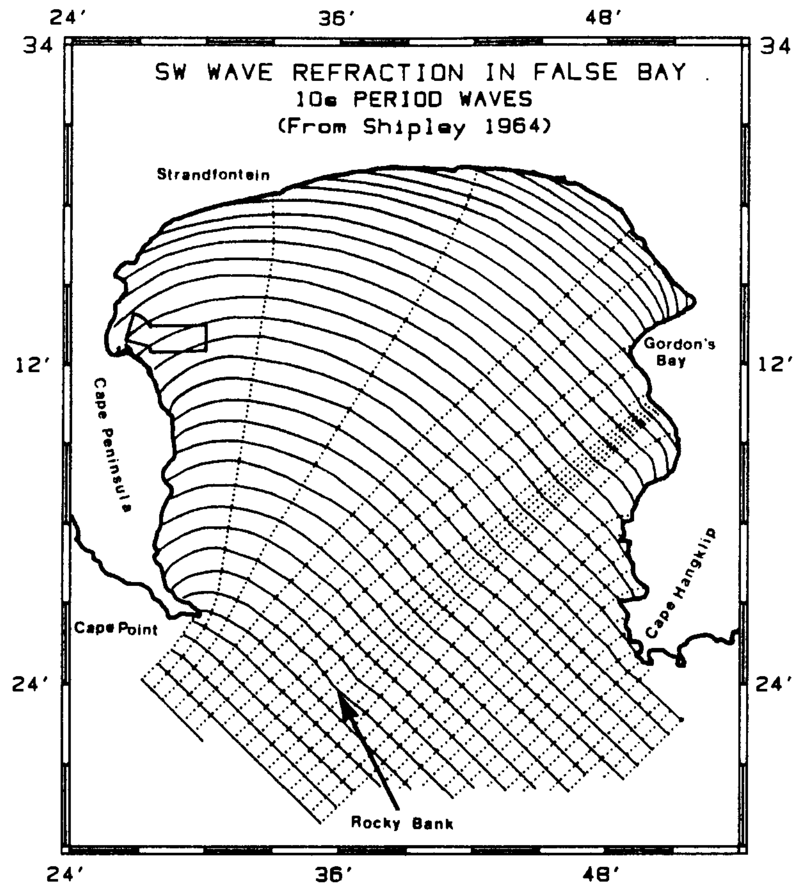

SW WAVE REFRACTION IN FALSE BAY .
10s PERIOD WAVES
(From Shipley 1964)
Strandfontein
Gordon's Bay
Cape Peninsula
Cape Hangklip
Cape Point
Rocky Bank
24'
36'
48'
34
12'
24'

Fig. 2.7

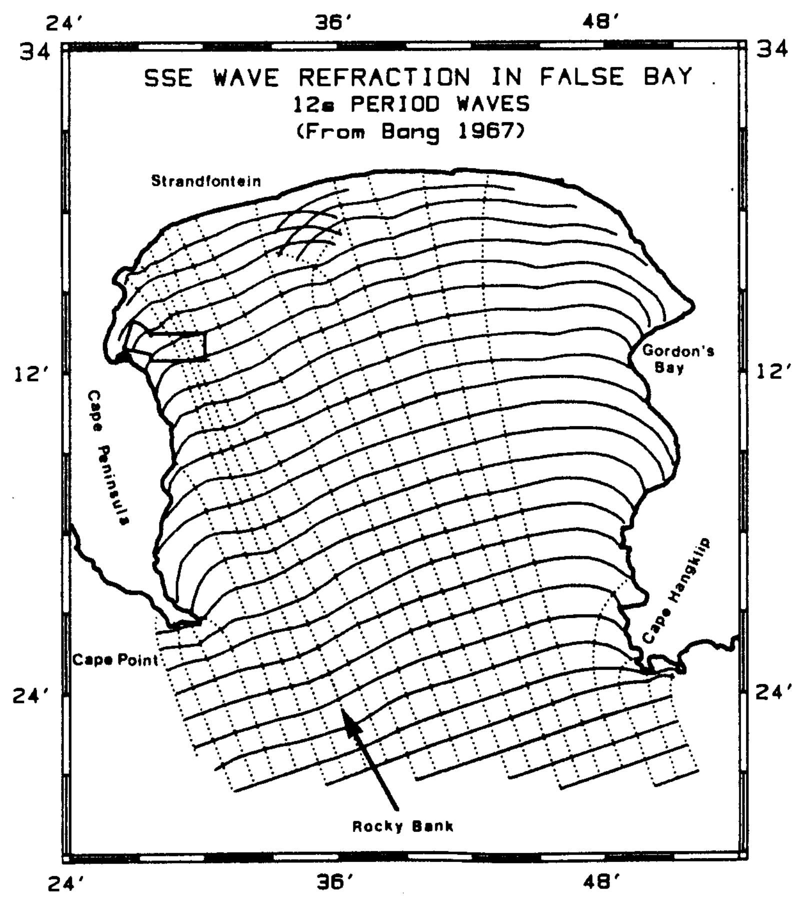

SSE WAVE REFRACTION IN FALSE BAY .
12s PERIOD WAVES
(From Bang 1967)
Strandfontein
Gordon's Bay
Cape Peninsula
Cape Hangklip
Cape Point
Rocky Bank
24'
36'
48'
34
12'
24'

Fig. 2.8

swells, but that it is exposed to the south-southeast swells. In fact, the energy of the south-southeast swells is focussed towards the study area by Rocky Bank (Fig. 2.8).

2.3.3 Tidal environment

Simon's Town experiences a spring-tide range of 1.48 metres (South African Navy tide-tables). This means that False Bay falls into a semi-diurnal upper microtidal (<2m tidal-range) environment, and that tide-driven currents are likely to be very weak in the study area (Davies, 1972).

2.3.4 Current patterns

Atkins (1970b) measured surface-currents in False Bay using a "dye-bomb" technique. His results show that the bay is dominated by wind-driven surface-currents. He describes a clockwise circulation driven by SE winds and an anti-clockwise circulation driven by NW winds. Weak tide-driven surface-currents occur during windless periods. A numerical model of the wind-driven circulation in False Bay, developed by Van Foreest (1984), Van Foreest and Brundrit (1985), and Van Foreest and Jury (1985), predicts more complicated surface-current patterns for different wind-speeds and wind-directions. However, both Atkins (1970b) and Van Foreest et al show that surface-currents off Simon's Town are driven northwards by SE winds, and southwards by NW winds.

Few data are available on bottom-current patterns in False Bay. The vectors of bottom drift-cards released off Simon's Town indicate that bottom-currents move northwards through the study area (Atkins, 1970b).

3. METHODS

3.1 Introduction

This chapter outlines the field-work and laboratory methods used in this study.

3.2 Field-work

3.2.1 Description of field-work

The field-work was carried out in two phases. The first phase consisted of the echosounder and side-scan-sonar surveys. In the second phase, sediment sampling and diver-inspections were carried out to aid the interpretation of the sonographs. The echosounder and side-scan-sonar surveys were carried out by IMT and Underwater Surveys (Pty.) Ltd., i.e. the writer was not personally involved. The writer was however, closely involved in organising the collection of sediment samples, and with the logistics and direction of the diver-inspections.

3.2.2 Boats used

The field-work was conducted from two twin-engined, catamaran boats, namely the "Shirley T" and the "Annie K" (Plate 3.1). Both were specially adapted for surveying and diving operations. The wide catamaran design provided ample working space, and was also very stable.

3.2.3 Position-fixing and navigation

A Plessey MRD-1 Tellurometer system was used to determine position-fixes and to navigate along predetermined tracks. The system uses an active onboard master-set and

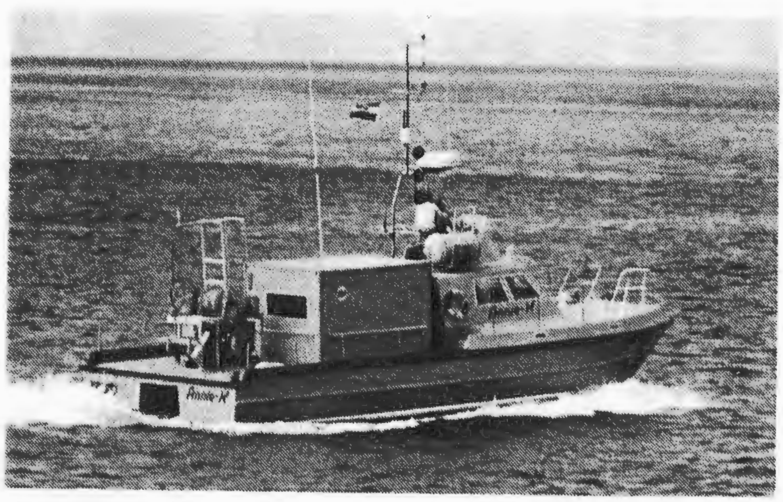


Plate 3.1 Photographs of (a) "Shirley-T" and (b) "Annie-K". Both catamaran boats are specially adapted for shallow-water surveying and diving operations. The computer-based, integrated survey-system onboard the "Annie-K" is housed in a removable container on the after-deck, aft of which is fitted a slip-ring winch used to deploy and recover the side-scan-sonar towfish. Note the MRD-1 Tellurometer antenna attached to the mast of each boat.

three passive shore-based slave-stations. Position-fixes are determined by micro-wave ranging between the master-set and the three slave-stations and, under ideal conditions, these are accurate to within one metre. In practice, the accuracy is affected by roll, pitch and yaw of the survey-vessel, and position-fixes are more likely to be accurate to within five to ten metres.

3.2.4 Echosounder and side-scan-sonar surveys

(a) Survey system

The echosounder and side-scan-sonar surveys were conducted using an integrated survey-system developed by IMT (Teichert, 1986). This consisted of the MRD-1 position-fixing system, a 33kHz Elac LAZ 721 echosounder, an EG&G Model 260 side-scan-sonar recorder and an EG&G Model 272-TD 105kHz towfish, interfaced to a Hewlett Packard-85 micro-computer. The computer was used to control certain survey functions. It programmed the MRD-1 to guide the vessel along predetermined tracks, and related position-fix data (position-fix, event-number, and time) to echosounder and side-scan-sonar data (Underwater Surveys (Pty.) Ltd., 1985).

(b) Echosounder survey

The echosounder measured depth along 66 east-west-orientated tracks, spaced 60 m apart. The computer recorded a depth and corresponding position-fix datum every second onto a floppy disk. In this way, 7811 depth measurements were recorded in the study area.

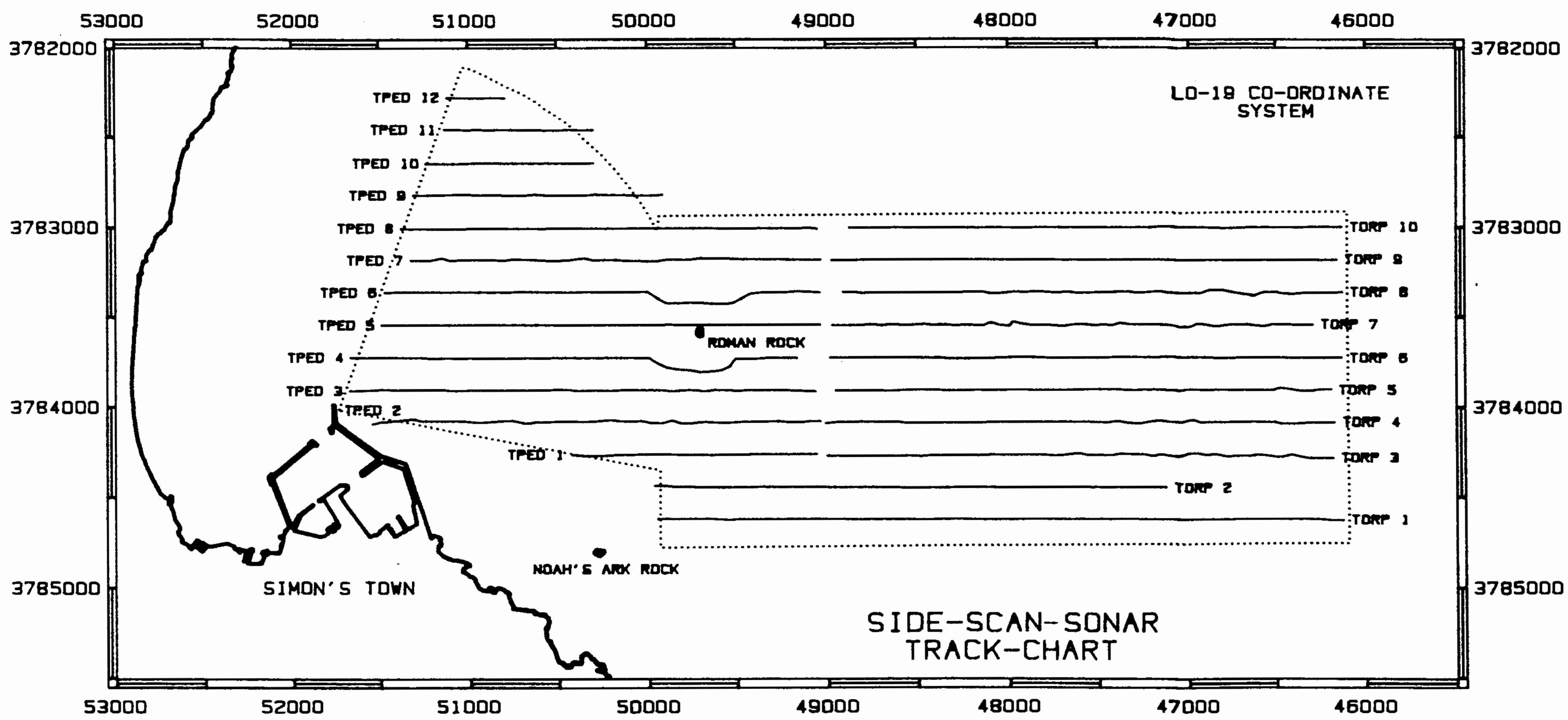
(c) Side-scan-sonar survey

The side-scan-sonar was operated at the 100m scanning-range. At this range, the across-track and along-track resolution were 0.25 and 2.09 metres respectively. (Appendix A shows how the resolution was calculated). The side-scan-sonar recorder automatically corrected for slant-range and towspeed distortion. The computer recorded a position-fix, event-number, and time every 30 seconds onto the sonographs and onto floppy disk. The towfish was towed at an optimum height of 10m or one tenth of the scanning-range above the seafloor, except where the seafloor appeared rugged on the sonographs, when the towfish height was increased to avoid collision with the seafloor (Flemming, 1976b). To ensure the best possible along-track resolution (2.09m), a slow towspeed of about 3.5 knots was maintained along each survey track. This is within the towspeed limits recommended by Flemming (1976b), Russell (1978), and Stefanon (1985). To achieve 100% insonification of the study area, 22 east-west-orientated survey-tracks, spaced 180m apart, were surveyed by side-scan-sonar (Fig. 3.1). The amount of overlap of adjacent swathes was 11 percent.

The total area insonified amounted to the swath-width multiplied by the total length of the survey-tracks, i.e. 200m X 54km, which equals 10.8 square kilometres.

3.2.5 Side-scan-sonar ground-control

An element of uncertainty exists in the interpretation of side-scan-sonar imagery, and good ground-control is required if valid interpretations are to be made (Williams, 1982; Bouma and Rappeport, 1984; Duck and McManus, 1985). To avoid misinterpretation of the sonographs, sediment



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TPED 2
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TORP 10
TORP 9
TORP 8
TORP 7
TORP 6
TORP 5
TORP 4
TORP 3
TORP 2
TORP 1
ROMAN ROCK
NOAH'S ARK ROCK
SIMON'S TOWN
SIDE-SCAN-SONAR TRACK-CHART

Fig. 3.1

samples and information from diver-inspections (i.e. ground-control information) were obtained from a number of selected locations within the study area.

(a) Sediment-sampling

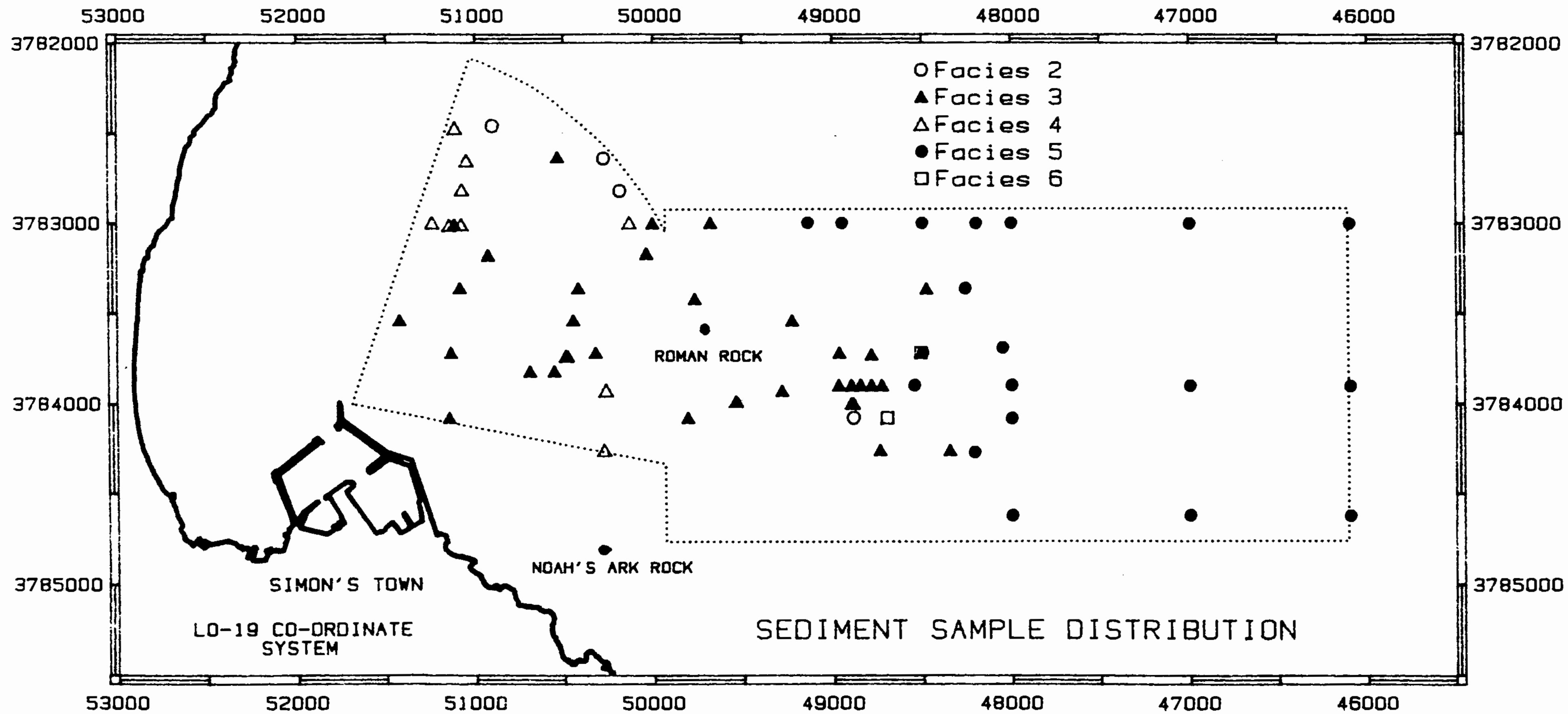
A total of 77 sediment samples were collected for this study. Of these, 66 samples were collected using a small Van Veen grab, and 11 samples were collected by SCUBA divers. The sampling sites (Fig. 3.2) were selected from the sonographs.

The small Van Veen grab was specially constructed for this study (Plate 3.2). It was made so that one person could operate it without the assistance of a winch. The sediment samples were small, and never exceeded 0.6 litres in volume. The contents of each grab were emptied into a plastic bucket and the fines were allowed to settle before the excess sea-water was drained away. A note was made of what macrofauna, if any, were present in the sample. These were removed before the sample was transferred into a labelled 700ml plastic jar.

The dived-samples were collected by simply scooping sediment from the seafloor into a pre-labelled 700ml plastic jar and capping it underwater before carrying it to the sea-surface.

(b) Diver-inspections

SCUBA divers inspected the different side-scan-sonar facies at 10 locations (Figs. 3.3 and 4.4). Ten divers, three of whom were marine geologists and one a marine biologist, took part in the diver-inspections. For safety reasons, these inspections were only undertaken in fairw-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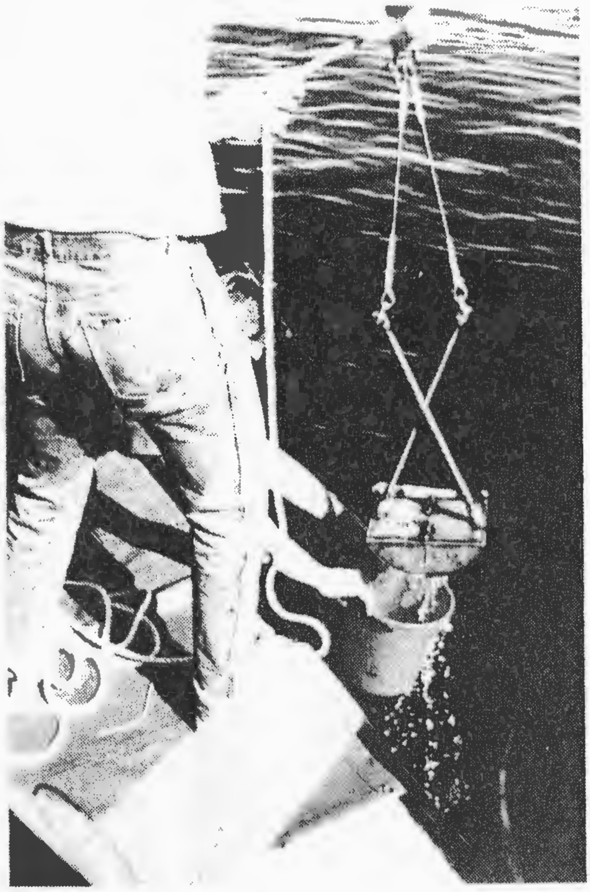
3782000
3783000
3784000
3785000
Facies 2
Facies 3
Facies 4
Facies 5
Facies 6
ROMAN ROCK
NOAH'S ARK ROCK
SIMON'S TOWN
LO-19 CO-ORDINATE SYSTEM
SEDIMENT SAMPLE DISTRIBUTION

Fig. 3.2



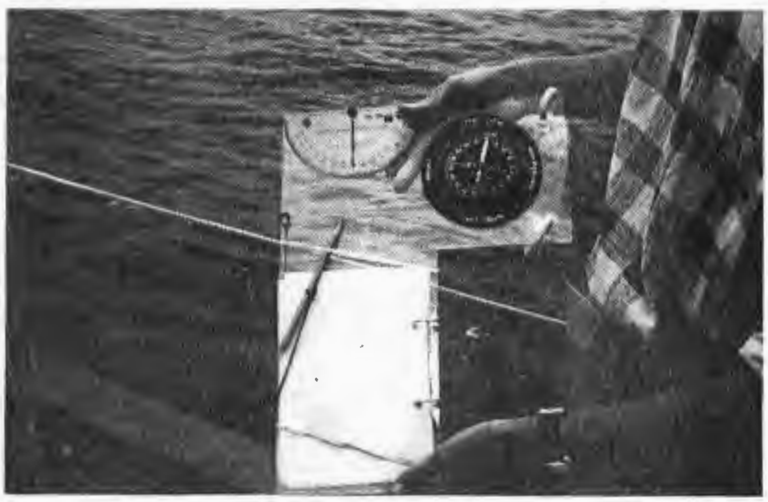


Plate 3.2 (a) A sediment sample being recovered using a small hand-held Van Veen grab.

(b) Photograph of the Perspex clipboard used in some of the diver-inspections. Note the compass, inclinometer, plastic note-paper and ordinary pencil used to measure and jot down notes about seafloor features. The compass was also used to navigate underwater.

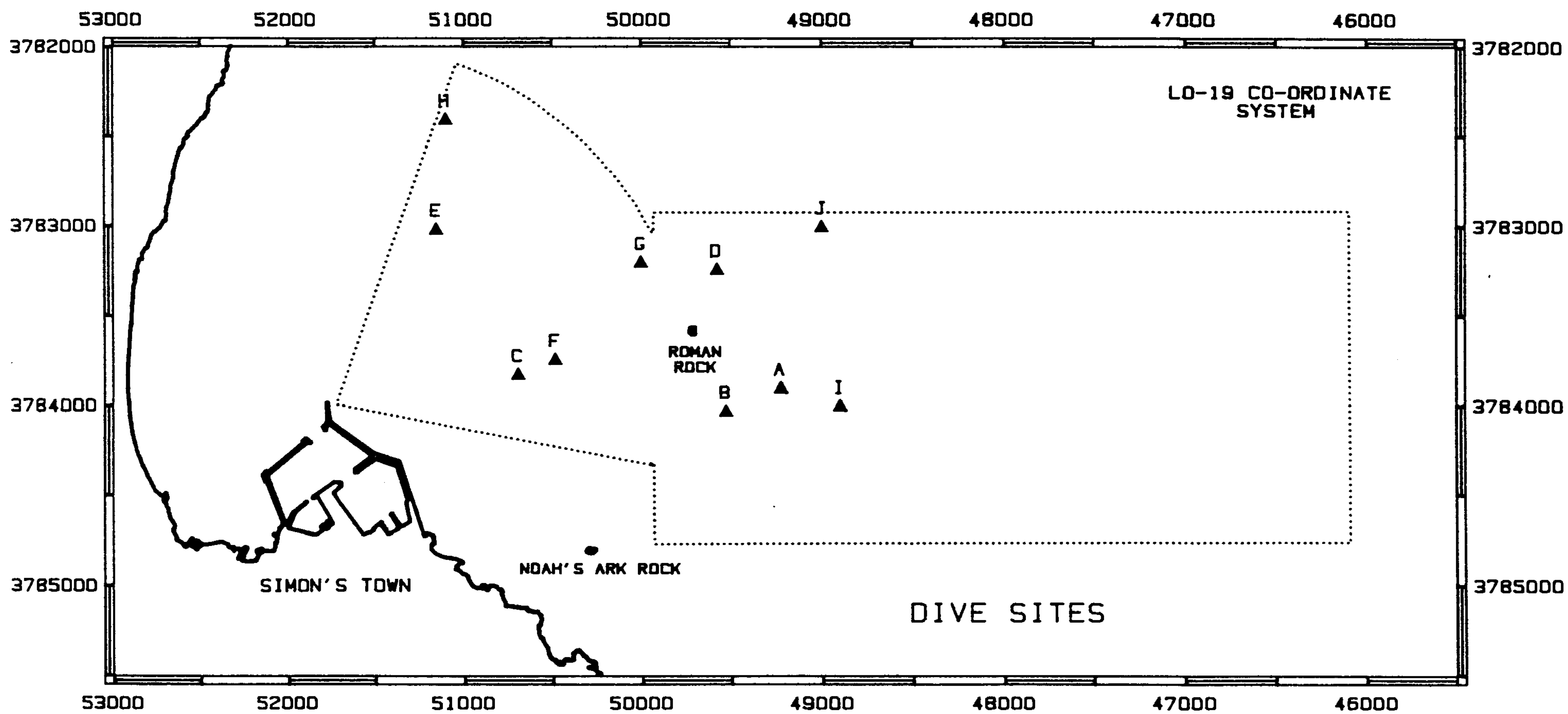

LO-19 CO-ORDINATE SYSTEM
DIVE SITES
SIMON'S TOWN
NOAH'S ARK ROCK
ROMAN ROCK
A
B
C
D
E
F
G
H
I
J
53000
52000
51000
50000
49000
48000
47000
46000
3782000
3783000
3784000
3785000

Fig. 3.3

eather conditions, and were limited to depths of less than 30 metres. As a result all the dive sites occur in the shallower western part of the study area. Apart from collecting samples, the divers noted their observations with a pencil either on underwater writing tablets, or on plastic sheets clipped to a perspex board equipped with a protractor and compass (Plate 3.2). Underwater-photographs were taken with 35mm Nikonos IV A waterproof-cameras, using both 28mm and 35mm lenses, with or without a flash (depending on the underwater visibility). The cameras were loaded with 200 ISO (ASA) daylight colour film. (Both slide and print films were used).

3.3 Data processing

3.3.1 Echosounder data

On completion of the echosounder survey, the raw depth-data (uncorrected for tide and swell) were transferred from floppy disk onto magnetic tape for processing on the University of Cape Town (UCT) Sperry Univac mainframe-computer. Using the UCT version of the SACLANTCEN graphics package, a 1m-contour-interval bathymetry map and a 3-D bathymetric image of the study-area, were generated. (See Appendix B for runstreams used). The accuracy of these, although uncorrected for tide and swell, was sufficient for descriptive purposes.

3.3.2 Side-scan-sonar data

The original sonographs were recorded by the side-scan-sonar recorder at 1:1000 scale. These were reduced by 50 percent on a Rank Xerox 2080 photocopier to a scale of 1:2000. The reduced sonographs were laid out on a laboratory floor to form a rough mosaic of the study area. The writer identified the individual sonograph facies (Kidd et al, 1985) from the mosaic and original sonographs, on the basis of tonal variation and pattern of acoustic-reflectivity.

The different sonograph facies were then plotted by Underwater Surveys (Pty.) Ltd. onto 1:2000 scale track-charts. The track-charts were computer-plotted using the side-scan-sonar position-fix data that were recorded onto floppy disk (Underwater Surveys (Pty.) Ltd., 1985). The 1:2000 scale sonograph facies maps were then photographically reduced to 1:10 000 scale. These reductions were used to compile a final 1:10 000 sonograph facies-map of the study area.

3.3.3 Sediment sample analysis

The procedure used to determine the textural and compositional properties of all the sediment samples is summarised in Fig. 3.4.

(a) Sample preparation

The wet-sample was split by coning and quartering and a quarter was put aside for laboratory analysis. The remaining sample was replaced into the plastic sample-jars and stored for reference. The sample for laboratory analysis was first desalinated before being split by coning and quartering once again (The salt was removed by placing the sample in dialysis tubing, and suspending it in a bucket of continually replenished tap-water overnight). Three-quarters was put aside for texture analysis and a quarter for composition analysis.

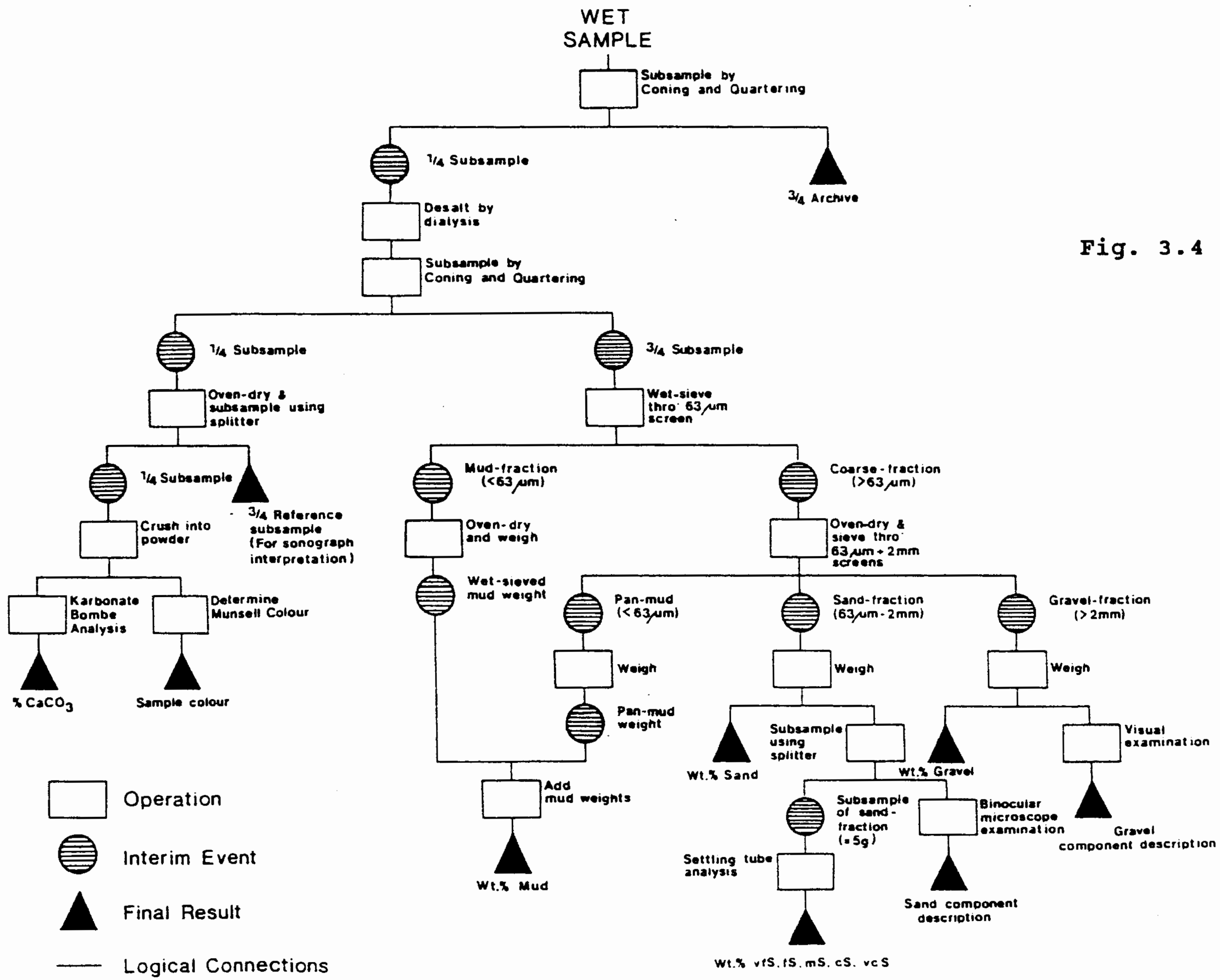

WET SAMPLE
Subsample by Coning and Quartering
1/4 Subsample
3/4 Archive
Desalt by dialysis
Subsample by Coning and Quartering
1/4 Subsample
3/4 Subsample
Oven-dry & subsample using splitter
Wet-sieve thro' 63 μm screen
1/4 Subsample
3/4 Reference subsample (For sonograph interpretation)
Crush into powder
Karbonate Bombe Analysis
Determine Munsell Colour
% CaCO3
Sample colour
Mud-fraction (<63 μm)
Oven-dry and weigh
Wet-sieved mud weight
Coarse-fraction (>63 μm)
Oven-dry & sieve thro' 63 μm + 2 mm screens
Pan-mud (< 63 μm)
Sand-fraction (63 μm - 2mm)
Gravel-fraction (> 2mm)
Weigh
Weigh
Weigh
Pan-mud weight
Add mud weights
Wt.% Mud
Wt.% Sand
Subsample using splitter
Wt.% Gravel
Visual examination
Subsample of sand-fraction (≈ 5g)
Binocular microscope examination
Gravel component description
Settling tube analysis
Sand component description
Wt.% vfS, fS, mS, cS, vcS
Operation
Interim Event
Final Result
Logical Connections

Fig. 3.4

(b) Sieving

The desalinated texture-split was first wet-sieved through a 63-micron screen to separate the mud (less than 63 microns) from the coarse (greater than 63 microns) fraction. The mud-fraction was put into two-litre plastic tubs and allowed to settle. Once the mud had settled, the excess water was decanted and the mud-fraction placed into glass beakers, dried at 100^{o}C, and weighed. The coarse-fraction was dried at 100^{o}C and then mechanically sieved for 5 minutes through 63-micron and 2mm screens, separating the gravel, sand, and "pan-mud" fractions. ("Pan-mud" refers to silt which did not get washed through the 63-micron screen during wet-sieving due to the screen-size being reduced by the surface-tension of water). These were weighed and the "pan-mud" weight was added to the wet-sieved mud weight to obtain the total mud weight. The amount of gravel, sand and mud were expressed as percentages of the total dry weight.

(c) Sand size-analysis

Less than 10g of the sand-fraction was subsampled using a splitter for settling-tube analysis. Logistical problems resulted in some of the the sand-fraction samples being settled in the Geological Survey settling-tube in Bellville and others being settled in the UCT settling-tube. Both are linked to micro-computers, allowing for rapid and precise statistical analysis of the sand-size distribution (Brink and Rogers, 1985).

(d) $CaCO_3$ analysis and colour determination

The desalinated composition-split was analysed for $CaCO_3$ using the "Karbonat Bombe" method (Muller and Gastner, 1971; Birch, 1981). The split was dried and a quarter was crushed into a very fine powder. The remaining three-quarters was put aside to be used as a reference sample for the sonograph interpretation. Five millilitres of concentrated hydrochloric acid (HCl) was added to 1 g of the crushed sample in an airtight container fitted with a pressure gauge. The pressure of the released gas was normalised against a standard for pure $CaCO_3$, giving the percentage $CaCO_3$ for the sample. Standards were determined every 5 samples since this method is sensitive to changes in air temperature and pressure.

The sample-colour was colour-coded by comparing the remaining crushed material with Munsell (1975) soil-colour charts.

(e) Megascopic description of components

The gravel- and sand-fraction components were examined using a procedure based on the Ingram (1965) method. The gravel-fraction was examined with the naked eye, while the sand-fraction was examined under a binocular microscope. The various components making up the coarse-fraction of each sample were identified and their relative abundances estimated and classified as either "dominant" (>50 percent), "major" (5 to 50 percent), "minor" (1 to 5 percent), or "trace" (<1 percent). Certain biogenic components could only be identified with the help of marine biologists.

4. OBSERVATIONS

4.1 Introduction

In this chapter, the side-scan-sonar, echosounder and ground-control data are presented.

4.2 Bathymetry

The study area is divided into two by a NW-SE orientated reef (Fig. 4.1 and Fig. 4.2 in folder). The reef, roughly two kilometres long and one kilometre wide, consists of a number of granite pinnacles which rise steeply between 2 and 20 metres above an otherwise smooth seafloor. Three of the pinnacles have been identified as navigational hazards (Fig. 4.1). These are Roman Rock, which protrudes just above above the sea-surface and upon which a lighthouse has been built (Plate 1.1), Castor Rock, which is 3.3 metres deep at its shallowest point, and Rambler Rock, which is 8.2 metres deep at its shallowest point (Fig. 4.2).

The seafloor to the northwest of the reef may be described as an extensive terrace, mainly 20 to 22 metres deep. It deepenens towards the southeast into a narrow trough that is less than a kilometre wide and up to 33m deep, between the reef and the coast (Fig. 4.2). East of the reef, the seafloor has little relief and deepens steadily from 25 to 38 metres towards the southeast corner of the study-area (Fig. 4.2).

4.3 Sonograph facies

Six patterns of reflectivity (sonograph facies) are identified on the sonographs (Plates 4.1 to 4.7 and Fig. 4.3). The areal distribution of these facies (Facies 1 to

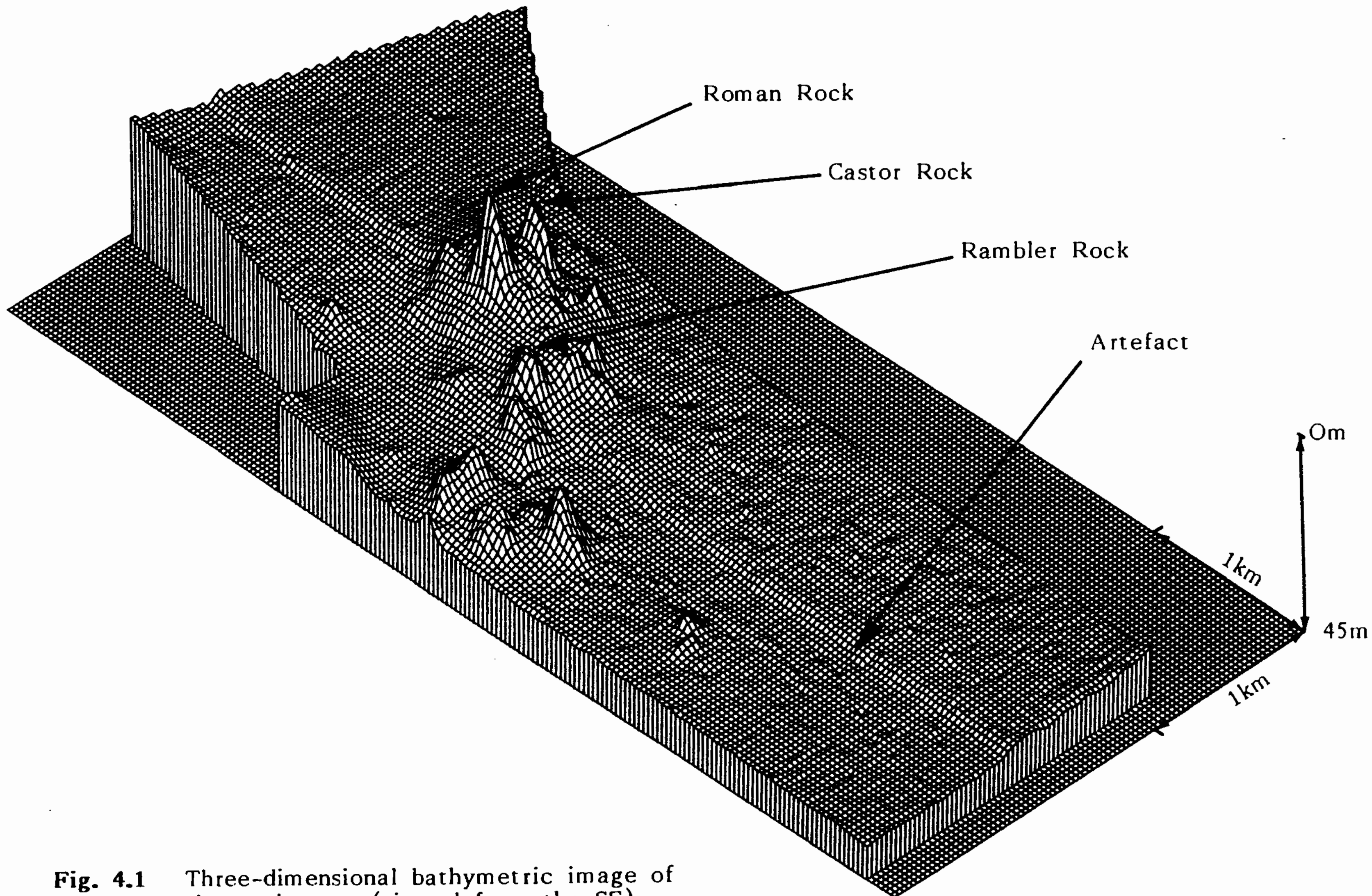


Fig. 4.1 Three-dimensional bathymetric image of the study area (viewed from the SE)

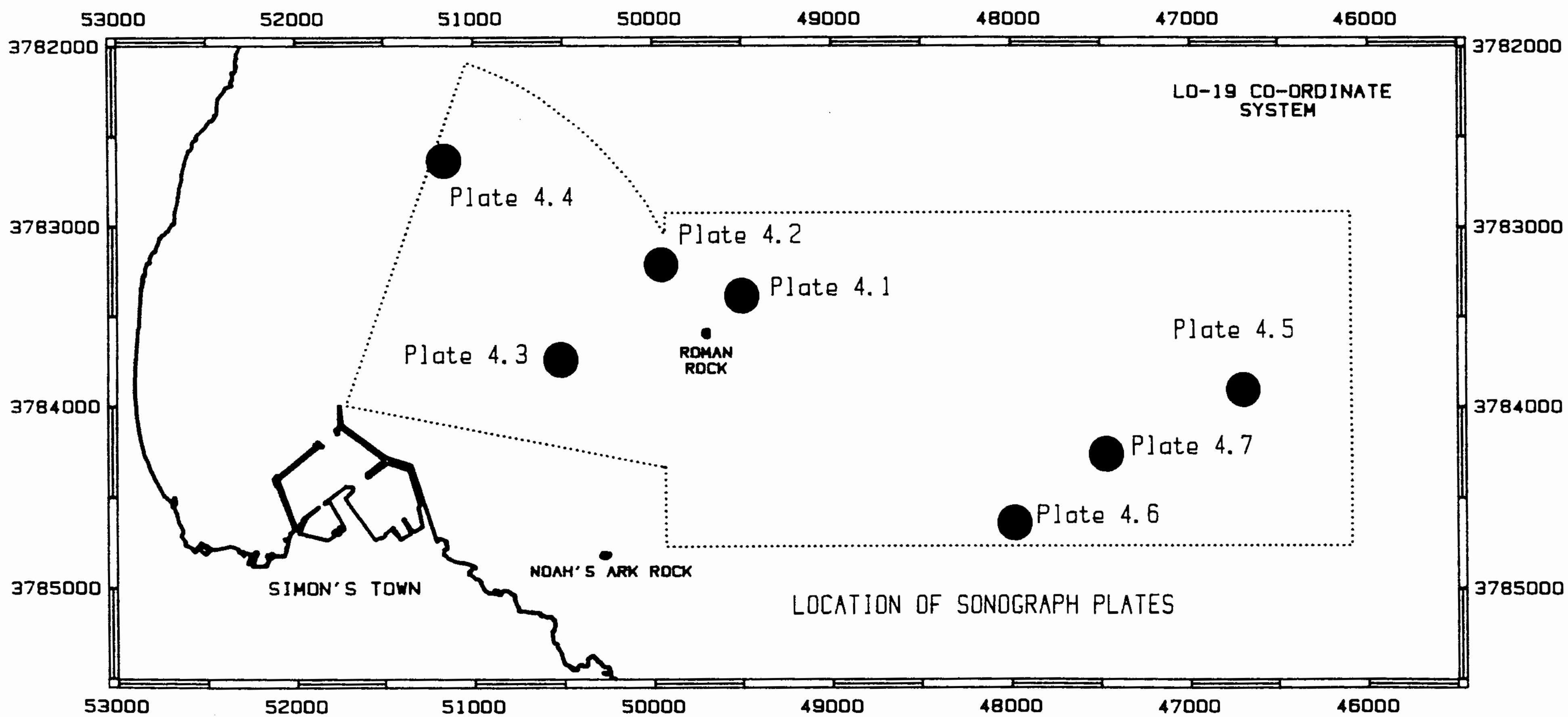

LO-19 CO-ORDINATE SYSTEM
Plate 4.4
Plate 4.2
Plate 4.1
Plate 4.3
ROMAN ROCK
Plate 4.5
Plate 4.7
Plate 4.6
SIMON'S TOWN
NOAH'S ARK ROCK
LOCATION OF SONOGRAPH PLATES

Fig. 4.3

6) is shown in Figure 4.4 (in folder). The characteristic features of the six sonograph facies, described in more detail below, are listed in Table 4.1.

4.3.1 Facies 1

Plate 4.1 shows the Facies-1 pattern of reflectivity (Table 4.1). The distribution of Facies 1 (Fig. 4.4) coincides with the granite pinnacles depicted in Figures 4.1 and 4.2. The lineaments seen on the sonographs follow several directions, but the best-defined lineaments trend WNW-ESE, parallel to the principal joint-direction in the granite outcrops onshore (Boocock, 1951; Van der Merwe, 1963; Benfield, 1964). Divers found that the rock pinnacles resemble the coastal granite outcrops found to the west of the study area (Plates 4.9a and 2.1). Large, well-jointed, rounded boulders (as tall as 5m), resting on a larger rounded rocky base (massif) or protruding above sediment, were observed at Site A (Rambler Rock) and Site I (Fig. 3.3). The outcrops were covered in both calcareous and soft-bodied marine-organisms, and were surrounded by calcareous skeletal debris (Plate 4.8).

4.3.2 Facies 2

The Facies-2 pattern of reflectivity is shown in Plates 4.1 and 4.2. This pattern is found usually near or immediately north of the rock pinnacles, at 20 to 35 metres depth (Fig. 4.4). A diver-inspection at Site D (Fig. 3.3) revealed that Facies 2 consisted of large-scale sedimentary bedforms (Plate 4.9). These bedforms, spaced 0.8 to 1.2 metres apart and 0.2 to 0.3 metres high, were symmetrical with long and straight crests that sometimes bifurcated in a crest-parallel direction (Plate 4.9c). The crests had the same ENE-WSW orientation as the light and dark bands on the

TABLE 4.1 Characteristic features of each sonograph facies

Facies	Relief	Acoustic Reflectivity	Sonograph Pattern	Sediment Texture (Shepard 1954)	Sediment Composition (%CaCO3)	SCUBA Diver Observations	Interpretation
1	Rugged (>1m)	Strong	Lineaments within an irregular, blocky pattern of light and dark tones.	–	–	Granite outcrop, similar to the coastal granite outcrops west of the study area. Outcrops are covered with marine organisms. The base of the outcrops is surrounded by calcareous debris.	Cape Peninsula Granite.
2	Low (<1m)	Moderate	Alternating bands of light and dark tones, orientated ENE-WSW and spaced about one metre apart.	Sand and gravelly sand	66 (50.7-85.5) n=4	Straight-crested, bifurcating bedforms Wave-length=0.8m to 1.2m, amplitude =20cm to 30cm, ENE-WSW crest-orientation.	Large-scale long-crested trochoidal wave-ripples
3	None	Moderate to weak	Uneven, featureless medium-grey tone.	Sand, gravelly sand and gravel	72.8 (26-91.5) n=33	Small (1 to 2 metre wide) patches of gravelly calcareous sediment overlying a relict quartzose fine to medium sand. Ophiuroids and crinoids common.	Patchy veneer of calcareous gravelly sediment overlying a quartzose fine to medium sand
4	None	Weak	"Cloud-like" and "tongue-like" patches of light tone.	Sand	47.4 (32.2-73.6) n=10	Rippled fine to medium sand-patches. Ripples are straight-crested, symmetrical and bifurcate. Wavelength= 10cm to 20cm and amplitude= 1cm to 3cm. ENE-WSW crest-orientation. Apart from some pinnid bivalves, the patches are barren.	Windows of quartzose fine to medium sand
5	None	Weak	Slightly speckled, featureless light tone.	Sand	23.1 (7.2-73.7) n=19	Rippled quartzose fine to medium sand. Ripples are straight-crested, symmetrical and bifurcate. Wavelength= 10cm to 20cm and amplitude= 1cm to 3cm. ENE-WSW crest-orientation. Few ophiuroids and asteroids present.	Blanket of quartzose fine to medium sand
6	None	Moderate	Patches of medium-grey tone.	Sand	39.5 (19.1-59.9) n=2	None.	Coarse sediment patches?

sonographs. The 0.8 to 1.2 metre wavelength of the bedforms is near to the 0.25m (across-track) and the 2.09m (along-track) resolution limits of the side-scan-sonar system (Appendix A) and thus it is not easy to distinguish them on the sonographs (Plates 4.1 and 4.2). The bedforms were developed in calcareous gravel and sand with coarser sediment and finer sediment on the crests (Plates 4.9c, 4.13a and 4.13b).

4.3.3 Facies 3

The Facies-3 pattern of reflectivity (Table 4.1) is depicted in Plates 4.1 to 4.4. It occurs in the western half of the study area, at depths between 20 and 35 metres (Fig. 4.4).

The sediment samples from Facies 3 range from a quartzose sand to a calcareous gravel. The samples nearest the granite pinnacles are usually composed of shell debris such as cirripede (barnacle) and mollusc fragments, whereas the samples farther away from the rock pinnacles, between Roman Rock and the Simon's Town harbour wall, are composed of a mixture of coralline-algal fragments and quartzose sand (Plates 4.13c to 4.13e).

Divers found both living and dead unattached coralline-algae (subfamily Melobesioideae) in Facies 3 at Sites C, E, F, and H (Fig. 3.3). The coralline-algae formed autochthonous three-dimensional growth structures, a few metres across and a few centimetres high, on top of quartzose, fine to medium sand (Plate 4.10a). Marine biologists refer to such structures as "marls" or "maerls" (e.g. Bosence, 1976 and Steneck, 1986). This may lead to confusion because "marl" is also a geological term for calcareous clay (Bates and Jackson, 1980). Because geologists working on the

British Continental Shelf use the term "maerl" to describe sediment composed of coralline-algal fragments (e.g. Stride, 1982), this term is used from now on.

The maerl often formed elongate strips, up to a couple of metres wide, about half a metre apart and orientated ENE-WSW, overlying the quartzose sand (Plate 4.10). The maerl attracted crinoids (feather stars), namely Comanthus wahlbergi and ophiuroids (brittle stars) (Plates 4.10a, 4.10c and 4.11c). Divers saw, amongst other things, pebble-size quartz and feldspar fragments (Site G, Fig. 3.3) and poorly preserved Venus verrucosa shell fragments (Site H, Fig. 3.3) on the seafloor in Facies 3.

4.3.4 Facies 4

The Facies-4 pattern of reflectivity (Table 4.1) occurs to the west of Roman Rock at depths between 20 and 30 metres (Fig. 4.4). The light-toned patches vary in shape and size, but two types stand out, namely "cirrocumulus cloud-like" patches, and long, narrow "tongue-like" patches (Plates 4.2 to 4.4). The cloud-like patches are slightly elongate, are 10 to 50 metres long and 5 to 20 metres wide and are orientated ENE-WSW. The tongue-like patches are up to 300m long and 50m wide and are orientated NNE-SSW to N-S. Underwater photographs taken at Sites E, F and H (Fig. 3.3) reveal that Facies 4 consisted of light grey, rippled, fine to medium sands (Plates 4.11a and 4.11b). The small-scale ripples were symmetrical, straight- and sharp-crested and orientated ENE-WSW, with a wavelengths between 10cm and 20cm and amplitudes of less than 3cm. The sediment samples from Facies 4 are all calcareous, fine to medium, quartzose sands (Plate 4.13f). The divers also noted that some of the sand patches attracted the large pinnid bivalve Atrina squamifera, also known as a horse-mussel. This delicate, filter-feeding bivalve grew up to 30cm long and lived embedded in the sand with only its posterior edges protruding vertically above the substrate (Plate 4.11c). The pinnid bivalves provided an attachment for crinoids (Comanthus wahlbergi) and other organisms and are were more abundant in the larger, tongue-like patches, where they were found in groups of two and three and can be seen on the sonographs as small black streaks within the tongues (Plate 4.4). Apart from the bivalves, the quartzose sand patches were relatively barren (Plates 4.11a and 4.11b).

4.3.5 Facies 5

The Facies-5 pattern of reflectivity (Table 4.1) is shown in Plate 4.5. It occurs in the deeper part of the study area (>25 m), to the east of Roman Rock (Fig. 4.4). The sediment samples recovered from Facies 5 are relatively homogeneous, i.e. they are all benthic-foraminifera-bearing, quartzose, fine to medium sands (Plate 4.13g). Many of the samples also contained infauna (polychaete worms). A diver-inspection at Site J in Facies 5 (Fig. 3.3), revealed small-scale ripples in the fine to medium sand (Plate 4.12a). These were orientated ENE-WSW and were symmetrical, with long, straight crests that bifurcated and had wavelengths between 10 and 20 centimetres and amplitudes less than 3cm. The divers also saw ophiuroids and asteroids (starfish), namely Marthasterias glacialis, but these were less abundant than in Facies 3 (Plate 4.12a and 4.12b)

4.3.6 Facies 6

The Facies-6 pattern of reflectivity (Table 4.1) is depicted in Plates 4.6 and 4.7. It is found to the east of Roman Rock as isolated patches within Facies 5 (Fig. 4.4).

The patches vary from a rounded shape, between 50m and 100m across, to an elongate shape, up to 400 m long and 50 m wide. The latter are orientated NNE-SSW. Only two sediment samples were recovered from Facies 6, and although both are medium sands, the one is calcareous (Sample 29) and the other quartzose (Sample 34).

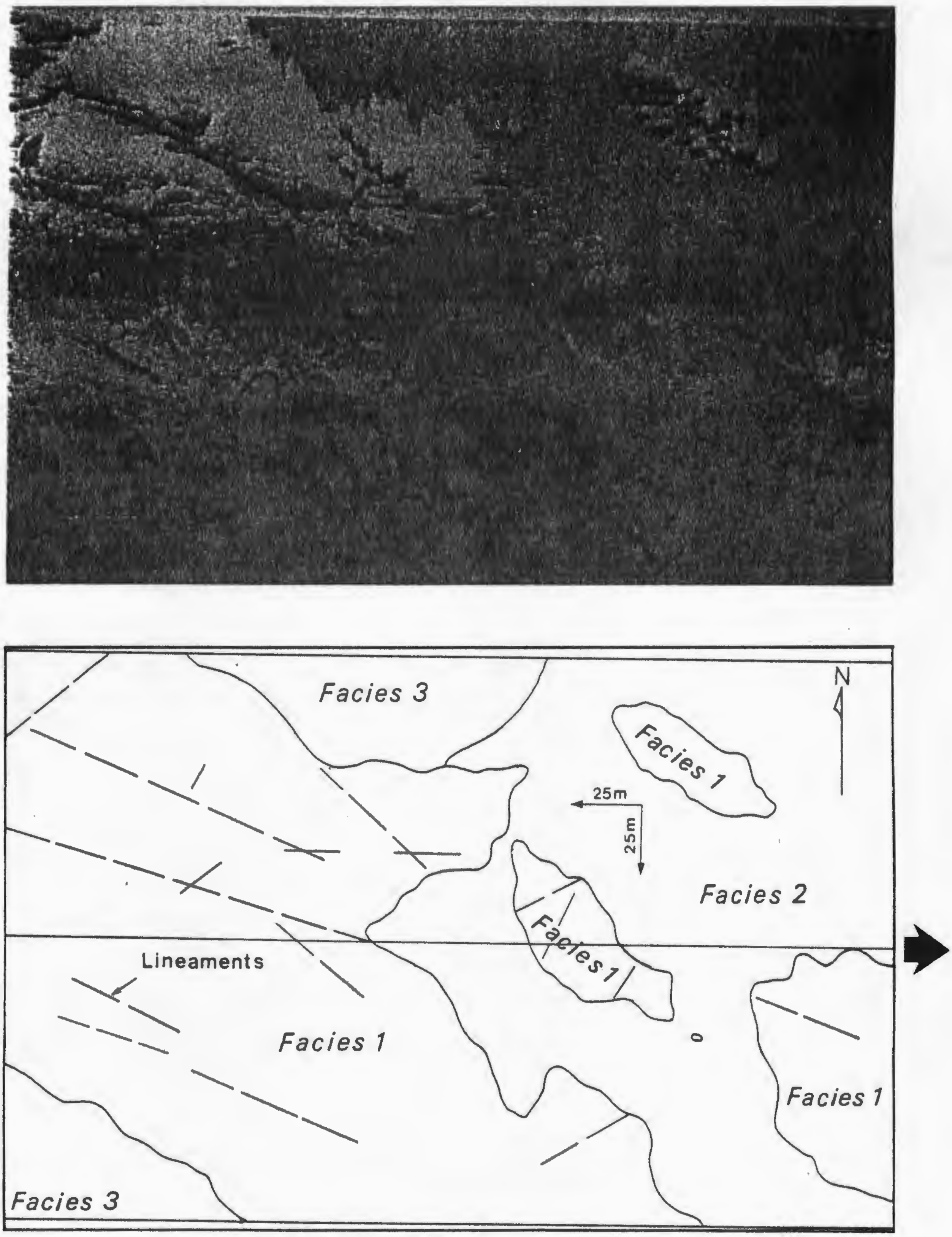


Plate 4.1 Sonograph of Facies 1, 2 and 3.

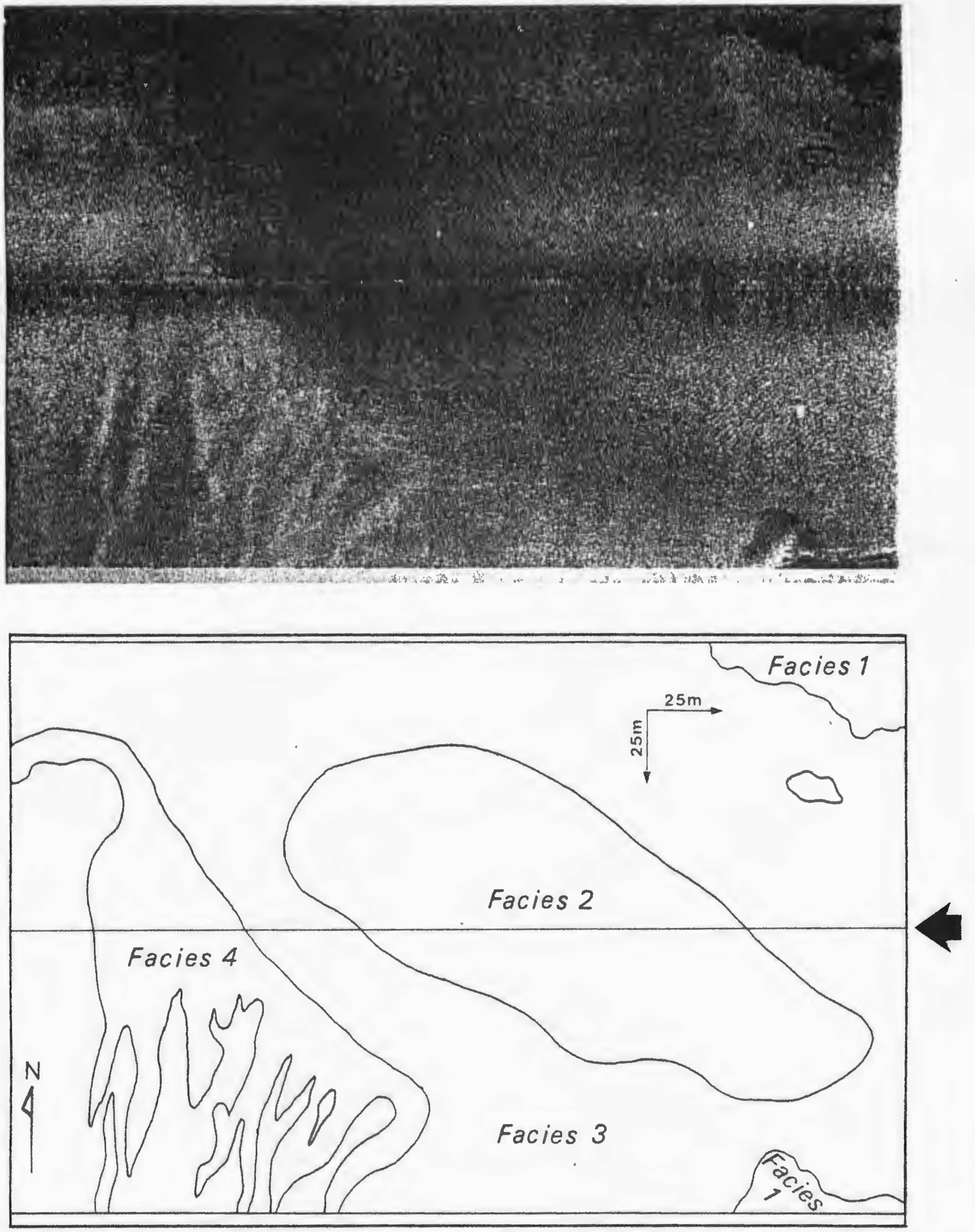


Plate 4.2 Sonograph of Facies 1, 2, 3 and 4.

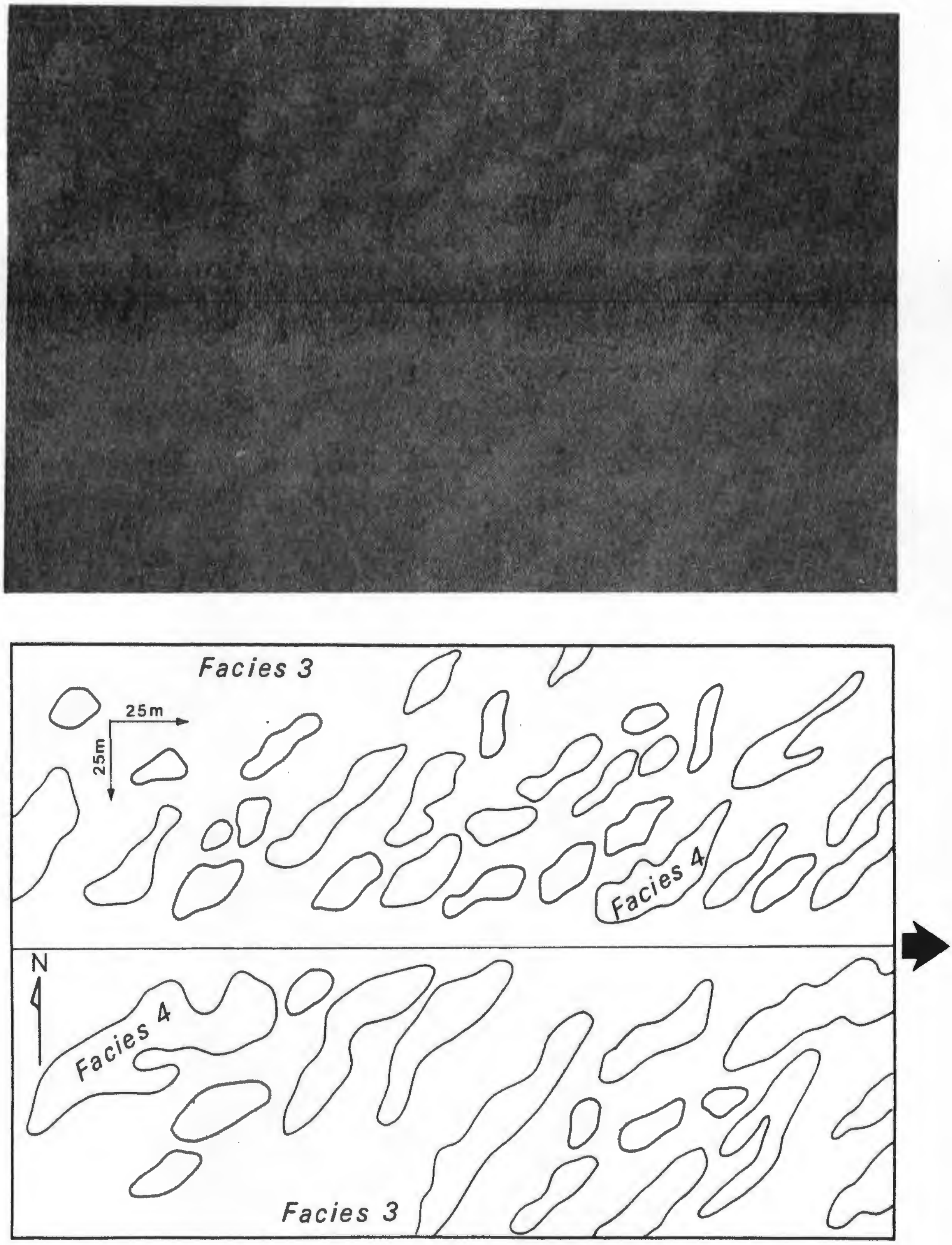


Plate 4.3 Sonograph of Facies-4 "cloud-like" patches in Facies 3.

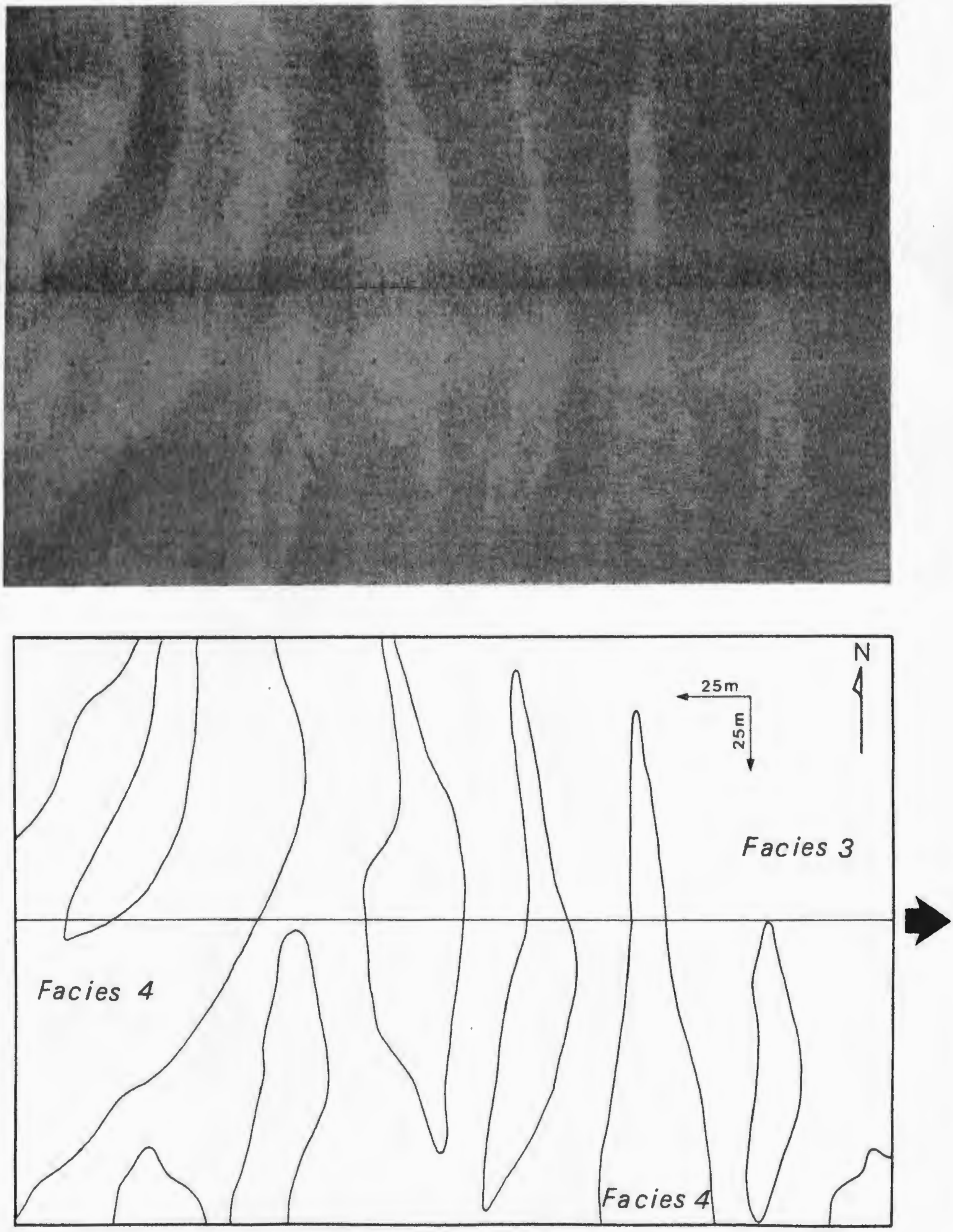
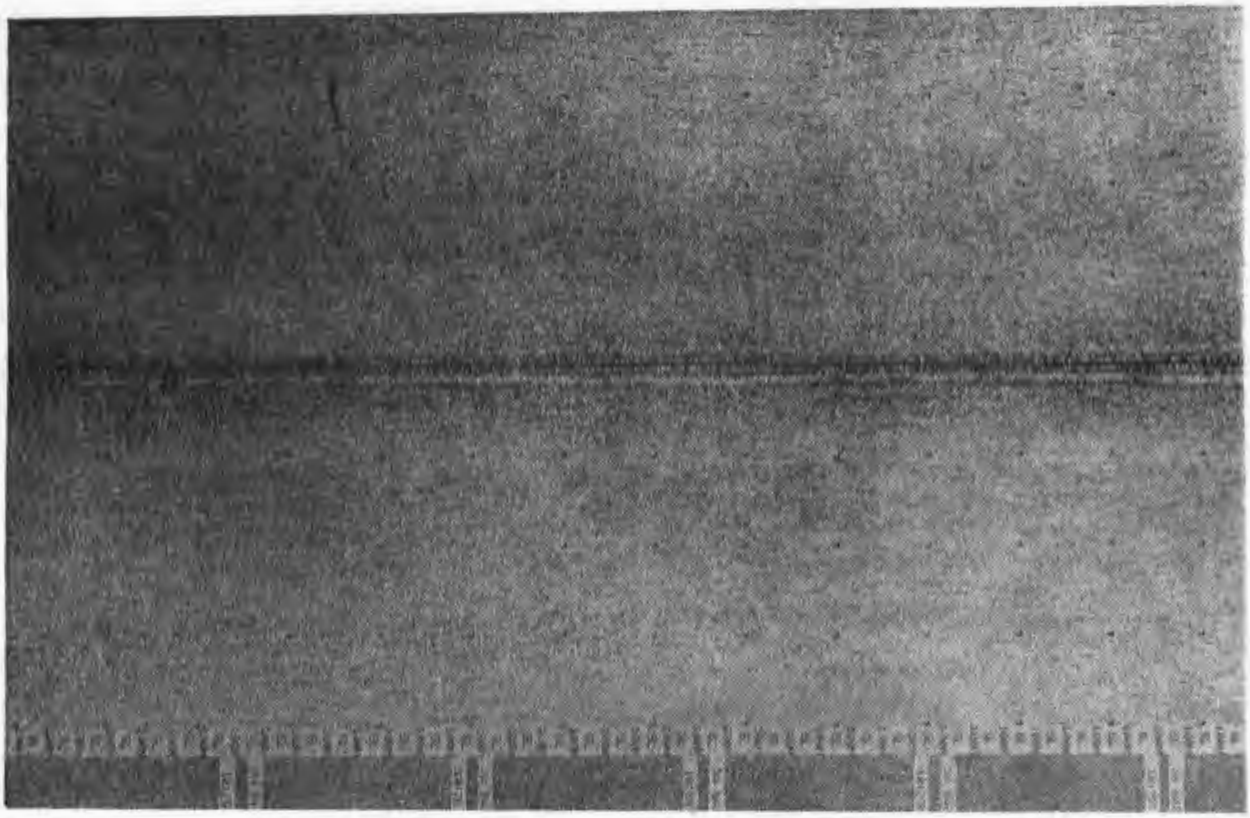


Plate 4.4 Sonograph of Facies-4 "tongue-like" patches in Facies 3. Note the little black streaks in the patches, in the bottom left-hand corner produced by pinnid bivalves (<u>Atrina squamifera</u>).



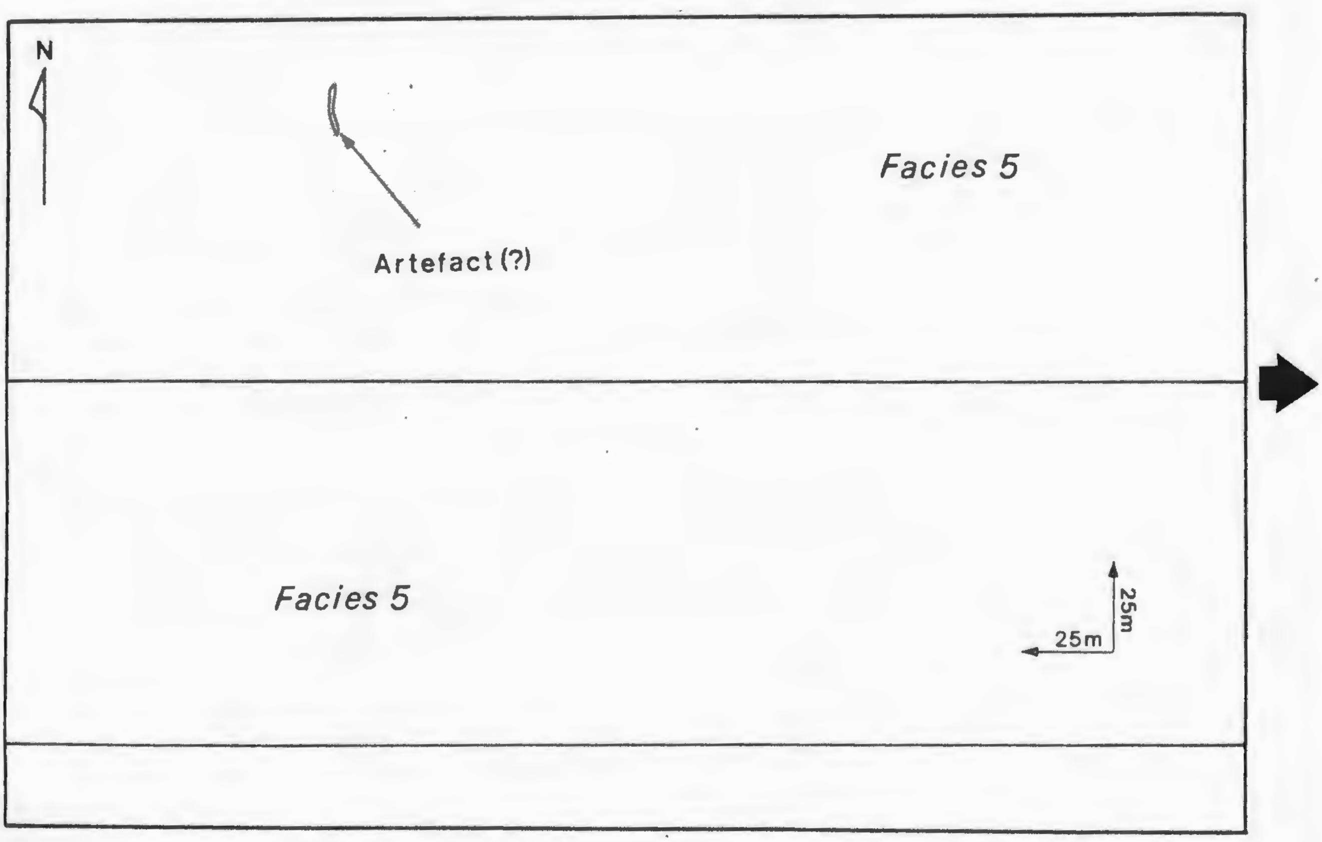


Plate 4.5 Sonograph of Facies 5.

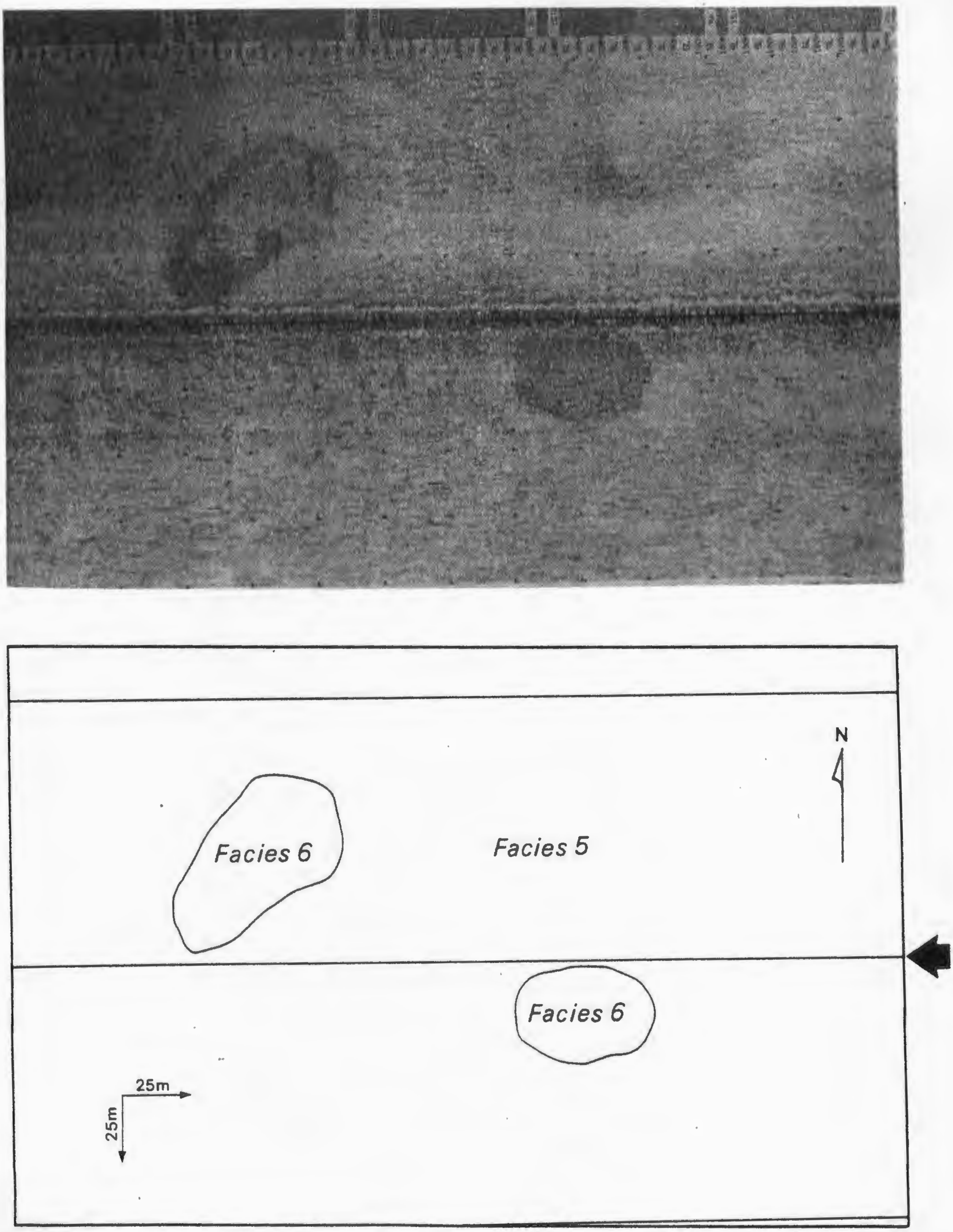


Plate 4.6 Sonograph of Facies-6 rounded patches.

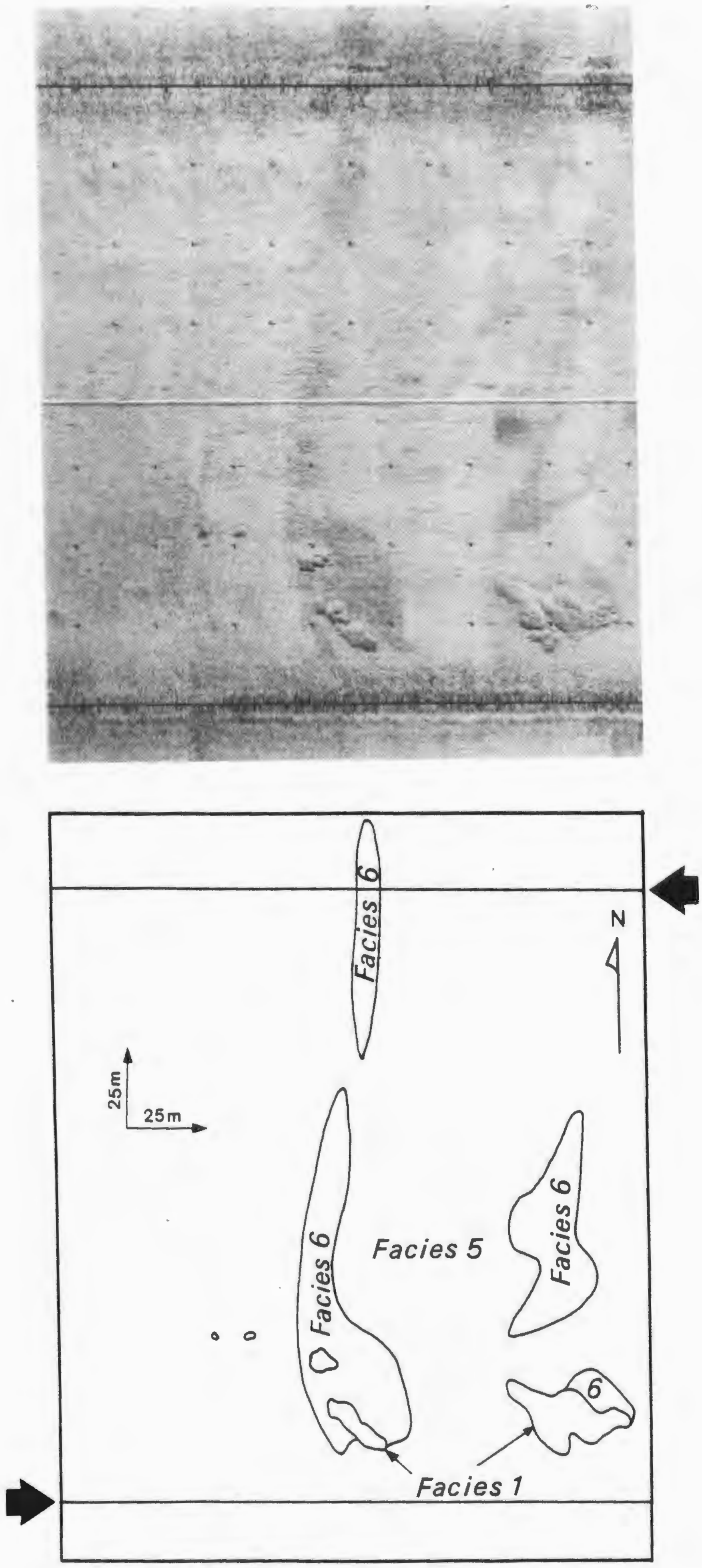


Plate 4.7 Sonograph of Facies-6 elongate patches.

Plate 4.8 Underwater photographs on and next to a granite outcrop (Facies 1) taken at Site I.

(a) This shows the marine growth that covers the granite. The gorgonians (seafans) occur on the south side of the outcrop and are orientated perpendicular to the predominant current. (The field of view is about one metre across).

(b) Facies-3 calcareous debris, mainly mollusc fragments, at the base of the rock outcrop. The compass seen on the left is 10cm in diameter.

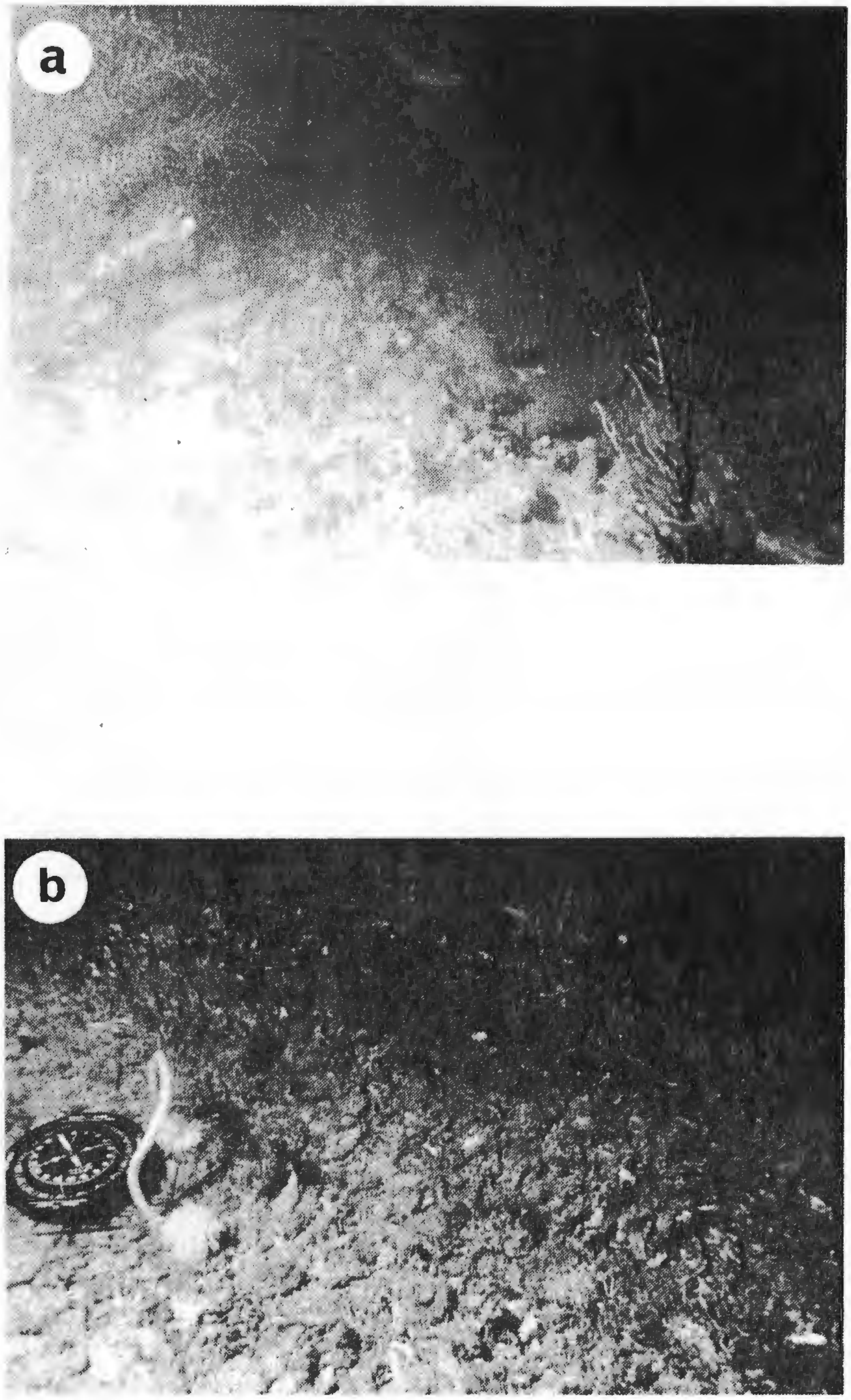


PLATE 4.8

Plate **4.9** Underwater photographs of large-scale, long-crested, trochoidal wave-ripples taken at Site D (Fig. 3.3) in conditions of excellent visibility (>10m).

(a) is taken looking towards the east, and shows an isolated granite boulder in the middle of the wave-ripple field (c.f. coastal granite outcrops in Plate 2.1). The wave-ripple crests are orientated WSW-ENE. Although obscure, one can see marine growth on the side of the boulder facing south, into the predominant current, and curved, refracted, wave-ripple crests on the northern side of the boulder.

(b) Plan-view of the wave-ripples. Note the bifurcation and symmetry of the crests. The feature to the right of the diver is a partially covered outcrop of granite.

(c) Side-view of the wave-ripples. The measuring-staff at the centre of the photograph is one metre long. Note the coarse calcareous material in the troughs, ripple-symmetry, and continuity of the crests.

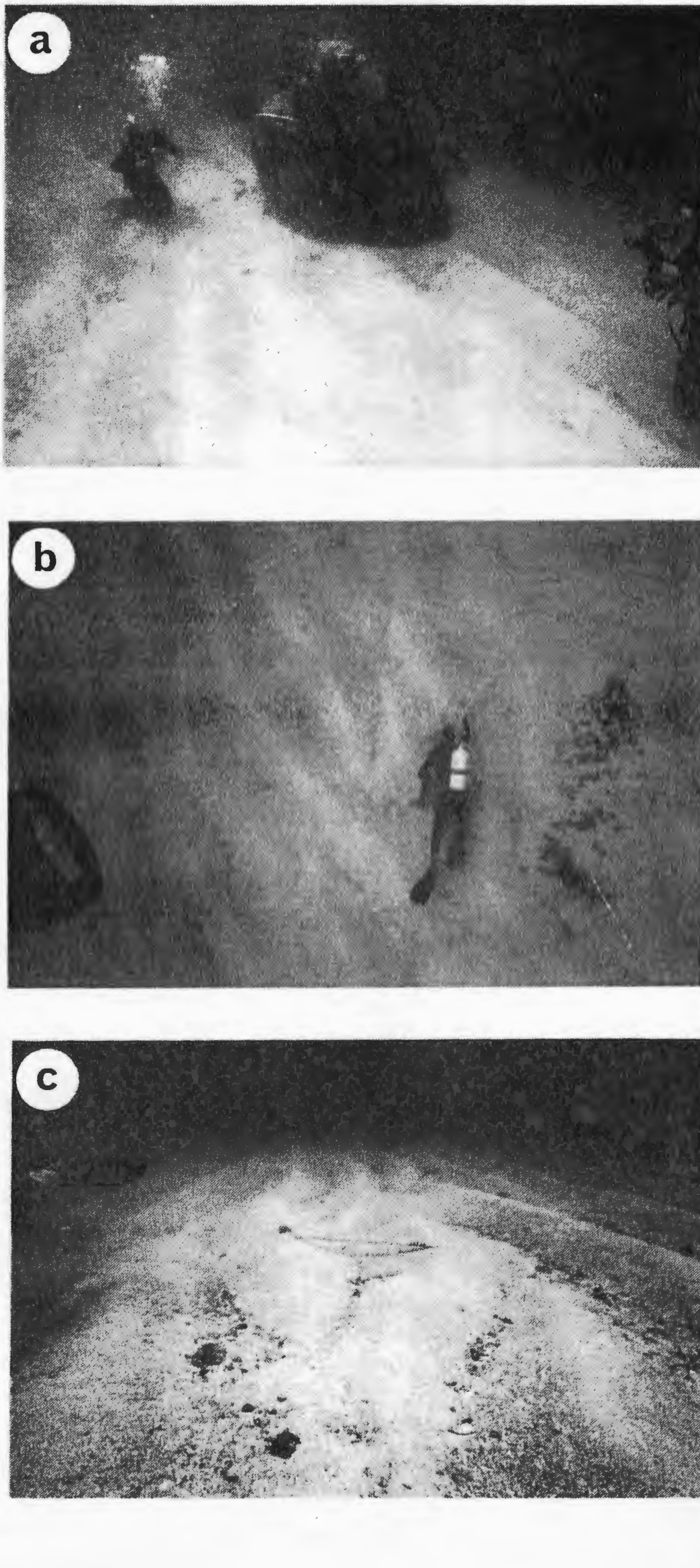


PLATE 4.9

Plate 4.10 Underwater photographs of Facies 3.

(a) View of the maerl (unattached, free-living, branching, coralline-algae) overlying the palimpsest quartzose sand. (The field of view is about one metre). Note the numerous, dark-coloured crinoids (feather-stars), Comanthus wahlbergi, and the elongate shape of the maerls.

(b) Photograph of maerl strips which are orientated WSW-ENE, are 30cm to 50cm wide, and are spaced 50cm apart. The anchor-weight seen in the middle is 40cm long.

(c) Dense assemblage of ophiuroids (brittle stars) on top of the maerl. The measuring-staff is marked at 1cm and 10cm intervals. The ophiuroids are moving out of the way of a carnivorous asteroid (starfish) Marthasterias glacialis.

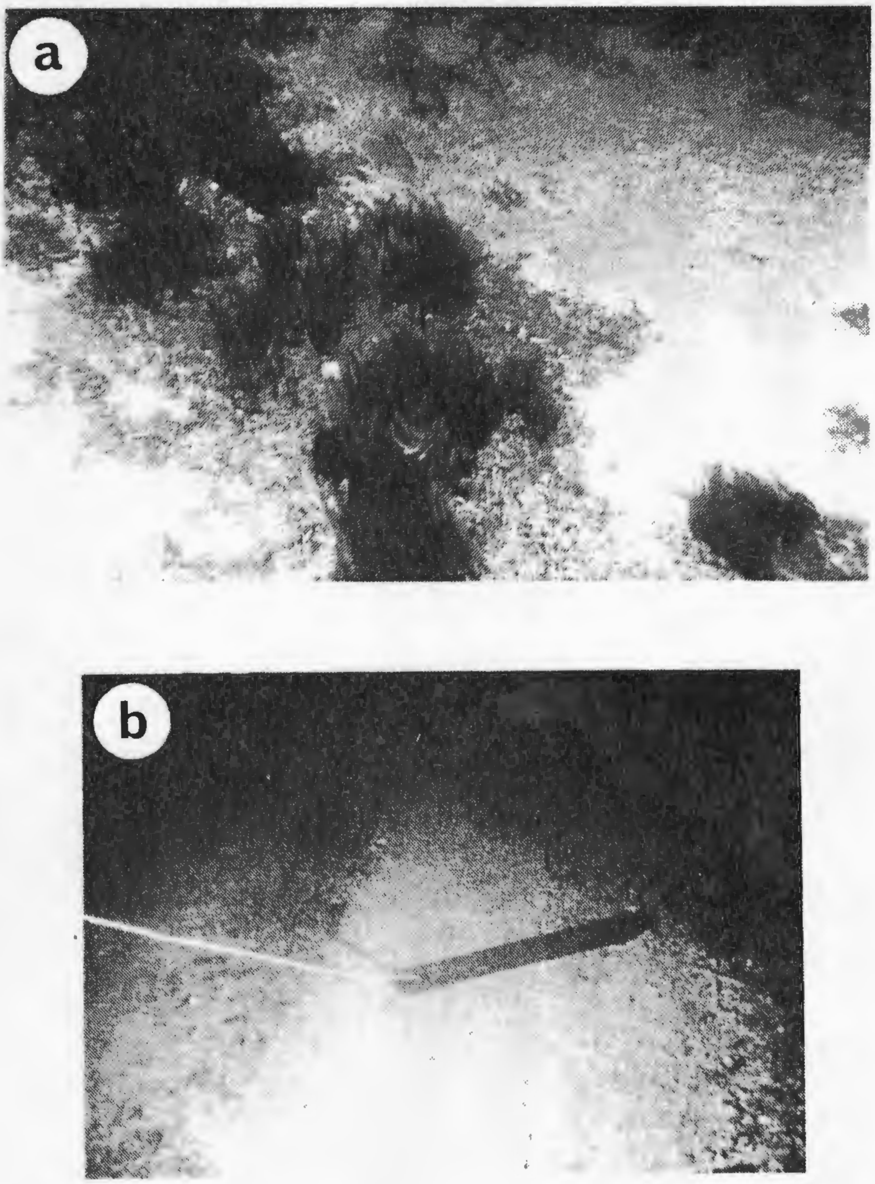


PLATE 4.10

Plate **4.11** Underwater photographs of Facies 4 taken at Sites F and H (Fig. 3.3).

(a) Rippled quartzose fine to medium sand in the "cloud-like" patches. The measuring-staff is marked at 1cm and 10cm intervals. The small-scale ripples are sharp and straight crested and bifurcate, with a WNW-ESE orientation. Note the slightly coarser material in the troughs and the relatively sparse epifauna on the sand.

(b) Rippled quartzose fine to medium sand in the "tongue-like" patches. The field of view is about one metre. The small-scale ripples also are orientated ENE-WSW, and are sharp and straight crested and bifurcate.

(c) Underwater photograph taken at the boundary between Facies 4 (top right-hand corner) and Facies 3. The field of view is about one metre. Note the attraction the maerl has for the ophiuroids, and the horse mussel (<u>Atrina squamifera</u>) protruding above the sand and which is covered with crinoids (<u>Comanthus wahlbergi</u>).

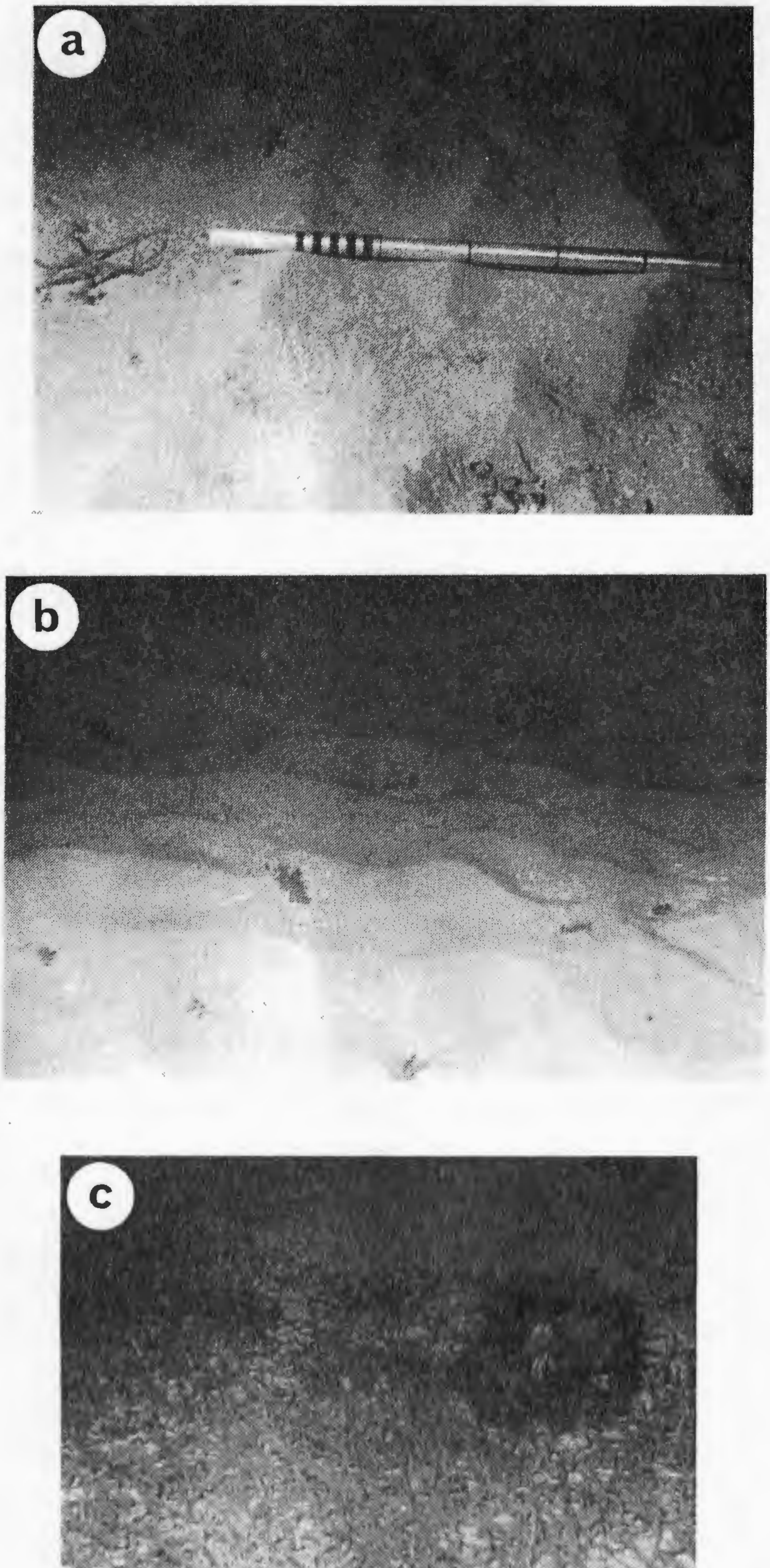


PLATE 4.11

Plate 4.12 (a and b) Underwater photographs of Facies 5 taken at Site J (Fig. 3.3) showing small-scale ripples in a quartzose fine to medium sand. (The field of view is about one metre). The ripples are orientated ENE-WSW and are straight and sharp crested, and show bifurcation. Note the fewer ophiuroids (brittle stars) and the asteroids (Marthasterias glacialis).

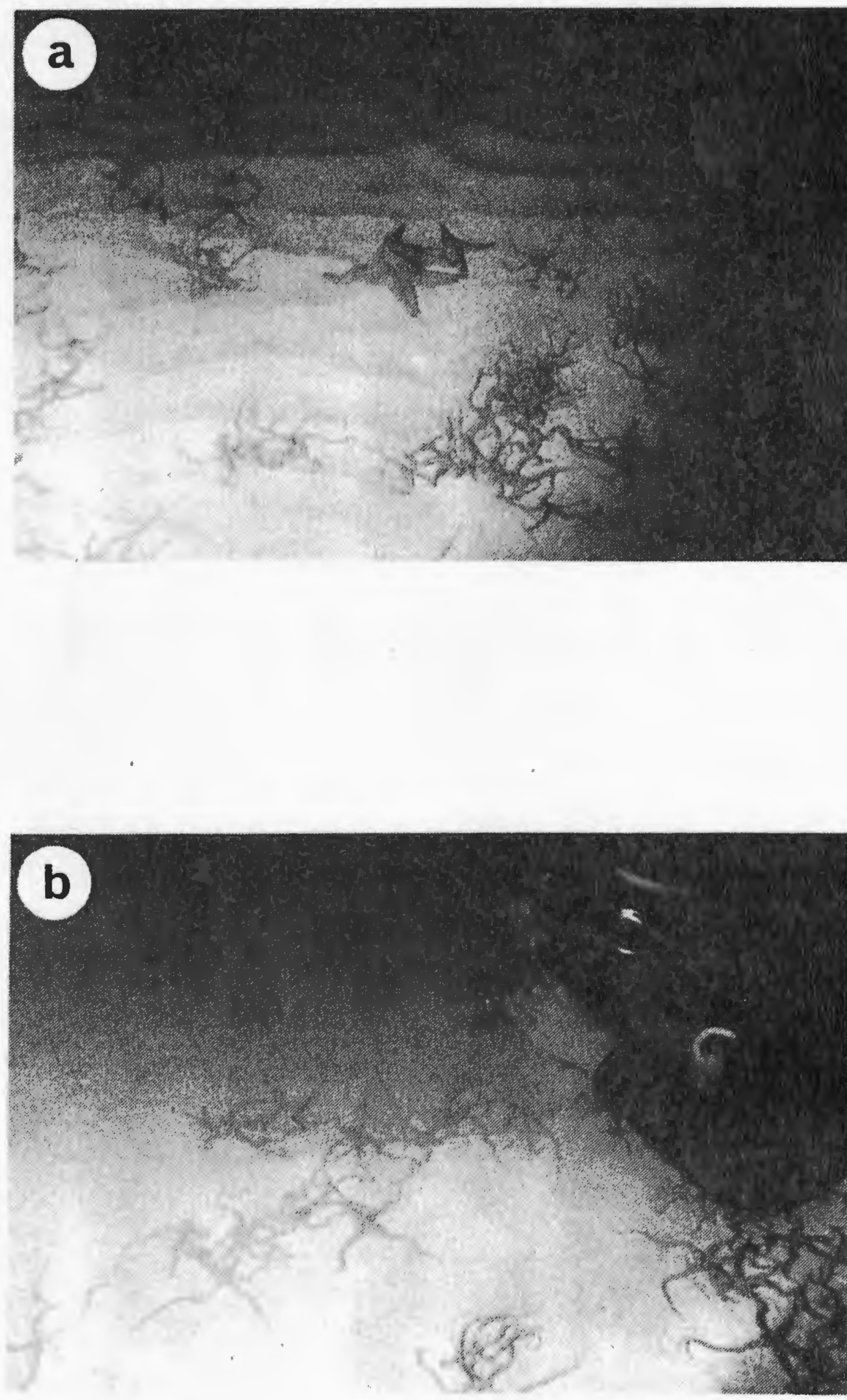


PLATE 4.12

Plate 4.13 Representative samples from Facies 2 to 5.

(a) Sample 28 from Facies 2. This is a coarse calcareous gravelly sand, consisting mostly of cirripede and mollusc fragments.

(b) Sample 20 from Facies 2. This is a quartzose calcareous, relatively well-sorted, coarse sand consisting of a mixture of quartz grains and maerl (fragments of coralline algae).

(c) Sample 62 from Facies 3. This is a calcareous gravel, consisting mostly of cirripede and mollusc fragments, and comes from near granite outcrops.

(d) Sample 46 from Facies 3. This is a calcareous gravelly sand, consisting mostly of cirripede and mollusc fragments, and also comes from near granite outcrops.

(e) Sample 24 from Facies 3. This is a calcareous gravelly sand, consisting of free-living, unattached, coralline algae (maerl) fragments and quartz grains. This sample is from halfway between Roman Rock and the Simon's Town harbour wall.

(f) Sample 70 from Facies 4. This is a calcareous quartzose sand. Note the admixture of coralline-algal-fragments (maerl) in the otherwise quartzose sand.

(g) Sample 5 from Facies 5. This is a benthic-foraminifera-bearing quartzose fine to medium sand.

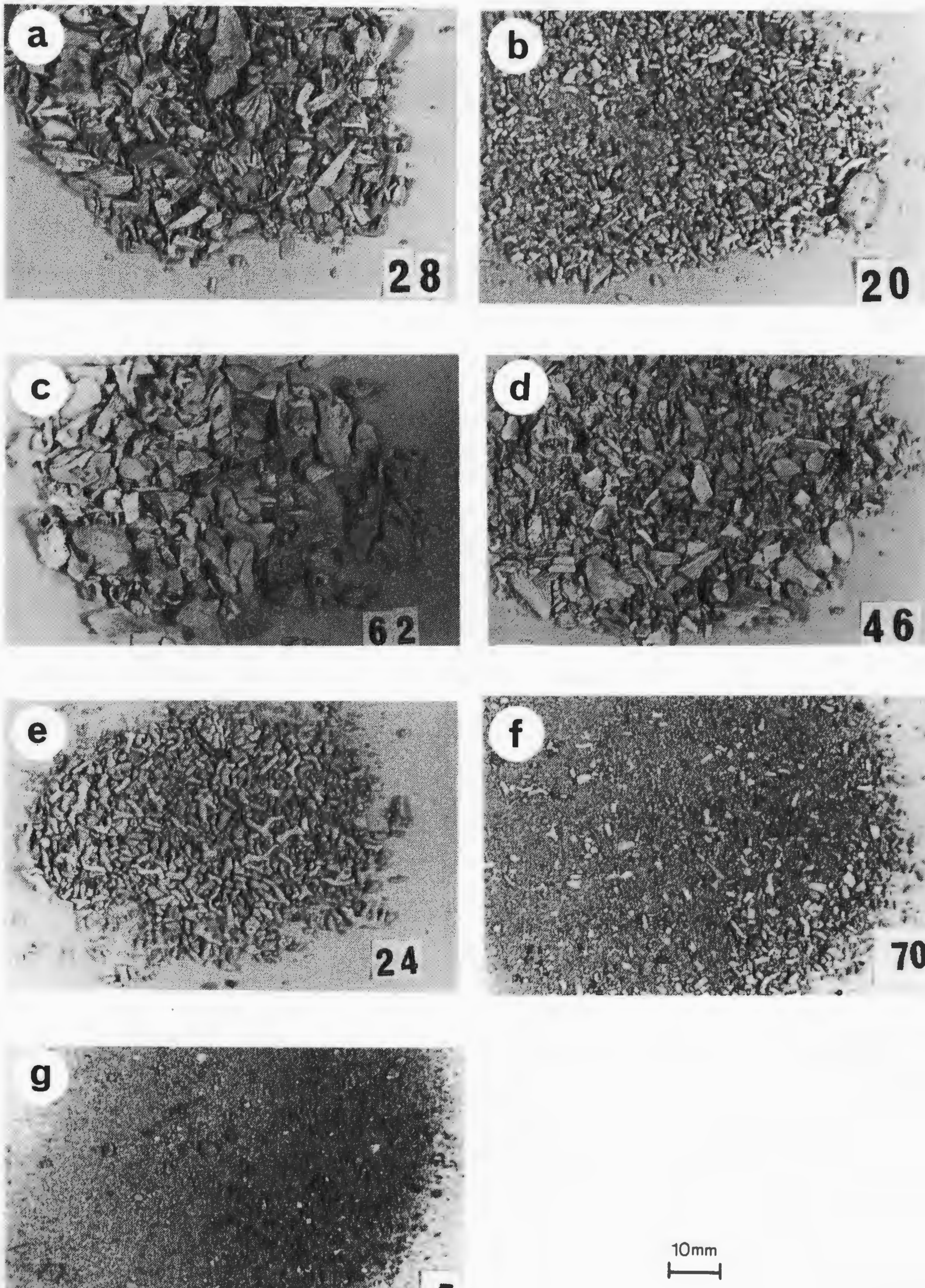


PLATE 4.13

5. DISCUSSION

5.1 Introduction

This chapter discusses the sonograph facies and interprets their significance in understanding the seafloor environment within the study area.

5.2 Sonograph facies

5.2.1 Facies 1 (Cape Peninsula Granite)

The pattern of reflectivity produced by the exposed Cape Peninsula Granite (Facies 1) has been observed elsewhere in False Bay (Gentle, 1971 and 1973) and further afield in Table Bay (Woodborne, 1982) and Saldhana Bay (De la Cruz, 1978) and is typical of granite. The WNW-ESE lineaments seen on the sonographs (Plate 4.1) correspond to the principal joint-direction in the Cape Peninsula Granite (Boocock, 1951; Van der Merwe, 1963; Benfield, 1964; Theron, 1984). As stated in Section 2.2.2, the granite crops out where it is least deeply weathered, and the depth of weathering depends largely on the joint frequency and direction (Linton, 1955; Glass, 1977). Thus the granite pinnacles probably occur where the joints are more widely spaced, and their general NW-SE alignment may be related to the principal WNW-ESE joint direction in the Cape Peninsula Granite.

5.2.2 Facies 2 (Wave-ripples)

The underwater photographs (Plate 4.9) taken by divers at Site D (Fig. 3.3) verify that the Facies-2 pattern of reflectivity (Plates 4.1 and 4.2) is produced by rippled calcareous gravelly-sand or sand (Plates 4.13a and 4.13b).

This pattern has been observed elsewhere along the South African coast in Saldhana Bay (De la Cruz, 1978) and off Namaqualand (Terhorst, 1983; De Decker, 1986; Woodborne, 1987).

The symmetry, WSW-ENE crest-orientation, crest-length, and bifurcation of the ripples indicate that they are formed by orbital currents generated by SSE waves, and therefore should be more accurately defined as long-crested trochoidal wave-ripples (Reineck and Singh, 1973; Inman, 1957).

The wave-ripples are located near or to the north of granite pinnacles (Fig. 4.4). This implies that the orbital currents forming these ripples are intensified where waves from the SSE pass northwards over the pinnacles. The wave-ripple symmetry (Plate 4.9b) indicates that they are stationary features (Inman, 1957; Blatt et al, 1980).

The sediment in which the wave-ripples occurs has a mean size of 0.56mm (coarse sand) and Figure 5.1 (Komar and Millar, 1975) shows that the minimum orbital current-velocity (U_m) needed to move sediment of this size is approximately 0.25 to 0.3 ms^{-1}. Substituting an arbitary wave-period of 10s (within the 8s to 14s range recorded by Shipley (1964)), a value for U_m of 0.3ms^{-1} and a depth (h) of either 20m or 35m (the depth-range of the wave-ripples) into equation 1 (Komar and Millar, 1973), the minimum wave-heights (H) needed for wave-ripple formation are 0.9m and 1.8m at depths of 20m and 35m.

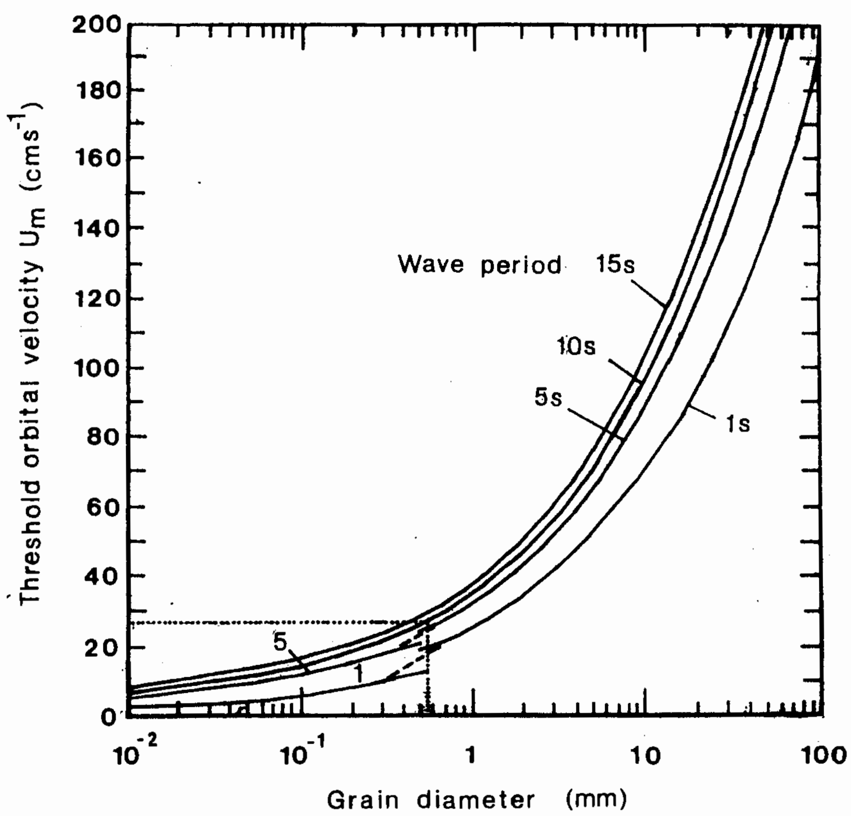


Fig. 5.1 Near-bed maximum orbital velocity U_m for the threshold of sediment movement under waves of different period (From Komar and Millar, 1975).

$$U_m = \pi H/T \ \mathrm{Sinh}(2\pi h/L) \quad \ldots\ldots\ldots (1)$$

U_m = threshold orbital velocity (ms^{-1})
H = Wave-height (m)
T = Period (s)
h = Water-depth (m)
L = Wave-length (m) ($L=1.56T^2$)

The wave-ripples depicted in Plate 4.9 were inactive when seen by divers during fairweather conditions. This, together with the 0.9m to 1.8m range of minimum wave-heights required to generate U_m, and the quiet-water epi-faunal assemblage found in the study area (Section 5.3), suggests that wave-ripple formation probably takes place during summer southeasterly gales, when the highest waves occur in False Bay (Schoonees et al, 1983).

5.2.3 Facies 3 (Patchy veneer of calcareous gravel or gravelly-sand)

The Facies-3 pattern of reflectivity (Plates 4.1 to 4.4) is produced by a patchy veneer of calcareous gravel or gravelly-sand overlying a fine to medium quartzose sand (Plates 4.10, 4.13c, and 4.13d). The patchiness of the calcareous sediment is attributed to a number of environmental factors such as the nature of bottom-currents, type of substrate, predation, and food-supply, that affect the distribution of $CaCO_3$-secreting organisms.

The WSW-ENE orientation of the maerl indicates that the direction of coralline-algal growth may be influenced by SSE-wave-generated orbital currents (Bosence, 1976). The concentration of detritus-feeding ophiuroids on top of the maerl (Plate 4.10c) may be because some entrained detritus becomes trapped in the interlocking branches of coralline-algae as the water filters through them.

The pebble-size quartz and feldspar fragments seen by divers in the vicinity of Site G (Fig. 3.3) are probably eroded out of the underlying saprolite (weathered granite) (Glass, 1977).

5.2.4 Facies 4 (Windows of calcareous fine to medium quartzose sand)

The reflective pattern distinguishing Facies 4 from Facies 3 (Plates 4.2 to 4.4) is produced by large patches of rippled, calcareous, fine to medium, quartzose sand (Plates 4.11, and 4.13f). Belderson et al (1972, p.72 to 74) present sonographs depicting similar light-toned sand patches from the Celtic Sea. The Facies-4 sand patches appear to be windows in the veneer of calcareous gravelly sediment, large enough for side-scan sonar to detect the underlying fine to medium quartzose sand. In contrast, in Facies 3, the much smaller windows of fine to medium quartzose sand in the veneer of calcareous sediment (Plate 4.10a) are too small to be resolved by side-scan sonar. This interpretation is based on evidence provided by underwater photographs taken by divers at Sites G and H (Fig. 3.3 and Plate 4.11).

The WSW-ENE orientation of the "cloud-like" sand patches is probably due to winnowing by SSE-wave-generated orbital currents, whereas the "tongue-like" patches are possibly produced by a predominant northward-moving bottom-current (Atkins, 1970b). The WSW-ENE crest-orientation and bifurcation of the small-scale ripples seen by divers within Facies 4 at Sites F and H (Plate 4.11, Fig. 3.3), suggest that these too are a product of SSE-wave-generated orbital currents.

5.2.5 Facies 5 (Slightly calcareous, fine to medium, quartzose sand)

The Facies-5 pattern of reflectivity (Plate 4.5) denotes an extensive blanket of slightly calcareous, fine to medium, quartzose sand (Plate 4.13g). The speckled areas seen on the sonographs in Facies 5 (Plate 4.5) are attributed to small wave-ripples and epifauna that cannot be resolved by side-scan sonar and not to a change in the sediment texture. This interpretation is verified by underwater photographs of small-scale ripples and epifauna taken at Site J (Fig. 3.3, Plate 4.12) and by the homogeneity of the Facies-5 sediment samples. Bouma et al (1982) and Bouma and Rappeport (1984) also found that an apparently featureless, even-toned seafloor may in fact be covered with features too small or of insufficient density to be resolved by side-scan sonar, and consequently they stress the importance of underwater photography in the verification of sonographs. This project confirms the value of this approach, particularly with respect to Facies 3 to 5.

The WSW-ENE crest-orientation and bifurcation of the small-scale ripples seen in Facies 5 at Site J (Fig. 3.3, Plate 4.12) also implies that these are produced by SSE-wave-generated orbital currents.

5.2.6 Facies 6 (Coarse sediment patches)

Any interpretation of Facies 6 is undermined by the lack of underwater photographs, diver-observations and sufficient sediment samples. The two sediment samples from Facies 6, one a medium quartzose sand and the other a medium calcareous sand, suggest that the Facies-6 pattern of reflectivity (Plates 4.6 and 4.7) represents a medium sand. Plate 4.7 shows Facies 6 as an elongate tongue extending northwards from a granite outcrop (Facies 1). This tongue probably consists of calcareous debris, originating from the rock outcrop, that has been transported northward by the predominant bottom-current. The rounded Facies-6 patches depicted in Plate 4.6 are unverified at present but the writer suspects that they are composed of coarse material derived from the underlying saprolite (weathered granite).

5.3 Modern subtidal energy regime

Due to the lack of subtidal wave- and wind-driven current-data from the the study area, the subtidal energy regime can only be deduced from the type and habitat of epifauna observed by divers and those occurring in sediment samples. The observed epifaunal assemblage indicates that the subtidal zone around Roman Rock is generally a low-energy environment.

The delicate, filter-feeding pinnid bivalve <u>Atrina squamifera</u> (horse-mussel) observed in Facies 4 (Plate 4.11c) typically occurs in fine sediment in a sheltered environment where it is least susceptible to breakage or burial (Day, 1969 p.143; Kilburn and Rippey, 1982 p.167). The same applies to the delicately-branched, free-living, coralline-algae (maerl) which have to live above the sediment in a quiet environment in order to survive (Steneck, 1986). The precarious attachment of the detritus-feeding crinoid <u>Comanthus wahlbergi</u> to the loose maerl and the protruding, vertically-embedded, pinnid bivalves (Plates 4.10a and 4.11c) indicates that bottom-currents must be weak, otherwise the crinoids would be unable to maintain their holdfasts. The great density of ophiuroids observed in Facies 3 (Plates 4.10c and 4.11c) is also indicative of a low-energy environment, according to Branch and Branch (1981, p.238) who comment: "Brittle stars are often gregarious and in deeper, calmer, waters dense assemblages may be found".

Another indication that the subtidal zone is a low-energy environment, is from a side-scan-sonar survey conducted three years earlier of an area overlapping the present study area (Russell-Cargill, 1982). Comparison of the sonographs from both the previous survey and the present study shows no noticeable change in the distribution of sonograph facies.

Thus it appears that in general, the modern subtidal zone in the study area is a stable low-energy environment (as indicated by the epifaunal assemblage), except during prolonged southeasterly gales in summer, when high-energy conditions, sufficient for Facies-2 wave-ripple formation, prevail.

5.4 Sediment mixing in the modern subtidal environment

Flemming (1982) states that the sediment distribution in False Bay can be explained in terms of the sediment-mixing model of Folk and Ward (1957). In his definition of the model, Flemming (1982, p.15) states: "In this model the mixing process between two hydraulic populations of different mean size follows a predictable pattern revealed in the appropriate scatter plots. Progressive mixing implies that a well-sorted coarse population will initially become increasingly finer, more positively skewed and less well-sorted as the proportion of fine sediment increases. By analogy, a well-sorted fine population will become increasingly coarser, more negatively skewed and less well-sorted the greater the proportion of coarse sediment."

Plotting percent carbonate against relative sand-sorting (Table 5.1 - Flemming, 1977 and in press) one sees that the quartzose sands from Facies 4 and 5 are not as well-sorted as the calcareous sediment from Facies 2 and 3 (Fig. 5.2). Figures 5.3 to 5.5 (where mean sand size, relative sand-sorting and skewness are plotted against each other) show that the coarse (Table 5.2) relatively well-sorted sand in Facies 3 becomes less well-sorted and more positively skewed as the proportion of fine sand increases. This trend conforms to the Folk and Ward (1957) sediment-mixing model. The mixing is most apparent in Facies 3 because it has diverse end-members, one a calcareous gravel and the other a moderately- to well-sorted fine to medium quartzose sand, whereas the other facies are predominantly either a coarse calcareous sediment or a fine to medium quartzose sand (Fig. 5.6 and 5.7).

The degree of mixing depends on the intensity of bottom-current activity and on the extent of bioturbation. The mixing of sediments in Facies 3 probably occurs because the underlying exposed fine to medium quartzose sand is more easily entrained than the overlying patchy veneer of coarse calcareous sediment. Once the bottom-current velocity decreases to a point where suspension is no longer possible, the fine to medium quartzose sand settles out on top of the calcareous sand and gravel and in this way the mixing process, as depicted in Figures 5.3 to 5.5, is thought to occur.

Relative Sorting Categories (Flemming, 1977)

0.5 - 1.0	Extremely well sorted
1.0 - 2.0	Very well sorted
2.0 - 4.0	Well sorted
4.0 - 8.0	Moderately sorted
8.0 - 16.0	Poorly sorted
16.0 - 32.0	Very poorly sorted

Table 5.1

Sand Size Classes

Size Class	phi	mm
Very Coarse Sand (vcS)	-1.0 - 0.0	2.0 - 1.0
Coarse Sand (cS)	0.0 - 1.0	1.0 - 0.5
Medium Sand (mS)	1.0 - 2.0	0.5 - 0.25
Fine Sand (fS)	2.0 - 3.0	0.25 - 0.125
Very Fine Sand (vfS)	3.0 - 4.0	0.125 - 0.063

Table 5.2

RELATIVE SORTING vs PERCENT CARBONATE

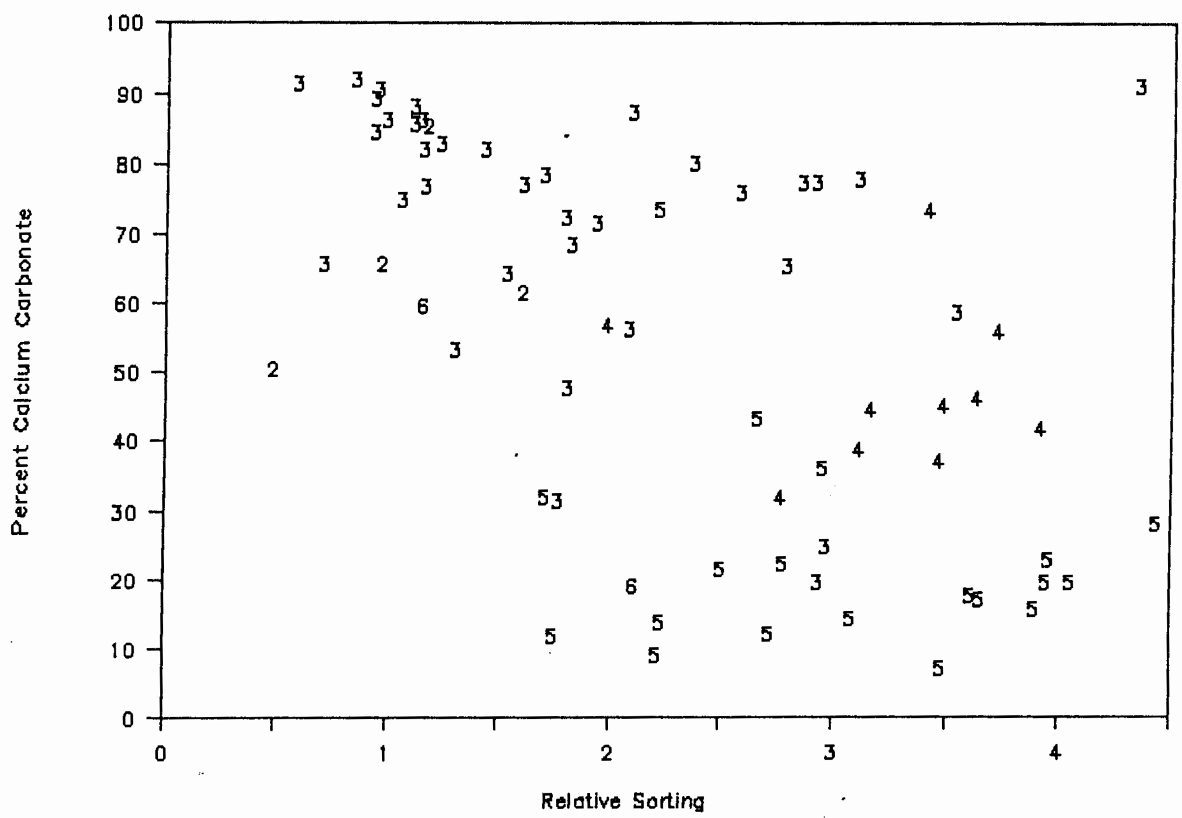


Fig. 5.2 Note that the numbers identify from which sonograph facies each sediment sample comes.

MEAN SAND SIZE vs RELATIVE SORTING

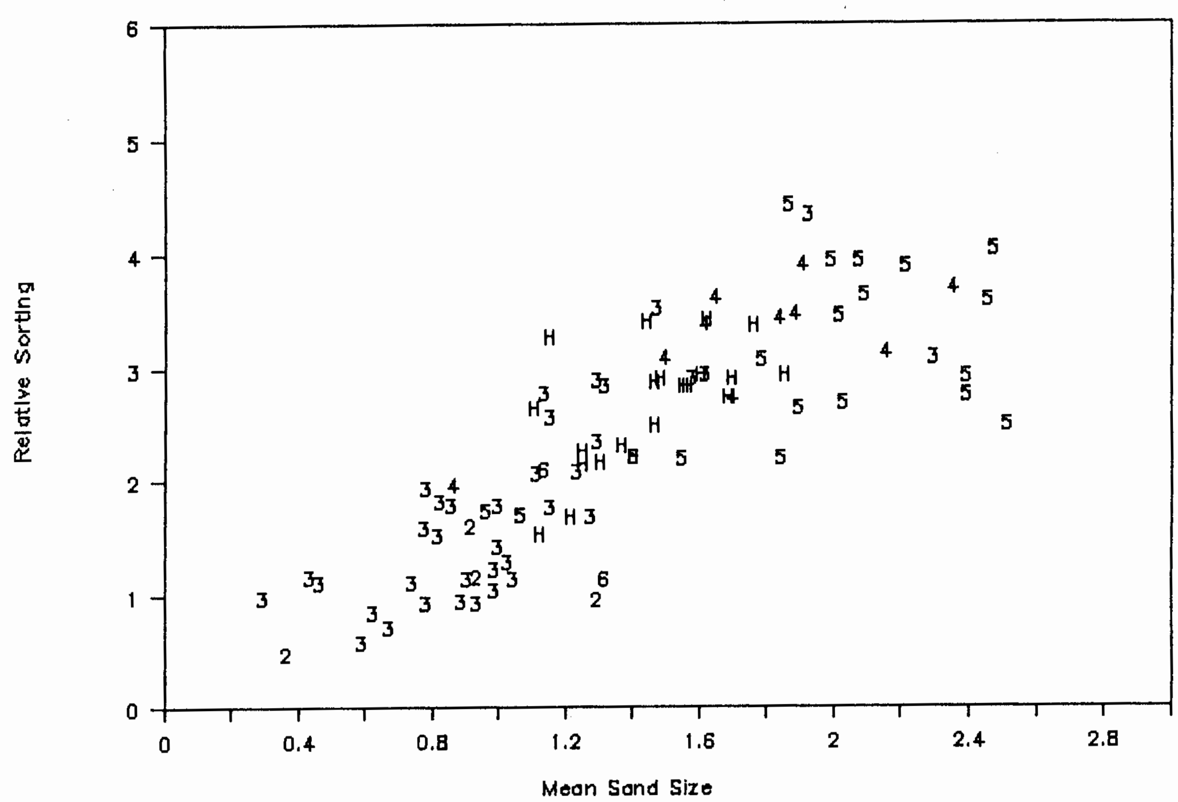


Fig. 5.3 Note the similarity between samples from Borehole B14 at Swartklip (labelled H, from Hay, 1981) with the fine to medium quartzose sands from Facies 3 and 5.

RELATIVE SAND SORTING vs SKEWNESS

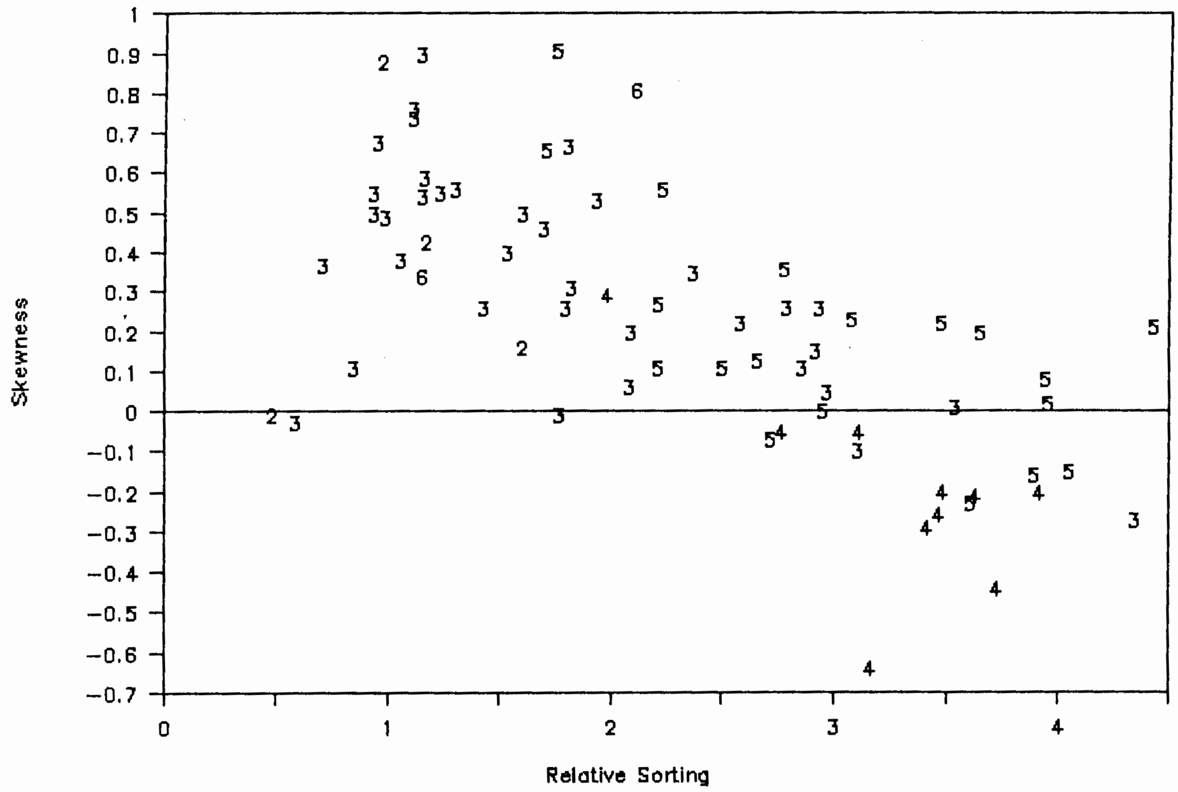


Fig. 5.4

MEAN SAND SIZE vs SKEWNESS

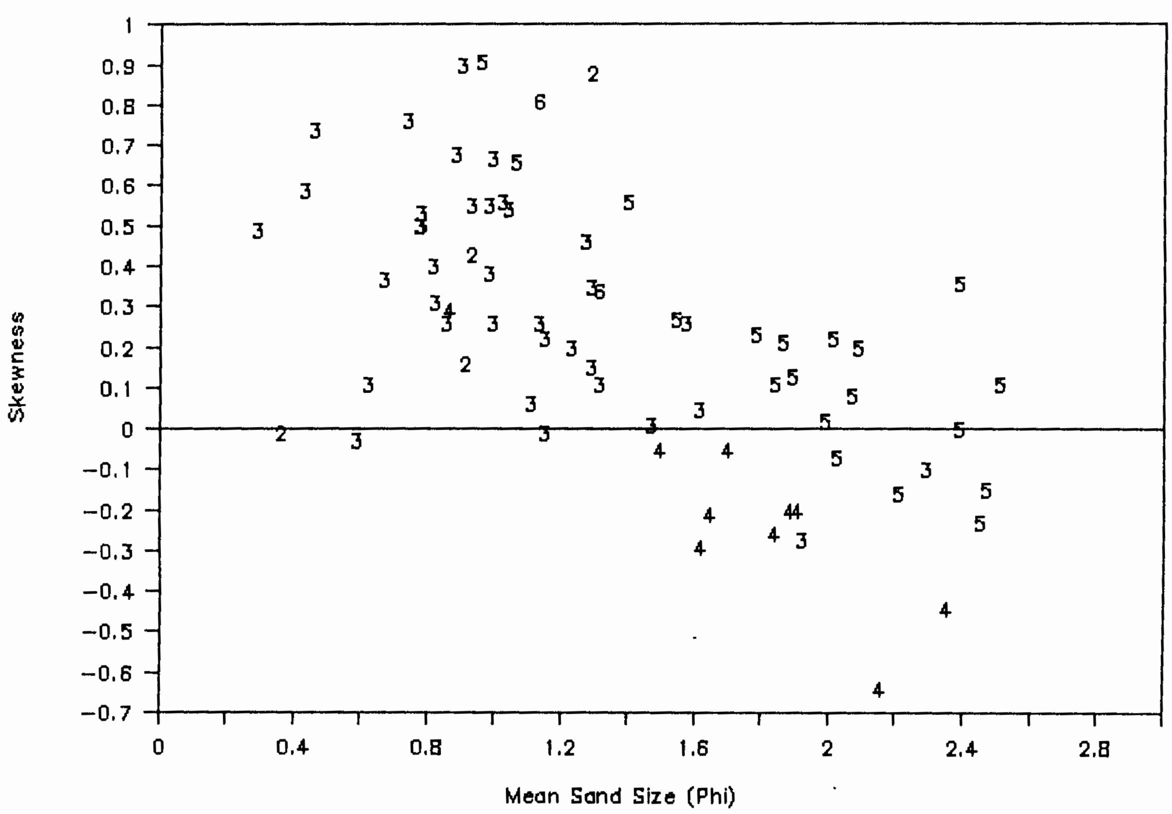


Fig. 5.5

PERCENT GRAVEL vs PERCENT CARBONATE

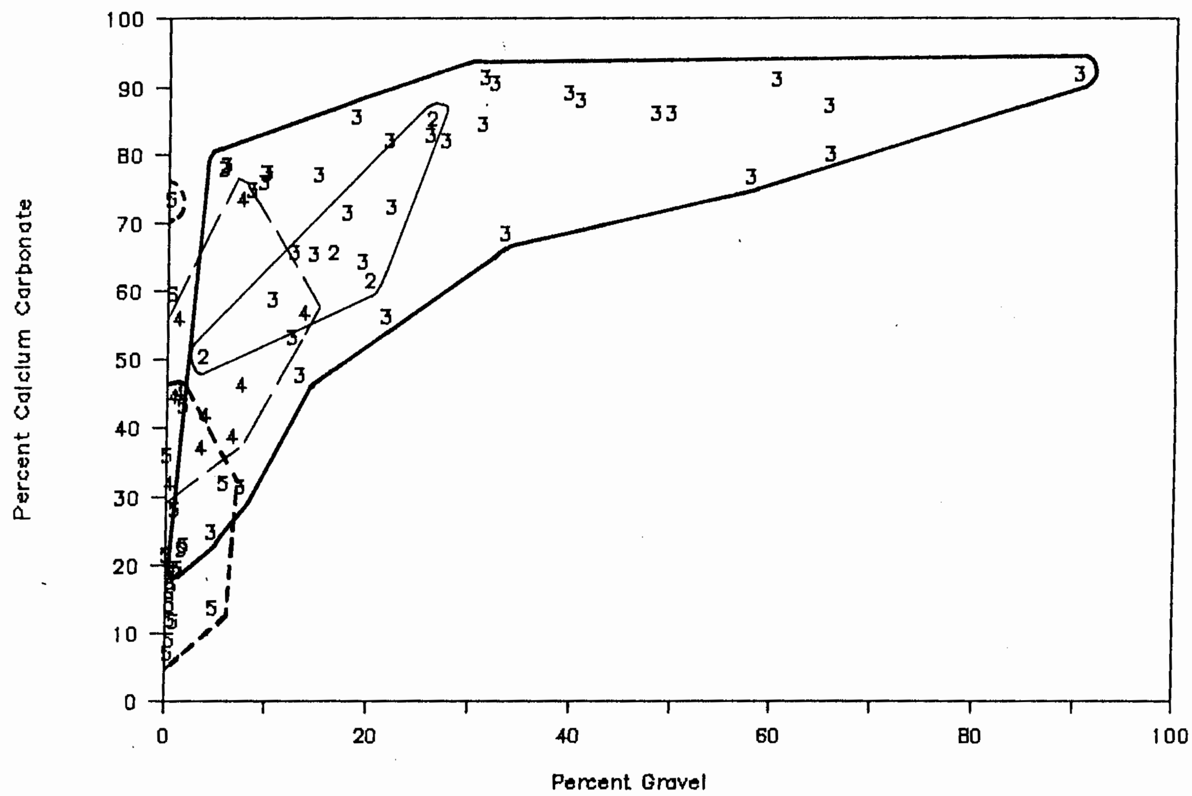


Fig. 5.6

MEAN SAND SIZE vs PERCENT CARBONATE

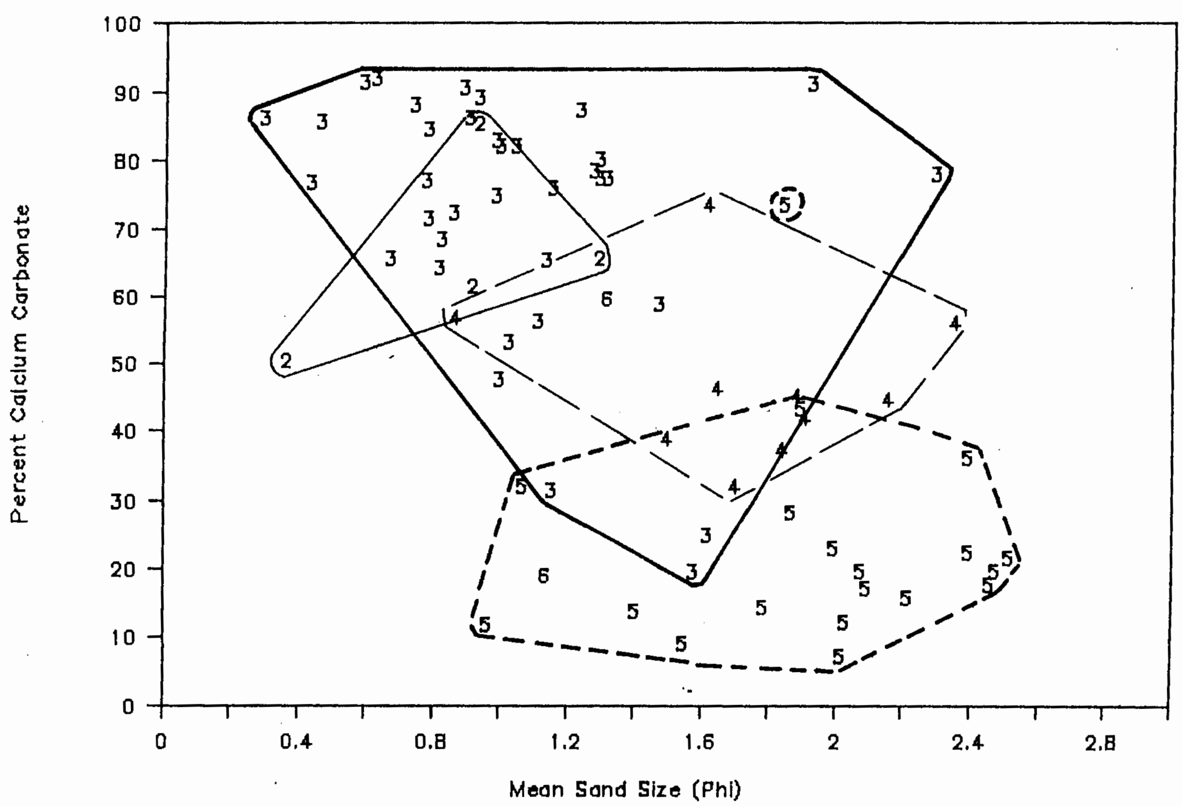


Fig. 5.7

5.5 Quaternary sedimentation

This section discusses the Quaternary sedimentary history of the study area, gleaned from literature on sea-level fluctuations and the relationship between the six sonograph facies (Fig. 5.8).

During the Late Pleistocene Würm II glacial, the sealevel dropped as much as 130m below its present elevation (Chappell, 1974; Tankard, 1976). The Cape Flats would then have extended just beyond the present-day mouth of False Bay (Fig. 1.2). Apart from the granite pinnacles, the study area would have formed part of an extensive dunefield deposited on the newly exposed floor of False Bay (Bowie, 1966). It is probable that parts of the area were also covered by sandstone debris (talus) deposited by mass wasting along the flanks of the Swartberge (Fig. 1.3). During the Flandrian transgression, these Late Pleistocene sediments were probably eroded and redistributed by wave-action as the sea transgressed across the study area.

This process is still occurring along the northern shore of False Bay at Swartklip (Fig. 1.1) where a 50m thick succession of Late Pleistocene sands is being eroded and redistributed by wave-action (Flemming, 1982). Barwis and Tankard (1983) recognise four depositional facies in the Swartklip succession. From the base up, these are beach, estuarine, washover-fan, and aeolian facies (i.e. a Late Pleistocene regressive sequence). The aeolian sediment seen at Swartklip and in boreholes north of Swartklip, consists of cross-bedded, slightly calcareous, moderately- to well-sorted, fine to medium, quartzose sand (Hay, 1981; Barwis and Tankard, 1983). As the quartzose sand found in the study area has similar textural properties to that found at Swartklip (Hay, 1981 - Fig. 5.3), it is concluded that it

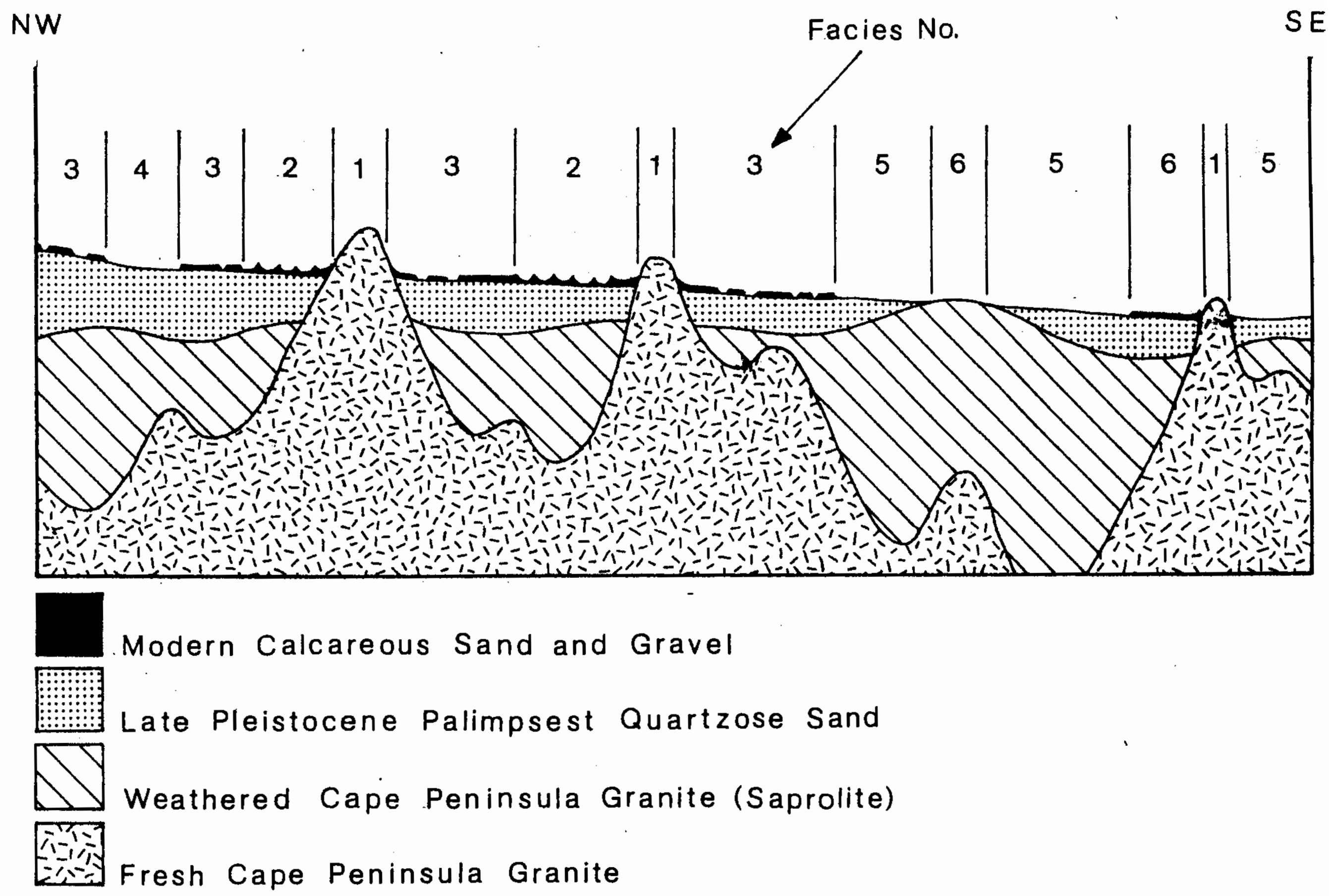


Fig. 5.8 Schematic NW-SE cross-section of the study area showing the probable relationships between the sonograph facies (Not to scale).

is also derived from aeolian deposits that were reworked by waves during the Flandrian transgression. In other words, the quartzose sand found in the study area is relict of both an aeolian and a shoreline environment, but today lies in a modern low-energy subtidal environment that is episodically affected by southeasterly gales in summer. Therefore, it is not only "relict" but also "palimpsest" (Swift et al, 1971).

Figures 4.1 and 4.2 show an extensive terrace, 20 to 22 metres deep, northwest of Roman Rock. Previous studies of Rocky Bank and the inner-shelf along the southwestern coast of Africa reveal wave-cut terraces and submarine cliffs consistent with a previous sealevel stand at approximately -20m (Murray et al, 1970; O'Shea, 1971; Flemming, 1976a; De Decker, 1986; Woodborne, 1987). These wave-cut features date back to the Late Tertiary and have further evolved during more recent re-occupation events (Nunn, 1984; De Decker, 1986; Woodborne, 1987). In the absence of appropriate high-resolution subbottom-profiles, it is difficult to say whether the abovementioned terrace is a relict wave-cut feature or not. However, due to its sheltered setting (Fig. 1.1) it seems improbable, even with a sealevel stand at -20m, that the study area was exposed to wave-action of sufficient intensity to erode a terrace.

The presence of Venus verrucosa shell fragments on the terrace in Facies 3 provides circumstantial evidence to support this statement. According to Day (1968, p. 146) Venus verrucosa lives on the surface of sheltered sand- or gravel-banks in the intertidal zone. This suggests that during the Holocene -20m sealevel stand, the terrace occurred in a low-energy intertidal zone that was covered by quartzose sand upon which Venus verrucosa thrived. As the Flandrian transgression progressed, the Venus verrucosa that once occurred in the former intertidal zone became stranded <u>in-situ</u> in the subtidal zone as the sealevel rose to its present position. This implies that wave-action was too gentle to have eroded a terrace during the Holocene-20m sealevel stand.

Towards the end of the Flandrian transgression, the study area would have become totally submerged, marking the onset of the modern sedimentary environment in which calcareous sediment derived from molluscs, cirripedes, coralline-algae, and other less important carbonate-secreting marine organisms, has accumulated on top of the palimpsest quartzose sand (Fig. 5.8).

6. CONCLUSIONS

Sonographs from an approximately 12 square-kilometre area off Simon's Town, in the northwestern corner of False Bay, show six patterns of acoustic reflectivity (sonograph facies) namely Facies 1 to 6. These have been interpreted with good ground-control in the form of echosounder data, bottom samples, and in-situ observations by SCUBA divers.

Facies 1 is characterised by lineaments within an irregular, blocky, pattern of light and dark tones, which define outcrops of Cape Peninsula Granite in the middle of the study area. The granite outcrops are aligned roughly NW-SE, and appear the same underwater as they do along the coast to the west of the study area. The lineaments seen on the sonographs correspond to the principal WNW-ESE joint-direction measured in the onshore granite outcrops. The granite presumably crops out where the joints are more widely spaced, and the NW-SE orientation of the pinnacles is thought to be controlled by the principal WNW-ESE joint-direction.

Facies 2 is distinguished by alternating bands of light and dark tones spaced about a metre apart and orientated WSW-ENE that occur mostly near granite outcrops (Facies 1). This pattern defines stationary, long-crested, trochoidal wave-ripples probably formed during prolonged southeasterly gales in summer.

Facies 3 is denoted by an uneven, featureless, grey tone that defines a patchy veneer of calcareous gravel and sand overlying quartzose fine to medium sand. It is found in the shallower western half of the study area at depths less than 35m. The calcareous sediment is derived from marine organisms which live either attached to outcropping granite, or on the seafloor surface.

Facies 4 is defined by "cloud-like" and "tongue-like" patches of light tone which represent windows of underlying rippled, quartzose, fine to medium sand in the overlying veneer of calcareous gravelly sediment (Facies 3). The shape of the patches probably reflects wind- and wave-generated current-action.

Facies 5 is characterised by a slightly speckled, but otherwise featureless, light tone that depicts a blanket of rippled, quartzose, fine to medium sand in the deeper (>25m) eastern part of the study area.

Facies 6 is defined by rounded and elongate patches of medium-grey tone that occur within Facies 5. This pattern probably represents coarse sediment. Additional sediment samples, diver-observations and underwater photographs are needed to verify this facies.

Judging by the type of epifauna seen by SCUBA divers and in the sediment samples and comparing the sonographs from the study area with those from an earlier side-scan-sonar survey, the subtidal zone of the study area is generally a low-energy environment. Extreme wave-energy conditions, sufficient to generate wave-ripples in Facies 2, probably occur during prolonged southeasterly gales in summer.

Analysis of the sediment samples shows that sediment-mixing occurs between the calcareous and quartzose sediments. The mixing is most apparent in Facies 3 because it has both calcareous gravel and fine to medium quartzose sand as end-members.

The quartzose sand found in the study area appears to have been derived from Late Pleistocene aeolian deposits that were reworked during the Flandrian transgression. If this is true, then the quartzose sands that now lie in a low-energy subtidal environment are not only "relict" but are also "palimpsest". The beginning of the modern subtidal environment is marked by the deposition of calcareous sediment on top of the "palimpsest" sand. The probable stratigraphic relationship between the sonograph facies is depicted in Figure 5.8.

Finally, it can be stated that side-scan sonar has shown that the surficial geology off Simon's Town is more complicated than previous research had indicated. This study has also emphasised the importance of bottom sampling, <u>in-situ</u> diver-observations and underwater photography in the verification of side-scan-sonar imagery. Long-term bottom-current- and wave-measurements, along with high-resolution sub-bottom-profiles verified by vibrocores are required before a more quantitative analysis of sediment movement can be made.

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REFERENCES

ATKINS, G.R. 1970a. Thermal structure and salinity of False Bay. Trans. Roy. Soc. S. Afr., 39(2): 117-128.

ATKINS, G.R. 1970b. Winds and current patterns in False Bay. Trans. Roy. Soc. S. Afr., 39(2): 139-148.

BANG, N.D. 1967. Oceanography and a naval tragedy. Lantern, 17(1): 84-87.

BARWIS, J.H. and TANKARD, A.J. 1983. Pleistocene shoreline deposition and sea-level history at Swartklip, South Africa. J. Sed. Petr., 53(4): 1281-1294.

BATES, R.L. and JACKSON, J.A. (Eds.) 1980. Glossary of Geology (2nd Ed.). Falls Church, Virginia: American Geological Institute, 749pp.

BELDERSON, R.H., KENYON, N.H., STRIDE, A.H. and STUBBS, A.R. 1972. Sonographs of the Seafloor. Amsterdam: Elsevier, 185pp.

BENFIELD, G.C. 1964. The Geology of a Portion of the Cape Peninsula., Hons. Proj., Geology Dept., Univ. Cape Town, 89pp.

BIRCH, G.F. 1981. The Karbonat Bombe: A precise, rapid and cheap method for determining calcium carbonate in sediments and rocks. Trans. geol. Soc. S. Afr., 84: 199-203.

BLATT, H., MIDDLETON, G. and MURRAY, R. 1980. Origin of Sedimentary Rocks (2nd Ed.). New Jersey: Prentice Hall, 782pp.

BOOCOCK, C. 1951. The structural features and inclusions of the Cape Peninsula Granite. Trans. Roy. Soc. S. Afr., 33(1): 243-278.

BOSENCE, D.W.J. 1976. Ecological studies on two unattached coralline algae from western Ireland. Palaeontology, 19: 365-395.

BOUMA, A.H., BRENNER, R.L. and KNEBEL, H.J. 1982. Continental shelf and epicontinental seaways. Mem. Am. Ass. Petrol. Geol., 31: 281-327.

BOUMA, A.H. and RAPPEPORT, M.L. 1984. Verification of side-scan sonar acoustic imagery by underwater photography. In: Smith, P.L. (Ed.). Underwater Photography- Scientific and Industrial Applications. New York: Van Nostrand Reinhold, 279-294.

BOWIE, D.K. 1966. The Marine Geology Of False Bay. M.Sc Thesis, Geology Dept., Univ. Cape Town, 135 pp.

BOWIE, D.K., FULLER, A.O. and SIESSER, W.G. 1970. The marine sediments of False Bay. Trans. Roy. Soc. S. Afr., 39(2): 149-161.

BRANCH, G. and BRANCH, M. 1981. The Living Shores of Southern Africa. Cape Town: Struik, 272pp.

BRINK, V.D.S. and ROGERS, J. 1985. Rapid granulometry of sand using a computer-linked settling-tube. Tech. Rep. jt. Geol. Surv./Univ. Cape Town mar. Geosc. Unit, 15: 73-125.

BROWNE, P.R.L. 1963. Geology of the Simon's Town Area. Hons. Proj., Geology Dept., Univ. Cape Town, 62 pp.

CHAPPELL, J. 1974. Late Quaternary glacio-hydro-isostasy, on a layered Earth. Quat. Res., 4: 405-428.

CRAM, D.L. 1970. A suggested origin for the cold surface water in central False Bay. Trans. Roy. Soc. S. Afr., 39(2): 129-137.

DARBYSHIRE, J. and DARBYSHIRE, M. 1964. Wave observations in South African waters. S. Afr. J. Sci., 60: 183-189.

DARBYSHIRE J. and PRITCHARD, E. 1966. Sea waves near the coasts of South Africa. Dt. hydrogr. Z., 19(5): 218-225.

DAVIES, J.L. 1972. Geographical Variation in Coastal Development. Edinburgh: Oliver and Boyd, 204 pp.

DAY, J.H. 1969. A Guide to Marine Life on South African Shores. Cape Town: Balkema, 300pp.

DAY, R.W. 1986. Magnetometric mapping of the False Bay dolerites. Tech. Rep. jt. Geol. Surv./Univ. Cape Town mar. Geosc. Unit, 16: 217-227.

DE DECKER, R.H. 1986. The Geological Setting of Diamondiferous Deposits on the Inner Shelf between the Orange River and Wreck point, Namaqualand. M.Sc. Thesis, Geology Dept., Univ. Cape Town, 258pp.

DE LA CRUZ, M.A. 1978. Marine geophysical and geological investigations in Saldanha Bay. Bull. jt. Geol. Surv./Univ. Cape Town mar. Geosc. Unit, 9: 1-115.

DINGLE, R.V. and ROGERS, J. 1972. Pleistocene palaeogeography of the Agulhas Bank. Trans. roy. Soc. S. Afr., 40(3): 155-165.

DUCK, R.W. and McMANUS, J. 1985. A sidescan sonar survey of a previously drawn-down reservoir: A control experiment. Int. J. Remote Sens., 6(5): 601-609.

FLEMMING, B.W. 1976a. Rocky Bank- Evidence for a relict wave-cut platform. Ann. S. Afr. Mus., 71: 33-48.

FLEMMING, B.W. 1976b. Side-scan sonar: A practical guide. Int. Hyd. Rev., L III(1): 65-92.

FLEMMING, B.W. 1977. Depositional processes in Saldanha Bay and Langebaan Lagoon. Bull. jt. Geol. Surv./Univ. Cape Town mar. Geosc. Unit., 8: 215pp.

FLEMMING, B.W. 1982. The geology of False Bay with special emphasis on modern sediments. Rep. S. Afr. Coun. sci. and ind. Res., C/SEA 8253: 1-20.

FLEMMING, B.W. (In press). Process and pattern of sediment mixing in a microtidal coastal lagoon along the west coast of southern Africa. In: De Boer, P.L., van Gelder, A. and Nio, S.D. (Eds.). Tide Influenced Sedimentary Environments and Facies. Dordrecht: D. Reidel Publ. Co.

FOLK, R.L. and WARD, W.C. 1957. Brazos River bar: A study in the significance of grainsize parameters. J. sed. Petr., 27: 3-26.

FULLER, A.O. 1961. Size distribution characteristics of shallow marine sands from the Cape of Good Hope, South Africa. J. sed. Petr., 31: 256-261.

FULLER, A.O. 1962. Systematic fractionation of sand in the shallow marine and beach environment off the South African coast. J. sed. Petr., 32: 602-606.

GENTLE, R.I. 1971. Pre-Quaternary geology of the continental Shelf between Cape Infanta and Cape Town. Tech. Rep. Univ. Cape Town SANCOR mar. Geol. Unit, 3: 13-27.

GENTLE, R.I. 1973. Sidescan sonar in marine geological investigations of the South African Continental Shelf. S. Afr. J. of Sci., 69: 360-367.

GLASS, J.G.K. 1976. The bathymetry and geology of False Bay. Tech. Rep. jt. Geol. Surv./Univ. Cape Town mar. Geosc. Unit, 8: 60-63.

GLASS, J.G.K. 1977. Deep weathering of the southwestern Cape Granite and Malmesbury Group: Palaeoclimatic implications. Tech. Rep. jt. Geol. Surv./Univ. Cape Town mar. Geosc. Unit, 9: 118-135.

GLASS, J.G.K. 1980. Geology, morphology, sediment cover and movement. In: Gasson, B. (Ed.). The Future Management of False Bay. Cape Town: False Bay Cons. Soc.: 15-25.

GLASS, J.G.K. and DU PLESSIS, A. 1976. The bathymetry of False Bay as an indicator of seafloor geology. Proc. 1st Interdisciplinary Conf. mar. and freshwater Res. S. Afr., Port Elizabeth. S.122: Fiche 6D5-E6, 1B6-E2.

HAUGHTON, S.H. 1933. The geology of Cape Town and adjoining country. Geol. Surv. S. Afr., Explan. Sh. 247 (Cape Town), 90pp.

HAY, E.R. 1981. A stratigraphic and sedimentological analysis of borehole data from a portion of the Cape Flats. Hons. Proj., Geology Dept., Univ. Cape Town, 43 pp.

HUNTER, R.E., THOR, D.R. and SWISHER, M.L. 1982. Depositional and erosional features of the inner shelf, northeastern Bering Sea. In: Nelson, C.H. and Nio, S.D. (Eds.): The northeastern Bering Shelf: New perspectives of epicontinental shelf processes and depositional products. Geologie en Mijnbouw, 61: 049-062.

INGRAM, R.L. 1965. Facies maps based on the megascopic examination of modern sediments. J. sed. Petr., 35(5): 619-625.

INMAN, D.L. 1957. Wave-generated Ripples in Nearshore Sands. U.S. Army Corps of Engineers Beach Erosion Board Tech. Memo no. 100, 67 pp.

JURY, M.R. 1980. Characteristics of Summer Wind Fields and Air-Sea Interactions over the Cape Peninsula Upwelling Region. M.Sc Thesis, Geography Dept., Univ. Cape Town, 131 pp.

KEEN, C.S. 1980. Meteorological aspects of False Bay. In: Gasson, B. (Ed.). The Future Management of False Bay. Cape Town: False Bay Cons. Soc.: 34-41.

KIDD, R.B., SIMM, R.W. and SEARLE, R.C. 1985. Sonar acoustic facies and sediment distribution on an area of the deep ocean floor. Mar. Petrol. Geol., 2: 210-221.

KILBURN, R. and RIPPEY, E. 1982. Sea Shells of Southern Africa. Johannesburg: Macmillan, 249pp.

KOMAR, P.D. and MILLAR, M.C. 1973. The threshold of sediment transport under oscillatory waves. J. Sed. Petr., 43: 1101-1110.

KOMAR, P.D. and MILLAR, M.C. 1975. On the comparison of the threshold of sediment motion under waves and unidirectional currents with a discussion of the practical evaluation of the threshold. J. Sed. Petr., 45: 362-367.

LINTON, D.L. 1955. The problem of tors. Geog. J., 71: 470-486.

MORGANS, J.F.C. 1956. Notes on the analysis of shallow-water soft substrate. J. Animal Ecol., 25: 367-387.

MURRAY, J. and RENARD, A.F. 1891. Deep-Sea Deposits, Rep. Sci. Res. H.M.S. Challenger 1874-1876. London: Her Majesty's Stationary Office, 525pp.

MULLER, G. and GASTNER, M. 1971. The "Karbonat Bombe", a simple device for the determination of carbonate content in sediments, soils and other minerals. N. Jb. Mineral., 10: 446-469.

MUNSELL SOIL COLOR CHARTS. 1975 Ed. Munsell color. Macbeth. Kollmorgen Corporation, Maryland, USA.

NUNN, P.D. 1984. Review of evidence for Late Tertiary shorelines occurring on South atlantic coasts. Earth Sci. Rev., 20: 185-210.

POTGIETER, E. 1986. Eienskappe van die windsnelheid en rigting soos gemeet in die Simonstadse Hawe vir die jare 1975-1981. Proj. Pamphlet. Inst. for Maritime Tech., MT066/006-86: 1-85.

REINECK, H.E and SINGH, I.B. 1973. Depositional Sedimentary Environments. Berlin: Springer-Verlag, 439pp.

RETIEF, G de F. 1970. Sediment transport in Gordon's Bay. Trans. Roy. Soc. S. Afr., 39(2): 115-120.

ROBERTSON, I.D.M. 1964. Progress Report on the Investigation of Wave-Cut Platforms. Oceanography Dept., Univ. Cape Town: 11 pp.

ROSSOUW, J. 1984. Review of existing wave data, wave climate and design waves for South African and South West African (Namibian) coastal waters. Rep. S. Afr. Coun. sci. ind. Res., T/SEA 8401: 1-66.

RUSSELL, I.C. 1978. Dual channel sidescan sonar- Uses and operation in hydrographic surveying. Int. Hyd. Rev., LV(1): 27-100.

RUSSELL-CARGILL, W.G.A. 1982. Project Hydra: General background to the project development. Tech. Rep. Inst. Mar. Tech., TV-019-82: 1-64.

SCHOONEES, J.S., SCHOLTZ, D.J.P., VAN TONDER, A., MOLLER, J.P. and LENHOFF, L. 1983. Valsbaai: Veldata verslag. Rep. S. Afr. Coun. sci. ind. Res., C/SEA 8219: 1-54.

SCHULZE, B.R. 1965. Climate of South Africa, Part 8: General survey. Weather Bur. Dept. of Transport S. Afr., WB 28: 1-330.

SHEPARD, F.P. 1954. Nomenclature based on sand-silt-clay ratios. J. sed. Petr., 24: 151-158.

SHIPLEY, A.M. 1964. Some aspects of wave refraction in False Bay. S. Afr. J. of Sci., 60: 115-120.

SIMPSON, E.S.W., DU PLESSIS, A. and FORDER, E. 1970. Bathymetric and magnetic traverse measurements in False Bay and west of the Cape Peninsula. Trans. Roy. Soc. S. Afr., 39(2): 163-182.

STEFANON, A. 1985. Marine sedimentology through modern acoustical methods: 1 Side scan sonar. Bolletino Oceanologia Teorica Ed Applicata, 3(1): 3-38.

STENECK, R.S. 1986. The ecology of coralline algal crusts: Convergent patterns and adaptive strategies. Ann. Rev. Ecol. Syst., 17: 273-303.

STRIDE, A.H. (Ed.) 1982. Offshore Tidal Sands- Processes and Deposits. London: Chapman and Hall, 222pp.

SWIFT, D.J.P., STANLEY, D.J., CURRAY, J.R. 1971. Relict sediments on Continental Shelves: A consideration. J. Geol., 79: 322-346.

TANKARD, A.J. 1976. Cenozoic sea-level changes: A discussion. Ann. S. Afr. Mus., 71: 1-14.

TEICHERT, E.S. 1986. A computer-based side-scan sonar survey system. Tech. Rep. Inst. Maritime Tech, TV-017-86: 1-34.

TERHORST, A.L.M. 1983. The Seafloor Character in Block 1 of State Alluvial Diggings Concession No. 3., Hons. proj., Geology Dept., Univ. Cape Town, 41pp.

TERHORST, A.L.M. 1986. Mapping a dynamic seafloor using side-scan sonar: A literature review. Tech. Rep. Inst. Maritime Tech., TV-012-86: 1-69.

THERON, J. N. 1984. The geology of Cape Town and environs. Geol. Surv. S. Afr. Explan. Sh. 3318 CD and DC, 3418 AB, AD and BA.: 77pp.

UNDERWATER SURVEYS (PTY.) LTD. 1985. Hydrographic Survey Results Simons Bay. Tech. Note, UWS/IMT/IR: 1-8

VAN DER MERWE, W.J. 1963. Geology of the Northern Cape Peninsula. M.Sc Thesis, Geology Dept., Univ. Cape Town, 170 pp.

VAN FOREEST, D. 1984. False Bay: A numerical model of the wind-driven circulation. Rep. S. Afr. Coun. sci. and ind. Res., C/SEA 8423: 1-15.

VAN FOREEST, D. and BRUNDRIT, G.B. 1985. Numerical modelling of the southern Benguela system. In: Shannon, L.V. (Ed.). South African Ocean Colour Experiment. Cape Town: Sea Fish. Res. Inst.: 111-124.

VAN FOREEST, D. and JURY, M.R. 1985. A numerical model of the wind-driven circulation in False Bay. S. Afr. J. Sci., 81: 312-317.

WILLIAMS, S.J. 1982. Use of high resolution seismic reflection and side-scan sonar equipment for offshore surveys. U.S Army, Corps of Engineers, Coastal Engineering Tech. Aid, Report No. 82-5.

WOODBORNE, M.W. 1982. Sediment Distribution and the Correlation Between Lithofacies and Associated Seismic Reflection Signatures in Table Bay. Hons. proj., Geology Dept., Univ. Cape Town, 34pp.

WOODBORNE, M.W. 1987. The Geology of the Diamondiferous Inner Shelf Off Namaqualand Between Stompneus Bay and White Point Just North of the Buffels River. M.Sc thesis, Geology Dept., Univ. Cape Town, 96pp.

APPENDIX A

This appendix explains how the resolution limits of the side-scan-sonar are determined.

(a) Along-track resolution

The along-track resolution is defined as the minimum distance between two objects in the along-track direction that will be recorded on the side-scan-sonar record (sonograph) as separate objects (Flemming, 1976b). This minimum distance is equal to the width of the sonar beam at any particular point on the seafloor, and this increases towards the far-range. At 100m range, the along-track resolution will be:

$$R_t = \text{Sin } 1.2^{\circ} \text{ X } 100\text{m} = 2.09\text{m}$$

Where R_t is the along-track resolution, 1.2° is the width of the sonar beam in the horizontal plane, and 100m is the across-track range.

(b) Across-track resolution

The across-track resolution is defined as the minimum distance between two objects perpendicular to the along-track direction, that will be recorded on the sonograph as separate objects (Flemming, 1976b). The EG&G Model 260 side-scan-sonar recorder, which has 100mm paper-width per channel, can separate objects spaced 0.25mm apart on the sonograph. Therefore, the across-track resolution will be:

$$R_r = 0.25\text{mm}/100\text{mm X } 100\text{m} = 0.25\text{m}$$

Where R_r is the across-track resolution, 0.25mm is the minimum distance needed to record two separate objects on the sonograph, 100mm is the paper-width per channel, and 100m is the scanning-range.

APPENDIX B

This appendix lists the runstreams used to call up the UCT version of the SACLANTCEN contour and three-dimensional (3-D) graphics package which was used to generate the 1m-contour-interval bathymetry map and the three-dimensional bathymetric image of the study area (Figs. 4.1 and 4.2). These were executed on the UCT Sperry Univac mainframe-computer.

(a) Contour program

```
@RUN, Z/NR ANDY, ACCNT/USER, MGEO, 30, 50
@ASG,A ANDY2.
@ASG, UP POLY
@DATA, IL POLY
51730 84000
51040 82100
49940 82925
46100 82925
46100 84750
49940 84750
49940 84340
@END
@GDP*ABS.INPUT PLOT.
@ADD SYS$*3D. XQT
RSPACED ,ANDY2
UCOORDS 46000 51730 82100 84750
GRID 150.70
CAY 10
NRNG 30
NDIV 4
NSM 3
BLPOLY ,POLY.
CONTOUR
CONTOURRECTAN 57,3 26,5
LEVINC 1,0 1,1
HGTC 0,2
@EOF
@FIN
```

(b) 3-D program

```
100 @RUN, Z/NR ANDY, ACCNT/USER, MGEO, 30 , 50
110 @ASG, A ANDY.
120 @ASG, UP POLY.
130 DATA, IL POLY.
140 51730 84000
150 51040 82100
160 49940 82925
170 46100 82925
180 46100 84750
190 49940 84750
200 49940 84340
210 @END
220 @GDP*ABS.INPUT PLOT.
230 @ADD SYS$*3D. XQT
240 PEN 3D, ''PEN P1-BK/I3''
250 RSPACED ,ANDY.
260 UCOORDS 46000 51730 82100 84750
270 BLPOLY ,POLY.
280 GRID 200,90
290 NRNG 30
300 THREED
310 ZBASE 0
320 ZMAG 30
330 THETA 135
340 PHI 45
350 THREEDRECTAN 40 30
360 @EOF
370 @FIN
```

APPENDIX C

This appendix lists the sediment-sample data. The data are tabulated in Tables 1 to 4. The abbreviations used in each of the tables are clarified below.

Table 1:

Grab - Van Veen grab-sample.
Diver - Diver-collected sample.
X and Y Co-ords - LO-19 Co-ordinates.
S - Sand.
G - Gravel.
gS - Gravelly sand.
sG - Sandy gravel.

Table 2:

GSO - Geological Survey.
UCT - University of Cape Town.
vfS - Very fine sand.
fS - Fine sand.
mS - Medium sand.
cS - Coarse sand.
vcS - Very coarse sand.
Std. Sort. - Standard sorting.
Rel. Sort. - Relative sorting.
Skew - Skewness.
Kurt - Kurtosis.

Tables 3 and 4:

D - Dominant (>50%).
Mj - Major (5 - 50%).
Mn - Minor (1 - 5%).
Tr - Trace (<1%).
Qtz. - Quartz grains.
Coral. - Coralline-algal and bryozoan fragments.
Cirri. - Cirripede (barnacle) fragments.
Moll. - Mollusc fragments.
Ech. - Echinoderm fragments.
Octo. - Octocoral fragments.
Oph. - Ophiuroid fragments.
Worm. - Worm-tubes.
Rock. - Rock fragments.
Min. - Heavy minerals.
bF - Benthic-foraminifera.
pF - Planktonic-foraminifera.
Ost. - Ostrocods.
Sp. - Sponge remains.
Bpd. - Brachiopods.

TABLE 1: Sediment texture and composition data

Sample Number	Sample Method	Facies	X Co-ord	Y Co-ord	Depth (m)	%Gravel	%Sand	%Mud	%CaCO3	Colour Code	Texture Shepard(1954)
1	Diver	3	3783930	49290	25	40.67	58.95	0.38	88.20	10YR8/2	gS
2	Diver	3	3783930	49290	25	31.07	68.90	0.03	91.50	10YR8/1	gS
3	Diver	3	3783990	49540	27	21.60	74.98	3.42	82.20	2.5Y8/2	gS
4	Diver	3	3783990	49540	27	65.29	32.72	1.99	87.50	2.5Y8/2	sG
5	Grab	5	3783000	46100	36	0.26	97.08	2.66	7.20	5Y8/2	S
6	Grab	5	3783000	47000	35.5	1.26	94.43	4.31	19.70	5Y7/2	S
7	Grab	5	3783000	48000	34.5	0.52	98.04	1.44	14.50	5Y8/2	S
8	Grab	5	3783000	48500	33	4.76	94.25	0.99	13.80	5Y8/2	S
9	Grab	5	3783900	46100	38	0.44	97.81	1.75	17.80	5Y7/2	S
10	Grab	5	3783900	47000	37	0.46	96.04	3.50	15.80	2.5Y7/2	S
11	Grab	5	3783900	48000	36	1.60	95.96	2.44	22.40	5Y7/2	S
12	Grab	5	3783720	48500	33	0.89	95.66	3.45	28.30	5Y7/2	S
13	Grab	5	3784620	46100	38	0.15	96.39	3.46	21.70	5Y7/3	S
14	Grab	5	3784620	47000	37.5	0.51	98.85	0.64	12.30	5Y8/2	S
15	Grab	5	3784620	48000	36.5	0.46	96.86	2.68	19.70	5Y7/2	S
17	Grab	3	3783180	50930	22	19.18	79.75	1.07	64.50	5Y8/2	S
18	Grab	4	3782813	51077	21	0.26	98.71	1.03	32.20	5Y8/1	S
19	Grab	2	3782640	50280	22	16.18	82.47	1.35	65.80	10YR8/1	S
20	Grab	2	3782820	50190	22.5	3.51	96.48	0.01	50.70	2.5Y8/2	S
21	Grab	3	3783003	50004	22.5	12.39	87.60	0.01	65.80	10YR8/1	S
22	Grab	3	3783825	50556	26	18.39	81.36	0.25	85.60	2.5Y8/2	S
23	Diver	3	3783825	50693	24.5	14.71	84.34	0.95	77.10	2.5Y8/2	S
24	Diver	3	3783825	50693	24.5	17.65	81.25	1.10	71.70	5Y8/2	S
25	Grab	3	3784260	48740	32.5	65.51	31.54	2.95	80.10	5Y8/2	sG
26	Grab	3	3784260	48350	22	27.36	71.86	0.78	82.20	2.5Y8/2	gS
27	Grab	5	3784270	48210	35.5	0.05	96.62	3.33	36.20	5Y8/2	S
28	Grab	2	3784080	48890	31	25.90	73.63	0.47	85.50	2.5Y8/2	gS
29	Grab	6	3784080	48700	33	0.44	99.41	0.15	59.90	5Y8/2	S
30	Grab	5	3784080	48000	36.5	0.79	94.53	4.68	11.80	5Y7/3	S
31	Grab	5	3783900	48550	33	5.73	93.19	1.08	32.20	5Y8/2	S
32	Grab	3	3783720	48966	29	39.55	60.19	0.26	89.40	5Y8/2	gS
33	Grab	3	3783730	48790	31	5.68	94.15	0.17	78.60	2.5Y8/2	S
34	Grab	6	3783720	48510	33	0.83	94.63	4.54	19.10	5Y7/2	S
35	Grab	5	3783690	48050	35	1.73	95.61	2.66	23.00	5Y7/2	S
36	Grab	3	3783360	48480	33	13.02	84.41	2.57	48.00	5Y8/2	S
37	Grab	5	3783360	48260	34	0.64	95.23	4.13	17.10	5Y7/2	S
38	Grab	5	3783000	48950	31	1.59	97.64	0.77	43.40	5Y8/2	S
39	Grab	5	3783000	48200	34	0.54	98.26	1.20	9.20	5Y7/2	S
40	Grab	3	3783900	48970	30	48.15	50.50	1.35	86.20	2.5Y8/2	gS
41	Grab	3	3783900	48900	31	32.17	67.27	0.56	90.80	2.5Y8/2	gS
42	Grab	3	3783900	48850	32	25.74	73.88	0.38	82.90	2.5Y8/2	gS
43	Grab	3	3783900	48790	32	8.17	91.70	0.13	75.00	5Y8/2	S
44	Grab	3	3783900	48730	32	12.25	87.27	0.48	53.30	5Y8/2	S
45	Grab	5	3783000	49140	30	0.35	99.30	0.35	73.70	5Y8/2	S
46	Grab	3	3783000	49680	24.5	30.88	69.00	0.12	84.80	2.5Y8/2	gS
47	Grab	4	3783000	50135	22	0.72	98.40	0.88	44.70	5Y8/2	S
48	Grab	4	3783000	51245	21	3.78	94.67	1.55	42.10	5Y8/2	S
52	Grab	4	3782650	51050	21	6.41	92.22	1.37	39.00	5Y8/2	S
53	Grab	3	3782630	50535	21.5	21.44	78.23	0.33	56.60	5Y8/1	S
55	Grab	4	3782470	51115	20.5	3.44	96.10	0.46	37.50	2.5Y8/2	S
56	Grab	2	3782460	50905	21	19.87	79.68	0.45	61.80	2.5Y8/2	S
58	Grab	3	3783170	50040	22	7.27	92.46	0.27	31.60	2.5Y8/2	S
59	Grab	3	3783360	51090	22	21.85	76.94	1.21	72.60	5Y8/2	S
60	Grab	3	3783360	50420	22.5	9.53	86.57	3.90	77.60	5Y8/2	S
61	Grab	3	3783420	49770	18	57.60	42.24	0.16	77.00	2.5Y8/2	gS
62	Grab	3	3783540	49230	24	90.25	9.71	0.04	92.20	10YR8/1	G
63	Grab	3	3783540	50450	23	9.69	87.75	2.56	77.60	5Y8/2	S
64	Grab	3	3783540	51430	21	10.24	87.04	2.72	58.90	5Y7/2	S
65	Grab	3	3783720	51140	23	14.39	81.83	3.78	65.60	5Y8/2	S
66	Grab	3	3783720	50325	24.5	9.34	88.79	1.87	76.00	5Y8/2	S
67	Grab	4	3783930	50270	26	1.01	96.91	2.08	56.20	5Y8/2	S
68	Grab	3	3784080	51150	22.5	4.48	93.84	1.68	25.00	5Y8/2	S
69	Grab	3	3784080	49810	29.5	1.12	93.64	5.24	19.70	5Y7/2	S
70	Grab	4	3784260	50280	27	1.17	96.96	1.87	45.40	5Y7/1	S
71	Diver	4	3783015	51150	21.5	7.10	89.53	3.37	46.50	5Y8/2	S
72	Diver	3	3783010	51120	21.5	33.20	63.75	3.05	68.60	5Y8/2	gS
73	Diver	4	3783010	51080	21.5	13.48	82.60	3.92	56.90	5Y8/1	S
74	Diver	3	3783740	50480	24.5	49.68	49.10	1.22	86.20	5Y8/1	sG
75	Diver	4	3783740	50490	24.5	7.13	92.08	0.79	73.60	5Y8/1	S
76	Diver	3	3784000	48900	31.5	5.39	92.71	1.90	78.00	5Y8/2	S
77	Diver	3	3784000	48890	31.5	60.16	33.23	6.61	91.20	5Y8/2	sG

TABLE 2: Sand-size data

Sample Number	Facies	Settling Tube	%vfS	%fS	%mS	%cS	%vcS	Median	Mean	Std. Sort	Rel. Sort	Skew	Kurt
1	3	GSO	0.00	2.64	8.56	46.60	1.16	0.63	0.74	0.53	1.10	0.76	2.96
2	3	UCT	0.00	0.40	5.22	60.77	2.50	0.59	0.59	0.30	0.59	-0.03	1.14
3	3	UCT	1.17	4.25	26.25	42.54	0.76	0.90	0.99	0.57	1.42	0.26	1.13
4	3	UCT	0.87	3.95	14.80	11.93	1.16	1.15	1.23	0.73	2.09	0.20	1.07
5	5	UCT	11.47	30.36	49.33	5.65	0.28	1.90	2.01	0.73	3.48	0.22	1.16
6	5	UCT	21.89	49.61	19.30	3.25	0.38	2.54	2.47	0.73	4.06	-0.15	1.06
7	5	UCT	8.23	25.73	52.48	11.04	0.57	1.68	1.78	0.74	3.08	0.23	1.08
8	5	GSO	3.84	10.18	53.40	26.83	0.00	1.29	1.40	0.69	2.23	0.56	1.65
9	5	UCT	17.26	60.98	15.05	4.51	0.00	2.53	2.45	0.65	3.61	-0.23	1.34
10	5	GSO	14.21	48.26	26.79	6.64	0.14	2.26	2.21	0.74	3.89	-0.16	-0.32
11	5	GSO	14.68	57.63	23.64	0.00	0.00	2.25	2.39	0.50	2.78	0.36	-0.40
12	5	GSO	17.06	19.72	36.57	21.84	0.00	1.63	1.86	1.02	4.43	0.21	-0.91
13	5	GSO	14.48	68.96	12.95	0.00	0.00	2.47	2.51	0.45	2.50	0.11	-0.38
14	5	GSO	4.53	47.91	41.92	4.50	0.00	2.03	2.02	0.57	2.71	-0.07	0.13
15	5	GSO	14.36	33.93	41.29	7.04	0.23	2.00	2.07	0.79	3.95	0.08	-0.39
17	3	GSO	0.47	4.22	26.07	44.64	4.35	0.67	0.81	0.69	1.53	0.40	0.21
18	4	UCT	3.10	27.36	54.03	13.08	1.14	1.69	1.69	0.69	2.76	-0.05	1.22
19	2	GSO	0.16	2.35	70.50	9.46	0.00	1.24	1.29	0.32	0.97	0.88	5.12
20	2	UCT	0.00	0.00	2.32	83.76	9.65	0.37	0.36	0.28	0.48	-0.01	1.02
21	3	GSO	0.00	0.29	12.82	74.49	0.00	0.66	0.67	0.34	0.71	0.37	1.63
22	3	GSO	0.21	2.20	10.90	52.53	15.52	0.27	0.46	0.61	1.11	0.74	2.45
23	3	GSO	0.53	5.44	19.47	52.21	6.68	0.61	0.77	0.72	1.60	0.50	0.47
24	3	GSO	2.00	6.00	18.42	42.90	11.93	0.48	0.78	0.87	1.93	0.53	0.56
25	3	GSO	1.14	5.40	11.46	13.08	0.46	1.07	1.29	0.78	2.36	0.35	-0.15
26	3	GSO	0.11	2.26	30.48	39.01	0.00	0.97	1.04	0.46	1.15	0.54	2.72
27	5	GSO	13.34	62.12	20.58	0.58	0.00	2.36	2.39	0.53	2.94	0.00	-0.02
28	2	GSO	0.10	2.49	24.39	45.24	1.41	0.86	0.93	0.50	1.16	0.43	1.69
29	6	GSO	0.09	4.61	78.43	15.94	0.34	1.27	1.31	0.38	1.15	0.34	2.61
30	5	GSO	3.17	3.07	29.39	57.01	1.89	0.84	0.96	0.70	1.75	0.91	4.35
31	5	GSO	1.45	6.54	34.30	50.89	0.00	0.94	1.06	0.63	1.70	0.66	2.17
32	3	GSO	0.00	1.15	19.87	39.18	0.00	0.87	0.93	0.40	0.93	0.55	2.63
33	3	GSO	1.27	7.53	54.96	30.39	0.00	1.19	1.27	0.56	1.70	0.46	1.66
34	6	GSO	5.16	4.64	35.40	48.00	1.45	0.97	1.13	0.78	2.11	0.81	2.77
35	5	UCT	10.18	37.62	36.28	10.43	1.09	1.97	1.99	0.83	3.95	0.02	0.96
36	3	GSO	2.33	5.00	26.17	48.63	2.28	0.85	0.99	0.72	1.80	0.67	2.24
37	5	UCT	12.31	33.91	43.72	5.09	0.19	1.98	2.09	0.73	3.65	0.20	1.10
38	5	GSO	4.88	33.66	52.58	6.52	0.00	1.85	1.89	0.61	2.65	0.13	0.10
39	5	GSO	2.95	16.50	62.97	15.84	0.00	1.45	1.54	0.62	2.21	0.27	0.74
40	3	GSO	0.35	1.37	13.24	35.55	0.00	0.82	0.90	0.49	1.14	0.90	5.20
41	3	GSO	0.00	1.63	16.78	48.86	0.00	0.82	0.88	0.41	0.95	0.68	3.13
42	3	GSO	0.21	3.03	24.51	45.47	0.66	0.89	0.98	0.49	1.22	0.55	2.90
43	3	GSO	0.00	2.24	35.87	52.63	0.96	0.93	0.98	0.42	1.05	0.38	1.95
44	3	GSO	0.58	3.73	35.43	47.00	0.54	0.96	1.02	0.52	1.30	0.56	2.64
45	5	GSO	2.28	32.48	59.78	4.76	0.00	1.80	1.84	0.53	2.21	0.11	0.61
46	3	GSO	0.00	1.20	14.00	52.32	1.48	0.75	0.78	0.42	0.93	0.50	2.74
47	4	GSO	4.34	70.19	18.42	4.53	0.92	2.21	2.15	0.60	3.16	-0.64	3.32
48	4	UCT	9.38	39.50	29.08	14.57	2.14	2.02	1.90	0.90	3.91	-0.20	0.97
52	4	GSO	4.04	20.17	41.79	21.55	4.68	1.59	1.49	0.87	3.11	-0.05	-0.41
53	3	GSO	0.74	7.44	37.61	27.19	5.25	1.24	1.11	0.77	2.08	0.06	-0.67
55	4	GSO	6.03	36.70	37.36	12.99	3.02	1.93	1.83	0.83	3.46	-0.26	0.01
56	2	GSO	0.22	4.23	32.82	35.85	6.56	0.92	0.91	0.69	1.60	0.16	-0.39
58	3	GSO	0.32	6.04	54.15	28.43	3.51	1.21	1.15	0.62	1.77	-0.01	0.17
59	3	GSO	0.22	5.89	25.92	36.81	8.10	0.68	0.85	0.77	1.79	0.26	-0.65
60	3	GSO	3.97	19.72	24.17	33.87	4.84	1.19	1.29	0.96	2.91	0.15	-0.99
61	3	GSO	0.00	0.29	1.67	36.28	4.00	0.40	0.43	0.36	1.16	0.59	4.82
62	3	UCT	12.31	33.91	43.72	5.09	0.19	0.62	0.62	0.43	0.84	0.11	1.46
63	3	GSO	3.54	19.09	29.61	30.16	5.35	1.36	1.31	0.94	2.85	0.11	-0.91
64	3	GSO	5.05	23.36	28.52	23.81	6.30	1.55	1.47	0.99	3.54	0.01	-0.86
65	3	GSO	4.27	15.41	20.03	33.87	8.24	0.94	1.13	1.03	2.78	0.26	-0.82
66	3	GSO	2.98	12.75	31.30	34.53	7.24	1.09	1.15	0.90	2.57	0.22	-0.43
67	4	GSO	13.02	63.35	15.74	4.80	0.00	2.42	2.35	0.67	3.72	-0.44	1.56
68	3	GSO	3.93	26.64	38.88	23.11	1.27	1.63	1.61	0.80	2.96	0.05	-0.53
69	3	GSO	5.84	17.23	51.60	17.39	1.58	1.44	1.57	0.79	2.93	0.26	0.34
70	4	GSO	6.23	42.22	32.87	14.38	1.26	2.00	1.88	0.80	3.48	-0.20	-0.05
71	4	UCT	5.50	32.90	25.24	21.33	4.56	1.81	1.64	0.98	3.63	-0.21	0.85
72	3	UCT	1.80	5.69	16.89	32.04	7.32	0.68	0.82	0.82	1.82	0.31	0.93
73	4	UCT	2.23	7.55	21.62	40.95	10.24	0.72	0.86	0.85	1.98	0.29	1.01
74	3	UCT	0.75	1.84	3.39	27.57	15.55	0.17	0.29	0.61	0.98	0.49	1.60
75	4	UCT	3.17	34.23	31.88	17.34	5.37	1.81	1.61	0.92	3.41	-0.29	0.94
76	3	UCT	8.26	61.13	19.77	3.37	0.18	2.32	2.29	0.59	3.11	-0.10	1.41
77	3	UCT	4.13	15.19	5.34	8.36	0.21	2.18	1.92	1.00	4.35	-0.27	0.74

TABLE 3: Gravel Components

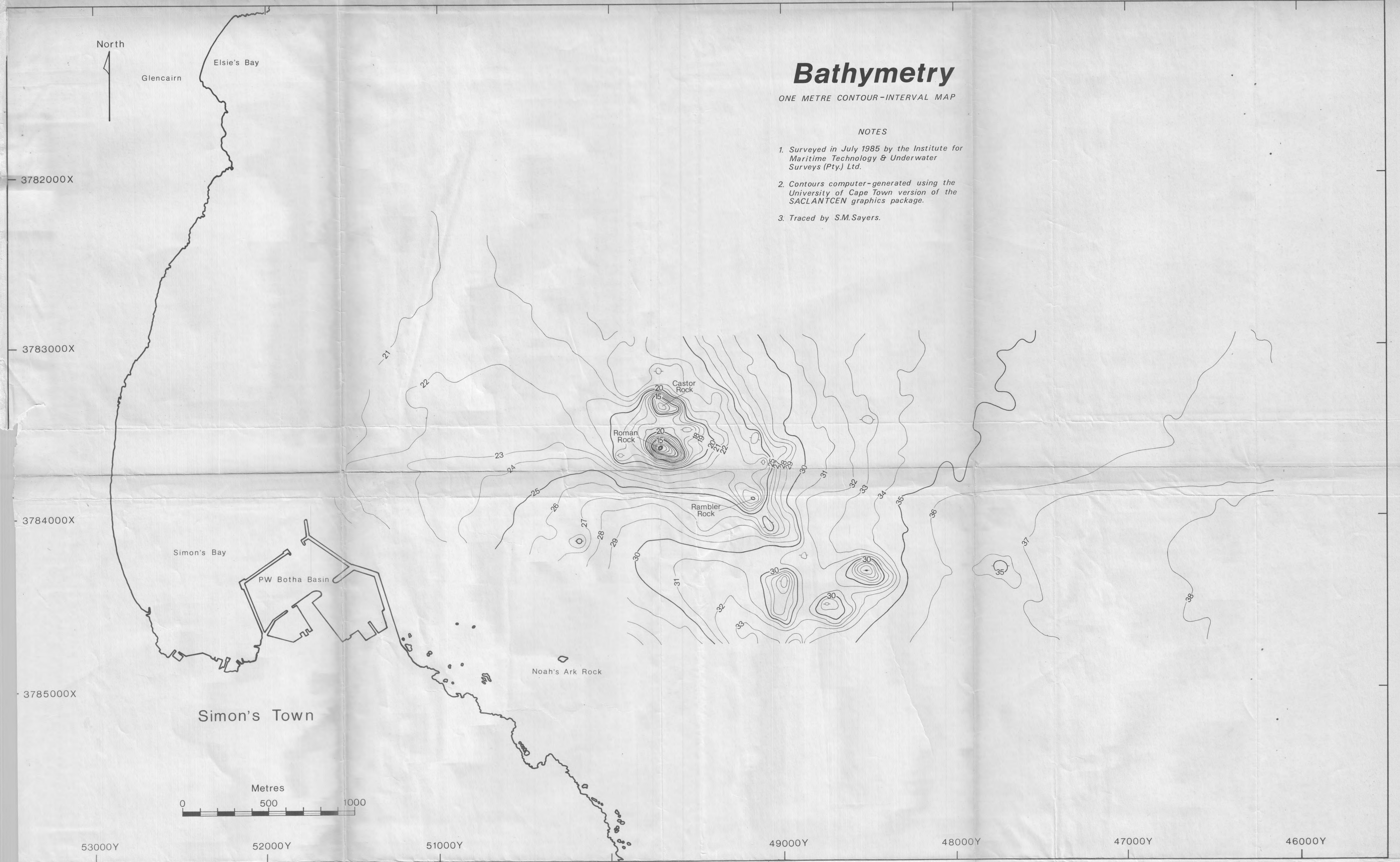
Sample Number	Facies	Qtz.	Coral.	Cirri.	Moll.	Ech.	Octo.	Oph.	Worm.	Rock.	Min.	Mica
1	3	-	Mn	D	Mj	-	-	-	Tr	-	-	-
2	3	-	Mj	D	Mj	Mn	-	-	Mn	-	-	-
3	3	-	Mj	Mj	Mj	-	-	-	Mn	-	-	-
4	3	-	Mj	Mj	D	-	-	-	Mn	-	Mn	-
5	5	-	-	Mj	D	-	-	-	-	-	-	-
6	5	-	-	Mj	D	-	-	-	-	-	-	-
7	5	-	-	Mj	D	-	-	-	-	Mn	-	-
8	5	Mn	Mj	Mn	D	-	-	-	-	Mn	-	-
9	5	Mj	-	-	D	-	-	-	-	-	-	-
10	5	Mj	Mn	-	D	-	-	-	-	-	-	-
11	5	Mj	-	Mn	D	-	-	-	-	Mn	-	-
12	5	Mn	-	-	D	-	-	-	-	Mn	-	-
13	5	-	-	-	D	-	-	-	-	-	-	-
14	5	-	-	Mn	D	Mn	-	-	Tr	-	-	-
15	5	-	-	-	D	-	-	-	-	Mj	-	-
17	3	-	D	Mn	Mj	-	-	-	-	-	-	-
18	4	-	D	Mn	Mj	-	-	-	-	-	-	-
19	2	Mn	D	-	Mj	-	-	-	Tr	Mn	-	-
20	2	Mj	D	Mn	Mn	-	-	-	-	-	-	-
21	3	Mj	D	Mj	Mj	Mn	-	-	Tr	Mn	-	Tr
22	3	Mj	D	Mn	Mn	-	-	-	-	Mj	-	-
23	3	-	D	Mn	Mj	-	-	-	-	Mj	-	-
24	3	Mn	D	Mn	Mj	-	-	-	-	Mn	-	-
25	3	Mn	Mj	Mj	D	Mj	-	-	Mj	-	-	-
26	3	-	Mj	D	Mj	Tr	-	-	-	Mn	-	-
27	5	-	-	-	Mj	-	-	D	-	-	-	-
28	2	-	Mj	D	Mj	Mn	-	Mn	Tr	Mn	-	-
29	6	-	Mj	Mj	D	Mn	-	Mn	-	Mn	-	-
30	5	Mj	-	Mn	Mj	-	-	-	Mn	D	-	-
31	5	-	Mj	-	D	-	-	Mn	Mn	Mj	Tr	-
32	3	-	Mj	D	Mj	Tr	-	-	Tr	-	-	-
33	3	-	Mj	D	Mj	Mn	-	Mn	Tr	Tr	-	-
34	6	-	-	Mn	Mj	-	-	Mj	Mj	Mj	-	-
35	5	-	-	-	D	-	-	-	-	Mj	-	-
36	3	-	Mj	D	Mj	-	-	-	Tr	Mn	-	-
37	5	-	-	-	D	-	-	-	-	Mn	-	-
38	5	-	-	-	D	-	-	-	-	-	-	-
39	5	-	-	Mn	D	-	-	-	-	Mj	-	-
40	3	-	Mj	Mj	Mj	Mn	Tr	-	Mn	Mn	-	-
41	3	-	Mj	D	Mj	-	Tr	Mn	Mn	Mn	-	-
42	3	-	Mj	D	Mj	Mn	-	Tr	Tr	Mn	-	-
43	3	-	Mj	D	Mj	Mn	-	Mn	Tr	Mn	-	-
44	3	-	Mj	D	Mj	Mn	Tr	-	Tr	Mn	Tr	-
45	5	-	Mj	Mj	D	-	-	-	-	-	Mn	-
46	3	-	Mj	D	Mj	-	-	-	Tr	Mn	-	-
47	4	-	D	-	Mj	-	-	-	-	Mn	-	-
48	4	-	D	-	Mj	-	-	-	-	Mn	Tr	-
52	4	-	D	Mn	Mj	-	-	Tr	-	Mn	Tr	-
53	3	-	D	Mn	Mn	-	-	-	-	Tr	-	-
55	4	-	D	Mn	Mj	-	-	-	Mn	Mn	Mn	-
56	2	-	D	Mn	Mj	-	-	-	-	Mn	-	-
58	3	-	D	-	Mn	-	-	-	-	Mj	-	-
59	3	-	D	-	Mj	-	-	-	-	-	-	-
60	3	-	D	Mn	Mn	-	-	-	Tr	Mn	-	-
61	3	-	Mj	D	Mj	Mn	-	-	Tr	Mj	-	-
62	3	-	Mj	D	Mj	Mn	Tr	-	Tr	-	-	-
63	3	-	D	Mn	Tr	-	-	-	-	Mj	-	-
64	3	-	D	Mn	Mn	-	-	-	Tr	Mj	-	-
65	3	-	D	-	Mj	-	-	-	-	Tr	-	-
66	3	-	D	Mn	Mj	-	-	-	-	Mj	-	-
67	4	-	D	Mj	Mj	-	-	-	-	Mj	-	-
68	3	-	-	Mj	D	Mn	-	-	-	Mj	-	-
69	3	-	Mn	Mn	D	-	-	-	Mj	Mj	-	-
70	4	-	Mj	Mn	Mj	-	-	-	-	Mj	Mn	-
71	4	Mj	D	-	Mj	-	-	-	-	Mj	-	-
72	3	-	D	Mn	Mj	-	-	-	-	Mj	-	-
73	4	Mj	D	-	Mj	-	-	-	-	Mj	-	Mn
74	3	-	D	-	Mn	-	-	-	-	-	-	-
75	4	Mn	D	Tr	Mj	-	-	-	-	Tr	-	-
76	3	-	-	D	Mj	-	-	-	Tr	-	-	-
77	3	_	Mn	Mj	D	-	-	-	-	Mn	-	-

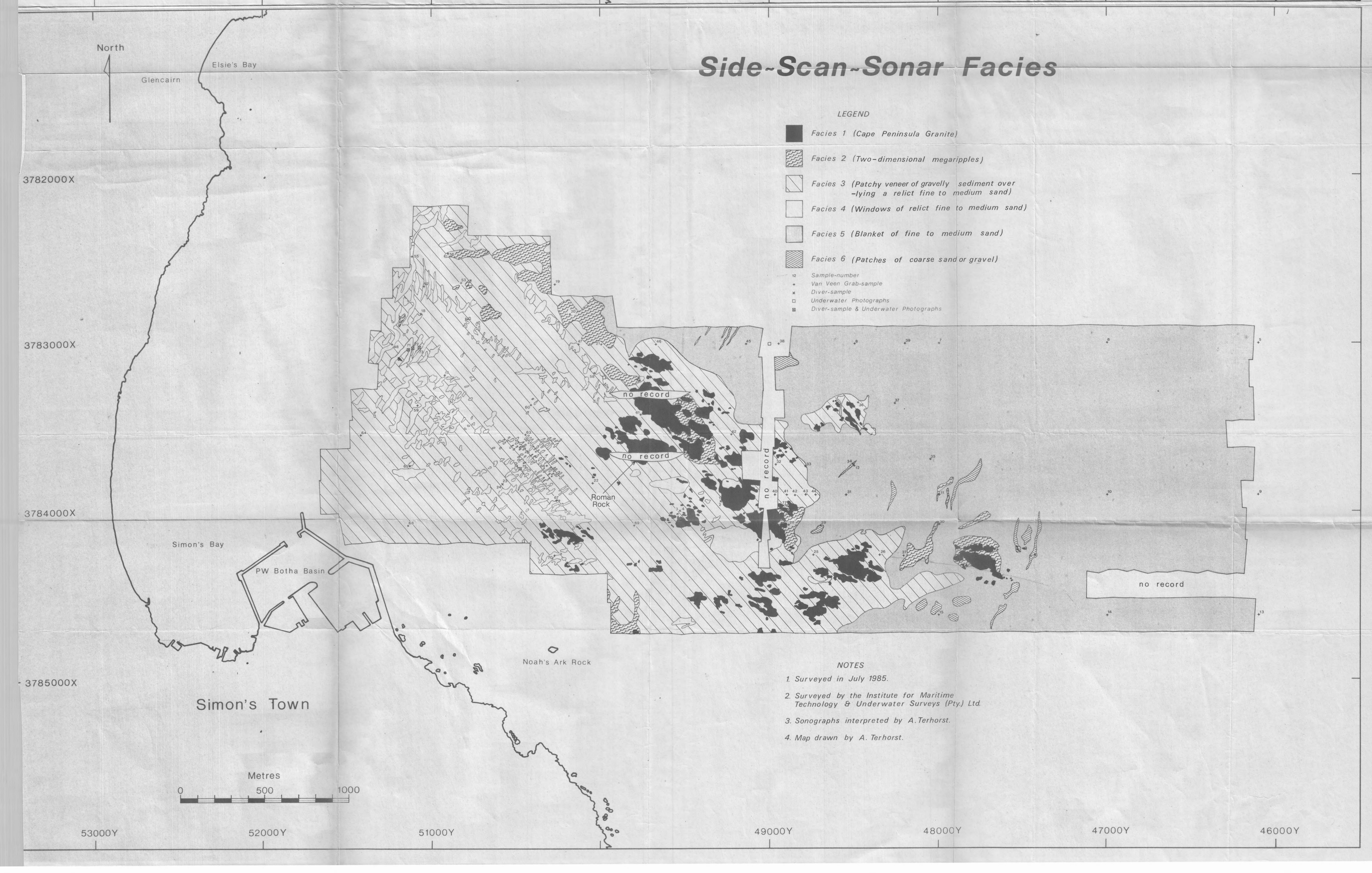
TABLE 4: Sand Components

Sample Number	Facies	Qtz.	Coral.	Cirri.	Moll.	Ech.	bF	pF	Octo.	Ost.	Oph.	Sp.	Worm.	Rock.	Bpd.	Min.	Mica
1	3	Mn	-	D	Mj	Mj	Mn	-	Mj	Tr	-	Tr	Mn	Tr	-	-	-
2	3	Mj	Mj	D	Mj	Mj	Mn	-	Mn	Tr	Tr	Tr	Tr	Tr	Tr	-	-
3	3	Mj	Mj	Mj	D	-	Mn	-	-	Tr	Mn	-	-	-	-	-	Tr
4	3	Mj	D	Mj	Mj	Mj	Mn	-	Mj	Tr	Mn	Tr	Tr	-	-	-	-
5	5	D	-	Mn	Mj	Tr	Mj	-	-	Tr	-	Mn	Mn	Mn	-	-	-
6	5	D	Mn	Tr	Mn	-	Mj	Tr	-	Tr	-	Mn	Mj	-	-	-	-
7	5	D	-	Tr	Mj	Tr	Mn	-	-	Tr	-	Mn	-	Mn	-	-	-
8	5	D	-	Mn	Mj	-	Mn	-	-	-	-	-	Mn	Mn	-	-	-
9	5	D	-	-	Mn	Tr	Mn	Tr	-	Tr	-	Mn	-	-	-	Tr	-
10	5	D	Tr	-	Mn	Tr	Mj	-	-	Tr	-	Mn	-	-	-	Tr	-
11	5	D	Mn	Tr	Mn	Tr	Mj	-	-	Tr	Tr	Mn	-	-	Tr	Tr	-
12	5	D	Mn	Tr	Mn	Tr	Mn	-	-	Tr	Tr	Mn	-	Tr	-	-	-
13	5	D	Tr	-	Mn	Tr	Mn	-	-	Tr	-	Mn	-	Tr	-	-	-
14	5	D	-	Tr	Tr	Tr	Mn	-	-	Tr	Tr	Tr	-	-	-	Tr	Tr
15	5	D	Tr	-	Mn	Mn	Mj	-	-	Tr	-	Mn	-	Mn	-	Tr	-
17	3	D	Mj	-	Mn	Mn	Mn	-	-	Tr	Tr	Tr	-	Tr	-	Tr	-
18	4	D	Mn	-	Mn	Mn	Mn	Tr	-	-	-	Mn	-	-	-	Mn	-
19	2	D	Nj	-	Mj	Mn	Tr	-	-	-	-	-	-	Tr	-	Tr	-
20	2	D	Mj	Mn	Mn	Mn	Tr	-	-	-	-	-	Tr	Tr	-	Mn	-
21	3	D	Mj	Mj	Mj	Mn	Tr	-	-	-	Mn	Tr	Tr	Mn	-	Tr	Tr
22	3	Mj	D	Mn	Mn	Mn	Mn	-	-	-	Tr	-	-	Mn	-	Tr	-
23	3	Mj	D	Mn	Mn	Mn	Mn	-	-	-	Tr	Tr	-	Tr	-	-	-
24	3	Mj	D	Mn	Mn	Mn	Mn	-	-	Tr	Mn	-	-	Tr	-	Tr	Tr
25	3	Mj	D	Mj	Mj	Mn	Mn	-	-	Mn	Mj	Mn	Mj	Tr	-	-	-
26	3	D	Mj	Mj	Mj	Mn	Mn	-	Mn	Tr	Mn	-	Mn	Tr	-	-	-
27	5	D	Mn	-	Mj	Mn	Mj	-	-	Tr	-	Mn	-	Tr	-	Tr	-
28	2	Mj	Mj	Mj	D	Mn	Mn	-	Tr	-	Mj	-	Tr	Tr	-	-	-
29	6	D	Mj	Mj	Mj	Mn	Mn	-	Tr	-	-	Tr	-	-	-	Tr	-
30	5	D	Mn	-	Mn	Tr	Mn	Tr	-	Tr	-	Mn	-	Mn	-	Tr	Tr
31	5	D	Mj	Mj	Mj	Mn	Mn	-	-	Tr	Tr	Mn	-	Mn	-	-	-
32	3	Tr	Mj	D	Mj	Tr	Tr	-	Mn	-	Tr	-	Tr	-	-	-	-
33	3	D	Mj	Mj	Mj	Mn	Mn	-	-	-	Mn	Tr	-	-	Tr	-	-
34	6	D	Mj	-	-	Mn	Mn	-	-	Tr	Mn	Mn	-	Tr	-	-	-
35	5	D	Mn	-	Mn	-	Mj	-	-	-	-	Mn	-	Mn	-	Mn	-
36	3	D	Mj	Mj	Mj	Mn	Mn	-	Mn	-	Mn	Tr	Tr	Tr	-	-	-
37	5	D	-	-	Mn	Tr	Mj	-	-	Tr	-	Mn	-	-	-	Mn	-
38	5	D	Mn	Mn	Mn	Mn	Mj	-	-	-	-	-	-	-	Tr	Mn	-
39	5	D	-	-	Mn	Tr	Mn	-	-	-	-	Mn	-	Mn	-	Mn	-
40	3	Tr	D	Mj	Mj	Mn	Mn	-	-	-	Mj	-	Tr	-	-	-	Tr
41	3	Mj	Mj	D	Mj	Mn	Mn	-	Tr	Tr	Mj	-	Tr	-	Tr	-	-
42	3	Mj	Mj	Mj	Mj	Mn	Mn	-	Mn	-	Mn	Tr	-	Tr	-	Tr	Tr
43	3	D	Mj	Mj	Mj	Mn	Mn	-	Mn	-	Mn	Tr	Tr	Tr	-	Tr	-
44	3	D	Mj	Mj	Mj	Mn	Mn	-	-	-	-	Tr	-	Mn	-	Tr	Tr
45	5	D	Mn	Mj	Mj	Mn	Mn	-	-	-	Tr	Mn	-	-	-	-	-
46	3	Mj	Mj	D	Mj	Mn	Tr	-	Mn	-	Mn	-	-	-	-	-	-
47	4	D	Mn	-	Mj	Mn	Mj	-	-	Tr	-	Tr	-	Tr	-	Tr	Tr
48	4	D	Mj	-	Mj	Mn	Mj	-	-	-	Tr	Mn	-	Tr	-	Tr	Tr
52	4	D	Mj	Mn	Mj	Mn	Mn	-	-	Tr	Mn	-	Tr	Tr	-	-	-
53	3	D	Mj	-	Mn	Mn	Mn	-	-	Tr	Mn	-	-	-	-	Tr	-
55	4	D	Mj	Mn	Mn	Mn	Mn	-	-	Tr	Mn	Tr	-	Tr	-	-	-
56	2	D	Mj	Mn	Mn	Mn	Mn	-	-	-	-	-	-	Tr	-	Tr	-

TABLE 4: Sand Components

Sample Number	Facies	Qtz.	Coral.	Cirri.	Moll.	Ech.	bF	pF	Octo.	Ost.	Oph.	Sp.	Worm.	Rock.	Bpd.	Min.	Mica
58	3	D	Mj	Mn	Mn	Mn	Tr	-	-	-	-	-	-	Tr	-	Tr	-
59	3	Mj	D	Mj	Mj	Mj	Mn	-	-	Tr	Mn	Tr	-	Tr	-	Tr	-
60	3	Mj	D	Mj	Mj	Mj	Mj	-	-	Tr	Mj	Mn	Tr	Tr	-	Tr	Tr
61	3	Mn	Mn	D	Mj	Mj	Mn	-	Mj	-	Mn	-	Mn	Mn	-	-	-
62	3	Mj	Mj	Mj	Mj	Mj	Mn	-	Mj	Tr	Mn	Tr	-	-	Mn	-	-
63	3	D	Mj	Mj	Mj	Mj	Mj	-	-	Tr	Mj	Tr	Tr	-	-	Tr	-
64	3	D	Mj	Mn	Mj	Mn	Mj	-	Tr	Tr	Mn	Tr	Tr	Tr	-	Tr	-
65	3	D	Mj	Mn	Mj	Mn	Mn	-	-	Tr	Mn	Tr	Tr	Tr	-	-	-
66	3	D	Mj	Mj	Mj	Mj	Mj	-	-	Tr	Mn	Tr	-	-	-	-	-
67	4	D	Mj	Mn	Mj	Mj	Mj	-	-	Tr	Mn	Tr	Tr	Tr	-	Tr	-
68	3	D	Mn	Mn	Mj	Mn	Mn	-	-	Tr	Tr	Tr	Tr	Mn	-	Mn	Tr
69	3	D	Mn	Mn	Mj	Mj	Mj	-	-	Tr	Tr	Tr	Mj	Mn	-	Tr	-
70	4	D	Mn	Tr	Mj	Mj	Mj	-	-	Tr	Tr	Mn	Tr	-	-	Tr	Tr
71	4	D	Mj	Mn	Mn	Mn	Mj	-	-	Tr	Mn	Mn	Tr	Mn	-	Mn	Tr
72	3	D	Mj	Mn	Mj	Mj	Mj	-	-	Tr	Mn	Mn	Tr	-	-	Tr	Tr
73	4	D	Mj	Mn	Mj	Mn	Mj	-	-	Tr	Mn	Tr	Tr	Tr	-	Tr	Tr
74	3	Mj	D	Mj	Mj	Mn	Mn	-	-	-	Mn	Tr	-	-	-	-	-
75	4	D	Mj	Mj	Mj	Mn	Mj	-	-	Tr	Mn	Tr	-	Tr	-	Tr	-
76	3	D	-	Mn	Mj	Mn	Mj	-	Tr	Mn	Mn	Mn	-	-	-	Tr	-
77	3	Mj	Mj	Mj	Mj	Mn	Mj	-	Tr	Mn	Mn	Mn	Mn	-	-	-	-


Bathymetry
ONE METRE CONTOUR-INTERVAL MAP
NOTES
1. Surveyed in July 1985 by the Institute for Maritime Technology & Underwater Surveys (Pty.) Ltd.
2. Contours computer-generated using the University of Cape Town version of the SACLANTCEN graphics package.
3. Traced by S.M.Sayers.
North
Glencairn
Elsie's Bay
3782000X
3783000X
3784000X
3785000X
Simon's Bay
PW Botha Basin
Simon's Town
Noah's Ark Rock
Castor Rock
Roman Rock
Rambler Rock
Metres
0
500
1000
53000Y
52000Y
51000Y
49000Y
48000Y
47000Y
46000Y


Side-Scan-Sonar Facies
LEGEND
Facies 1 (Cape Peninsula Granite)
Facies 2 (Two-dimensional megaripples)
Facies 3 (Patchy veneer of gravelly sediment over-lying a relict fine to medium sand)
Facies 4 (Windows of relict fine to medium sand)
Facies 5 (Blanket of fine to medium sand)
Facies 6 (Patches of coarse sand or gravel)
Sample-number
Van Veen Grab-sample
Diver-sample
Underwater Photographs
Diver-sample & Underwater Photographs
North
Glencairn
Elsie's Bay
3782000X
3783000X
3784000X
3785000X
no record
no record
no record
no record
Roman Rock
Simon's Bay
PW Botha Basin
Simon's Town
Noah's Ark Rock
NOTES
1. Surveyed in July 1985.
2. Surveyed by the Institute for Maritime Technology & Underwater Surveys (Pty) Ltd.
3. Sonographs interpreted by A.Terhorst.
4. Map drawn by A. Terhorst.
Metres
0
500
1000
53000Y
52000Y
51000Y
49000Y
48000Y
47000Y
46000Y