

CRUISE REPORT NO. 63

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NEARSHORE SURVEYS, TARAWA, KIRIBATI

5 November - 23 December 1981

by

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COMMITTEE FOR CO-ORDINATION
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MINERAL RESOURCES IN SOUTH
PACIFIC OFFSHORE AREAS
(CCOP/SOPAC) WORK PROGRAMME
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Cruise Report No. 63
of PE/KI.4 & PE/KI. 5

INTRODUCTION AND BACKGROUND

Sea bed surveys were undertaken in south Tarawa by UNDP staff and consultants assisted by personnel supplied by the government of Kiribati during November and December 1981.

A major dredging project is proposed in Tarawa lagoon to provide material for the construction of a road causeway, and possibly an airfield, linking Betio and Bairiki islands. Drilling surveys have been undertaken on behalf of the government of Kiribati in the area of the planned causeway borrow pit and it was proposed to undertake a geophysical survey to attempt to extrapolate the borehole data over the whole area of interest and to obtain as much additional data as possible on the nature of the sea bed and sub-bottom soils materials. In addition, it was proposed to gather a certain amount of marine baseline environmental data from the site of the proposed causeway and lagoon borrow pit, and from nearby areas. It is intended that this data should in part provide a basis for determining the long term effects of the causeway construction.

It is planned that the east Betio mole be extended by up to about 50001 to provide a deepwater shipping berth and obviate the necessity of lightering cargo at Betio. A bathymetric, geophysical and jet-probing survey was undertaken over the area of the proposed mole extension in order to obtain sea bed and sub-bottom information for the engineering design of that extension.

The Marine Superintendent at Betio has reported possible changes in the shallow areas in the main Betio shipping channel since the major hydrographic survey carried out by H.M. survey ship COOK in 1959. In order to update this survey soundings were made across the width of the main shipping channel from Betio to the western reef entrance.

The above work was undertaken as part of the CCOP/SOPAC work programme elements CCSP-1/KI.4 (Surveys for Landfill/Construction Materials) and CCSP-1/KI.5 (Coastal Zone Surveys on Sedimentation, Erosion and Pollution Problems). The present report deals with the results of the bathymetric, geophysical and geological surveys. Results of the baseline environmental work will be reported separately.

PERSONNEL PARTICIPATING

The following UNDP project staff participated in the field work:

G A Gauss: Marine Geologist (Engineering)

E.Saphore: Electronics Technician

S Motuiwaca: Geological Assistant

The following non-reimbursable consultants participated in the baseline data gathering work:

L Zann: Lecturer in Marine Biology, University of the South Pacific

W.Kimmerer: Marine Biologist, University of Hawaii

Survey assistants were provided by the Ministry of Natural Resources and boat drivers by the Ministry of Communications and Works, Tarawa.

EQUIPMENT AND FACILITIES

The following major items of UNDP equipment were used during the survey work:

- A continuous seismic reflection profiling system with a boomer sound source.
- A Trisponder VHF Radio Positioning system with Data Printer;
- Raytheon DE-719 survey echo sounder;
- Klein model SA-350A side scan sonar transceiver and tow fish;
- Inflatable rubber dinghy and diving equipment;
- Water pump and jet probe equipment.

Shore support facilities, including the provision of a vehicle and labour, were provided by the Ministry of Natural Resources. Shore control data for navigation and position fixing was provided by the Survey Department at Bairiki.

A flat-bottomed work boat provided by the Marine Department was used for the survey work up until December 9th. From December 9th onwards a catamaran was used and this was provided by the Fisheries Department.

In addition, a research launch and shore facilities were provided by the Atoll Research Unit of the University of the South Pacific for the baseline data gathering work.

RESULTS

Presentation of Results

(1) Betio Mole

The results of the survey over the area of the proposed Betio east mole extension are presented on the following drawings included in Appendix I of this report:

- Figures I and 2: Navigation Plans for the Boomer and sidescan sonar surveys respectively, showing the position fixes and lines run. *The* echo sounder was operated for fixes 1 to 108 and 251 to 533 of the boomer work and 10r the whole of the sidescan sonar work.
- Figure 3: A Bathymetric Chart showing seabed depth contours in feet.
The datum of the chart is the zero of the Betio harbour tide pole which is reported by the British Hydrographic Department to be 0.21 metres below COOK (datum and by the NOAA of the U.S. to be 4.06ft. below Mean Sea Level. The position of the main outcrops of coral rock on the sea bed, as shown by the sidescan sonar, and the jet probe locations are also plotted on this chart.
- Figure 4: Seabed/Sub-bottom Profiles along the two most likely centre lines for the mole extension, one straight out from the present Mole and the other at an angle of 30° to it. The positions and summary results of the jet profiles are shown on these profiles.

All plans were originally prepared at a scale of 1:1000. The profiles of figure 4 were originally drawn at scales of 1:1000 horizontal and 1:200 vertical.

(ii) Betio Shipping Channel

Results of the sounding survey of the main Betio shipping channel are presented on figure 5 of Appendix I attached. This was originally drawn at scale 1:18000 to conform to the scale of the largest chart available showing the results of the bathymetric survey carried out by H.M. COOK in 1959. Datum for this chart is COOK Datum and soundings have been reduced by means of Admiralty tidal predictions.

(iii) Betio-Bairiki Causeway Borrow Pit Site

The results of this survey are presented on the following drawings:

- Figures 6 and 7: Navigation Plans for the Boomer and Sidescan Sonar Surveys respectively, showing the position fixes and the lines run.

- Figure 8: A Bathymetric Chart showing seabed depth contours in metres
The datum of the chart is the zero of the Betio tide pole.
- Figure 9: A Geological Map showing sea bed soils types present and their thickness where this has been determined by the boomer survey. The positions of jet probes and dives carried out during the present survey and of the boreholes undertaken previously by Kiribati Government contractors are also shown. The approximate edge of the inshore reef plotted from the sidescan sonar records is shown.
- Figure 10: Profiles along two boomer lines in the area of occurrence of soft sediment at the sea bed at the west of the survey area. These illustrate the distribution of soils materials in this area.

All plans were originally prepared at a scale of 1:5000. The profiles of Figure 10 were drawn at scales of 1:5000 horizontal and 11:250 vertical.

Discussion of Results

(i) Betio Mole

The sea bed slopes generally towards the north from a depth of 5 feet (1.5m) at between about 80 to 165ft. (25 to 50m) north of the end of the mole to a depth of between 36 and 45ft. (11 and 14m) at the northern end of the area surveyed (see figure 3, Appendix I). Depths are greatest in the northeast corner of the survey area where the sea bed slopes quite steeply down to a depth of 45ft. (13.7m). Superimposed on this general northerly sea bed slope are numerous bathymetric lows and highs, the latter often associated with coral outcrops on the sea bed (see figs. 3 and 4, Appendix I).

The sea bed surface material, from observation during jet probe operations, is generally a silty sand, often with subordinate shell fragments and some coral gravel material and small boulders. The feel of the probe during jetting into the sea bed suggests that over much of the area the uncemented material underlying the fine grained surface layer is much coarser and is probably generally composed of sand, gravel, cobbles, small boulders and in situ coral (see figure 3 and Table 1, Appendix I). This is supported by the boomer results, for the nature of the sea bed reflection and lack of strong sub-bottom reflectors are consistent with such a sea bed soils material. In some places weak, discontinuous sub-bottom reflectors do occur up to about 25ft. (7.5m) beneath the sea bed. Where there occur this indicates that the material above them is probably largely uncemented (see figure 4, Appendix I). All jet probes except number 7 failed to reach the full penetration depth of 10ft. (3m)

and stopped at hard material which could either be a large boulder, a cemented layer, or in situ coral material. The character of the boomer records from this area is generally very similar to that of those from the proposed Betio-Bairiki Causeway fill area. Drilling surveys there have indicated that the sub-bottom soils material is a mixture of sand, gravel, boulders and coral with great lateral variations in distribution and thickness of the various types of material. It is considered that the sub-bottom soils material in the proposed Betio mole extension area is likely to be very similar to a depth of at least 25ft. (7.5 m) beneath the sea bed.

(ii) **Betio Main Shipping Channel**

A comparison of the soundings chart produced from the present survey with that produced as a result of the HM Survey Ship ICOOK survey in 1959 reveals no obvious large changes in sea bed depths. However because of the relatively large scale of the chart significant sea bed depth changes would probably not be detectable unless they occurred over an area in excess of about 200m square.

Hi) **Betio-Bairiki Causeway Borrow Pit Site**

The approximate edge of the lagoonside shoreline "reef" has been plotted on figure 9 from the sidescan sonar records. In general this line falls about 50m north of the line plotted from aerial photographs during the site survey carried out on behalf of the Kiribati government in 1969. This inshore 'reef' is not a continuous unbroken feature but is composed of numerous patches of coral rock separated by areas of sand and gravel. The line plotted on figure 9 marks the change from the area of numerous coral rock patches on the south to an area of scattered coral rock patches to the north.

The lagoon floor descends from the shallow inshore reef to a depth of 5m at between 100 and 700m to the north. Over much of the area surveyed the general level of the lagoon bed lies at between about 5 and 7.5m (see figure 8) but in the western and central parts of the area this general level is considerably modified.

In the west a deep water channel occurs, the axis of which runs parallel to the shoreline in the south, at a distance from the inshore reef of about 600m, and then turns towards the northeast and north to form a distorted "U" shape open to the west. Water depths in this channel increase from a maximum of about 12.5m in the south to 17.5m in the north and the average channel width is about 250m. Numerous coral patch reefs occur in the channel (see figure 9).

In the central part of the survey area, at about 1300m from the inshore reef, an area of shallows occurs some 400m by 900m cross. Minimum water depths here are less than 1m.

Except in the base of the western channel, the lagoon floor is generally moderately rough on the small scale with depth variations of 1 to 2m common over short distances. The sidescan sonar records indicate that many of the small bathymetric highs are formed by coral outcrops on the lagoon floor. Coral outcrops in the area of rough sea bed are too numerous to differentiate individually but between about 25 and 35% of this area may be composed of coral outcrop.

On the basis of the sub-bottom seismic profiling results the survey area can be divided broadly into two subareas. The floor of the channel occurring in the west of the area, except where coral patch reefs are present, is composed of a layer of soft sediment up to 7.5m thick. Jet probe results indicate that this material is mainly silt. Elsewhere, the profiling results suggest that the soils material immediately underlying the lagoon bed is everywhere mainly composed of cemented material, gravel or rubble, or a mixture of these types, with subordinate sand and silt. On the basis of the 1969 drilling survey the consultants to the government of Kiribati concluded that "A mean depth of at least ten feet of compacted sand over hard coral was proved within a range from five to more than nineteen feet. Numerous coral niggerheads were observed." During the most recent drilling survey undertaken in late 1981 in essentially the same area as the previous one, the mean thickness of sand and gravel determined from 16 boreholes is about 1.7m (5.6ft. with a range of from 0m to more than 4m (13ft.). The difference in the results of the two drilling surveys is possibly due to changes in the lagoon bed soils material between 1969 and 1981 but this is considered to be unlikely. It is much more likely that the apparent differences are partly due to differences in drilling or core logging methods and to differences in drilling technique, as well as to a great real variation in the soils material present. The seismic profiling records indicate that there is no laterally continuous homogenous sand formation of any significant thickness present immediately beneath the lagoon floor. In places uncemented sand may occur to the depths indicated in the boreholes but it is considered that the sand is in the form of pockets or lenses of small lateral extent. On the basis of the seismic profiling records and the drilling results it is considered that the lagoon floor material everywhere in the survey area except beneath the deepwater channel in the west is composed of a mixture of gravel, boulders, sand, silt, and cemented or semi-cemented coral, the proportions of which vary tremendously over very short distances both laterally and vertically.

CONCLUSIONS

Betio Mole Site

At the site of the proposed Betio East Mole extension the sea bed falls to a depth of 36 feet (Urn) at a distance of between 1550 and 2160ft (500 and 670m) from the end of the Mole. A number of areas of coral rock occur on the lagoon bed in the area surveyed. Elsewhere the lagoon bed surface material is generally silty sand with shells and gravel. The seismic profiling records and the jet probe results indicate that the sub-bottom soils material to a depth of at least 25 feet (7.5m) is composed of a mixture of sand, gravel, boulder and coral with great lateral and vertical variations in distribution and thickness of the various soils types. Fine grained material is probably subordinate, however.

Betio Shipping Channel

The hydrographic survey of the main Betio shipping channel revealed no major changes in the channel bed level since the last detailed survey in 1959. However, significant changes over an area of at least 200 by 200m (650 by 650ft.) would probably have needed to have occurred to be detected at the scale of the survey.

Betio-Bairiki Causeway Fill Site

An area of the lagoon floor out to between 1600 and 2200m (5250 and 7200ft.) from the reef was surveyed off the site of the proposed Betio-Bairiki Causeway. The lagoon bed slopes down from the inshore inter tidal reef to a general depth of between about 5 and 7.5m (16 and 25ft.) over the survey area. In the west a deep water channel occurs with an average width of about 250m and maximum water depths of 12.5m at the inshore end and 17.5m at the offshore end. The channel has a distorted 'U' shape open to the west. A shallow lagoon bed area measuring about 900m by 400m (2950 by 1300ft.) occurs in the central, off shore, part of the area surveyed. Minimum water depths here are less than 1m (3.3ft.).

Numerous coral patch reefs up to about 100 across occur in the deep water channel on the western side of the area surveyed but otherwise the channel floor is smooth. Elsewhere, however, the lagoon floor is rough on the small scale, with vertical variations of up to about 2m over short distances common. This roughness appears to be caused largely by coral rock outcrop and the sidescan sonar records indicate that between 25 and 35% of the lagoon floor surface outside the deepwater channel may be hard ground.

The sub-bottom soils material beneath the channel in the west is largely composed of soft silt to a depth of between about 4 and 7.5m (13 and 25ft.) except where

coral reefs occur. Elsewhere in the area surveyed the seismic profiling records and the borehole results indicate that the soils material immediately underlying the lagoon floor is composed of a mixture of gravel, boulders, cemented or semi-cemented coral, sand and silt. The proportions of these various materials vary tremendously over very short distances both laterally and vertically. There appears to be no continuous, homogeneous sand formation of any significant thickness immediately underlying the lagoon floor.

WORK REMAINING

It had been proposed to undertake a magnetometer survey over the site of the proposed Betio Mole extension but this was not completed because of technical difficulties. The purpose of the survey was to attempt to determine whether any World War II ordnance is present in the area. If required, this work could be undertaken at a later date, but in order to obtain meaningful results it would be necessary for all shipping to be kept clear of the survey site during the work.

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- A. The views expressed in this report are those of the author and do not necessarily reflect those of the United Nations.
- B. Mention of any firm or licenced process does not imply endorsement by the United Nations.

APPENDIX I

TABLE 1: Jet Probe Results
(See Figures 3 and 9 for locations)

Number	Local Coordinates		Water Depth (unreduced)	Description
	E	N		
A. Betio Mole				
1	8496.5	150653.3	-	Silt and fine sand on sea bed. 1.5m probe penetration. Stopped on hard layer.
2	8520.6	150799.7	7m	A few inches of silt and sand over coral gravel at sea bed. Few scattered boulders. 0.4m penetration stopped hard.
3	8560.1	150855.8	7.6m	Silty fine to medium sand on sea bed. Smooth bed. Relatively easy probe penetration to 2.1m.
4	8568.6	150939.0	9.1m	Few inches silty sand over coral gravel on sea bed. 1.75m penetration.
5	8627.1	151055.4	9.1m	Coral rock sea bed with thin film of silt on top. Halimeda (algae) covered.
6	8531.2	150752.3	6.1m	Few inches silty sand over gravel. 1.6m penetration.
7	8608.2	150699.8	5.5m	Silty sand and gravel with small boulders on sea bed. Penetration 3m plus - gravelly feel.
8	8701.5	150802.0	7.6m	Fine, silty, sandy, smooth sea bed. 0.75m penetration. Gravelly feel.
9	8792.4	150876.9	7.9m	Silty sand on sea bed - Halimeda (algae) covered. 0.75m penetration. Gravelly feel.
10	8899.5	150994.0	10m	Silty, sandy sea bed with Halimeda. 0.9m penetration - gravelly feel.
11	8612.5	1510130.0	10.4m	Silty sandy sea bed - smooth. 1m penetration to hard layer.
B. Causeway Borrow Pit Site				
12	10814.32	150179.9	13.7m	Soft mud sea bed; fairly easy probe penetration to 3m+.
13	11249.3	150003.4	6.1m	Coral rock outcrop.
14	11452.6	150260.3	-	Soft mud sea bed; penetration to 3m+ - fairly easy with some resistance at 2.5m.

APPENDIX I

TABLE 2: Diving Results - Causeway Borrow Pit Site
(See Figure 8 for location)

Dive Station No.	Water Depth (unreduced)	Description
1	3.35m	Sea bed surface sediment mainly silt and fine to coarse sand with approx. 25% coral gravel material and occasional dead coral boulders up to 45cm across.
2	6.1m	Silty, fine to coarse sand at sea bed. Extensively burrowed. A little living algal "weed".
3	8.8m	Sea bed surface sediment mainly silt with some coral fragments but a few inches beneath the sediment feels gravelly. Some live and dead coral heads and patches occur up to 3m across. Algal "weed" common.
4	-	Mainly silty, fine to coarse, burrowed sand at sea bed but some areas of mainly silt material occur as well as several pieces of dead acropora coral up to 25cm across. Some algal "weed".
5	7m	Sea bed similar to Station 3.
6	6.4m	Mainly burrowed silty sand at sea bed with acropora gravel. Algal "weed" common. Two outcrops of dead coral observed which were up to 1.5m across and 60cm high.
7	6.1m	Silty, fine to coarse sand at sea bed with an area of dead coral outcrop up to several tens of metres across. This has the algae Halimeda on it as well as acropora gravel and small boulders.
8	5.2m	Silty, fine to coarse sand at the sea bed with algal "weed" common.
9	4.6m	Silty, fine to coarse sand at the sea bed with burrow holes up to ½m deep and 1m across. Some acropora gravel in places.
10	3.7m	Silty, fine to coarse sand at sea bed with some acropora gravel and small boulders. Also an extensive area of rocky, algal "weed" covered sea bed with live and dead coral heads, acropora gravel, boulders and shells.

APPENDIX II

SURVEY NARRATIVE

<u>Date</u>	<u>Activity</u>
5 Nov. 1981	Gauss and Zann departed Suva, for Tarawa.
6 Nov. 1981	Visits made to Public Works, Fisheries, and Lands and Survey offices.
7 Nov. 1981	Inspection of sea bed in area) of proposed Betio-Bairiki causeway made by diving.
8 Nov. 1981	Sunday
9 Nov. 1981	Diving and temperature/salinity measurements made in area of proposed causeway.
10 Nov. 1981	Diving and temperature/salinity measurements made in area of proposed causeway.
11 Nov. 1981	Air photographs of South Tarawa taken and visit made to Atoll Research Unit.
12 Nov. 1981	Preparations made for hydrographic survey. Reef transects carried out.
13 Nov. 1981	Study of air photos at Lands and Surveys office made. Reef transects continued.
14 Nov. 1981	Preparation of hydrographic survey plotting sheets. Reef transects continued.
15 Nov. 1981	Inspection of sea bed around Betio made by diving.
16 Nov. 1981	Preparation of biological samples for shipping back to Suva carried out. Inspection of coastal erosion sites made.
17 Nov. 1981	Packing of samples for shipping back to Suva. Inspection of coastal erosion sites.
18 Nov. 1981	Zann departed for Suva. Hydrographic/Geophysical survey equipment arrived by ship from Suva.
19 Nov. 1981	Saphore and Motuiwaca arrived from Suva. Preparations made for equipment clearance.
20 Nov. 1981	Equipment cleared customs. Survey base map preparation.
21 Nov. 1981	Awaiting offloading of equipment. Survey base map preparation.
22 Nov. 1981	Sunday
23 Nov. 1981	Installation of equipment on survey vessel commenced.

<u>Date</u>	<u>Activity</u>
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24 Nov. 1981	Installation continued.
25 Nov. 1981	Installation and testing of equipment
26 Nov. 1981	Commenced survey operation at proposed Causeway fill site.
27 Nov. 1981	
to	Boomer and hydrographic survey completed at Causeway fill site.
2 Dec. 1981	
3 Dec. 1981	Sidescan sonar survey and hydrographic survey completed at Cause-
to	way Fill Site. Sounding survey commenced in Betio Channel.
5 Dec. 1981	Consultant Kimmerer arrived.
6 Dec. 1981	Sunday Plotting of survey results.
7 Dec. 1981	Kimmerer carried out baseline data collection in area of proposed
	Causeway. Plotting of geophysical/hydrographic survey results.
8 Dec. 1981	Sounding survey in Betio Channel continued.
9 Dec. 1981	Sounding survey in Betio channel continued.
10 Dec. 1981	Survey vessel developed leak. Commenced transfer of equipment
	to fisheries boat.
11 Dec. 1981	Completed transfer of equipment. Commenced boomer and hydro-
	graphic survey off Betio Mole.
12 Dec. 1981	Carried out sidescan sonar and hydrographic survey work off
	Betio Mole.
13 Dec. 1981	Sunday. Plotting of results.
14 Dec. 1981	Completed boomer survey off Betio Mole.
15 Dec. 1981	Completed Betio Channel hydrographic survey.
16 Dec. 1981	Carried out jet probing operations off Betio Mole.
17 Dec. 1981	Carried out jet probing operations at Causeway Fill Site. Tech-
	nical problem with Trisponder system developed.
18 Dec. 1981	Survey vessel swamped by overnight rain deluge. Salvage and
	cleaning of equipment commenced.
19 Dec. 1981	Salvage and cleaning of equipment continued.
20 Dec. 1981	Inspection of sea bed in area of proposed Causeway fill site carried
	out by diving.
21 Dec. 1981	Packing of equipment commenced.
22 Dec. 1981	Packing of equipment completed.
23 Dec. 1981	Gauss, Saphore and Motuiwaca returned to Suva.