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CRUISE 75/03

INSTITUTE OF GEOLOGICAL SCIENCES

GEOPHYSICAL DIVISION

# GEOLOGICAL & GEOPHYSICAL TEST RANGES IN THE FIRTH OF FORTH

24.2.1975 — 12.3.1975

TRIALS REPORT No 2

FIRTH OF FORTH ENGINEERING CRUISE

MV "WHITETHORN"

CRUISE 75WH03

by

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GP/MG/5.55 .2

IGS TRIALS REPORTS

This report is one of a series which will describe geological and geophysical tests made across a group of test ranges in the Firth of Forth. Initial surveys will be made by IGS using a wide range of equipment, after which commercial operators and equipment manufacturers will be invited to make use of the range and where possible, make test data available for distribution as reports in this series.

A set of two 1:25 000 base maps have been prepared on National Grid projection with conspicuous coastal land marks shown for visual fixing purposes. Copies are available to users of the test range.

An open file of test range data will be held in Marine Geophysics Unit, Edinburgh, for consultation purposes which will include records and documents additional to those copied for circulation in this report series.

Enquiries relating to this work should be addressed to Mrs S E Deegan, Marine Geophysics Unit, 14 Braefoot Terrace, Edinburgh EH16 6AA.

# GEOLOGICAL AND GEOPHYSICAL TEST RANGES

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Report Dated 11/4/1975

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## INTRODUCTION

The aims of this cruise were:

i) The testing and assessment of sampling methods in unconsolidated marine sediments with the object of obtaining undisturbed samples for geotechnical tests.

ii) Evaluation of radiometric "down hole" logging techniques for use in unconsolidated marine sediments.

iii) Testing and evaluation of acoustic "down hole" logging techniques.

Six borehole sites were planned in the Firth of Forth area, five being in Kirkcaldy Bay and one in the approaches to the firth. All sites were in areas of known geology and were sited to give boreholes in 30 - 40 metres of unconsolidated sediments. They were also in close proximity to the Firth of Forth geophysical test range, an area with very dense shallow seismic coverage.

Geophysical traversing and sediment sampling facilities were available as stand-by activities in the event of drilling/logging down time.

## NAVIGATION AND POSITIONING

Navigation on geophysical traverses, and when locating anchors on borehole sites, was by Decca Main Chain No. 3B.

After anchoring on each site, multiple deccometer readings were taken to obtain an accurate Decca position.

Transponders were set up at two suitable vantage points on the coast of Kirkcaldy Bay (by land based personnel). These were interrogated by the Whitethorn's Alpine Radar Ranging equipment, accurate ranges obtained to each known point and the position plotted.

The position of each of the boreholes drilled is detailed below and illustrated in Dog. 6. Discrepancies are due to the use of uncorrected Decca readings.

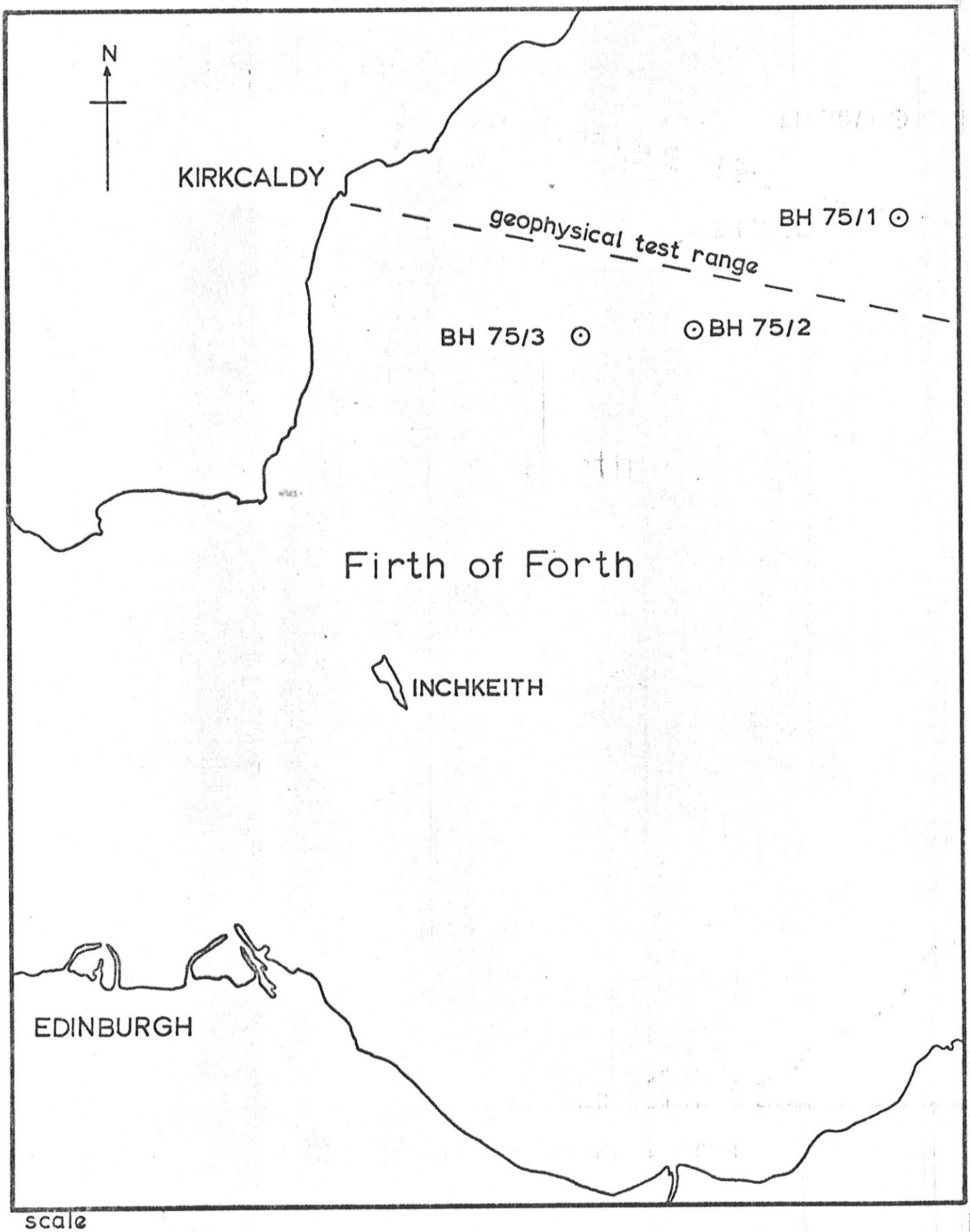
| BOREHOLE | DECCOMETER READINGS | | | DECCA | | RADAR | |
|---|---|---|---|---|---|---|---|
| | RED | GREEN | PURPLE | LAT | LONG | LAT | LONG |
| 75/1 | B 8.44 | C34.54 | C69.98 | 56°06.50' | 02°58.96' | 56°06.65' | 02°58.75' |
| 75/2 | - | C33.16 | C70.40 | 56°05.48' | 03°02.61' | 56°05.51' | 03°02.47' |
| 75/3 | B09.20 | C32.28 | C71.90 | 56°05.43' | 03°04.74' | 56°05.46' | 03°04.55' |

## PERSONNEL

The following is a list of personnel involved in this cruise on Whitethorn full time, part-time and occasionally.

| | |
|---|---|
| R. OWENS (PARTY LEADER) | I.G.S. (C.S.U. II) |
| P. WIGGINS | " " |
| R. BARIA | I.G.S. (E.G.U.) |
| R. CRATCHLEY | " " |
| J. HALLAM | " " |
| P. HOBBS | " " |
| J. LAMBERT | " " |
| D. McCANN | " " |
| J. PATERSON | " " |
| C. CLAYTON | A.E.R.E. (HARWELL) |
| N. MERRIL | " " |
| R. SOBNACK | " " |
| G. SYMONS | " " |
| M. WORMALD | " " |
| A. DAVIES | I.G.S. (M.G.U.) |
| R. FLOYD | " " |
| P. ROBERTS | " " |
| J. MILLER | I.G.S. (R.M.M.U.) |
| P. ROBERTS | " " |
| J. McENTEE | WIMPEY |
| R. MUNDAY | " |
| D. HINSLEY | B.R.S. (WATFORD) |
| G. HENDERSON | " " |
| I. MURRAY | U.D.I. (ABERDEEN) |

Movements of the personnel listed above are detailed in appendix II. This is an approximation and takes no cognizance of time spent on Quintail, or part day presence.




scale
1:100 000

Cruise 75 WH Ø3 Operational Area

INSTITUTE OF GEOLOGICAL SCIENCES
FORTH TEST RANGE
DOCUMENT NUMBER 6
REF. GP/MG/5.55

## PRELIMINARY ASSESSMENTS OF RESULTS

The following assessments are compiled from reports prepared by:

J. HALLAM (E.G.U.), R. BARIA (E.G.U.),
J. MILLER (R.M.M.U.) and R. OWENS (C.S.U. II)

## DRILLING AND SAMPLING

The prime objectives of this cruise were:-

I. An attempt at obtaining continuous undisturbed samples of unconsolidated sediments, suitable for geotechnical testing.

II. Evaluation of a Pitcher sampler and new P.Q. wireline soil sampling equipment (property of Wimpeys).

III. Evaluation of radiometric and acoustic borehole logging techniques.

The lithological sequence at the three sites drilled was similar and comprised 30 - 40 metres of soft to firm silty clays with occasional thin sand horizons (Forth beds and St. Abbs beds) on a thin layer of till (Wee Bankie beds). Where rockhead was reached beneath the till, Carboniferous sandstones and marls were proved.

Normally, "Whitethorn" would drill the unconsolidated sediments by shell and auger, initially in $9\frac{5}{8}$" casing and later in 6" casing. Given suitable material, this method would be used until rockhead was reached. On reaching rockhead or a horizon impenetrable by shell and auger, a rock roller would be used. Sampling, when using the shell and auger, would be by:

a) Taking bag samples of the material brought to the surface in the shell.

b) Driving U4 sample tubes.

To improve the quality of these sampling methods, U4 and 3" Shelby tube drift samples were taken by lowering the sample tubes into the borehole on a drill rod string. Restrictions imposed by the shortness of samples obtained by this method resulted in construction of a longer sampler from a 20' vibrocorer barrel. This was employed in a similar manner and gave samples 1.2 metres long.

The Pitcher sampler is a device capable of "drilling in" thin walled Shelby sample tubes and is suitable for obtaining "undisturbed" samples in stiff materials, such as clays. A suitable opportunity to try this equipment did not arise.

The new P.Q. rotary flush soil sampling gear, supplied by Wimpeys, had not been proved prior to the cruise and it was hoped to evaluate it in marine conditions. It can be used as:

i) A wire line triple core barrel (cf. MAZIER or T.I.R. types) - similar equipment has been used on land to obtain high quality samples of problematic soils. Use in this configuration was precluded by problems with the split steel core liner.

ii) A thin wall, punch-core tube sampler - modifications effected during the cruise converted this mode to a wire-line Pitcher-type sampler using 3' Shelby tubes. An opportunity to test this configuration did not arise.

iii) A rock bit wire line corer - by attaching a roller bit to the bottom of the inner barrel the equipment can cut and recover core in materials sufficiently coherent to be drilled by conventional means. This configuration was used to recover 6.5 metres of core in till, sandstone and marl at borehole 75/3B.

RESULTS

Sample recovery for the cruise totalled 9 U4s, 6 Shelby tubes and 23 modified vibrocover barrel samples.

The quality and degree of disturbance will be assessed when all samples have been examined in detail.

The cruise has indicated problems with ships, equipment and techniques when attempting sampling of unconsolidated marine sediments for geotechnical purposes. A detailed review of these problems will be given at a later date.

## SUMMARY OF DRILLING AND SAMPLING

BOREHOLE

75/1/B Drilled by shell and auger to 25.1 metres in approximately 10 hours on 2nd March.
5 U4 samples taken, each with two tubes.
Soft grey silty clay throughout.

75/1/C Drilled by shell and auger to 30.3 metres in approximately 12 hours on 2nd/3rd March.
7 modified Vibrocore tube samples.
Lithology as 75/1/B.

75/2 Drilled by shell and auger to 42.9 metres in about 24 hours on 3rd/4th March.
4 U4 samples, 3 Shelby tube samples and 5 Vibrocore tube samples taken.
Soft to firm grey brown silty clay with some sandy horizons.
The 4 U4 samples were taken while the Vibrocore tube sampler was under repair.

75/3/A Drilled by jetting casing 37.55 metres in 7 hours on 7th March.
This hole was put down purely for radiometric logging, and no samples were taken.

75/3/B Drilled by jetting 6" casing to 36.6 metres and P.Q. wireline drilling to 49.6 metres. Total time 24 hours on 8th/9th March.
11 Vibrocore tube samples to 29.4 metres.
2 Shelby tube samples to 36.0 metres.
Rotary coring with standard P.Q. inner barrel from 36.6 to 42.7 metres.
Open holing with rock-bit version of special P.Q. equipment from 42.7 to 49.6 metres.
Lithologies of 75/3/A and 75/3/B similar to 75/2, down to 36 metres, below which till then Carboniferous sandstone and marl was encountered.

## ACOUSTIC LOGGING

To evaluate seismic techniques for marine borehole logging three logging methods were tried:

i) A seismic pulse source (100 element multi-electrode sparker) was deployed on the seabed from "Quintail" at a distance of 25 metres from the borehole. A hydrophone array was lowered to the bottom of the borehole in 1 metre steps, then withdrawn at a constant slow rate.

ii) Identical techniques and equipment were used but with the sparker 100 metres from the borehole.

iii) The sparker and hydrophone were both inserted in the borehole, the sparker being stationary at seafloor level. The hydrophone was lowered from seafloor level in one metre steps to the borehole bottom, then raised at a constant slow rate.

The hydrophone output, after summing, preamplification and filtering, was fed into a TEKTRONIX 549 oscilloscope run in parallel with a FENLOW fm tape recorder, a VENNER counter-timer and an E.P.C. analogue recorder. All were triggered externally from a common 9v pulse generator.

Measurements of first arrivals and photographs of waveforms were made on the oscilloscope.

Triggering of the capacitor banks was from the 9v pulse generator on "WHITETHORN", the pulse being fed through 200 metres of 50 ohm coaxial cable. The 1000 J energy output of the sparker seismic pulse source deployed from "QUINTAIL" was more than adequate.

## CONCLUSIONS

a) The results obtained with the sparker deployed on the sea bottom at 25 and 100 metres from the borehole are encouraging. With further interpretation, using the direct arrivals, it will be possible to produce values for the velocity of sound in the sediment layers penetrated by the borehole. It will also be possible to evaluate the significance of the acoustic interfaces detected as reflectors. This work will require to be integrated with the logs of geological and geotechnical parameters of the borehole sediments.

Owing to lack of time it was not possible to fully evaluate the third acoustic logging method (source and receiver in the borehole). The time available did show that source - receiver separation required to be greater than 20 metres before the signal pulses could be separated.

b) Experimental free field work with the borehole sparker in single and multi-element modes showed the latter to produce seismic pulses of very short duration (2 to 3 milliseconds). This will improve considerably resolution and, hence, interpretation of all forms of acoustic borehole logging.

## RADIOMETRIC LOGGING

a) RMMU/AERE - The gamma spectrometer logging equipment used consisted of a down-hole probe containing a sodium iodide gamma detector, a cable and hand operated winch, power unit, ratemeter and spectrum stabiliser and a multi-channel analyser.

b) WIMPEY - Two probes were used:

i) Gamma-gamma probe, containing a radioisotope gamma source and Geiger-Muller detector.

ii) Gamma and neutron-neutron probe, containing a radioisotope neutron source and detector and a Geiger Muller detector.

The probes were lowered and raised on cable via an electrically operated winch. Results were recorded on a three pen analogue recorder.

## OPERATIONS

a) RMMU/AERE - BOREHOLE 75/2: Two total radioactivity profiles were obtained. Fourteen 2000 second radioelement channel scalar counts were taken at significant points on the total activity profile. Following logging by the Wimpey team and lifting of most of the $9\frac{5}{8}$" casing, the borehole was re-logged twice (total activity), the second time at very slow speed and long time constant.

BOREHOLE 75/3A: Two total gamma activity logs obtained.

BOREHOLE 75/3B: One total gamma activity profile and several 2000 second channel counts were obtained.

b) WIMPEY - BOREHOLE 75/2: Two gamma-gamma, neutron-neutron and total gamma profiles were initially obtained. Anomalous features in the gamma-gamma profile resulted in the $9\frac{5}{8}$" casing being lifted so that only a 20' length remained in the seabed. A further gamma-gamma profile was then obtained.

BOREHOLE 75/3A: Gamma-gamma, neutron-neutron and total gamma profile were obtained.

PRELIMINARY ANALYSIS OF RESULTS

a) RMMU/AERE GAMMA LOGGING - In borehole 75/2 the gamma activity profile can be divided into three units:

I. An upper moderately active relatively homogenous unit corresponding with muds with a relatively high silt content.

II. A transition zone towards the base of the profile with a downward increase in activity corresponding to an increase in argillaceous content.

III. A highly active basal unit corresponding with 'grey-brown clays', presumeably highly argillaceous.

In Borehole 75/3 the activity profile was generally similar with the exception of an initial 1 m low activity layer at the sea bottom, corresponding with some compacted muddy sands.

A steep rise in activity at the base of the profile is associated with the presence of a dusky red stony till. The activity level is similar to that noted at the base of 75/2, implying possible lateral equivalence of the units.

Anomalies in the profile of borehole 75/3A are discussed below.

b) WIMPEY GAMMA-GAMMA, NEUTRON-NEUTRON AND GAMMA LOGGING - On both holes logged the neutron-neutron profiles were similar to the gamma profiles obtained by RMMU/AERE and clearly provide a representation of the lithologies penetrated by the boreholes. However, as the count rate was an order of magnitude lower, the detail of the profile is much less well defined.

The initial gamma-gamma logging of borehole 75/2 demonstrated the inability of the energies to penetrate both the $\frac{1}{4}$" thick 6" inner casing and the $\frac{1}{2}$" thick $9\frac{5}{8}$" outer casing. No variation in the profile would be seen unless the probe was in the single 6" casing.

In the case of the jetted borehole (75/3A) the cavitation around the casing caused by the method of drilling has adversely affected the gamma and gamma-gamma profiles. This disturbance greatly reduces the value of the logs and severly limits the worth of the rapidly jetted hole for logging purposes.

A fuller analysis of the profiles will not be possible until more complete lithological and geotechnical logs of the boreholes have been prepared.

## GEOPHYSICAL TRAVERSING AND BOTTOM SAMPLING

During mobilization of "Whitethorn" at Newcastle geophysical equipment (1000 J sparker, 500 J bommer, pinger, Klein dual sidescan scnar, transit sonar) and sampling equipment (20' vibro-corer, gravity corer and Shipek grabs) were installed as part of the routine commissioning of the ship for the season's operations.

Geophysical traversing and bottom sampling was considered a standby activity during any time the ship was not engaged in the prime objectives of the cruise. Activity was as follows:

i) GEOPHYSICAL TRAVERSING

a) Testing - Since equipment was newly installed, tests under operational conditions were performed whilst steaming from Newcastle to the Firth of Forth. All instruments performed satisfactorily. However, during the only long traverse run (see below) apparent deterioration was confirmed on traverse along the geophysical test range in the Firth of Forth (Kirkcaldy pier to Fidra light), corrected and the correct functioning later confirmed on the test range.

b) Traverse lines - Owing to naval exercises in Kirkcaldy Bay drilling operations could not be commenced before 0900 hours on 1/3/75. To use the time between the personnel transfer on 27/2/75 and then a traverse was run between 01° 27'W and 01° 19'E using the sparker and pinger.

On 11.3.75 abandonment of the drilling programme allowed a series of short pinger traverses to be run in Kirkcaldy Bay in an attempt to delineate areas of "pseudo-Becken" effect (Pseudo-Becken effect is a term applied to zones where pinger frequency sound waves - 3.5 KHZ - cannot penetrate horizons penetrable in adjacent areas. The effect is thought to be caused by some form of acoustic damping.). A promising area was located and mapped for vibrocoring.

ii) BOTTOM SAMPLING

No systematic bottom sampling was undertaken in the course of this cruise. Gravity cores were obtained at the site of borehole 75/3 and indicated a very firm muddy sand bottom. Attempts to vibrocore at borehole sites were frustrated by faults in the vibrocorer toe winch and power cable.

Vibrocoring at the chosen pseudo-Becken effect site was precluded by poor holding ground for the ships anchors. This, and the presence of an abundance of shelly material on the anchors when drawn home, may indicate the pseudo-Becken effect in this area to have been caused by the damping effect of a concentration of shells.

## BOREHOLE LITHOLOGICAL LOGS

Subsamples of materials used for shipboard geotechnical tests were examined for preparation of the initial lithological log for each borehole drilled. The logs for each hole are given in appendix 1.

BOREHOLE 75/1 (REDRILL OF BOREHOLE 71/32) - the uniformly clayey lithology of this hole corresponds with the Forth and St. Abbs beds (see Doc. 6) previously mapped in the Firth of Forth.

BOREHOLE 75/2 (REDRILL OF BOREHOLE 74/1) - again the relatively uniform clay or mud lithology corresponds with that expected for the Forth and St. Abbs beds.

BOREHOLE 75/3 (REDRILL OF BOREHOLE 71/33) - the clay and mud lithology of the Forth and St. Abbs beds was as expected down to 36.6 metres where the till of the Wee Bankie beds was encountered. This was 0.3 metres

thick and was succeeded by Carboniferous sandstones to 49.6 metres where 0.4 metres of marl was cored. This differed from the log of borehole 71/33 where till was logged from 34.8 metres to 49.0 metres. An explanation of the discrepancy is that, using the shell and auger for borehole 71/33 it was possible to drive through the relatively friable sandstones to 48.0 metres. Thereafter, using the rock roller, significant resistance would only be encountered at the marls which, by allowing the roller to slip, are difficult to penetrate. Location of the marl at approx. 49 metres supports the above hypothesis.

## CONCLUSION

The drilling and sampling activity suffered from equipment deficiencies which only became apparent under operational conditions. Sampling of unconsolidated marine sediments with minimal disturbance and an acceptable degree of positional precision requires a stable working platform. The long period (tidal) and short period (wave) vertical movements of the ship preclude any possibility of accurate sampling without casing sited on a firm stratum. The disturbance of driving casing through the yielding beds and the impracticability of sampling out of suspended casing renders samples, taken prior to having casing firmly set, of dubious value. A need for some form of heave compensation is indicated.

Preliminary review of the acoustic logging results indicated the possibility of achieving a measure of success greater than anticipated. The results will have significance from geotechnical and geophysical considerations.

The experience with the radiometric logging has illustrated the problems associated with casing and drilling techniques, as required in unconsolidated marine sediments. The full value of the logs will not be known until they have been integrated with the geotechnical, geophysical and geological results.

One of the major successes of this cruise has been the ability of a large number of multi-disciplinary personnel to co-operate and interdigitate their activities to optimise an unique data gathering opportunity.

The co-operation and advice of the Wimpey drilling personnel, particularly the drilling foreman, P. McLaughlin, the drillers, B. Saville and B. Rogers and the agent F. Browning was particularly significant in ensuring the success of the cruise. Similarly, the advice and discussions provided by J. McEntee on logging techniques are gratefully acknowledged.

# APPENDIX I

## BOREHOLE LITHOLOGICAL LOGS

BOREHOLE 75/1
(redrill of Borehole 71/32)

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Clay; Plastic, soft, very slightly silty. Reacts moderately c̄ H Cl. Dark grey (10R4/1) | 0.04 | 5.54 |
| Clay; Plastic, soft, very slightly silty. Reacts c̄ H Cl giving $H_2$ S odour. Very dark grey (10YR3/1) | 0.05 | 5.87 |
| Clay; Plastic, soft, very slightly silty. Slight reaction c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) c̄ black streaks. | 0.04 | 6.04 |
| Clay; Plastic, soft, very slightly silty. Moderate reaction c̄ H Cl giving $H_2$ S odour. Slightly micaceous. Very dark grey (10YR3/1) c̄ black streaks. | | 6.40 |
| Clay; Soft, highly plastic, very slightly silty. Strong reaction c̄ H Cl giving $H_2$ S odour. Dark greyish brown (10YR4/2) c̄ black streaks. | | 12.10 |
| Clay; Soft, plastic, silty. Moderate reaction c̄ H Cl giving $H_2$ S odour. Dark greyish Brown c̄ black streaks. (10YR4/2) | | 12.60 |
| Clay; Soft, plastic, silty, weak reaction c̄ H Cl giving $H_2$ S odour. Grey (10YR5/1) | | 13.45 |
| Clay; Soft, plastic, silty. Weak reaction c̄ H Cl giving $H_2$ S odour. Very dark greyish-brown (10YR3/2) | | 15.70 |

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Mud; Soft, plastic, very clayey. Moderate reaction c̄ H Cl giving $H_2$ S odour. Dark greyish brown (10YR4/2) | | 16.15 |
| Clay; Soft, highly plastic, slightly silty. Contains lamina of mud, micromicaceous. Moderate reaction c̄ H Cl giving $H_2$ S odour. Grey (10YR5/1) | | 16.60 |
| Clay; Soft, highly plastic, slightly silty. Weak reaction c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) c̄ faint black streaks. | | 20.40 |
| Clay; Soft, plastic, slightly silty. Weak reaction c̄ H Cl giving $H_2$ S odour. Dark greyish brown (10YR4/2) | | 20.85 |
| Clay; Soft, plastic, slightly silty. Moderate reaction c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 21.30 |

NOTE

Borehole 75/1 is a re-drill of borehole 71/32.

BOREHOLE 75/2
(redrill of borehole 74/1)

| LITHOLOGY | THICKNESS | DEPTH FROM SURFACE (M) |
|---|---|---|
| Clay; Moderately soft, moderately plastic, silty. Slight reaction c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 12.70 |
| Clay; Moderately firm, moderately plastic, Silty. Slight reaction c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 13.18 |
| Mud; Moderately firm, reacts c̄ H Cl to give $H_2$ S odour. Dark grey (10YR4/1) | | 15.45 |
| Mud; Soft, clayey, reacts c̄ H Cl. Greyish brown (10YR5/2) | | 15.90 |
| Clay; Moderately firm, silty, plastic. Reacts c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 17.35 |
| Mud; Moderately firm, micromicaceous, reacts strongly c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 17.80 |
| Clay; Soft, plastic, silty. Reacts c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 17.85 |
| Mud; Moderately firm, moderately plastic, micromicaceous. Weak reaction c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 18.30 |
| Clay; Soft, plastic, silty. Moderate reaction c̄ H Cl giving $H_2$ S odour. Dark Grey, (10YR4/1) c̄ black streaks. | | 19.65 |

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Clay; Soft, plastic, silty. Reacts $\bar{c}$ H Cl giving $H_2$ S odour. Very dark greyish brown (10YR3/2) | | 20.10 |
| Mud; Soft, plastic, reacts $\bar{c}$ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | | 20.15 |
| Clay; Soft, plastic, very weak reaction $\bar{c}$ H Cl giving faint $H_2$ S odour. Dark Grey (10YR4/1) | | 20.60 |
| * Clay; Moderately firm, plastic, reacts $\bar{c}$ H Cl giving $H_2$ S odour. Dark brown (7.5YR4/2) | | 37.90 |
| * Clay; Moderately firm, plastic, reacts weakly $\bar{c}$ H Cl giving faint $H_2$ S odour. Dark brown (7.5YR4/2) | | 42.90 |

NOTE

Borehole 75/2 is a re-drill of borehole 74/1.

* SHELBY TUBE SAMPLES.

## BOREHOLE 75/3A

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Till; Sandy c̄ clasts 2mm. - 50mm. Dusky red (10R3/2) | | |

BOREHOLE 75/3B

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Clay; Soft, plastic, reacts c̄ H Cl giving strong $H_2$ S odour. Dark grey (7.5YRN4) | 0.60 | 6.60 |
| Mud; Soft, very silty, micromicaceous. Reacts c̄ H Cl giving $H_2$ S odour. Grey (7.5YRN5) | 0.05 | 9.20 |
| Clay; Soft, highly plastic, reacts c̄ H Cl giving $H_2$ S odour. Dark grey (7.5YRN4) | 0.05 | 12.60 |
| Mud; Soft, plastic, micromicaceous. Reacts c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | 0.07 | 16.63 |
| Mud; Soft, micromicaceous. Reacts c̄ H Cl giving $H_2$ S odour. Dark grey (10YR4/1) | 0.08 | 18.47 |
| Sand; Fine, muddy, micromicaceous. Reacts c̄ H Cl giving $H_2$ S odour. Very dark grey (10YR3/1) | 0.05 | 18.55 |
| Mud; Soft, plastic, micromicaceous. No reaction c̄ H Cl. Dark grey (10YR4/1) | 0.06 | 19.89 |

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Sand; Fine, muddy, micromicaceous. Reacts c̄ H Cl giving strong $H_2$ S odour. Greyish brown (10YR5/2) | 0.05 | 20.20 |
| Sand; Fine, muddy, micromicaceous. Reacts c̄ H Cl giving faint $H_2$ S odour. Dark grey (10YR4/1) | 0.05 | 21.80 |
| Sand; Fine, muddy, micromicaceous. Reacts c̄ H Cl. Grey (10YR5/1) | 0.05 | 25.60 |
| Clay; Moderately firm, plastic. Reacts weakly c̄ H Cl. Dark greyish brown (10YR4/1) | 0.10 | 29.30 |
| Clay; Moderately firm, plastic. Reacts c̄ H Cl. Dark grey (10YR4/1) | | 30.35 |
| Till; Tough, sandy c̄ abundant, clasts to 100mm. Dusky red (10YR3/2) | 0.30 | 36.60 |
| Sst; Fine, well sorted, subrounded, quartzose. Bedding dips @ N15°. Pinkish grey (5YR6/2) | 2.75 | 36.90 |

| LITHOLOGY | THICKNESS (M) | DEPTH FROM SURFACE (M) |
|---|---|---|
| Sst; Fine, well sorted, subrounded, quartzose. Weak red (10R5/3) c darker mottling - weak red (10R4/2) | 3.05 | 39.65 |
| Marl; Soft, well laminated. Laminae dipping @ 15°. Weak red (10R4/3) | 0.40 | 49.60 |

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Borehole 75/3B is located on the site of borehole 71/33 where rockhead was thought to have been found at 49.00m. 75/3B clearly shows rockhead to be at 36.90m.

APPENDIX II

PERSONNEL MOVEMENTS

75/WH/03 PERSONNEL MOVEMENTS. ( X Denotes presence on 'Whitethorn').

| Date | UDI | BRS | | WIMPEY | | RMMU | | CSUII | MGU | | AERE | | | | | EGU | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. MURRAY | D. HINSLEY | G. HENDERSON | R. MUNDAY | J. MC ENTEE | P. ROBERTS | J. MILLER | P. WIGGINS | R. OWENS | P. ROBERTS | R. FLOYD | A. DAVIES | M. WORMALD | G. SYMONS | R. SOBNACK | N. MERRIL | C. CLAYTON | J. PATERSON | D. MC.CANN | J. LAMBERT | P. HOBBS | J. HALLAM | R. CRATCHLEY | R. BARIA |
| 24.2.1975 | | | | | | | | x | x | x | | x | | | | | | x | | | x | x | | |
| 25.2.1975 | x | | | | | | | x | x | x | | x | | | | | | x | x | | x | x | | x |
| 26.2.1975 | x | | | | | | | | x | | | x | | | | | | | | | | | | |
| 27.2.1975 | x | | | | | | | | x | | | x | | | | | | | | | x | x | | |
| 28.2.1975 | | | | | | | | | x | | | | | | | | | | | | x | x | | |
| 1.3.1975 | | | | | | | | | x | | | | | | | | | | | | x | x | | |
| 2.3.1975 | | | | | | | | | x | | | | | | | | | | | | x | x | | |
| 3.3.1975 | | | | | | | | | x | | | | | | | | | x | x | | x | x | | x |
| 4.3.1975 | | | | | | x | x | | x | | | | | x | x | | | x | x | | x | | | x |
| 5.3.1975 | | | | x | x | | x | | x | x | x | | | x | | | | x | x | | x | | x | x |
| 6.3.1975 | | | | | | | x | | x | | | | | x | | x | | | | | x | x | | |
| 7.3.1975 | | | | | | | x | | x | | | | | x | | x | x | | | | x | x | | |
| 8.3.1975 | | | x | | | | | | x | | | | | | | | | x | x | | x | x | | x |
| 9.3.1975 | | | | | | x | | | x | | x | | | | | | | x | x | | x | x | | x |
| 10.3.1975 | | | | | | x | | | x | | | | | | | x | | | | | | | | |
| 11.3.1975 | | | | | | | | | x | | | | x | | | x | | | | | x | x | | |
| 12.3.1975 | | | | | | | | | x | | | | | | | | | x | | | x | x | | |

APPENDIX III

CRUISE SUMMARY

75/WH/03 CRUISE SUMMARY

| | | |
|---|---|---|
| Mon. | 24.2.75 | Commence mobilisation of 'Whitethorn' at Newcastle. F. Browning (Wimpey agent) advises Wimpeys have received notification, from the Ministry of Defence, of a mines-sweeping exercise in Kirkcaldy Bay in the period 24th - 28th February 1975, during which time drilling activity would be unacceptable. |
| Tues. | 25.2.75 | Mobilisation proceeds. Sailing postponed from 24.00 hours to 11.00 hours 26.2.75. |
| Wed. | 26.2.75 | Cast off 11.15 hours. Sail for Forth testing geophysical equipment (pinger, sparker, transit sonar, klein sonar and boomer) en route. Decca main chain receiver faulty. |
| Thurs. | 27.2.75 | Anchored off Inchkeith and made personnel transfer from Quintail. Decca repaired. Attempted to steam for site of BH 74/9 to make next slack but fog slowed ship and attempt abandoned at 14.00 hours. Steamed for Geophysics line. Commenced running line at 21.30 hours. |
| Fri. | 28.2.75 | End of line 16.00 hours. Commenced steaming for Forth. |
| Sat. | 1.3.75 | Commenced anchoring at borehole site 269 at 09.00 hours and finished at 11.12 hours. After personnel transfer from Quintail commenced vibrocoring operations as fill in activity while waiting for next tidal slack to run casing. Vibrocoring curtailed by clutch failure on toe winch. Casing and sampling operations started at 17.00 hours. |
| Sun. | 2.3.75 | Pulled out of borehole 75/1 at 14.00 hours, warping ship 20' astern on anchor wires and re-ran casing at 15.30 hours. This allowed sampling of the entire hole using a sampler prepared from a 10' vibrocore barrel. |
| Mon. | 3.3.75 | Ceased drilling and sampling at 03.00 hours and commenced lifting casing. Anchors lifted by 08.00 hours and commenced running sparker and pinger on geophysical test range. Mooring on borehole 75/2 commenced at 11.00 hours. At 11.45 hours a mine appeared on the surface approximately 200 M away, apparently caught on our port quarter anchor wire. Operations suspended while minesweeper H.M.S. NERTON cleared and recovered the mine. Commenced running casing and gravity coring at 15.00 hours. Casing and drilling only from 16.00 hours. Drilling ceased at 20.30 hours following failure of weld on modified 10' vibrocorer barrel sampler. Recommenced at 22.45 hours using shell and auger and U4's. |
| Tues. | 4.3.75 | Drilling ceased at 19.30 hours at 44.6 M and RMMU/AERE gamma logging commences. |
| Wed. | 5.3.75 | Gamma logging ceases at 10.00 hours and preparation for EGU acoustic logging commences. Logging started at 13.00 hours using sparker source deployed from Quintail and 'down-the-hole' hydrophone. Sonic logging ceases at 19.00 hours and Wimpey logging team (gamma, gamma-gamma &. neutron-neutron logging) occupy hole. |
| Thurs. | 6.3.75 | Main Wimpey logging program ceases at 04.30 hours and $9\frac{5}{8}$" casing lifted until only 20' remains in seabed. |

Thurs. 6.3.75
Continued... Wimpey logging team then logs through 6" casing from 08.30 hours to 10.30 hours. RMMU/AERE gamma logging then resumed until 12.30 hours when a personnel transfer was made from Quintail. Borehole washed clean of all slurry for re-logging. Vibrocoring attempted between 17.00 hours and 19.00 hours but was abandoned owing to an apparent electrical breakdown in the power cable. Preparation and gamma logging commenced at 19.00 hours.

Fri. 7.3.75 Gamma logging completed 06.30 hours and casing withdrawal commenced. Anchors lifted at 10.30 hours and proceed for rendezvous with Quintail for personnel transfer. After personnel transfer test sparker and pinger on geophysics test range until 15.00 hours when commenced mooring operations for borehole site 270. Commence running casing and jetting borehole 75/3a at 17.00 hours. Borehole completed at 24.00 hours and Wimpey logging team start logging.

Sat. 8.3.75 Wimpey logging team complete program at 06.30 hours and RMMU/AERE gamma logging commences. Logging ceases at 09.30 hours and casing pulled. After warping the ship 30' astern on the anchor wires casing was run and drilling of borehole 75/3b commenced at 13.00 hours following a personnel and equipment transfer onto Quintail.

Sun. 9.3.75 Borehole 75/3b completed at 11.00 hours. Acoustic logging commences at 12.00 hours and proceeds until 19.30 hours. RMMU/AERE gamma logging commences at 20.00 hours.

Mon. 10.3.75 Gamma logging completed at 02.45 and commenced pulling casing at 03.00 hours. Anchors lifted by 08.12 and commence run on geophysical test range. While running line close to next borehole site (265) observed minesweeper H.M.S. BONNINGTON apparently commencing operations close to site 265. Radio contact established with difficulty, owing to malfunction of BONNINGTON's transmitter. At 12.00 hours they advised of practice mines on the site of borehole 265 and that they would be sweeping an area from our proposed borehole site to 1 mile away on bearing 035° T. The remaining undrilled borehole site (266) was 3 miles ENE of our position. The combination of steaming time, time to haul in geophysical gear, time to prepare an anchoring track-plot and limited duration of the slack-water anchoring window precluded this site. BONNINGTON advised the nearest clear position was ½ mile south of site 265, corresponding with site 270 (boreholes 75/3a and 75/3b). At 12.42 hours commenced anchoring at site 270 and completed by 14.00 hours. The wind and sea state deteriorated during the anchoring period to NE 6/7 with a heavy swell. Quintail was advised not to attempt a personnel transfer. Casing operations suspended. The wind and sea state continued at 6/7occ.8 throughout the day.

Tues. 11.3.75 Continuing poor weather conditions and forecast results in decision to abandon attempt to drill borehole. Commenced lifting anchor at 07.30 but halted at 08.20 hours owing to dangerous movement of unsecured casing. Recommenced lifting anchors at 12.45 hours and completed at 14.15 hours. Proceeded for rendezvous with Quintail off Inchkeith at 15.30 hours for personnel transfer. Commenced running geophysics lines in "pseudo-Becken effect" area of Kirkcaldy Bay at 16.15 hours completed at 19.30 hours, then proceeded to anchor at Largo Bay.

Wed. 12.3.75 Weighed anchor at 05.50 hours and proceeded to vibrocore site in Kirkcaldy Bay. Commenced anchoring at 06.40 hours. Anchors dragged in poor holding ground but held on second attempt at mooring. Commenced vibrocoring at 08.00 hours but proceed to abandon before any penetration made owing to anchor again dragging. Anchors lifted and proceeded to Leith harbour for docking. Alongside Imperial Dock at 12.30 hours and demobilisation completed by 16.00 hours.

INSTITUTE OF GEOLOGICAL SCIENCES

FORTH TEST RANGES GP/MG/5.55

DOCUMENT NO.

1. .. .. LOCATION DIAGRAM OF TEST RANGES

2 .. .. LOCATION MAP OF PINGER LINE 1 AND SPARKER LINES 4 AND 5

3 .. .. EXAMPLE PINGER RECORD LINE 1 FIXES 1-20

3A .. .. EXAMPLE PINGER RECORD LINE 1 FIXES 40-49

4 .. .. EXAMPLE SPARKER RECORD LINE 4 COMPLETE

5 .. .. EXAMPLE SPARKER RECORD LINE 5 COMPLETE

6 .. .. LOCATION MAP OF MV "WHITETHORN" BORE HOLES 75/1.75/2 AND 75/3

DOCUMENT NOS. 1-5 ARE IN TRIAL REPORT NO.1

DOCUMENT No. 6 IS IN TRIAL REPORT NO.2