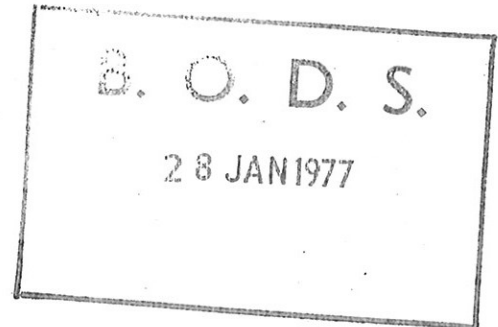


INSTITUTE OF GEOLOGICAL SCIENCES

CONTINENTAL SHELF UNIT NORTH

Report No. 76/9



M.V. Emerald Cruise 76/EM

East Shetland Area

by

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M.V. Emerald Cruise 76/EM

(Duration Monday 20th September-Tuesday 28th September)

1. Objectives

The purpose of the cruise was to confirm the solid geological interpretation of the East Shetland area by use of shallow drilling techniques. The drilling involved the use of the Bedford Institute of Oceanography (B.I.O.) Drill and the Institute of Geological Sciences (I.G.S.) 1m rock drill.

The East Shetland area (Fig. 1) defined between latitudes 60°N and 61°N and longitudes 0°W and 1°W , was selected because of the excellent control provided by previous IGS geophysical surveys (Briarthorn Cruise 74/4) and the presence of abundant near surface outcrops ideally suited for sampling by the above methods.

Evaluation by IGS and IKU (Norway) of the new developments of the Bedford Institute Drill, initiated following the participation by D.A. Ardus in BIO drill operations in 1975, was also a prime cruise objective,

2. Personnel

| | | | |
|--------------|-----|-----------------------------------|--------------------|
| D.A. Ardus | IGS | CSUN | (Senior Scientist) |
| J.A. Chesher | IGS | CSUN | |
| C. Himsworth | IGS | CSUN | |
| W. Lonie | IGS | CSUN | |
| J. McGuigan | IGS | CSUN | |
| C. Graham | IGS | CSUN | |
| G. Bradley | IGS | CSUS | |
| G. Fowler | | Bedford Institute of Oceanography | (Canada) |
| R. Cassivi | | Bedford Institute of Oceanography | (Canada) |
| R. Jemne | | IKU | (Norway) |
| O. Kjolseth | | A.S. Geoteam | (Norway) |

Cruise details are summarised in Appendix I

3. Equipment

The following equipment was used aboard the M.V. Emerald, a 183 foot Ice.A Sterntrawler.

- B.I.O. drill - drilling capacity 6m,
- IGS rock drill - drilling capacity 1m,
- Gravity corer
- Shipek grab
- MS47 Kelvin Hughes transit sonar
- Spirotechnique and Sub Sea television systems.
- National Parasonic video-tape recorders.
- Simrod EQ echo sounder (ship equipment)
- Decca (MK12) main chain navigator (ship equipment)

An account of equipment performance is listed in Appendix II

4. Cruise Results

The table summarises the number of stations occupied in the East Shetland area and the equipment used.

| <u>Date</u> | <u>Station No.</u> | <u>Shipek</u> | <u>Gravity Corer</u> | <u>IGS drill</u> | <u>BIO drill</u> | <u>T.V.</u> |
|--------------|--------------------|---------------|----------------------|------------------|------------------|-------------|
| 21/9/76 | NV 93 | | 1 | | | 1 |
| 22/9/76 | NV 94 | 1 | 1 | 1 | | 1 |
| | NV 95 | | | 1 | | 1 |
| | NV 96 | | | | 1 | 1 |
| 23/9/76 | NV 97 | 1 | 1 | | 1 | |
| | NV 98 | 1 | | | | |
| 24/9/76 | NV 99 | | | 1 | 1 | 1 |
| | NV 100 | 1 | 2 | (1) | 3 | 1 |
| 25/9/76 | NV 101 | | | 1 | 1 | 1 |
| 26/9/76 | NV 102 | | | | 1 | |
| | NV 103 | | | | 1 | |
| | NV 104 | | | | 2 | |
| Total | 6 | 4 | 5 | 4 | 11 | 7 |

Summary of sample station data is given in Appendix III

Fig. 2 illustrates position of sample stations occupied during Emerald Cruise 76/EM.

5. Geological Results

On the basis of geophysical evidence the geology of the East Shetland area was interpreted as an area of predominantly Dalradian basement in which a NNE trending Mesozoic basin extends from $60^{\circ}20'N$ to north of $61^{\circ}N$. The basin is 5km wide in the south of the area and widens to more than 30km in the NE. It occurs as a downfaulted half graben in the presumed Dalradian basement which forms a platform to the east of Shetland with small faulted inliers of bedded sedimentary rocks.

Drilling aboard M.V. Emerald has confirmed the existence of extensive Dalradian basement to the east of Shetland, evidenced by boreholes NV 94, NV 95, NV 96, NV 99 and NV 101. The Dalradian consists of hornblende gneiss and metamorphosed pink and pale grey psammitic rocks, often colour banded. The presence of faulted inliers of sedimentary rocks within the basement area is proven by borehole NV 104. Micaceous red and green fine grained sandstones recovered from this borehole tend to suggest these faulted inliers consist of Old Red Sandstone strata.

The Old Red Sandstone exposed on land in the region of Bressay, probably only extends for a limited distance offshore as proven by borehole NV 102 which recovered micaceous red siltstones and fine greenish grey banded sandstones of probable Old Red Sandstone age, while 2km to the east of this position borehole NV 103 recovered grey quartzitic sandstones of possible Dalradian age.

Boreholes situated in the Mesozoic basin failed to produce conclusive evidence as to the nature and possible age of the strata within the basin, although borehole NV 100 recovered white coarse conglomeratic sandstones that may well be Permo-Triassic in age.

Appendix I

Ships Log : Period - Monday 20th September 1976 - Tuesday 28th September.

Wednesday 15th September

M.V. Emerald arrived Leith during International Oceanographic Congress.

Monday 20th September

0730

On charter

0730-2400

Depart from Leith steaming en route to East Shetland area. Preparation of drilling and sampling equipment.

Tuesday 21st September

0000-0800

Steaming to East Shetland area.

0800-0900

Stopped ship to fit transit sonar.

0900-0915

Continued steaming to East Shetland area

0915-1050

Stopped ship to adjust transit sonar, which required retapping of bracket screws. Attempted shipek and gravity core, NV 93. Shipek failed to fire due to body distortion. Changed over to spare shipek. Set up T.V. Shipek winch brake required adjustment. Continued steaming to south end of Mesozoic basin in the East Shetland area.

1050-1120

PDR and transit sonar traverses across East Shetland basin.

1120-1530

bas

1530-1630

Laying anchors on basement on east side of east Shetland basin.

1630-1730

Preparing IGS drill and relaying stern anchor due to drag on bottom, NV94.

1730-2300

Replacing incorrect caged belt on IGS drill. Hydraulic fault also suspected in shuttle valve but identified as incomplete opening of tap valve.

2300-2400

At anchor at above site. Weather unsuitable for geophysical traverses. SE 6-7, locally 8.

Wednesday 22nd September

0000-0730

At anchor.

0730-0930

Final checks on IGS drill and T.V. T.V. gave unstable picture. Correction of T.V. Fault.

0930-0945

Lowering IGS drill to seabed

0945-1000

Examination of seabed by T.V. on drill.

1000-1015

Drilling NV94.

1015-1030

Lifting drill aboard.

1030-1120

Shipek and gravity core at above site NV 94. Shipek handle too short to prime the grab easily.

1120-1200

Drifting on stern anchor using T.V.

1200-1240

Lifting anchors.

1240-1320

Echo sounder traverses over above site.

| | |
|-----------|---|
| 1320-1340 | Replacing pressure compensation bag on IGS drill. |
| 1340-1425 | Laying anchors in vicinity of above site NV 94. |
| 1425-1500 | Replacing hydraulic pressure bag on IGS drill. |
| 1500-1525 | Lowering IGS drill to seafloor. |
| 1525-1550 | Drilling NV 95. |
| 1550-1600 | Lifting drill aboard ship |
| 1600-1720 | Raising anchors. |
| 1720-1800 | Steaming to west side NV 96 of East Shetland basin, echo sounder traverse en route. |
| 1800-1900 | Laying anchors at above site NV 96. Stiffening transit sonar pole and refitting. |
| 1900-2000 | Stern anchor wire snapped over pinnable on seafloor. Re-splicing new anchor. |
| 2000-2030 | T.V. at above site. |
| 2030-2400 | Echo sounding across Mesozoic basin. |

Thursday, 23rd September

| | |
|-----------|---|
| 0000-0700 | Echo sounder and transit sonar across basin. |
| 0700-0830 | Laying anchors at NV 96 re-occupations. BIO drill ready for use. |
| 0830-1000 | Lowering BIO drill and drilling at NV 96. |
| 1000-1130 | Raising anchors. |
| 1130-1300 | PDR traverse at NV 97 in Mesozoic basin. Effecting repairs to T.V., loose screws. |
| 1300-1500 | Site investigation with T.V. at NV 97, and lowering stern anchor. |
| 1330-1400 | Lowering BIO drill to seabed. |
| 1400-1430 | Re-splicing BIO lift cable due to fraying during lowering. Gravity core and shipek grab. |
| 1430-1540 | Lowering BIO drill to seabed and drilling at NV 97. No recovery due to bent barrel caused on previous lowering. |
| 1540-1600 | Manoeuvring ship onto above site to redrill. |
| 1600-1845 | Changing barrel on BIO drill. |
| 1845-1930 | Lowering BIO drill to seabed, drilling and recovery at NV 97. |
| 1930-2000 | Raising stern anchor. |
| 2000-2100 | Steaming and routine sampling NV 98 in basin. |
| 2100-2115 | Repairing broken accelerator cable on shipek winch. |
| 2115-2400 | Steaming to northern part of East Shetland basin site NV 99. |

Friday 24th September

| | |
|-----------|--|
| 0000-0100 | Steaming to NV 99. |
| 0100-0110 | Stop to take in transit sonar due to damaged cable. |
| 0110-0730 | PDR traverse at site, NV 99, on basement west of basin. |
| 0730-0830 | Laying anchors at Nv 99. |
| 0830-0918 | Preparing and lowering IGS drill to seabed. Modifying SSS T.V. to be compatible with video National Panasonic recorders. |
| 0918-1006 | Drilling at NV 99. |
| 1006-1010 | Lifting IGS drill aboard. |
| 1010-1135 | Preparing and lowering BIO drill to sea floor and drilling. |
| 1135-1200 | Lifting drill abroad. |
| 1200-1315 | Raising anchors. |
| 1315-1400 | Steaming to site in Mesozoic basin NV 100 |

| | |
|-----------|--|
| 1400-1500 | Laying anchors at NV 100. |
| 1500-1545 | Shipek and gravity core whilst awaiting BIO repairs to barrel threads. |
| 1545-1700 | 1st attempt at drilling with BIO drill. |
| 1700-1730 | Lifting drill aboard. |
| 1730-1755 | 2nd attempt with BIO drill at NV 100. |
| 1755-1815 | Lifting drill aboard after drifting off station. |
| 1815-2000 | 3rd attempt with BIO drill. |
| 2000-2030 | Repositioning ship onto site, NV 100. |
| 2030-2300 | 4th attempt BIOdrilling at site. |
| 2300-2400 | At anchor site, NV 100. Fault in electric cable to BIO drill, loss of signals. |

Saturday 25th September

| | |
|-----------|---|
| 0000-0820 | At anchor on site NV 100. |
| 0820-1045 | Lowering IGS drill and T.V. to seafloor, search and drilling. |
| 1045-1130 | Lifting anchors. |
| 1130-1400 | Steaming to site NV 101 on basement east of basin. |
| 1400-1500 | Laying anchors at site NV 101. |
| 1500-1630 | Lowering IGS drill to seabed. Failure of T.V. due to water leakage. Effecting repairs. |
| 1630-1730 | Re-lowering IGS drill to seafloor and operating T.V. Failure of T.V. due to cut in lamp cable which caught on rocks. |
| 1730-1800 | Replacing T.V. camp cable. |
| 1800-1830 | Lowering IGS drill to seafloor. T.V. failed almost immediately on reaching seafloor. Drill difficult to start. Drilled for short period but stopped when barrel jammed and high amperage indicated.. This was subsequently found to be due to disconnection of the water pump hose. Lifting drill aboard. |
| 1830-2200 | Preparing and lowering BIO drill to seabed. Ommitted to fit diamond bit, lifted aboard. |
| 2210-2250 | Preparing BIO drill again and lowering to seabed at site, NV 101 |
| 2250-2330 | Drilling at NV 101 |
| 2330-2400 | Lifting drill aboard. |

Sunday 26th September,

| | |
|-----------|---|
| 0000-0040 | Lifting anchors. |
| 0040-0300 | Steaming to S end of East Shetland Basin. |
| 0300-0700 | PDR traverse across Dalradian/ORS boundary due east of Lerwick. |
| 0700-0800 | Laying anchors at site, NV 102, on Dalradian/ORS boundary. |
| 0800-0930 | Lowering BIO drill to seafloor, drilling and recovery aboard. |
| 0930-1030 | RAising anchors. |
| 1030-1120 | Steaming to next site, NV 103, due east of ORS boundary. |
| 1120-1220 | Laying anchors. |
| 1220-1250 | Lowering BIO drill at site NV 103. |
| 1250-1330 | Drilling ar site NV 103. |
| 1330-1430 | Lifting BIO drill aboard and raising ships anchors. |
| 1430-1630 | Steaming to site NV 104 at SE of area. |
| 1630-1730 | Laying anchors at site NV 104. |
| 1730-1745 | Drilling with BIO drill at NV 104. |
| 1745-1800 | Lifting drill aboard. |
| 1800-2000 | Redrilling with BIO drill at site NV 104. |
| 2000-2050 | Lifting anchors. |
| 2050-2400 | Steaming S to Fraserburgh to rendezvous with Challenger. |

Monday 27th September

| | |
|-----------|---|
| 0000-1000 | Steaming en route to Fraserburgh. |
| 1000-1200 | PDR traverse for site investigation off Fraserburgh, whilst awaiting rendezvous with Challenger. |
| 1200-1500 | Steaming to position north-east of Fraserburgh to avoid fishing vessels. |
| 1500-1515 | Lowering BIO drill to seafloor. Ship not anchored. |
| 1515-1545 | Drilling to investigate Dalradian/Permo-Trias boundary north-east of Fraserburgh. |
| 1545-1555 | Lifting drill aboard. Electric cable broke around ship's propellor, due to buoy on cable snagging on transom, allowing slack to develop while drill was being lifted. |
| 1555-1605 | Freeing cable from propellor. |
| 1605-1800 | Steaming to rendezvous with Challenger east of Peterhead. |
| 1800-2000 | Standby waiting for Challenger. |
| 2000-0800 | Steaming to Leith. |
| 0800-1700 | In port Leith for demobilisation. Off charter. |

Appendix II

Equipment Performance

M.V. Emerald

The use of a stern trawler proved satisfactory in the handling of equipment over the stern by the use of releasable guide lines suitably attached to prevent pendulum motion of equipment. The high stern sides provided protection from the weather with a large working platform. The laboratory and workshop were situated adjacent to the stern platform enabling easy access. An adequate chartroom was available on the bridge, although the decca navigator and the intercom would have been preferable in the chart room. Another operations room was available at the stern, although a little inaccessible during use of ship's winches. Accommodation was good with 9 double cabins.

The only significant problem was excessive noise and vibration from the bowthrust which prevented the night crew from sleeping during the day. The ship was stable for roll but was prone to some pitching in heavy weather.

BIO drill

The initial part of the cruise was spent preparing the drill for operation. This delay could have been avoided had the drill reached Edinburgh earlier as planned prior to sailing. Delay was caused due to external shipment problems between Canada and UK. During operation the drill proved highly satisfactory achieving 90% recovery on several occasions and on varying sea bottoms. The facility to drill to 6m was exceptionally valuable in confirmation and identification of in situ strata.

Careful handling is essential due to the vulnerability of the barrel and electric cable. The only significant breakdown was due to current drag

pulling cable around transom and parting the signal conductors, while some initial trouble was experienced with the penetration counting instrumentation.

The major limitation was an inability to core softer rocks overlain by a gravel or cobble horizon and to cure this the fitting of a double wall drill barrel of perhaps slightly increased diameter (BX) and a retractable pilot bit is advocated. This would permit boring to penetrate the cobble and gravel horizon so prevalent on Tertiary and Mesozoic subcrop prior to coring the strata beneath. At present cobbles block the bit and open hole boring then proceeds. In addition the electronics should be usefully arranged on printed circuit boards to permit servicing in the absence of the development specialist present on this cruise.

IGS midi drill

In general only minor problems were encountered with the midi drill which were easily rectified, such as a tight new water pump and a punctured hydraulic pressure compensation bag. However, the drill proved difficult to start on several occasions due to the captive nut holding the drill carriage having too fine a thread and requiring excessive torque.

In operation the drill proved satisfactory and its T.V. facility enabling its positioning on definite rock outcrop invaluable.

Gravity Corer system

This proved satisfactory although one batch of liner tube was found to be outside acceptable tolerances. The gravity core winch experienced some clutch problems.

Shipek Grab

One shipek grab was distorted and could not operate, while the other required loading handles longer than those supplied. These problems could have been prevented by checking prior to issue.

The shipek winch had a seized brake handle that required freeing before the winch was usable.

MS 47 Transit Sonar

The transit sonar worked satisfactorily, but the pole proved inadequate becoming unstable. In addition retention of the guide in the shoe proved difficult after limited use. It is necessary to deploy the transducer at the maximum possible practical depth compatible with hull mounting in order to achieve good results and the installation must therefore be competent to withstand significant drag.

T.V. Systems

T.V. and video tape recording of drill sites proved an invaluable geological tool. In general the spirotechnique T.V. cameras proved somewhat unreliable largely due to the rough treatment to which they were subjected on rocky sea bottoms. These cameras need to be located in vibration free environment, and the fitting of shock absorbing mountings must be considered. Servicing of the cameras is advised.

Simrod Echo Sounder

This ship equipment proved satisfactory throughout the cruise, although a metric scale would have been preferable to the fathom scale.

| Station No. | Position | | Sample data |
|-------------|-------------------------|-----------|---|
| | Lat | Long | |
| NV 102 | 60°3.40N | 0°58.00'W | D.B. - 2.75m micaceous red siltstone and greenish grey banded sandstone ?ORS. |
| NV 103 | 60°4.30'N | 0°54.40'W | D.B. - 3.18m coarse grey moderately friable quartzite sandstone. Less indurated than Dalradian psaminite. ?ORS or ?Dalradian. |
| NV 104A | 60°4.75'N | 0°18.50'W | D.B. - 0.92m Micaceous red fine grained sandstone and greenish fine sandstone. ?ORS |
| NV 104B | (100m to the west of A) | | D.B. - Greenish grey fine grained compact sandstone- 1.40m |

Appendix III

Sample station summary data

| Station No. | Position | | Sample data |
|-------------|---------------|-----------|---|
| | Lat. | Long | |
| NV 93 | 60°17.75'N | 0°27.90'W | T.V. - sandy bottom with ripples C.S. - Coarse gravelly sand |
| NV 94 | 60°21.50'N | 0°29.90'W | T.V. - Coarse gravelly sandy bottom with occasional hollows C.S., G.S. - Coarse gravelly shelly sand. |
| NV 95 | 60°21.50'N | 0°30.20'W | T.V. - rock pavement with boulders. D.M. - 0.06m ?Dalradian pink grey metapsammite. |
| NV 96 | 60°21.50'N | 0°36.90'W | T.V. - Boulders and interstitial sand. D.B. - 2.3m banded greenish grey medium metapsaminite ?Dalradian. |
| NV 97 | 60°21.60'N | 0°34.60'W | G.S. - medium grey sand. C.S. - 0.6m medium grey muddy shelly sand D.B. - 0.45m banded grey metapsaminite. 0.05m siliceous conglomerate. 0.53m banded grey metapsaminite ?Dalradian boulders |
| NV 98 | 60°22.50'N | 0°34.80'W | G.S. - no recovery C.S. - Olive grey muddy sand. |
| NV 99 | 60°43.85'N | 0°13.05'W | T.V. - Boulders on sandy bottom. D.M. - 0.17m coarse grained gneiss ?Dalradian. D.B. - 1.81m pink and grey green gneiss ?Dalradian. |
| NV 100A | 60°43.20'N | 0°23.00'W | G.S. - Red terraceous clay with small pebbles C.S. - Fine clean yellow sand. D.B. - 0.06m metapsaminite ?Dalradian pebble. |
| NV 100B | (100m S of A) | | D.B. - 0.01m metapsaminite ?Dalradian pebble C.S. - 0.9m fine yellow sand, shelly at base. |
| NV 100C | (100m S of B) | | D.B. - 0.05m red siliceous conglomerate ?pebble. 0.29m friable white conglomerate sandstone ?Permo-Trias T.V. - Sandy bottom |
| NV 101 | 60°36.90'N | 0°3.90'W | T.V. - rock pavement with pebbles. D.M. - 0.05m pink metamorphic psaminite ?Dalradian D.B. - 4.77m pale grey meta psaminite with conglomerate fragments ?Dalradian. |

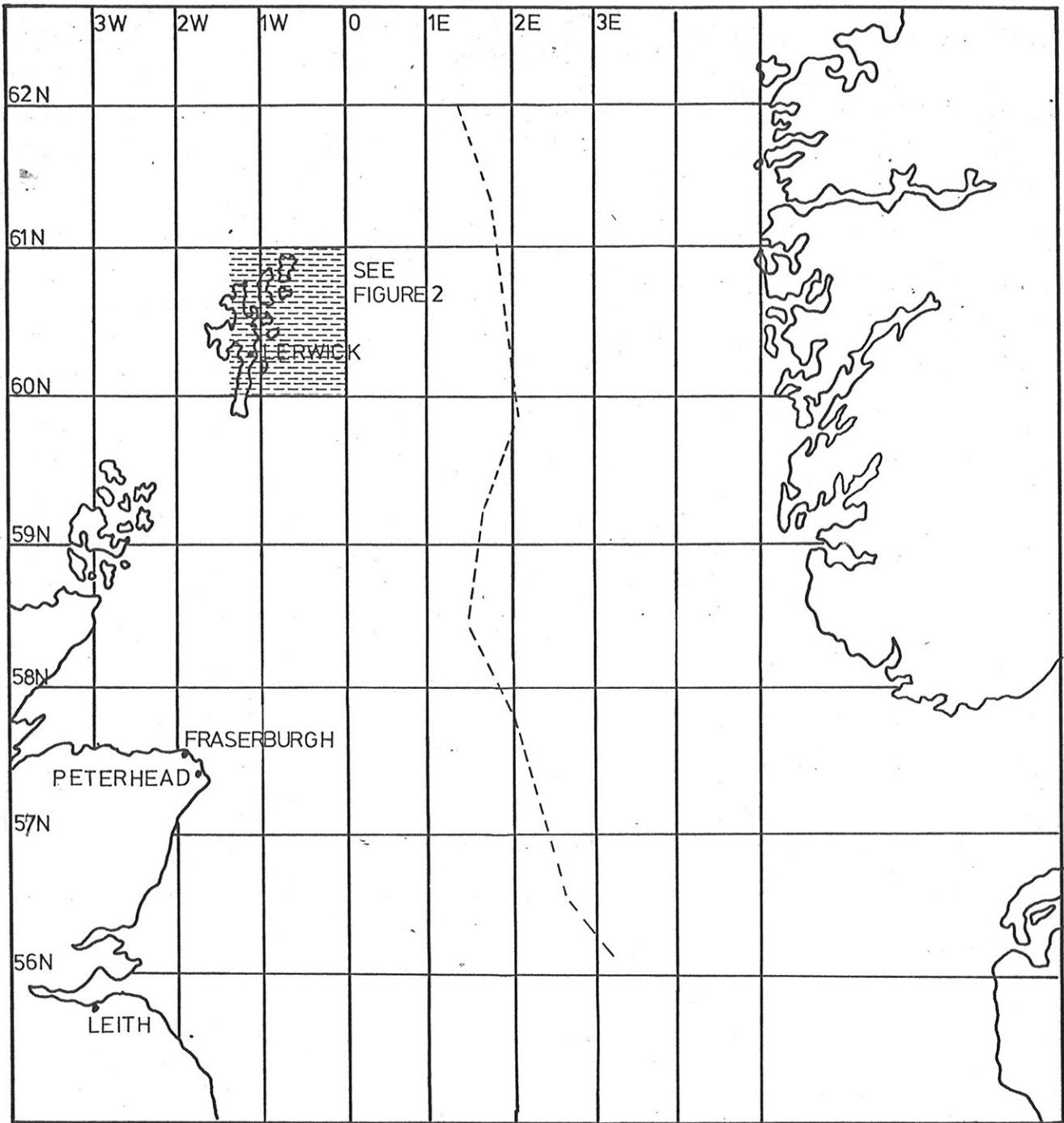


FIG.1- LOCATION MAP, EMERALD 1976

| Date | In Port | Steaming | Sampling and Traversing | Laying and Lifting Anchors | On Station | | | Delays | | | | Remarks | | | |
|-------|--------------|----------|-------------------------|----------------------------|------------|-----------|------|---------|------|------------|-----------|---------------|--------------------------|---|--|
| | | | | | IGS Drill | BIO Drill | T.V. | Weather | Ship | IGS Drill | BIO Drill | | T.V. | Misc. | |
| 20 | (7.5)* | 16.5 | | | | | | | | | | | * Charter commenced 07.3 | | |
| 21 | | 8.5 | 5.5 | 2.0 | | | | | | | 5.5 | (12) | 2.5* | * Remaining at anchor 1.5. Transit sonar mounting 1.5. | |
| 22 | | | 4.0 | 4.0 | 2.0 | | 1.4 | | | 1* | 1.4 | (12) | 7.5** (1)*** | * Anchor lost ** Remaining at anchor *** Broken transit sonar mounting. | |
| 23 | | 2.8 | 9.5 (0.5) | 3.5 | | 5.9 | 0.6 | | | | | | 0.4 (0.3) | | |
| 24 | | 1.8 | 7.1 | 3.2 | 1.7 | 8.2 | | | | 0.3 | | | 0.7 | | |
| 25 | | 2.5 | | 2.0 | 2.2 | 2.5 | | | | | 0.5 | 2.8 (13.3) | 3 | 8.5* | * At anchor on site and manoeuvring onto position. |
| 26 | | 8.0 | 4.0 | 7.0 | | 5.0 | | | | | | | | | |
| 27 | | 18.9 | 2.0 | | | 0.9 | | | | 0.2 | | | | 2.0 | |
| 28 | 9.0 | 8.0 | | | | | | | | | | | | | |
| Total | 9.0 (7.5) | 67.0 | 32.1 (0.5) | 21.7 | 5.9 | 22.5 | 2.0 | | | 1.5 (2) | 7.4 | 4.6 (48.1) | 5.5 (5.5) | 20.6 (1.6) | |
| % | 4.49 | 33.28 | 15.96 | 10.79 | 2.95 | 11.19 | 1.02 | 0.00 | 0.77 | 3.70 | 2.31 | 2.75 | 10.74 | | |

M.V. Emerald time analyses (to nearest 0.1 hour) and percentage of total charter time from 20.9.76 to 28.9.76

N.B. Figures in brackets indicate delays that did not impede other work