UNIVERSITY OF GLASGOW

Department of Geology

Cruise 8/77 of R.R.S. 'Challenger', 10-23 May 1977

CRUISE REPORT

Geophysical and geological work in the Firth of Lorne, on the West Coast of Scotland

Contents

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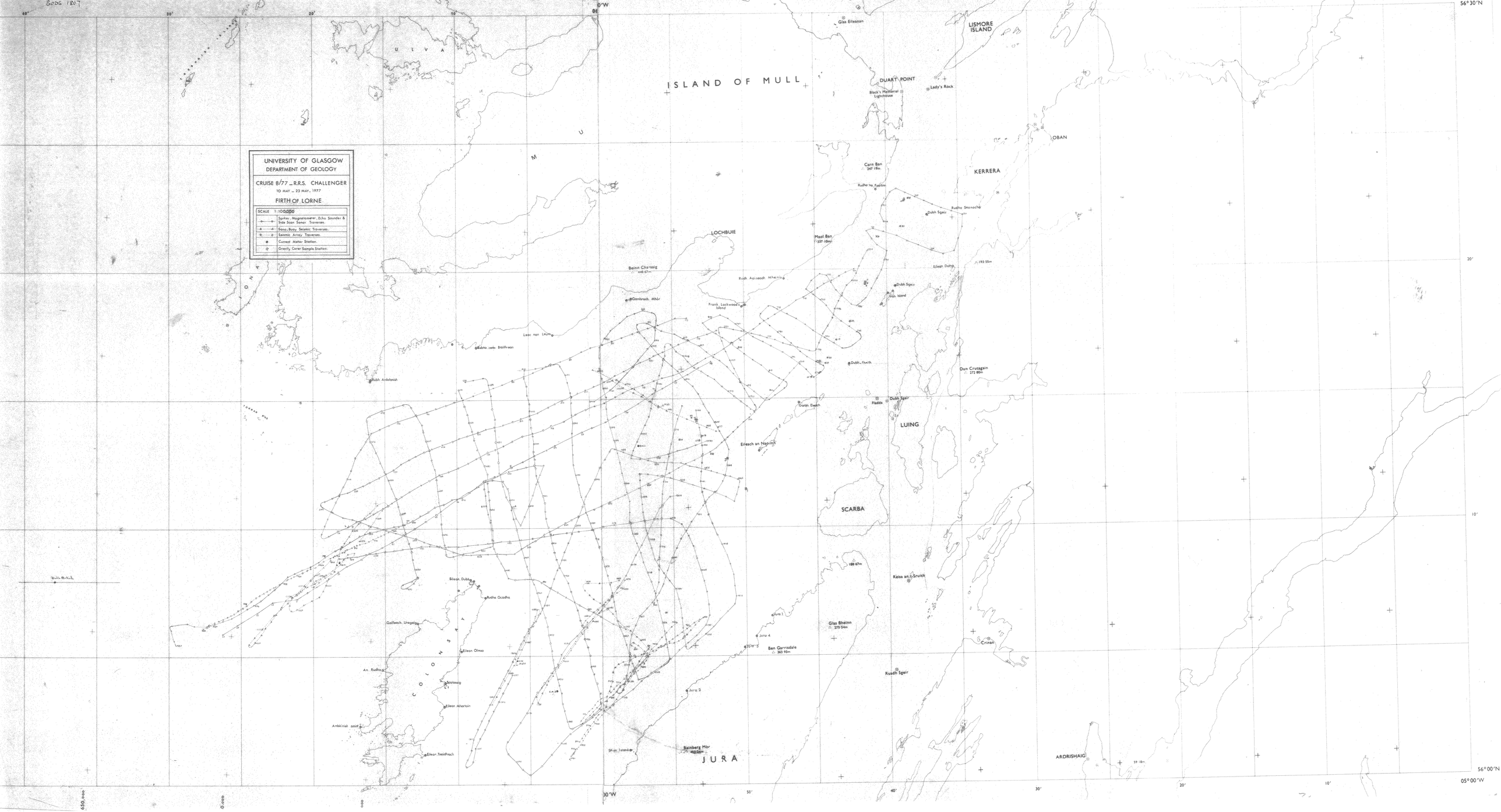
Summary

26 gravity-core samples were obtained from the 40 sites attempted but no in-situ rock samples were retrieved. The I.G.S. rock-drill was not deployed because of manoeuvring problems. 21 grab samples of recent sediment were acquired.

360 n. miles of sparker/magnetometer profiling were completed, together with 5 short-range sono-buoy seismic refraction lines and a 15 km deep seismic reflection line along the broad trough associated with the Great Glen Fault N.W. of Colonsay.

2 stations were monitored with current-meters.

The geophysical work has enabled us to draw a much improved geological map of the area, but more sampling of solid rock is needed to add to that of Dobson et al. for confirmation.


UNIVERSITY OF GLASGOW
DEPARTMENT OF GEOLOGY
CRUISE 8/77 – R.R.S. CHALLENGER
10 MAY – 23 MAY, 1977
FIRTH OF LORNE
SCALE 1:100,000
Sparker, Magnetometer, Echo Sounder & Side Scan Sonar Traverses.
Sono-Buoy, Seismic Traverses.
Seismic Array Traverses.
Current Meter Station.
Gravity Corer Sample Station.
ISLAND OF MULL
LISMORE ISLAND
DUART POINT
Black's Memorial Lighthouse
Lady's Rock
OBAN
KERRERA
LOCHBUIE
Beinn Chaisaig 449.67m
Maol Ban 337.10m
Eilean Duirinish
193.55m
Frank Lockwood's Island
Dun Cruttagain 272.80m
Fladda
LUING
SCARBA
188.67m
Raisa an t-Sruith
Glas Bheinn 375.54m
Ben Garrisdale 363.93m
Crinan
Rudh' Sgeir
JURA
Rainberg Mor 451.54m
ARDRISHAIG
56° 30'N
56° 00'N
05° 00'W

2. Aims of the programme

To study the geological history of the Firth of Lorne by sampling of rock and soft sediments on the sea-bed (using gravity corers, grabs and the I.G.S. rock-drill), by geophysical measurements, particularly sono-buoy seismic refraction work, shallow reflection profiling, deep reflection profiling using a multi-channel array and magnetometry, and by monitoring tidal currents in some of the ice-gouged troughs in the Firth.

3. Scientific equipment used and its performance

(a) Sampling equipment. Sediment grabs and sediment gravity corers worked entirely satisfactorily. Attempts to obtain rock samples using the gravity-corer with rock barrels were unsuccessful, the barrels were often damaged by impacts but failed to retain any samples of the rather hard rocks (e.g. quartzites) anticipated.

It was a major disappointment that the I.G.S. rock drill was not deployed. The difficulties of holding station by using the ship's engines, including the bow-thruster, had been demonstrated during the unsuccessful first attempt at deployment of the current meters. The strong tidal currents and cross-winds encountered, and the longer time required for deploying the drill, were considered by the Master to eliminate deployment of the drill this way as a reasonable exercise. Further, the suggested system of using the bow thruster against two bow anchors to keep the ship on station was not considered stable enough in these same conditions of tide and wind. It was suggested by the Master that a better system, to attempt on future occasions, would be to use auxiliary Danforth anchors, and to include a stern anchor to prevent 'yawing'. In retrospect, it seems a pity that the dubiety of Barry staff about the originally suggested anchoring system was not a little more strongly expressed at pre-cruise discussions, including the visit to Barry by Glasgow University personnel.

(b) Current meters. The deployment of current meters at the first site (in 200 m. depth) proved unsuccessful; eventually only two of the six planned sites were occupied, two being considered difficult from a navigational standpoint and two too difficult because of strong currents. It was suggested that single wire moorings might have

been deployed at the sites at which it proved too difficult to lay the U-shaped moorings used.

(c) Magnetometer

The Varian magnetometer operated satisfactorily throughout, though the records are distinctly noisier than those obtained on previous cruises using the same model.

(d) Continuous seismic profiling

(i) Kelvin-Hughes MS 47 Side Scan sonar worked satisfactorily throughout.

(ii) P.E.S.echo-sounder worked satisfactorily throughout, giving some sub-sea-bed penetration through sediments to rock head.

(iii) The O.R.E. pinger system worked satisfactorily but gave no useful sea-bed penetration. It has been suggested that the EDO-Western-system would have been a better intermediary between the sparker and P.E.S. system.

(iv) Routine sub-seafloor profiling was done using an E. G. & G. 1kJ, 3-candle sparker system recorded filtered on an EPC recorder and wideband on an FM tape recorder for later replay. The system proved quite successful and records were of consistently good quality from an E.G. & G. 263 hydrophone.

(e) Sono-buoy refraction surveys

Previous work in this area using free floating sono-buoys and explosives had not given enough points on the time-distance graphs to give satisfactory resolution of arrivals. On this cruise, we experimented with anchored buoys and sources with high repetition rates. A Glasgow University hydrophone was moored on the sea bed (in up to 100 m water depth) and the transmission of the hydrophone signal

to the ship was effected by the Glasgow University Bradley sono-buoy system, with the buoy anchored separately from the hydrophone. The acoustic signal retrieved on-board was recorded on the same combination of filtered signal on EPC and unfiltered signal on FM tape as was used for the routine traversing. Sources of 1 kJ and 5 kJ sparker, and 40 cu. in. and 150 cu. in. air guns (firing usually at 4 s and 16 s respectively) were compared.

The sparker sources gave sea-bed refraction arrivals in only the odd case up to a range of 1 km or so. The 40 cu. in. air gun gave highly satisfactory results with clear first-arrivals to at least 6 km range. The 150 cu. in. air gun was never extended and would probably be usable for much deeper penetration than was required in this survey.

For determination of rock-head velocity, the 40 cu. in. air gun system proved the best.

The bubble-pulsing effects of the air guns gave rise to some difficulties in picking later refracted arrivals, and a wave-shaping kit attachment for the guns might be a valuable help at source in reducing this. We hope to experiment with deconvolution of the data to see to what extent the level of later arrivals can be improved.

At one or two sites no signal was detected by the hydrophone: this remains a mystery, but we expect the fault to lie in the detector rather than in the sea-bed conditions.

(f) Deep seismic reflection profile

We had hoped to use the Geomechanique multi-channel array in refraction surveys to compare with the sono-buoy technique. Difficulties of towing such a long array in the restricted seas of some of the sites prevented us doing this adequately.

Logistically, we feel sure the sono-buoy technique is superior for

such purpose.

What we did instead was to examine the sediment basin NW of Colonsay by using the Geomechanique array (11 live sections, spread length approximately 700 m) to detect arrivals from the 40 cu. in air gun used in a reflection mode: that is, shooting every 350 m approx. (using a pre-plotted firing schedule on a Decca Main Chain track plotter) to give single coverage. Recordings were made using the Glasgow University T.I. 8000 12-channel amplifier/filter system recorded on paper and directly on mag. tape. The system worked without any problems and about 1 s worth of useful reflection energy was obtained. The reverberation/bubble-pulse problem was partially solved by mixing adjacent channels (the apparent wavelength of the reverberation being about 2 station intervals) but will be tackled again in different ways in the processing of the data. Quite good reflectors occur at up to 1 s, and preliminary estimates of interval velocities have been made.

(g) Location. The Decca Main Chains in the area being inaccurate, the primary means of location was by radar (done at 5 minute intervals). From fix-point changeovers and line intersections we expect that the locations are correct to about ± 50 m.

4. Comments on programme and preliminary results

The solid-rock sampling programme was unsuccessful but this was balanced by the success of the geophysical programme, especially the quality of the sparker data and by the good results of the experimental seismic surveys. We are presently drawing up a geological map of the area with the aid of the detailed Admiralty bathymetry. The map will need confirmation by further direct sampling, probably best done by divers.

Tentative conclusions at the moment include

(i) NW of Colonsay, along the line of the Great Glen Fault zone, there appear to be areas of Mesozoic sediment, capped by Tertiary lavas, extending down to at least 1.5 km.

(ii) the lateral extent and thickness of the red-beds cored in I.G.S. borehole 71/9, east of Colonsay is insignificant.

(iii) Dalradian metamorphic rocks probably occupy nearly all the area between Colonsay, Jura and the Garvellachs but are overlain by lavas and sediments of Old Red Sandstone age towards Mull and Kerrera in the Firth of Lorne.

The sono-buoy work was particularly successful when used with an air gun source; there are some lines that need shooting close to shore (e.g. at Carsaig Bay, Mull to tie in to land geology) and R.R.S. 'Challenger' is too big for this work. A vessel of the size of R.V. 'Calanus' would be better, provided there were space for the air gun system.

Considering that we had only 9 full days in the area, a very satisfactory portion of the original programme was completed.

5. Summary log

10 May. Weather fine, visibility good, wind force 4. Departed Ardrossan, 1610. Engine trials in Firth of Clyde. Changed course towards Greenock, 2300, for engine control repairs.

11 May. Weather overcast, moderate to good visibility, wind force 3 - 6. Anchored off Greenock, 0800. Repairs effected. Proceeding down Firth of Clyde, 1615, round Mull of Kintyre to survey area.

12 May. Weather fine, visibility good, wind force 6. Traversing (sparker, magnetometer, side-scan, pinger) towards current-meter station, 0900 - 14.00.

Attempt to lay current-meter in station 3, NW of Corrievreckan, unsuccessful because of strong currents and wind. Gravity coring 1800 - 2130 - no recovery of 'in-situ' rock. Traversing overnight.

13 May. Weather fine, visibility good, wind force 4. Traversing until 0800. Gravity coring until 1200. Personnel exchange outside Dunstaffnage. Current-meter deployed at station 6 (C.M.1 on map) by 1800. Gravity coring west of Colonsay until 2130. Traversing overnight.

14 May. Weather fine, visibility very good, wind force 2. Traversing until 0800. Gravity coring until 1530. Current-meter brought inboard from station 6. Traversing overnight.

15 May. Weather fine, visibility good, wind force 2 - 5. Traversing until 1100. Current-meter deployed at station 4 (C.M.2 on map). Streaming hydrophone array, 55 shots fired on single-coverage line using 40 cu in air gun. Streamer brought inboard after manoeuvring trials. Traversing overnight.

16 May. Weather fine, visibility good, wind force 2. Traversing until 1000. Current-meter retrieved from station 4. Traversing towards

Dunstaffnage for personnel exchange effected at 1600. Gravity coring until 2000. Traversing overnight.

17 May. Weather fine, visibility good, wind force 1. Traversing until 0940. Sono-buoy refraction work on line 6, using 1kJ, 5kJ sparker and 40 cu in and 150 cu in air guns, in turn. Buoy recovered at 2200. Grab-sampling overnight in Colonsay-Jura area.

18 May. Weather fine, visibility good, wind force 1. Sampling until 0900. Sono-buoy work on line 5 using large air gun, buoy redeployed because of incorrect location and u/s operation; engine trouble; line repeated after 1500 hours and finished with short-range run with 1kJ sparker, changed to small air gun. Grab-sampling continued from 2200 - 2400.

19 May. Weather fine, visibility good, wind force 3. Traversing until 0800. Sono-buoy lines 9 and 10 shot. Velocity meter deployed successfully. Traversing overnight from 2230.

20 May. Weather fine, visibility good, wind force 2. Traversing until 0830. Sono-buoy/air gun lines 2, 2A and Carsaig Bay attempted with success on 2A only. Gravity coring 2030 - 2300. Traversing overnight.

21 May. Weather fine, visibility good, wind force 1. Traversing until 0500. Proceeding to Dunstaffnage. All scientific personnel except I.O.S. staff disembarked via M.V. 'Calanus' at 1000. R.R.S. 'Challenger' proceeding to Barry.

6. Scientific personnel participant in the cruise

Jeremy Hall	10 - 21 May	University of Glasgow
Basim Rashid	10 - 21 May	University of Glasgow
Mavis Wilson	10 - 21 May	University of Glasgow
Robert Cumberland	10 - 21 May	University of Glasgow
Brian Brown	16 - 21 May	University of Glasgow
Robin Powell	10 - 23 May	I.O.S. Barry
Stan Smith	10 - 23 May	I.O.S. Barry
Phil Taylor	10 - 16 May	I.O.S. Barry
Lew Tan Sin	10 - 21 May	University of Science of Malaysia
Henry Allen	13 - 21 May	University of Strathclyde
Bill Lonie	10 - 16 May	I.G.S. Edinburgh
John Chesher	10 - 13 May	I.G.S. Edinburgh
David Smythe	10 - 21 May	I.G.S. Edinburgh

7. Acknowledgements

I wish to thank the officers and crew of R.R.S. 'Challenger' for their help, Messrs. Powell, Smith and Taylor of I.O.S. for keeping the programme moving without any instrumental failures or delays, and I.G.S. staff for their co-operation in loaning apparatus and giving personal assistance. The efforts of N.E.R.C. staff at Barry in preparing the cruise are much appreciated.

9. Circulation List

N.E.R.C.:	H.Q.:	Mr. J. Cleverly
		Dr. A. J. Huntingdon
	Barry:	Capt. D. Stobie
		Dr. L. Skinner
		Planning Office
		Mr. K. Robertson
		The Master R.R.S. 'Challenger'
I.G.S.	C.S.U.(N):	Mr. D. Ardus
	M.G.U.:	Mr. R. McQuillin
University of Durham:		Prof. M. H. P. Bott
University of Glasgow:		Dr. A. C. McLean
		G.P. Data Room
		Dr. J. Hall
University College, London:		Dr. E. J. W. Jones
University College of Wales, Aberystwyth:		Dr. M. R. Dobson
University of Science of Malaysia:		Dr. P. Ryall/Lew Tan Sin