PROCEEDINGS OF

THE GEOLOGICAL SOCIETY

OF GLASGOW

Session 146 **2003 – 04**

CONTENTS

SESSION 146 (2003 – 2004)

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	Mr Michael Pell
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	Dr R.M. Ellam

Ordinary Members Mr Philip Close, Miss Margaret Donnelly, Dr John Hughes, Dr Brendan J. Hamill, Mrs N.G. Hornibrook, Dr Jim MacDonald, Mrs Rosemary McCusker, Dr A.W. Owen, Dr Joan Walsh.

MEMBERSHP

	At end 146 30 Sep., 2004	At end 145 30 Sep., 2003
Honorary Members	4	5
Ordinary Members	325	331
Associate Members	56	65
Junior Members	20	13
TOTAL Members	**405**	**414**
New Members	28	

Deletions	
Terminated	19
Dormant *	18
Total	37

* Dormant members are those who had not paid their subscription by 30 September although three reminders were sent out.

C.M. Leslie

LIBRARY

The Society's library has been operating normally during the session, and has been used by a small number of members. As always, among these items have been guidebooks from the Society's extensive collection, which covers many geologically significant areas in the UK and Europe, together with other areas worldwide. Accessions include:
A geological guide to the Island of Kerrera.
Basic Geological Mapping. Barnes & Lisle.
Exploring the Landscape of Assynt. Goodenough et al.
A Future for Stone in Scotland. Hutton & Rostran.
The Mapping of Geological Structures. McClay.
The Geology of Northern Ireland. Mitchell.
Earth: Portrait of a Planet. Marshak.
Rocks, Minerals and Fossils of the World. Phillips & reliant.
The Mines and Minerals of Campsie. Skillen.

There are a number of other volumes.

The Library is open on meeting evenings and during weekdays. Copies of the updated leaflet "The Society's Library" are distributed to all new members by the Secretary. The leaflet describes the full facilities available for members, including books, journals and maps from the combined libraries of the Society and the Division of Earth Sciences.
The Society's rare books have now found a home in the University Library, where

they are shelved together as a special collection, and available to members for consultation. The Divisional map collection, formerly housed within the Gregory Building, and accessible to members, has moved in a similar fashion to the University Library. Members wishing to consult the books and the maps should apply to Mr. J. Moore – the Physical Sciences librarian.
Members should further note that their membership of the society allows them full access to all sections of the University Library.

C. J. Burton.

SCOTTISH JOURNAL OF GEOLOGY

The efforts of the Board this year have thankfully been marked by a return to our "normal" level of submission and we have produced the two 96 page parts of volume 40 on time. Although we have long encouraged the inclusion of thematic groups of papers it is only in the last two years that this policy has really borne fruit. The publication of part 39/ I on graptolites in the Southern Uplands has been well received and was reported in glowing terms in other Journals. Plans are in place for two others (on diverse topics) over the next two years, but until the papers for these are in hand we cannot count them as complete. We have maintained a steady flow of good quality papers submitted and the one (and only) benefit of the 2001 period has been that we now consistently offer an attractively short publication delay to prospective authors.
Members will have noted a number of changes in the Editorial Board and more are to follow. It is difficult to find individuals willing to devote their valuable time without payment, particularly when there is a specific subject niche to be filled.
After two years in which the Board was able to pay the full cost of the Journal from accumulated funds it was necessary to approach the Societies in 2003 and again this year. This is the normal way in which the Journal is financed but after four years of inflation, costs have increased significantly. At the same time Trade subscriptions have fallen every year (by 2.7% in 2002 and 7.9% in 2003), although the good news is that this year they seem to have stabilised. Nevertheless, each cancellation results in an increase in the proportion of costs to be borne by the Societies. The average industry increase for Earth Science Journals in the last year has been around 9% whereas our page rate in 2005 will only increase by 3.6%. It is clear that our publishers are doing all they can on our behalf.

C.J.R. Braithwaite and R. Ellam

PUBLICATIONS

Our total sales this year were £1741, about half the previous year. Sales to members and classes accounted for about two thirds of the total. Most of the remainder was sales to the trade of the last of the Arran Guides. Geology of Scotland, maps and dictionaries continued to be popular. New titles are bought in where there is a demand. A number of titles were passed to the Society's Library. The year finished with a modest surplus of £142.54.

Roy Smart

TREASURER

Income and Expenditure Account for Year Ended 30th September 2004

(Scottish Charity Number SCOO7013)

Income			**2002 - 03**
Subscriptions received	£ 5900.38		
Deduct paid in advance	46.00		
		£5854.38	£5754.57
Investment Income:			
Dividends	472.75		457.65
National Savings	1485.77	1958.52	1871.66
Net surplus from publication sales		172.01	838.55
Tax refunds (Gift Aid)		862.23	722.05
		£8847.14	

Expenditure

Scottish Journal of Geology		2750.00	nil
Meetings		1146.66	1271.36
Billets, programmes, postage, telephone, stationery etc		927.69	899.57
Insurance		588.55	549.67
Library		584.11	350.03
Euroseminar 2005 – Microscopy/Bld. Materials		500.00	–
Conoco Philips Scottish Geol. Societies' prizes		300.00	300.00
T N George Celebrity Lecture		281.50	223.10
Hunterian 2007 fund		250.00	250.00
Excursions		112.50	
AGM – Expenditure	77.00		
– Income	44.00	33.00	36.00
Affiliation fee		30.00	25.00
Depreciation on computer @ 20% of cost		nil	313.48
Surplus of income over expenditure		1343.13	4185.48
		£8847.14	

Publication Sales Account For Year Ended 30th September 2004

Gross Sales	£ 1718.23	
Deduct Expenses	90.69	£ 1627.54
Stock at 1/10/03	£ 11375.12	
Add Purchases	900.76	

Publications available for sale	12275.88	
Deduct stock at 30/09/04	10820.35	
Cost of publications sold		£ 1455.53
Net surplus on sale of publications		£ 172.01

Balance Sheet as at 30th September 2004

Assets			**2002 – 03**
Debtors for publications at 30/9/04		£ 77.96	£ 130.95
Monies due to Society		800.00	
Cash in hand:			
Membership Secretary		130.45	
Publications Sales Officer		33.22	
Cash at Bank:			
Royal Bank of Scotland Account	£ 10307.54		
National Savings Investment Account	36877.30	47184.84	44664.31
National Savings Income Bond		12000.00	
Investments at Cost		1025.70	
Stock of Publication		10820.35	11375.12
Computer (at 20% depreciation)		nil	
		£ 72072.52	

Liabilities

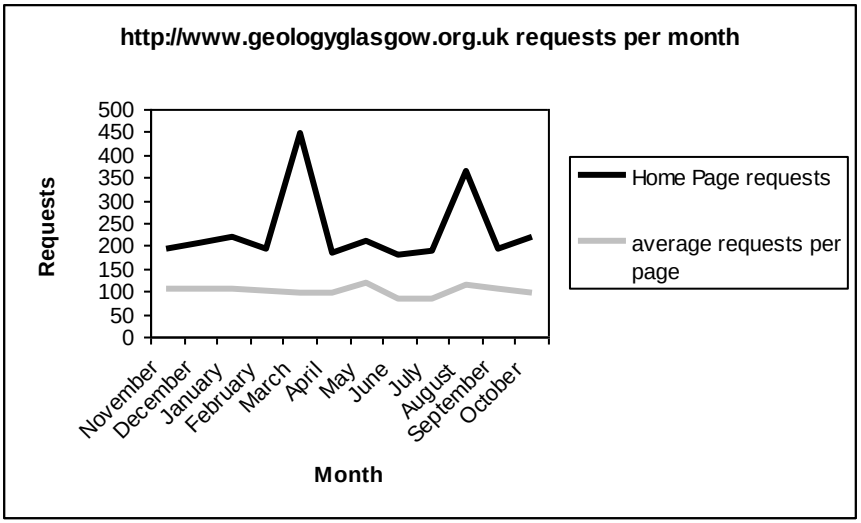
Subscriptions in advance		46.00	187.00
Uncashed cheques		1449.70	579.28
Monies due by Society		900.90	622.12
T.N.George Fund		399.80	399.80
Hunterian 2007 fund		500.00	250.00
Accumulated fund at 30/09/03	67432.99		
Add surplus for year	1343.13	68776.12	
		£ 72072.52	

We have compared these statements with the books and records presented to us and find them to agree.
We have verified the investment certificates and bank balances held by the Society at the 30th .September 2004

Honorary Auditor **Ben H Browne**
Honorary Auditor **Dorothea M Blake**
Honorary Treasurer **Mervyn H Aiken**

WEBSITE

Over the last year the website home page has been requested an average of over 230 times per month, becoming the most requested page used as a gateway to the rest of the website. The next most popular pages are the excursions, lectures and publications pages with, on average, just over 100 requests per month (an increase of between 20 and 40 requests per month on last year). The two most outstanding months for requests in the last year were March 2004 (2,028 requests recorded) and August 2004 (1,020 requests recorded). The March total may reflect planning for the Easter holidays or the National Science Week. The August high may also reflect planning for holidays. Overall, there was an increase in the number of requests during the last year by over 800. Comments and suggestions for the web pages are always welcome, but the content is reliant on information being provided by members.



Dr Neil DL Clark

MEETINGS

The session's meetings opened with a lecture by Kevin Pickering from University College, London, on "Mid-Eocene sedimentation and its tectonic control in the south Spanish Pyrenees". In November Petra Mudie, with affinities both to Glasgow and Canada expounded the geological evidence for the date of Noah's Flood. The year closed with the AGM and Colin Braithwaite's Presidential Address entitled "Reef Encounter: Biography of an elusive idea".

In January 2004, local stalwart John Faithfull gave an entertaining presentation on "Mineral Names: Then and Now" and this was followed in February by a joint meeting with the Royal Statistical Society given by statistician John Aitchison. In

March, Martin Lee explained how one can explore the early history of our Solar System using meteorites.
Lectures for the session were nicely rounded off by Nigel Trewin from Aberdeen, world authority on the Rhynie beds, who talked to us on "Wildlife in Early Devonian Scotland: a natural history tour". The session's programme ended with an excellent set of presentations on Members' Night.

J. M. Morrison

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Thursday 16th October 2003
Professor Kevin T. Pickering, University College, London

TECTONIC CONTROL, RATE OF LATERAL MIGRATION AND GROWTH PATTERNS OF CONFINED BASIN-FLOOR SUBMARINE FANS AND IMPORTANCE OF MASS TRANSPORT COMPLEXES, MID EOCENE, SOUTH SPANISH PYRENEES

Global (eustatic) sea-level changes exert a first-order control on deep-marine sedimentation, even at active plate margins. The time scale and circumstances under which tectonics is the principal driver, however, remains poorly understood. The lecturer showed, using a Mid Eocene deep marine foreland basin, Spanish Pyrenees, the ~ 500,000-1,000,000-year scale, lateral migration of sandy basin-floor submarine fans away from an active fold-and-thrust belt. Tectonic pulses began with the large-scale basin-slope collapse as debris flows/sediment slides that formed much of the seafloor topography for each fan, and contributed to their lateral confinement. The narrow shelf then collapsed to redeposit unconsolidated sands and gravels into deep water, and headward erosion to the feeder fluvio-delatic systems caused coarse-grained river sands to be fed directly into deep water. Decreased seismic activity caused the gradual abandonment of the submarine fans as an overal1 fining-upwards, and a new equilibrium profile was established. The stepwise physical migration of each fan, and the time scales involved are inconsistent with eustatic sea-level as the main control. This organised, predictable, vertical, sedimentary sequence provides a new and testable generic model for submarine fan evolution and deposition within other active modern and ancient plate margins.

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Thursday 13th November 2003
Dr Petra Mudie, Dept of Natural Resources Canada & University of Glasgow

7,100–YEAR OLD NOAH'S FLOOD IN THE BLACK SEA: FACT OR FICTION

Ryan and Pitman, American geologists, claim that the "Noah's Flood" story of a great deluge in the Bible and other ancient literature was the result of cataclysmic flooding of Neolithic communities on the Black Sea shores 7,100 years ago (1). They believe that the flood transformed the Black Sea from freshwater lake to saltwater sea, destroying the farmland and forcing emigration into Europe, the Middle East and Far

East. Seismic stratigraphy and mollusc data on which this hypothesis is based was presented and compared with similar data collected by Canadian geologists (2) and microfossil, palynological and geochemical data from many cores along a transect from the Black Sea to the Mediterranean. The Canadian data clearly show that the Black Sea was full and overflowing to the Mediterranean by 10,000 years ago, and there is no evidence of sustained agriculture until early Bronze Age about 4.000 years ago.

(1) Ryan, R. and Pitman, W., 1999, Noah's Flood. Simon and Schuster, UK Ltd., London.

(2) Aksu, A.E. et al., 2002. Persistent Holocene outflow from the Black Sea to the eastern Mediterranean contradicts Noah's flood hypothesis. GSA Today 12, 5.

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Thursday 11th December 2003

ANNUAL GENERAL MEETING

Thanks were expressed to retiring members of Council Colin Braithwaite, President, Janey MacDougall, Vice President, Iain Allison, Hon Secretary, Chris Burton, Librarian, Margaret Greene, Minutes Secretary, and Mervyn Aiken, Treasurer, and Muriel Alexander, Mike Keen, Jim MacDonald and Joan Walsh – all ordinary members, for their contribution to the work of the Society over the past three years.
The business of the AGM was followed by the Presidential address:

Dr Colin J. R. Braithwaite

REEF ENCOUNTER : BIOGRAPHY OF AN ELUSIVE IDEA.

This entertaining lecture explored the different concepts of the term 'reef', from an outcrop of various rocks in the sea, such as that encountered by sailors, pirates and smugglers of old, in Cornwall and other wild places, to a modern carbonate reef. Our president started by asking "What is a Reef?" – apart from the obvious danger to shipping! The origin of the term and changing views on its meaning were discussed, followed by an explanation of why the formation of a reef is not as clear-cut as might seem. Fossil reefs of the Carboniferous and Permian Periods in northern England were compared to those found now in the Bahamas and elsewhere. Their contrasting modes of construction, because of their different constituent animals and plants, were described, in the hope of producing a satisfactory definition. The conclusion, after many years of study, is that geologists still cannot agree on what a reef is! However, we enjoyed a fascinating description of today's many coral reefs and there were plenty of beautiful slides to look at!

This was followed by our festive event including wine, soft drinks and nibbles.

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Thursday 8th January 2004
Dr John Faithfull, Hunterian Museum, University of Glasgow.

MINERAL NAMES, THEN AND NOW.

There are nearly 4000 mineral species regarded as valid today. Some of these have been recognised since antiquity, while new ones continue to be discovered at a steady rate. The talk took a light-hearted look at mineral names, and the stories behind them, as well as describing how new species are recognised, described, and vetted for validity nowadays.

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Thursday 12th February 2004
Dr John Aitchison and Dr Christopher W. Thomas, Department of Statistics, University of Glasgow and British Geological Survey, Edinburgh, respectively.

PERTURBING GEOLOGICAL DATA : FROM GREGORY AND BECKE TO NAPIER AND THE NEW EUCLID

Many problems in geology and related disciplines involve compositional data showing substantial variability; for example, major oxide and trace element compositions of metamorphosed Scottish limestones, granulometric compositions such as deposits (sand, silt, clay) in Arctic lakes, pollen zonation data. Despite warnings and pleas from geologists, such as Felix Chayes, in the 1960's, statisticians have been slow to develop meaningful analysis of such 'constant-sum' data. It is only within the last two decades that sensible methods have been developed. This talk demonstrated how collaboration between geologist and statistician can apply a simple methodology to answering substantial questions in geology.

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Thursday 11th March 2004
Dr Martin Lee, Division of Earth Sciences, Centre for Geosciences, University of Glasgow.

EXPLORING THE EARLY HISTORY OF OUR SOLAR SYSTEM USING METEORITES

Meteorites have been dubbed the "poor man's space probe" because they represent samples of planets, asteroids and possibly comets that come to Earth for free. Some land in remote regions, such as the Sahara desert and Antarctica, where they accumulate and can be recovered, whereas others are seen to fall in populated areas, occasionally hitting the residents. A number of varieties of meteorite have been described and this talk featured two types: the Nakhlites from Mars and carbonaceous chondrites, which have come to Earth from the asteroid belt.
The Nakhlites comprise a group of around half a dozen meteorites that are named after the first of the group to fall, in Nakhla (Egypt) in 1911, which is reputed to have

landed on a dog. Little did this animal know, but it was the first earthling to have been killed by an invader from Mars! Nakhlites are samples of igneous rock, possibly an intrusion such as a sill, which has been partially altered by water, producing veins of carbonate and clay minerals. Recent research in Glasgow on these Martian rocks was described and there was an opportunity to examine a sample first hand. In contrast to the Nakhlites, which tell us about the history of the most Earth-like planet, carbonaceous chondrites contain evidence of the very earliest stages in the formation of our Solar System. These meteorites come from outer parts of the asteroid belt and are the oldest, least altered and probably the most complex rocks available for study. Carbonaceous chondrites are made of three distinct groups of mineral grains, which nicely trace the early history of the Solar System. The most exciting grains are tiny crystals of diamond, which were manufactured in the atmospheres of stars in another part of our galaxy. These interstellar diamonds formed part of a large cloud of dust and gas within which the Solar System was born. The planets grew within this cloud by collisions between particles of progressively larger sizes and some of the first grains to form, 4.5 billion years ago, were millimetre-sized spheres called chondrules that are still preserved in carbonaceous chondrites. The last event recorded by these meteorites was a brief period of alteration of minerals within asteroids by slowly flowing warm water that produced clay-like minerals very similar to those that form on the Earth's surface at the present day.

Meteorites therefore are exceptionally important rocks that allow scientists to glimpse not only events that took place in the distant reaches of our galaxy and long before the Earth had formed, but also processes that took place on the surface of Mars, and may ultimately provide clues to the origins of life on Earth.

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Thursday 15th April 2004

Dr Nigel Trewin, Department of Geology and Petroleum Geology, University of Aberdeen

WILDLIFE IN DEVONIAN SCOTLAND : A NATURAL HISTORY TOUR

During the Devonian Period Scotland experienced a variety of climatic changes that impacted on the wildlife of the time. Several famous localities were used to illustrate the variety of plant and animal life that colonised the land surface and populated the lakes and rivers. The journey started with the Early Devonian rivers and lakes of Forfar inhabited by acanthodian fish and large eurypterids. We then moved north to the sea plants and arthropods living around the hot-springs of Rhynie. Finally, we visited the Middle Devonian Orcadian lake, with its remarkable fish fauna, on our way back to the present.

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Thursday 13th May 2004

MEMBERS' NIGHT

We acknowledge with thanks the contribution of our members noted below to the success of this evening.

Short talks

What it's like being an Earth Sciences Undergraduate in 2004	Jessica Smith
The Making of Mountains	Michael Pell
World's smallest footprint and trichomes from Mexico	Neil Clark
Secrets of Meadow Hill and Palace Brae	Brendan Hamill
The Mystery of Quartz Fingers	Gordon Todd
New slate from old quarries	Joan Walsh

Displays

World's smallest footprint	Neil Clark
Secrets of Meadow Hill and Palace Brae	Brendan Hamill
Eastern Mediterranean : various excursions	Bill Lamb
Society excursions : Stonehaven, Glasgow Basin, Glen Taggart, Loch Lomond, Ardmore (RIGS)	Charles Leslie
Fossil Collection	Craig Mains
Rock Collection	Sally Rowan
Book Shop	Roy Smart
The Mystery of Quartz Fingers	Gordon Todd
Scottish slates	Joan Walsh

EXCURSIONS

Weekends

This year we undertook two very different excursions, one to County Clare in the Irish Republic and the other to Durham and its surroundings.

Dr Peter Haughton of UCD offered to lead us through the rocks of Ireland's south west corner which he showed were very similar in deposition to the Mississippi delta, and his graphic description and wit made this a memorable weekend. Naturally we also enjoyed being in the relaxed atmosphere of that part of the Republic and the good food and drink that went with it. Janey MacDougall volunteered to lead a group to the NE coast of England and, thanks to her very detailed knowledge of this area and its geological viewpoints, we managed to cram a lot of very interesting and contrasting rock structures into a short period.

These weekend excursions are enjoyable, not only for the geological content, but also for the opportunity to relax with and enjoy the company of members of the Society during the day and in the evenings over a meal and a little drink or two. I hope that we may be able to widen the group that participates in the coming year - if you have never been on one, do think about joining us in 2005 and I promise that you will not be disappointed.

Day Excursions

Six excursions were arranged this year with transport provided by Essbee coaches on four occasions and members' cars being used twice (because of groups).

April 24th : 11 members visited the St Ninians opencast mine led by Dr Neil Gray, geologist and Mr Jim Docherty the site manager.

May 29th : 22 members joined the bus for the trip to Ballantrae and Downan Point led by Dr Mike Keen.

June 26th : 9 members joined Dr Neil Clark at Leadhills Mining Museum to go gold panning but nobody retired rich!

July 31st : Our visit to Dob's Linn, led by Dr Keith Ingham, was attended by 23 members and still had a waiting list. The trip proved a resounding success.

August 28th : Again a large waiting list for the journey down the Clyde led by Dr Chris Burton but eventually all were accommodated and nobody missed out on a fascinating day.

September 18th : This excursion was meant to be the one held jointly with the Edinburgh Society but a mutually convenient date could not be found. Dr Brendan Hamill came to the rescue and took a depleted party around the Gargunnock Hills basalt, the Kirkwood Formation and the limestone sequence of the Bannock Burn.

The Society wishes to record its thanks to all the leaders who give up their time so willingly to lead our excursions and who, with their infectious enthusiasm, make these outings so enjoyable for all.

Carolyn Mills and Michael Pell

ST NINIANS, NEAR DUNFERMLINE – OPENCAST COAL MINE

24 April 2004

Leaders : Dr Neil Gray, geologist, Mr Jim Docherty, site manager, Scottish Coal

Report by : *Hammy Corrance* Participants : 11

We set off in cars, to the St Ninians Opencast Coal Mine, near Kelty in Fife, for the first field trip of the year. On the journey, we passed the Devonian lavas of the Ochil Hills and the Carboniferous vents and sills of the Cleish, Benarty and Lomond Hills, before stopping for lunch at a picnic area overlooking Loch Leven.

On arrival at the mine car park, Dr Neil Gray and Site Foreman Jim Docherty, our Leaders, met us. After the issue of safety helmets and fluorescent jackets, we were given a short talk about the mining operation. The coal being mined is from the Limestone Coal Group from the Lower Namurian of the Carboniferous Period. The geology is complicated by two synclines with fold axes plunging to the North-East, and a number of NW-SE trending faults. There had been coal mining in the area till the early 1950's, with shallow opencast for a short time after the deep mining ceased. As well as coal, a dolerite sill is quarried for use as aggregate. At present, 60 personnel are employed in the operation, producing 20,000 tonnes of coal weekly, mainly for the power stations at Longannet and Cockenzie.

Before the tour of the site we examined two fossilised tree trunks found in one of the coal seams.

The first stop on our tour was the top of one of the spoil heaps where we had

a panoramic view of the entire site. Some of the areas where coal had been extracted have already been backfilled and returned to agricultural use. We then passed by the large stockpile of coal already mined, before entering the working area. In the quarry faces there were several cycles of seat-earth, coal and sandstone, with coal seams varying in thickness from about 2m to 0.5m. Old mine workings were still visible near to the quarry face. Some of the pit props were still in place, although the tunnels were completely filled in. Further into the quarry, a 1m thick coal seam about the size of a football pitch had been exposed ready for extraction. In the seat-earth beneath the coal there were fossilised roots and plant remains. Faulting in this area limited the extent of quarrying due to safety.

Our final stop was a close-up look at one of the massive excavators. The huge shovel with its 20 tonne capacity was a perfect place for a group photo before leaving the site.

Back at the car park we thanked Neil and Jim for an excellent day before heading home.

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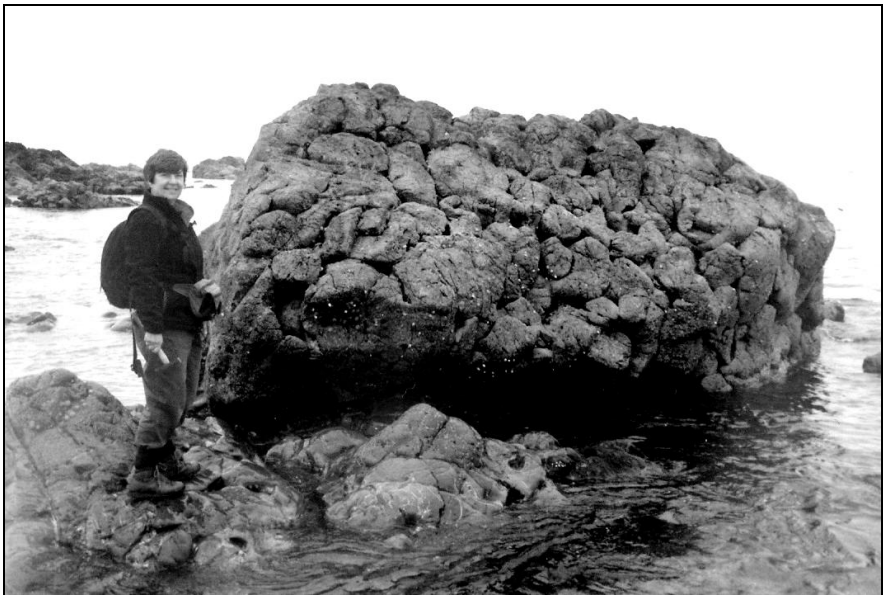
BALLANTRAE COMPLEX : 29 May 2004
Leader : Dr. M.C. Keen
Report by : *Charles Leslie, Margaret Donnelly* Participants : 22

The Ballantrae Ophiolite (obducted or accreted oceanic crust) is now believed to be from the floor of a back-arc basin, rather than from a deep mid-ocean ridge. The back-arc basin lithosphere is made up of sediments, pillow lavas, gabbros and peridotite, lacking only the sheeted dykes found in deep oceanic ridges. (The best example of a present day back-arc basin, between a continent and an island arc, is the Sea of Japan). In fact all the major ophiolites studied in the Troodos Mountains of Cyprus and elsewhere are thought to be of back-arc basin and NOT mid-ocean ridge origin. Geochemically, the Ballantrae lavas have a 'within-plate' or 'island arc' affinity. It is believed that the Ballantrae accretion/obduction took place in three phases, over a period of more than 110 Million years, from Pre/Early Cambrian to Mid Ordovician. Of the various layers of oceanic lithosphere, today we saw the sediments of Layer 1, the pillow lavas of Layer 2, but not the dykes and gabbros of Layer 3 (although these can be seen elsewhere in the Girvan area) nor the serpentinite of Layer 4.

The first location was at Downan Point (NX 070 807). We were dropped off at the start of the track leading to shore (NX 081 812). Our excellent and ambitious driver then managed to take the 25 seater coach to the end of the track to pick us up! The Stinchar Valley Fault is now considered to be the Southern Uplands Fault at the coast, so Downan Point is on the Southern Uplands Terrane while Ballantrae is on the Midland Valley Terrane. Spectacular pillow lavas are exposed on a headland here on the shore, showing the finer margins chilled by contact with water. They are vesicular with some amygdales and the lava has cooled into tubular forms, so that they are more bolsters than pillows. There is little indication of the depth of the water into which the lava was injected but it was probably not deep ocean. Much of the lava has been

altered to spilite, in which the calcium of the lava has interchanged with sodium from the superheated sea water.

The group then moved on to Bennane (NX 091 861 – 865). Here, red sandstone of Permo/Triassic age in the beach sand lies over contorted volcanic rocks. The beach to the south is underlain by dune bedded Permo/Triassic red beds, deposited in a basin which is fault-bounded in the north on this beach section. Also, nearby, are exposures of serpentinite (soapstone) of layer 4 of the ophiolite suite – at this location, of reddish colour. This is ultra basic mantle rock, peridotite. As it rose due to decreased pressure, the olivine has been altered by the addition of water and the formation of serpentine minerals. In this fault zone, complex assemblages of rock types predominate, with calcite veining between the serpentine, volcanic lavas and radiolarian chert. Today radiolaria flourish in the surface layers of tropical oceans as planktonic single celled (c.f. amoeba) Protozoa. They are small, (0.5mm diameter) with skeletons and shells made of silica, and on death, rain on to the deep ocean floor to form an ooze from which the chert forms. In places, the bedded chert has been broken up and redeposited as a matrix-supported breccia, and as the bedded chert has been folded, disruption has taken place on the nose of the fold.



Pillow lavas at Downan Point, with Member Seonaid Leishman

Some agglomerate has formed as lithified rock was blasted out by a volcanic eruption, to settle or be deposited by running water close to its point of eruption, so that the angularity of the clasts has been maintained. Other agglomerates have formed by the disruption of a conglomerate with well rounded clasts. Organisms with calcite skeletons are not preserved in water deeper than the Calcium Compensation Depth

(approx.3600m), by which point all of the calcite has been reabsorbed into the water. With today's sea water chemistry, silica is dissolved in shallow waters and does not survive in water shallower than 1000m. Just beyond Bennane Head are pillow lavas, similar to those of Downan Point. So in this small area we have found evidence of explosive volcanic products reworked in what would today be deep water chert. Explosive volcanicity, especially the tuffs, suggests shallow water, while pillow lavas are produced at constructive margins, mid-ocean ridges, but not necessarily in deep water. If the shallow water hypothesis is accepted, as it is at present, perhaps the Ordovician seawater chemistry, e.g. oxygen concentration, was different from that of today.

Our last stop was at Pinbain Bridge (NX 147915). Here, brecciated submarine basalts, spilites (pillow lavas) – part of the Ballantrae Igneous Complex – show signs of red colouration which could indicate sub-aerial weathering i.e. the basalt, after extrusion on the ocean floor, was lifted up out of the water before weathering! Ordovician granite clasts within the mélange are only slightly older than the sediments and may be derived from the Midland Valley. (In the Betics range of SE Spain, granites were uplifted, unroofed and their erosion products incorporated in sediments only 2 Million years younger than the granites).

A possible sequence is that in the early Ordovician, the area was in a back-arc basin behind the volcanic arc to the south. That basin then closed up and the arc was thrust on to the Midland Valley Terrane, with granite emplacement to the north of the subduction zone. By late Ordovician, the area lay in the fore arc basin and received the erosion products from the rising Midland Valley stacks. These avalanched down as turbidity flows, deposited in Bouma sequences. The basal unit of a Bouma sequence, with abrasive, sharp edged sands, grades upwards into finer sands and shales as forward motion was lost and organic matter rained down. Few fossils have survived but those which have belong to distinctive North American fauna of brachiopods, graptolites and especially trilobites.

At the end of the day our leader was thanked enthusiastically for a most enjoyable and informative excursion to this complex region of Scottish rocks.

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CLARE BASIN 11 -13 June 2004

Leader: Dr Peter Haughton (University College Dublin)
Reporters : *Bob Diamond, Margaret Donnelly*

Friday 11 June, 2004

After the successful trip to the Stonehaven area with Peter Haughton, we managed to persuade him to take us to the west coast of County Clare, specifically the area between Loop Head and Kilkee. The rocks were deposited in Namurian times as one of the basins making up the Shannon Trough. The exposures were superb examples of a cross section from the basin floor to the delta mouth. Peter kept relating all that were seeing to the present day Gulf of Mexico, with the Mississippi delta pouring sediment onto the shallow continental shelf and over the edge into a deep ocean basin. Having survived the 'interesting' journey by Ryanair from

Prestwick to Shannon, we settled into the warm hospitality of the Haplins Hotel, with a welcome and brief overview of the Clare Basin from our leader.

Introduction.

The Atlantic coastline and outer Shannon estuary of south County Clare, western Ireland (Fig 1), are renown for their world-class exposures of deep water, slope and delta deposits dating from the Upper Carboniferous Period (c.340 Ma). The area includes spectacular examples of soft sediment deformation features, and one of its main attractions is that high sea cliffs provide large, 'reservoir-scale' slices through the various deposits.

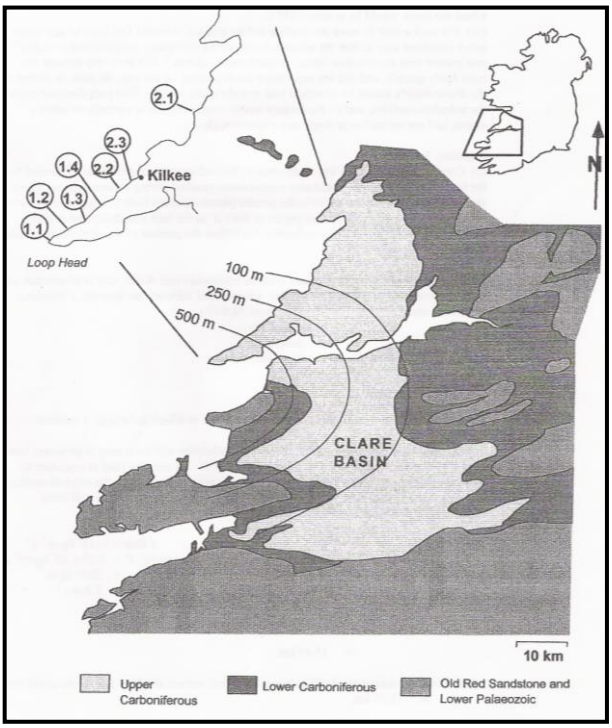

Figure 1. Outline geology of Clare Basin and localities visited. Isopachs are for the basin floor and slope deposits, adapted from Rider (1974).

1.1 – Loop Head
1.2 – Ross and Bridges of Ross
1.3 – Gull Island Formation near Ross
1.4 – Trusklieve : the Tullig Cyclothem
2.1 – Spanish Point
2.2 – Doonlicky Cyclothem
2.3 – Diamond Rocks

The Namurian (Upper Carboniferous) sections of our excursion are part of the Clare Basin fill, an area over which there was prolonged subsidence from early in the Carboniferous Period, when regional crustal stretching allowed a thick succession of limestones to accumulate first (as seen in the Burren area of north Co Clare, with its well known karstic landscape and unique flora). During this early phase, western Clare was part of a platform-to-basin transition: a persistent shallow water platform area to the north passed into a deeper water area to the south in the vicinity of the Shannon Estuary (the so-called Shannon Trough). By the end of the Lower Carboniferous, Kerry and probably South Clare lay in deep water with limestone turbidites already accumulating on the basin floor. The succeeding Namurian Clare

Basin can thus be thought of as a successor basin inheriting much of its geometry from this earlier subsidence.

During the Namurian, deposition of carbonate changed to that of clastics, indicating new sediment sources and routes. Much of counties Clare, Kerry and Limerick was first blanketed by fine grained black shale deposits (the Clare Shale Formation) – a period of sediment starvation. Deep water sandstone (the Ross Sandstone Formation) was then deposited in the area of the Shannon Estuary, whilst the original platform in North Clare remained starved of sediment and continued to accumulate a condensed blanket of black shale (and phosphate – a classic indicator of slow sedimentation rates). The sandy sediment came from the west – now out under the Atlantic! However, these environments 'come to us', as the Upper Carboniferous basin fill gradually becomes shallower upwards such that the Ross Sandstone 'turbidites' are overlain by a thick succession of slope deposits (the Gull Island Formation) and eventually by shallow-water delta deposits of the Central Clare Group (Fig 2). This vertical evolution of environments can be interpreted simply as a single progressive shoaling cycle: the environments superimposed vertically may originally have been laterally equivalent – a straightforward application of Walther's Principle. However, it is equally plausible that the types of environment along the margin of the basin may have changed through time, and that deposits of Central Clare Group type may never have been laterally equivalent to Ross Sandstone Formation type in deeper water.

Sediment type and supply. The total thickness of sedimentary rocks that accumulated in the Clare Basin is around 1500 m. Sediment supply was from major (transcontinental?) river systems, probably draining distant, tectonically inactive, source areas. These rivers had a mixed load of clay, silt and medium grained sand. High sedimentation rates, the dominance of fine grained sediment and the draping of inherited slopes probably explains why we see such a lot of evidence for slope instability in the deposits. A similar situation pertains in the case of the modern Mississippi delta front. The supply of sediment to the subsiding basin was clearly episodic for the succession contains many regional scale drapes of fine grained, organic-rich shales which have a rich and condensed fauna of goniatites, bivalves, gastropods, crinoids, carbonaceous material and rare brachiopods. These so-called 'marine bands' (laterally very extensive) are stratigraphically extremely important because they allow the succession to be split up and correlated over long distances, and at high resolution. It is estimated that marine bands, each with their own distinctive fauna, recur every c. 65,000 years!

Receiving basin characteristics. The Clare Basin was part of a network of Carboniferous basins in stretched continental crust throughout NW Europe. These basins were distant from and poorly connected to the main oceanic water bodies at the time, and as a result tides were insignificant and the water may even have been brackish (this latter is controversial). The discharge of large rivers into these basins may have resulted in dilution of the marine waters. Fully marine faunas are only found in the 'marine bands' – almost certainly times of rising sea level when marine water flooded into the basins. The Clare Basin was large enough to promote significant deep water waves which approached the coastlines from the SE. These waves had an important role in distributing sediment carried to the delta fronts.

Saturday 12 June, 2004

After a good night's rest, our first day started out at Loop Point where we were introduced to the deep water deposits (the Ross Sandstone Formation), with an overview of the turbidites in large cliff exposures. These layered, amalgamated sheet systems of sandstones have extensive bed continuity, with subordinate interbedded shales, 'marine bands', and slumped horizons of mixed lithology. With relatively fine grained sands, in metre-scale beds, these have areas showing signs of clasts (mostly sand) coming from the slumping of the slope sediments. It was hard to keep our concentration with the tremendous views, the choughs, and the thrift, but we persevered, and it was worth it.

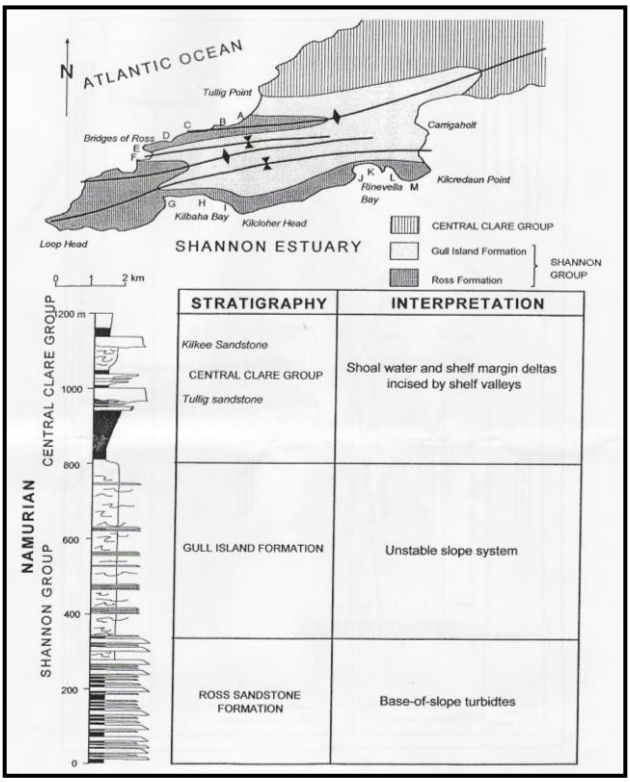

Figure 2. Outline geology of the Loop Head area (after Chapin et al. 1994) and summary stratigraphic section.

There were some spectacular sand volcanoes at our second stop, Bridges of Ross. These features, where sand from the underlying layer is forced through the upper layer, were caused by the squeezing of water out of the sediment. We have seen these before e.g. Fife coast, but these examples were really spectacular, some more than a metre across. We also saw examples of megaflute erosion surfaces – the forerunners of channels within the turbidite sediment. It was difficult to see these without the expert tuition from Peter. Nonetheless an interesting insight into how dynamic the deep ocean basin sediments can be.

We moved into the Gull Island Formation: turbidites showing remobilisation in base-of-slope and slope settings, with an upward transition from the basin floor to slope to the shallow water deltas. The lower part contains siltstones interbedded with

Mud slump, County Clare

sheet sandstones, while the upper is mainly siltstones. There is extensive soft sediment deformation (growth faults, slump features). It is interpreted as a fine grained, unstable (delta?) slope which prograded eastward into the basin (Fig 3). As we continued to walk up section, the signs of slumping became more pronounced. We were clearly getting nearer the slope between the shallow water and the deep basin. Here we could clearly see how some of the neat layers of sediment had been spectacularly jumbled up by mud avalanches down the slope. There were some quite clear channels, presumably where stronger currents were also flowing down the slope.

Finally at the end of a long but very interesting day we reached the delta edge, at Trusklieve. Lots of signs of channels, or was the delta covering an existing valley? The width of the channels lead people like Peter to believe that these channels are in fact following pre-existing erosional features i.e. palaeovalleys. A complex pattern of sand bars was also evident, as was the fine to coarse sequence of the first of the cyclothems, the Tullig cyclothem.

Back to the hotel for a good meal and bed.

Central Clare Group. Delta systems of the Central Clare Group (maximum thickness 900 m) transitionally overlie the Gull Island progradational slope system. The group can be divided into five major cycles (or cyclothems) separated by prominent marine bands. Only the lower three cycles (Tullig, Kilkee and Doonlicky) can be widely traced across the area and we examined the lowest cycle: the Tullig cyclothem. Each cyclothem broadly coarsens upwards and has classically been interpreted as a prograding delta system (Fig. 3, perhaps analogous to the modern

Mississippi Delta); the deltas were fine grained, river-dominated with moderate wave-reworking of the delta front mouth bars. The delta front slopes show varying degrees of instability, with relatively stable shoal water deltas sitting on the shelf, and unstable shelf margin deltas where rivers fed sediment to the shelf-slope break.

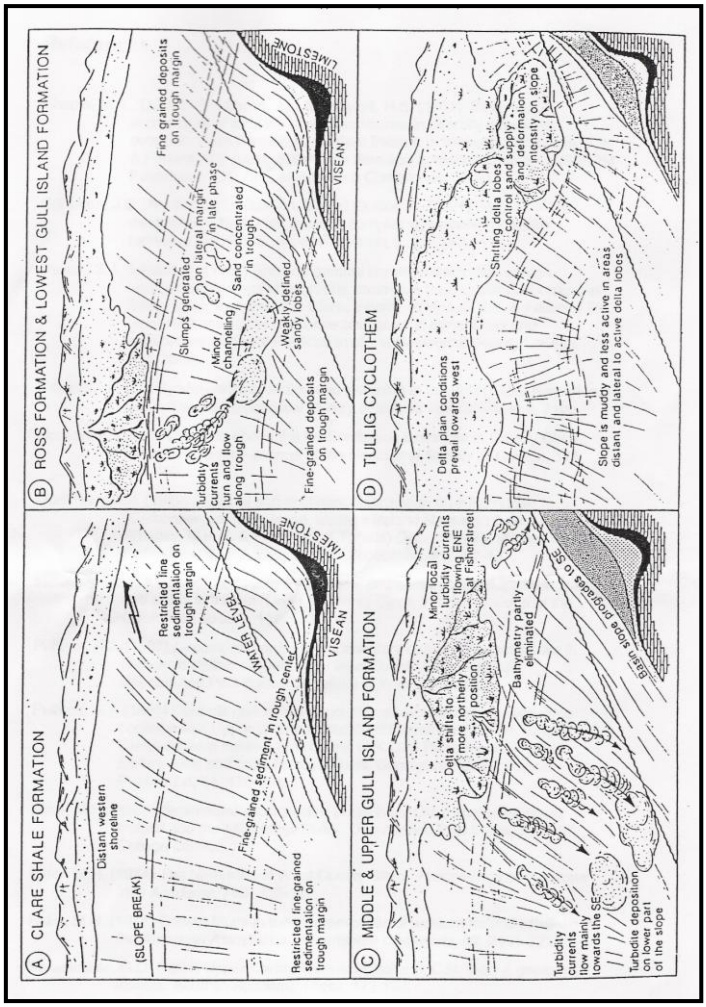

Figure 3. Cartoons (from Collinson et al. 1991) showing evolving palaeography during basin filling.

Each cyclothem typically begins with a silty succession reflecting the build out of unstable deep water delta fronts. Mouth bar sandstones (up to 15 m thick, 2-3 km across) in the top of these progradations are erosively cut by sandstone-dominated fluvial channels. The Tullig cyclothem has sandstones up to 35m thick – the Tullig Sandstone. Original interpretations stressed autocyclic mechanisms: the erosively based sandstones represented the advance of the delta top distributive feeder channels

over the delta front with its mouth bars. However, discrepancies in the sediment grain size in the 'channels' and the delta front, the huge scale of the channel sand bodies (>20 km wide) and evidence for significant basal erosion indicate that these may instead be palaeovalleys. The stratigraphy may thus be responding to external forcing by sea level changes – falls in sea level driving both shelf and valley incision. This is important for understanding the turbidites down dip; the evidence from the deltas suggests that there were times when much of the sediment was held in shallow water shoal deltas and estuaries, and others when deltas migrated to the shelf edge or the shelf itself was incised and rivers fed sediment directly to the top of the slope. These latter two scenarios would have favoured transfer of sediment into deeper water.

Sunday 13 June, 2004

The second day was an investigation of the processes within the delta itself. Our first stop at Spanish Point allowed us to see erosional surfaces which had been covered several times by other layers of sediment – evidence for shelf exposure and reflooding. There were both interfluve and maximum flooding surfaces. This was interpreted as representing a series of marine transgressions. Whether this was due to changes in sea level or changes in the sedimentary cycle i.e. relative or eustatic changes in sea level, seemed to be a moot point.

At our second stop, Foohagh Point, the Doonlicky Cyclothem produced evidence of how fluid the delta front itself could be. There was even evidence of some faulting in the muds, and plenty of evidence for structures such as sand bars to be constantly moving. This was delta front growth faulting and demonstrated its impact on mouth bar sand distribution.

The third location, Diamond Rocks, displayed mud diapirism and its significance in the upper part of the Tullig Cyclothem. A diapir is a vertical columnar plug of rock or magma that is forced through a more dense rock, by buoyancy, tectonic forces, or a combination of the two. The deformation of a succession of sedimentary strata containing highly incompetent material often results in the upward intrusion of this material through the overlying layers, causing doming and piercing, as could be seen at this location.

Finally we left County Clare for the short journey back home. It had been an instructive, enjoyable and very worthwhile weekend.

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GOLD PANNING IN THE LEADHILLS : 26 June 2004
Leader : Dr Neil Clark, University of Glasgow
Report by : *Margaret Donnelly* Participants : 9

We met at 10.00 am on a rather dull, grey morning, at the Wanlockhead Mining Museum. The weather forecast was poor, and we were equipped with warm clothes, waterproofs – and Wellington boots for wading in the stream. Our leader gave us an introduction to the area, describing the mineralisation and showing us some of the ores – galena, chalcopyrite, sphalerite etc – which were lying about. The metal compounds had been washed in from the surrounding country rocks, when the area had been a sedimentary basin in the Ordovician (505 – 438 Ma). After being dissolved by hot fluids, they were injected as an earlier quartz vein, and a later metallic one, of lead and zinc, during the Carboniferous. Small amounts of gold were associated with these two metals. The first recorded recovery of gold is from the early 16th Century (reign of King James IV), while gold from the Crawfurd Muir was incorporated into the new crowns for the King and Queen during the reign of James V. The ring around the Scottish Parliamentary Mace contains gold panned by amateurs, and donated in 1999.

We drove a few miles from Wanlockhead, and parked by a stream, well-sheltered by overhanging trees. Dr Clark demonstrated the use of the sluice which is placed in the stream so that water and sediment are washed through and small heavy particles are trapped by its ridges. Alternatively, a hand pump may be used to transfer water and sediment to the pans, while a more drastic method uses a shovel – much of the gold is deep in the stream bed so this method tends to produce the best results. The next step is to swirl each pan repeatedly, removing the lighter material (by saltation), in the best Western cowboy/prospector tradition! Hopefully, the dense gold will settle out and be trapped in either the base of the pan or in its ridges. A couple of members of our group had success quite quickly, and shouts of triumph were heard, even though the gold was only in tiny amounts! And so we had a happy morning, sheltered beneath the trees from the rain which in fact turned out to be merely brief showers, and fighting off the midges with a selection of anti-insect potions. Around 1.15pm, it was remarked that this was the first field trip where no one had yet mentioned lunch – however, some of us felt that it was now time, while others continued in the their prospecting. Our leader at one point seeded each of our pans with some previously acquired gold so that at least we had the experience of finding it – although some members were having a fair bit of success without this added help. By mid afternoon we called a halt, and travelled back to Wanlockhead and the

spoil tips. Here there were plenty of the various minerals, and we rooted around collecting the better specimens, before heading for the Museum and a cup of tea. The day was extremely enjoyable, fascinating and satisfying, and many thanks are due to our leader for keeping us entertained, busy and happy.

DOB'S LINN : 31 July 2004
Leader : Dr Keith Ingham
Report by : *Robin Painter* Participants : 23

The Dob's Linn locality, where the Ordovician-Silurian boundary is exposed, was the subject of this field trip led by Dr. Keith Ingham, and is in Moffatdale, Southern Uplands. The Moffatdale setting is a text book U-shaped glaciated valley landform. The surrounding area is virtually treeless with green rough pasture covering the lower sides of the main valley and some outcropping scree slopes of greywacke and shales. The main valley sides are cut laterally by hanging valleys with characteristic high waterfalls. The most dramatic of these is the Grey Mare's Tail, observable from an off road parking area, our first stopping point on this warm, largely dry but overcast day.

Moffat glacial valley

Dob's Linn itself is another, slightly less dramatic hanging valley, if only because its falls are not visible from the road, though the valley itself is accessed by a short walk from a lay-by about 1 km further up the road from the Mare's Tail

stopping point, in the direction of Selkirk. The stratigraphic importance of this area was first recognised by Lapworth in the 1860's, then a young local teacher, and who was later to become one of the most prominent figures in geology of his time. Lapworth, as his career developed, was able to reconcile the conflict between the assignment of strata that were then being identified by Murchison as Cambrian with overlapping strata that were being assigned by Sedgwick to the Silurian. Lapworth's work on the Moffat Shale Group in this area enabled him to persuasively propose, and ultimately have accepted, that what had hitherto been described as either late Cambrian or early Silurian should be reclassified as a new system, the Ordovician.

He used graptolites as the zone fossils to establish precise, ordered changes in the graptolite assemblages through the sequences of these black and grey shales, and to thereby unequivocally demonstrate his stratigraphic interpretation. The Dob's Linn site has subsequently become the internationally recognised (in 1985) stratotype location which is used to characterise the boundary between the top of the Ordovician and the base of the Silurian system. It is now therefore the location of a metaphorical golden spike that marks this important boundary between geological periods. For the trophy-minded, the identification of this boundary became one of the objectives of the field trip.

Walking up the route of the Long Burn from the lay-by on the valley road, we come to the Linn Branch which joins the Burn from the left. A little way up the Linn Branch, the high Linn Branch Falls come into view dropping down over two near vertical cliffs, first of the Gala Greywackes and then a cliff of the underlying Birkhill Shale. The golden spike is close to the base of the Birkhill Shale, just above the Upper Hartfell Shale. These shales are exposed on the northern side of the Linn Branch gorge. In particular the Anceps Bands, which are close to the top of the Upper Hartfell Shale, are easy to find with the help of the excursion guide and the materials provided by Dr. Ingham. Shale samples containing *Climacograptus* were easily broken out of the B Anceps band, which dip at about 70 degrees at this location. Passing further to the left, crossing a thin yellowish metabentonite layer, and about 5 metres left from the B Anceps bands into the darker Birkwell Shale, lies the Ordovician-Silurian boundary. Sadly no golden spike, or even *Parakidograptus acuminatus*, zone fossil for the boundary, were to be found.

Without maps, and lacking the single-minded motivation of our illustrious predecessors who unravelled its complex stratigraphy, we would have made nothing of this important location. Nonetheless, with the expert guidance to hand, in our short visit we were able to carry away very satisfying impressions, and some modest samples, from a site where giants of the science of geology must have stood.

THE GLASGOW BASIN II – THE SOUTHSIDE 28 August 2004
Leader: Dr Chris Burton
Report by : *Audrey Lancaster*

This enjoyable excursion took us to the western edge of the Strathmore Basin known as the Glasgow Basin. This basin extends into Ayrshire and Renfrewshire, exposing sediments from different sources. The different layers and

rocks found in a basin each have a story to tell about the environment at the time they were laid down, and the sediments' origins.

We found evidence of the basin's origins near the Cloch lighthouse: an iron rich material, mixed with agglomerate from a nearby vent was mugearite, a mineral associated with oceanic islands. Back-arc basins are formed when subduction causes the crust to stretch and fracture. Together with the nearby presence of a row of volcanoes at that time, this is convincing evidence that the Glasgow Basin is a back-arc basin. Along the coast we found examples of caliche formation, right from the early stages of cornstones, via nodules to pillars, and finally to massive beds. These structures are only formed in arid and semi-arid conditions, telling us that the basin went through a long dry period. The absence of plant remains confirms this view.

Further south we found Upper Old Red Sandstone of Upper Devonian age. This was mixed in with breccia from a Highland source. Here we were looking at a period of alluvial fans, and a time of mass mudflows from the Highlands. This was yet another phase in the life of the basin. At Auchengarth, where we have a Late Carboniferous vent, the agglomerate associated with it contains a large range of clasts, representing the local wall rocks of the vent ripped out by the explosive gases which were erupted by this rare type of volcano. The clasts originate from a range of strata from the Lower Palaeozoic, to the lower crust, and even the upper mantle.

Our excursion took us from the Carboniferous to the Lower Devonian, and a glimpse of the very basement of the basin.

THE GARGUNNOCK HILLS AND THE KIRKWOOD FORMATION
18 Sept 2004
Leader: Dr Brendan Hamill
Report by : *Moira Salter*

The Gargunnock Hills Basalts, the Kirkwood Formation and the Limestone sequence of the upper Bannock Burn.

We had a really fascinating day in the Gargunnock Hills. Although it was marred by wet weather and a swollen Bannock Burn, making access difficult in places, the geology more than made up for it.

Our first stop was at the North Third Reservoir. Walking over the field to the dam we saw rocky outcrops of mugearite, which were overlying a coarser markle basalt. On the far side of the dam, at the water's edge, was mugearite, with the Kirkwood Formation on top of it. Above this was the Lower Limestone Sequence, capped by the Midland Valley Sill.

In the afternoon we walked up the Bannock Burn, looking at the Lower Limestone sequence. This was a down-faulted block, so the Clyde Plateau Lavas would be below it. However there were layers of basalt intercalated at different points in the limestone sequence, and always between the limestone and the basalt was the Kirkwood Formation. The Kirkwood Formation has been regarded as a marine sedimentary layer. It looked ashy and shaley with pellets of limestone and basalt clasts. Brendan showed us a photo of these limestone clasts, containing fossils which he had found in the Kirkwood Formation at the reservoirs. There were signs of

Part of the Midland Valley Sill

upthrusting in the Kirkwood Formation. The whole limestone sequence was capped by the basalt which extends as far as Fintry. At the base of this top layer the basalt had clasts of shale, indicating it was younger than the shale, and therefore younger than the underlying Clyde Plateau Lavas. At one point we saw veins of basalt penetrating the shale.

This excursion posed intriguing questions. How did the basalt get there? Brendan believes that it may have been injected at great speed from a meteorite impact. This would seem to explain why it was found at different points in the limestone sequence. However this explanation poses new questions. The Kirkwood Formation was not baked hard, and had a layered structure. One would have expected more severe deformation of the adjacent limestones, considering the force required to intrude the basalt in this way. How would fossils have survived the intense heat?

The meteorite theory is fascinating, but does not answer all the questions – yet! Thanks to Brendan for introducing us to this puzzle, and possible solution.

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DURHAM : 10 -12 Sept 2004
Leader : Mrs Janey MacDougall
Report by : *Julian Overnell* Participants : 18

Friday 10 Sept, 2004.

We left the Gregory Building, University of Glasgow at 9am, by bus.

The first location visited was at Appleby, Yorkshire. Here, above the flood plain of the River Eden, just below the church (NY 687,199) bright orange/red cliffs of bedded sandstone were exposed. These had been quarried in the past and one face had been left smooth, approximately at right angles to a weathered face; this gave the opportunity to see the bedding structures in 3D. The party were invited to examine the sandstone to try to deduce evidence for the depositional conditions. The bedding

comprised wide (5-10m) concave structures with the tops truncated. The hand lens showed well rounded, polished quartz grains with a restricted size range of approx 0.25-0.5mm and no micaceous component nor obvious matrix, and only occasional dark (lithic) or white (feldspar) grains. It was concluded that this was probably an aeolian deposit. The formation is known to be Permian in age and represents a dune field laid down in the Eden basin. Previous detailed mapping has shown structures consistent with barchan dunes and prevailing wind from (the present) NE.

Location 2 was an exposure of carboniferous limestone pavement at the roadside between Appleby and Orton, with fairly evenly spaced weathering fissures. There were many small shell fragments and rounded fossils of the large brachiopod *Productus*.

Location 3. Road cutting on A685 south of Tebay, NY 611,019. Here a variety of structures were seen in fine-grained Silurian greywackes. There was an angular synclinal chevron fold with a ~ 45° axial dip towards the road which could be clearly seen where a large overlying section had gone. There was an adjacent rounded synclinal fold with no apparent dip of the axis. Under the base of the fold slickensides could be seen suggesting movement between adjacent strata, and the base of the fold was cut by a small reverse fault. On a high small overhanging section intricate bottom/sole structures could be made out at the base of stratum, but it was too high up to examine in detail. Sigmoidal tension gashes filled with a white material were examined. The white material was softer than a copper coin, indicating probable calcite.

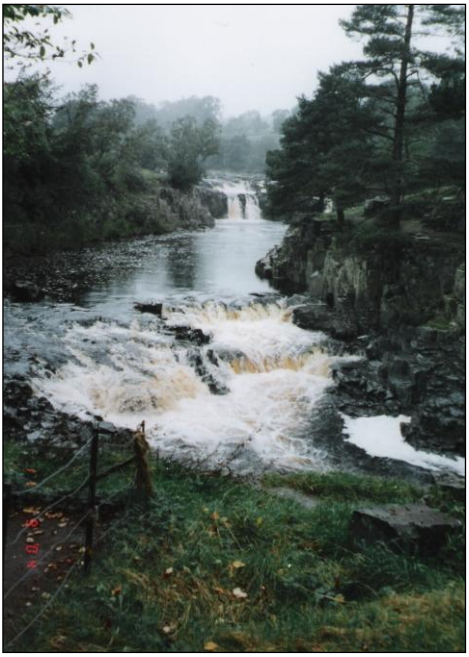
Accommodation for the two nights was at St Mary's College, University of Durham and it was comfortable with good food.

Saturday 11 Sept., 2004

In the morning the party were given the opportunity to visit the old town of Durham where the local building sandstone was seen to be liable to deep weathering with repairs needed to the exterior fabric of the cathedral. A brick building was seen with "kink band folding" in the courses, presumably due to slight subsidence. Durham is built on coal measures. At 11am the bus departed for the next location, and on the way the party saw large trenches in the ground which represented quarried-out sections of the Cleveland Dyke. This is a large impersistent Tertiary dyke, 10-15m wide. When mapped the dyke appears to extend from Mull through Inverkip to the North Yorkshire Moors.

Location 4. Gibson's cave and Summerhill Force, Tees Valley, NY 910,288. Here the Bowlees Beck has carved out a cave under the "5 yard limestone". A fallen block of this limestone showed outlines of *Productus*. Below this in the hollowed out section of the cave was a series of thin siltstone and shale beds, one of which was possibly an oilshale, overlying a thick (1-2m) shale bed. The riverbed downstream was formed by a series of sandstone beds with ripple marks and flaser bedding of a very thin shale drape, which made the strata look bluish.

Location 5. Low Force waterfall on the River Tees, NY 904,279. Here the waterfall was seen to be formed by the outcrop of the Great Whin Sill and the party were able to stand on the top margin of the sill. Here it showed small blocky jointing where the sill had been emplaced into siltstone. Approx. ¼ miles downstream on the



Low Force….

SW bank, sediments were seen to dip ~ 20° to the north, with a large block of whinstone on the top with crude vertical jointing. It was concluded that the sediments represented a siltstone raft near the top of the sill. From the NE bank one edge of this raft could just be seen through the trees.

Location 6. High Force waterfall, NY 880,284. The party followed the public path to view High Force (in the River Tees) from below. On the way the path crossed over the Tees fault, with downthrow to the N. High Force was seen also to have been formed by the Great Whin Sill and the waterfall face was comprised of three horizontal sections, the middle one of which was a hornfelsed siltstone raft in the sill. A feature of the fallen columns of whinstone at the base of the fall was that the whole length of the column seemed to have been formed in one single smooth fracture event. The "chisel marks", characteristic of repeated small fracture events in tertiary lava columns, were absent. The siltstone raft could be examined at the side of the access path on the return journey.

Location 7. High Force upper quarry, NY 879,920. This disused quarry showed no included raft of sediment. However, near the base of the quarry face was a nearly horizontal band of light coloured speckled pegmatite. This contained an elongate dark mineral, up to 2 x 25mm with cleavage lines at right angles to the long direction, in a white matrix. The dark mineral was pyroxene with an unusually long crystal form, and the matrix was an intergrowth of quartz and feldspar (although this could not be observed in the hand sample). The quartz dolerite of the sill contains no free silica (it is called a quartz dolerite because it contains no olivine). The pegmatite band probably represents a late-stage crystallization of a "filter pressing" of residual melt, and does contain free silica.

<u>Sunday 12 Sept., 2004.</u>

Location 8. The first location was near Clachheugh Rock on the south bank of the River Wear in Sunderland, NZ 359,575. From here yellow Permian beds on the north bank of the Wear were seen to overlie red Carboniferous beds with a probable unconformity above the red.

Location 9. A few hundred yards further down the valley at NZ 363,576, grey-coloured Permian magnesian limestone was seen to overly the yellow sandy

……..and High Force

beds. The uneven contact suggested an unconformity, but no unconformity was marked on the geological maps.

Location 10. Marsden Grotto on the cliff top north of Sunderland at NZ 39964,64726. Here the party descended to the beach via the wooden steps to examine the yellow Permian rocks. These were fine-grained and gently effervesced with 10% HCl. They were magnesian limestone, but not with as much Mg to be classed as dolostone. They showed roughly horizontal strata ~ 10cm thick. In places, diagenetic clasts weathered to cannon ball horizons. At several locations (e.g. NZ 3977,6517) some strata appeared to thoroughly mixed up and disturbed. The party failed to identify the cause of the disturbance, and were told that the probable explanation was that it was due to collapse of overlying strata into cavities created by leaching of evaporites. The evaporites arose in the hypersaline Permian Zechstein Sea.

After lunch Janey MacDougall was thanked for her excellent leadership during the excursion and the bus returned to Glasgow, arriving at approx. 6.45pm.

GENERAL INFORMATION

Scottish Geological Societies-ConocoPhillips Awards. These were awarded to pupils with highest marks in Intermediate 1 and 2 and Higher exams. As there were two at Higher Level with exactly the same mark, both received the full prize, with the three contributing Societies providing the extra funds. The winning pupils were from George Watson's, Dollar Academy, and from schools in Alness and Cumnock.

Scottish Journal of Geology On-Line. Articles from Volumes 38 and 39 of the Journal can now be viewed /printed from the Internet. Members eligible to receive

the Journal should contact the Membership Secretary for details of the registration procedure. Abstracts and articles from earlier volumes are **not** available on-line.

George Rae's Fossils. George Rae was a member of the Society from 1989 until his death in 1998 when his large fossil collection was bequeathed to the Hunterian Museum. An exhibition of these was opened here on September 8th.

Strathclyde RIGS. The group has identified a number of sites worthy of consideration. They include Ardmore Point, Trearne Quarry and Saltcoats.

Scottish Geology Festival 2003. The Society donated £90 and copies of the Glasgow Guide as prizes which were presented at the BGS Open Day (Sat 27/9/03) to three primary school and three secondary school pupils for their models based on the theme of the 'Ice Age'. As 2004 was an 'Inter Festival' year, the main focus was on schools, with competitions held on a chosen geological subject.

TNG Memorial Medals. A further ten of these were cast in silver. At the February meeting, one was presented to Donal Bateson, of the Numismatic Section of the Hunterian Museum, for their collection.

INTIMATIONS

With regret, we record the deaths of the following members :

Sir Alwyn Williams (Honorary Member, member since Session 123 (1980-81)

Passionate geologist, expert on marine invertebrates and modernising Principal of Glasgow University. Born June 8th, 1921; died April 4th, 2004.

Sir Alwyn Williams, who has died aged 82, was a geologist who will be best remembered for his varied and pioneering work on brachiopods and as a forceful, modernising principal of Glasgow University from 1976 to 1988.

He attended grammar school in the south Wales mining town of Aberdare, where he was born. He excelled in athletics, though he spent much of 1939 in a sanatorium suffering from tuberculosis before winning a scholarship to the University College of Wales, Aberystwyth, to read Geology. In 1948 he participated in the first post-war international Geological Congress, held in Britain. Between 1948 and 1950 he was awarded a Harkness Fund Fellowship in Washington DC, where he worked with the world's leading brachiopod expert, G. Arthur Cooper, at the Smithsonian Institution.

Alwyn Williams's first job was as Lecturer in Geology at Glasgow University (1950-54) before moving to Queen's University, Belfast, where he held the post of Professor of Geology until 1974. During the mid-1950s he worked on a major geological and palaeontological regional study of the Bala area in central Wales. In Belfast he became increasingly devoted to brachiopods, known to some as "lamp shells" and having a 600 million-year evolution to their current, diminished range today). There, his keen intellect and ability were used to pioneer new techniques in their study and description. The development of transmission and scanning electron microscopy enabled him to further study brachiopod shell structures.

In 1974 Alwyn moved to Birmingham University as Professor of Geology, and in 1976, he returned to Glasgow University as principal, where he remained until 1988. There he was faced with the need to modernise the University. He hired new young staff, introduced a computing department and recognised the need for scientific disciplines to be applied more widely. He set out a tough and decisive programme of rationalisation, emphasising the need for good teaching and research, so that the University soon gained a considerable reputation. At this time, he also set up the palaeobiology unit to expand his research in collaboration with biochemists and geneticists, widening his leading studies on the interrelationships between the soft tissues of brachiopods and their hard skeletal covering shells. He retired in 1988, retaining his University study and continuing to publish some of his most important papers. During his Belfast years, Alwyn had begun the co-ordination of the production of the Brachiopod volumes for the American series 'Treatise On Invertebrate Palaeontology'. This work involved 18 other authors and led to the publication of the two-volume Brachiopod Treatise in 1964.

Since 1985 there has been a quinquennial series of International Brachiopod Congresses held in various cities around the world, always strongly supported by Alwyn. At the 1990 Congress, he accepted the request that he start co-ordinating the total revision of the Brachiopod Treatise. This time the number of authors rose to 46 experts; the first 540 pages of Volume 1 were published in 1997. At the London Brachiopod Congress (2000), he received a presentation in honour of his brachiopod studies over 50 years.

Three more Treatise volumes have since been published and two more are in preparation, representing a vast increase in our knowledge of brachiopods: their physiology, genetics, anatomy, shell structure and growth, together with illustrated descriptions of approximately 5,000 genera. The 14 years of this project is brief in terms of most Treatise productions, and is a testimony to Alwyn's organisational ability and drive. The revised Brachiopod volumes will stand as a tribute to his knowledge, vigour and ability.

As a friend Alwyn was a delight, witty and hospitable, most ably supported by his wife Joan, whom he had met when they were both students at Aberystwyth and married in Canada in 1949. The focus of his mind was awesome; he could read at great speed on a wide range of subjects. He had time for people and, as a supervisor of research, he inspired students and was always willing to stop and discuss a problem, technique or doubtful conclusion. His knighthood was conferred in 1983. He was interested in the arts and was chairman of the Committee on National Museums and Galleries in Scotland between 1979 and 1981.

In retirement he took pleasure in his garden and grandchildren. He is survived by Joan, his daughter Sian and son Gareth.

William Stuart McKerrow. 1922 – 2004 (Honorary Member, member since Session 103 (1960-61)

Stuart McKerrow, known to many generations of Oxford geologists as "Mac", was an amiable and excellent communicator and innovator, who was particularly good at getting geologists of very varied subdisciplines to talk to each other and then work together. He was born in Glasgow on June 28th 1922, and after

boarding at Abbotsholme School, Derbyshire (where he picked up his love of geology) went up to Glasgow University in 1939. He was called up to the Royal Navy in 1942 and spent much of the war as a High-Frequency Direction-Finding expert in Atlantic convoy escorts, during which he was awarded the Distinguished Service Cross (DSC) for gallantry. He returned after the war to finish his Glasgow geology degree in 1947 and was then hired by Oxford University, initially as a temporary Departmental Demonstrator. He stayed there, with appropriate promotions, until his death. After the award of his Oxford Doctor of Science degree (DSc), he was proud of being "DSC squared".

During his first few years at Oxford, he completed a doctorate on Fuller's Earth brachiopods and published several papers on the Jurassic, but in the late 1950s he began field work on the Silurian of north-west Ireland, and subsequently the Palaeozoic, particularly the Ordovician and Silurian, came to dominate most of his working life. Also during the late 1950's he developed strong links with North American geologists and later had sabbatical years at Caltech, Chicago and Williams College. Thus he was at the forefront of the recognition of the geological links across the Atlantic during the Palaeozoic, both before and after the understanding of plate tectonics. He had a string of notable collaborators and nearly 30 research students. He also developed an interest in palaeoecology and edited the substantial and influential 1978 book 'The Ecology of Fossils'. The changing geography and structural dynamics of the Earth always fascinated him, and he, together with Chris Scotese, organised an important conference on Palaeozoic geography, which was subsequently published as a Society Memoir in 1990.

Mac was also very much of an organisational innovator. He early saw the need for a fully illustrated British-based palaeontological journal in the 1950s, and became elected to the Geological Society Council (together with Norman Hughes) to pursue that aim through the founding of a new Society journal. Unfortunately Council did not agree with the proposal – a decision that led directly to the founding of the independent Palaeontological Association (1957) of which McKerrow was the first Treasurer. He was later elected its President. Years later he was re-elected to Council and subsequently the Society recognised his work by the award of the Lyell Medal. He was also awarded the Clough Medal by the Edinburgh Geological Society, the T.N. George Medal of the Glasgow Geological Society and the Founder's Medal of the Belgian Geological Society. Mac and a few others also saw the need for more postgraduate collegiate organisation and accommodation at Oxford, which eventually led to the foundation of Wolfson College, of which he became a fellow, and eventually Vice-Gerent. He continued working right up to his death on 12th June 2004.

He married Jean Brown, also from Glasgow, in 1949, who survives him: they have three sons.

Mr R.S. Brown, member since Session 109 (1966-67) who died November, 2003.

Mr J.R. Elston, member since Session 135 (1992-93) who died 24th March, 2004.

Front cover photograph – Pillow lavas, Downan Point, near Ballantrae (*taken by Charles Leslie*).

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