PROCEEDINGS OF

THE GEOLOGICAL SOCIETY

OF GLASGOW

150TH ANNIVERSARY SESSION

2007 – 08

SESSION 150 (2007 – 2008)

150th Anniversary
1858 – 2008

SESSION 150 (2007 – 2008)

Members of Council

President	Dr Alan W. Owen
Vice Presidents	Dr Chris J. Burton
	Mr Mervyn H. Aiken
	Mr Charles M. Leslie
Honorary Secretary	Dr Iain Allison
Treasurer	Mr Michael J. Pell
Membership Secretary	Dr Robin A. Painter
Minutes Secretary	Mrs Margaret L. Greene
Meetings Secretary	Dr J.M. Morrison
Publications	Miss Muriel Alexander
Librarian	Dr Chris J. Burton
Asst Librarian & Hon Archivist	Mrs Seonaid Leishman
Proceedings Editor	Miss Margaret Donnelly
Publicity	Dr Neil D.L.Clark (web)
	Dr R. A. Painter (meetings etc)
Excursion Secretaries	vacant (Saturdays)
	Mr David McCulloch (Residential)
Strathclyde RIGS Chairperson	Mr Stuart Fairley
Rockwatch Representative	vacant
Junior Member	Miss Rachael Ellen
Journal Editors	Dr Colin J.R. Braithwaite
	Dr B.R. Bell
Ordinary Members	Miss Karen Baillie
	Dr Simon Cuthbert
	Dr T.J. Dempster
	Mr R. McNicol
	Mrs Margaret Niblock
	vacancy
Independent Examiner	Mrs Beth Diamond

PRESIDENT

The Society celebrated its 150th anniversary during 2007 – 2008. To mark the event, the Lord Provost's Office of Glasgow City Council hosted a Civic Reception and Dinner in the City Chambers which was greatly enjoyed by some 50 members of the Society. Glasgow City Council also kindly provided a carpet bedding display in Victoria Park, showing the Society's logo. A one-day conference entitled 'Local geological heroes and characters – a selection' hosted by Glasgow University's Department of Adult and Continuing Education attracted 60 registrants, and extended abstracts of the eleven presentations were published as a Special Edition of the Society's Proceedings.

The eight evening meetings of the Society were extremely well attended and, as part of the 150th Anniversary celebrations, they included joint meetings with some of our sister societies: the Glasgow Natural History Society, the Astronomical Society of Glasgow and the Scottish Hellenic Society. The Joint Lecture with the Astronomical Society was also the Joint Celebrity Lecture with the Edinburgh Geological Society and was delivered by Professor Monica Grady of the Open University. Professor Richard Fortey of the Natural History Museum received the Society's T. N. George Medal at the opening meeting of the Session. Fittingly, Professor Fortey was also the President of the Geological Society of London which was celebrating its 200th Anniversary during 2007 – 2008.

Membership numbers have fallen slightly and lie at just under 400 but despite this, the Society is in good health. In addition to the excellent attendance figures for the lecture programme and anniversary events, the four one-day field excursions were very well supported and the two weekend field trips were fully booked. The RIGS (Regionally Important Geological and Geomorphological Sites) group, a subcommittee of the Society's Council, has continued to be very active and other such groups are investigating coming under the Society's umbrella. Such activity in promoting geodiversity is an important part of the Society's outreach into the wider community and in this context the Society attracted plenty of interest with a display of geological maps and other materials at the Glasgow Science Centre as part of its contribution to Scottish Geology Month, along with a silver panning expedition. The Society was also able to fulfil its aim of promoting geology through a contribution to the production of Rock Kits for Schools by the Scottish Earth Science Education Forum.

In terms of publications, two parts of the Scottish Journal of Geology were published along with a 'normal' edition of the Proceedings as well as the Special Edition noted above. The efforts of the various editors in the production of these publications are greatly appreciated. In addition, the Society published a field guide to the geology of Madeira written by two former presidents, Drs Jim MacDonald and Chris Burton.

As noted in the report for 2006 – 2007, the rise in cost of publishing the Scottish Journal of Geology, coupled with the reduction in advertising revenue is causing concern to the members of Council as this has resulted in the need to use funds from reserves for the past four years. The Journal is published in conjunction with the Edinburgh Geological Society and is one of the core elements of the Society's Constitution. Negotiations are now at an advanced stage for the Geological Society of

London Publishing House to publish the Journal on behalf of the two Societies in both hard copy and electronically. This will not only stem the drain on Society's reserves but it will also enhance the Journal's exposure to the international geological community both by electronic publication and by digital versions of the entire back run being made available as part of the GSPH 'Lyell Collection'.

This has been an extremely busy and successful year for the Geological Society of Glasgow. None of its many activities could have been achieved without the expertise and time so freely given by the members of its Council for which I am extremely grateful.

Alan W. Owen

MEMBERSHIP

	At end 150 30 Sep., 2008	At end 149 30 Sep., 2007
Honorary Members	5	5
Ordinary Members	281	306
Associate Members	66	62
Junior Members	22	19
TOTAL Members	374	392
New Members	31	34
Memberships Closed	49	24

Under the new Constitution we have reduced the period of time members remain on our membership list once their membership subscription becomes overdue. Therefore our overall membership numbers appear to have declined in Session 150, though this is hopefully a one-off effect, due to this change in treatment of members whose payments are overdue.

(The memberships closed category rolls up the numbers resigning and the terminations due to non payment of subscriptions.)

R. A. Painter

SCOTTISH JOURNAL OF GEOLOGY

Once again the full 192 pages for volume 44 were published in 2008. Hardcopy uptake via libraries and trade subscriptions continues to be an issue, although data suggest that the Journal suffers slightly less from this than some comparable publications. Online use continues to grow and it is gratifying to see the continuing increase in full text downloads. These raise the profile of the Journal and should eventually influence our impact factor. Discussions are now at an advanced stage regarding a wider electronic exposure within the Lyell Collection of the Geological Society of London and details are in the Billet enclosed with these reports. The trade

subscription for volume 44 was £160 and the subvention from the Society for volume 45 has been held at the same figure as last session.

C.J.R. Braithwaite

PUBLICATIONS

This has been a year of change on the publications scene. The stalwart of the bookshop, Roy Smart, decided that he wishes to demit office as Publications Officer after 13 years of dedicated service. Among his many duties, Roy was always to be found on Society nights behind an extensive display of books and maps, quietly selling, answering questions or taking orders for special requests. In all that time Roy missed only one evening and on our behalf I would like to thank him most sincerely for serving the Society so well and with such loyalty over all these years.

Until recently we held a huge overstock of the guides "Geological Excursions around Glasgow and Girvan" and the "Building Stones of Glasgow" resulting in the Council deciding to write off a large proportion of them. I am pleased to report that the Glasgow City Council was happy to accept many of them and it intends to distribute them to conference delegates to the City; others will be offered to Countryside Rangers and other interested parties.

At the start of the Session, the bookshop was well stocked holding around 48 different publications plus maps and various other items. Only two new titles were added and we hold stock valued at £1856.13. Unfortunately sales this year have been slow giving a surplus of only £149.40 with the majority of these sales being to our own members and to Adult and Continuing Education classes.

On the positive side, we now have on sale a new publication, "Geology of Madeira" published by the Society and written by two long-standing members and former Presidents, Dr J.G. MacDonald and Dr C.J. Burton. This has added considerably to our stock value and we hope many Society members will purchase the guide and be inspired to enjoy a visit to Madeira to explore the geological excursions outlined in it. There are retail outlets on the island prepared to sell it to visitors and other outlets have been contacted throughout the UK.

Muriel Alexander

LIBRARY

Work on the updating and reorganisation of the Society's library has continued this Session, with the following results:

<u>Reorganisation.</u>

Much of the reorganisation of the Society's library has now been completed with the exception of those out of date journal runs still housed in the book library and the British Geological Survey publications still in the journal library. Council will be asked to decide on a disposal policy for the out-of-date journals, the place of which will then be taken by the BGS publications.

<u>Catalogues.</u>

The Society possesses a series of catalogues for the book stock, including separate catalogues for excursion guides, which, with the exception of the latter, are now well out-of-date. Re-cataloguing is a massive task and will take some time, and will

commence as soon as can be arranged. Copies of the catalogue to the excursion guides will be placed in the library shortly.

Map Collection.

Forty-three new BGS maps have been added to the Society's collection, including a bequest of 26 maps from the late Dr. J. M. Allan. Because of pressure on space these maps have to be housed along with the departmental map collection and cannot easily be accessed by members. However a catalogue of our holdings has been prepared and will be placed in the library for consultation. Members wishing to borrow maps (and the departmental collection is also open to them) should contact the librarian who will provide them.

Book Accessions.

Accessions continue at a rapid pace, 43 new books being received to date. Accessions are such that the library shelves are becoming crowded, hence the need to remove old journal runs. A small number of books which time has rendered of antiquarian rarity and value have been removed and placed in our existing collections within the University library. These remain accessible to members on application to GUL.

Library Access.

Members were informed at the start of the Session that daytime access to the library had been booked on Tuesdays between 12 noon and 3 pm from October to December. Further bookings will be made for January – May. Members may rely on the library being accessible at the times mentioned, with the possibility of it being available at other times of day/week. Members should consult the timetable next to the door before entering.

Library Use.

A small number of dedicated borrowers have made extensive use of the library this Session, and members have been directed to the library on Meeting evenings. Prior to evening Meetings either the Librarian or the Assistant Librarian (or both!) will be present to advise and direct members, fetch books, maps, etc. Come and use your library!

C. J. Burton, Librarian, and S. Leishman, Assistant Librarian.

STRATHCLYDE RIGS GROUP

The Second Scottish RIGS Workshop, held in Perth Museum on 4 October 2008, was attended by all the RIGS and geodiversity groups in Scotland, including the two Geoparks. It provided an opportunity to share information and experiences of managing geodiversity including integration in the planning and development process and promotion to the wider public. A Scottish RIGS Development Officer post is still being pursued and a follow-up Workshop will be held in the spring.

The good news is that two new RIGS Groups have been formed covering Argyll and Dumfries, both of which are interested in affiliation to GSG. Arrangements for this are being considered; meanwhile the Groups are looking at sites – and for enthusiastic members. There is also the possibility of a RIGS Group being set up on Arran. Anyone interested in these areas can make contact via strathrigs@tiscali.co.uk.

At the start of the year Strathclyde RIGS were invited by East Dunbartonshire Council to assist in drawing up a contract for the evaluation of Local Nature

Conservation Sites (LNCS). A review of biodiversity sites began in the summer. The geodiversity contract will shortly be let and is based on a list of sites provided by the RIGS Group which have important geological and geomorphological features. This survey will help in writing the Council's Local Plan 2 and eventually a Local Geodiversity Action Plan (LGAP). East Dunbartonshire with support of RIGS is the first Council in Scotland to carry out a geodiversity LNCS Review.
The Group continue to make progress with specific sites:
The Fossil Grove promotional flyer was circulated throughout the City from Easter, and it would appear that this summer's visitor numbers have increased. The Society and RIGS are represented on the City Council's Steering Group which is planning development of this World class geological site.

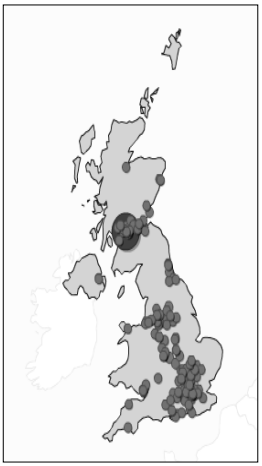
- Spireslack opencast mine at Muirkirk has now been designated a RIGS. This is an important stage in the development of the site for education and recreation.
- Balmaha will be the subject of a RIGS-type leaflet next summer with support from the Loch Lomond & the Trossachs National Park.
- Portencross RIGS proposal has been welcomed by Friends of Portencross Castle. A leaflet is in preparation and designation being progressed.
- Rouken Glen SSSI (for the Orchard Limestone) was reported by a Society member as being damaged. After meetings with East Renfrewshire Council agreement has been given to RIGS designation of an extended area around the gorge and to future promotion of the geology of the Park.
- Waulkmill Glen in Dams to Darnley Country Park was promoted as part of Scottish Geology Festival and RIGS have ensured that geodiversity is included in the Aims and Objectives of the Park.
- The Ardmore Point leaflet has been reprinted and continues to be circulated widely in the area.

Seonaid Leishman and Stuart Fairley

WEBSITE

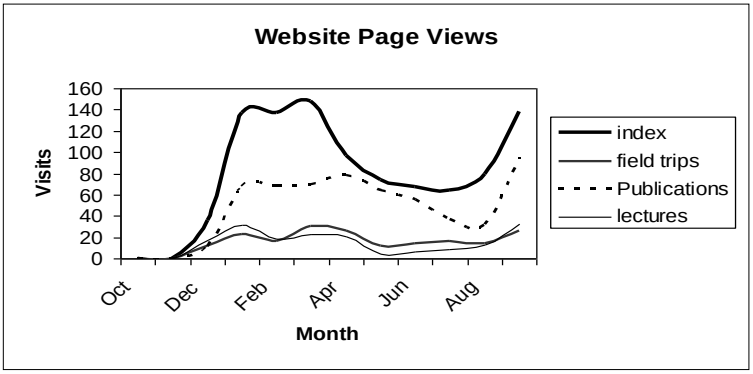
The website reporting is now conducted in a more realistic manner using Google Analytics to produce data on site usage. In the past data produced relied on page hits which included images on pages as well as visits to the pages giving an over inflated view of site usage. Google Analytics has been used since the end of December 2007, so data covers just slightly more than the last 9 months to the end of September 2008. For this period, the website home page has been requested a total of 978 times, becoming the most requested single page. No direct comparison can be made with previous data, but it seems quite a healthy number considering the size of the membership of the Society. The next most popular pages are the publications pages with over 579 visits over 9 months, followed by the pages for excursions (about 189 requests) and lectures (with about 176 requests). This follows the pattern of previous years of the most popular pages. The pattern of page visits stayed at about 100 visits per month with an average time spent on the site of just over 1 minute, with a slight dip over the summer months and a rise again in September for the Scottish Geology

Festival. 56% of visitors looked at only one page, 19% looked at two pages and 8.5% looked at 3 pages tailing off to a maximum number of pages viewed to 18 for 0.1% of visitors. Visitors from around the Globe have come to the GSG website including one in New Zealand! However, the vast majority of visitors are from the UK which accounts for 700 of the 978 total visits. Of these, 141 come from Glasgow (not including Cumbernauld and other nearby towns), 152 from London, and even 1 from Cheadle Hulme, near Stockport, who visited 9 pages. Some improvements to the pages have been undertaken throughout the year, and news items have been added occasionally.



Map of towns where visitors to the website originated.

Comments and suggestions for the web pages are always welcome, but the content is reliant on information being provided by members.



http://www.geologyglasgow.org.uk/. **Neil D.L. Clark**

PROCEEDINGS

The Proceedings for Session 149 (2006 – 07) were published in March 2008 and about 80 distributed by hand at the April Meeting to save on postage costs. Following our 150th Anniverary Symposium, 'Local geological heroes and characters: a selection', in February, a 'Special Proceedings Edition' was produced, comprising the transcripts of the lectures on that day, together with the speeches delivered at the Civic Reception held in the City Chambers in June. Many thanks are due to Dr Alan Owen, President, who helped enormously in the preparation of this 'Edition'. It was published in September and distributed in October 2008.

Margaret Donnelly

TREASURER

Income and Expenditure Account for Year Ended 30th September 2008

(Scottish Charity Number SCOO7013)

Session 149 2006 – 07				Session 150 2007 – 08	
		Income	**note#**		
		1. Subscriptions			
	3979	Received by Bankers Order		4171	
	2355	Received by payment to Memb Sec		1792	
	-300	Deduct paid in advance this year		-41	
6154	120	Add received in advance last year		300	6222
		2. Investment Income			
	546	Dividends		592	
2502	1956	National Savings	**1**	2137	2729
1048		3. Tax refund (gift aid) payment awaited	**2**		1054
117		4. ConocoPhillips prize	**3**		1050
246		5. Net surplus Publications sales			149
	1175	6. Saturday excursions income		880	
15	1160	expenditure		843	37
	2070	7. Weekend excursions income		6931	
57	2013	expenditure		6877	54
200		8. Donations (incl meetings coffee)			467
0		9. Repayment of unpresented cheque (now cancelled)			40
10339		**Total income**			**11802**
		Expenditure			
4,500		1. Scottish Journal of Geology			4,500
658		2. Meetings incl speakers, meals, etc			1190
345		Room hire session 148b			0
365		Room hire session 149a			0
1043		Room hire session 149b (accrued in session 150)			0
		Room hire session 150a			668
		Room hire session 150b (accrual)			1200
440		3. Publication of Proceedings			418
389		4. Billets, production incl Hon Sec's expenses			406
500		5. Sponsorship grants			1500
535		6. Library	**4**		583
522		7. Insurance			139
350		8. ConocoPhillips prizes			350

0		9. Madeira Guide (costs in Publications stock in balance sheet)		0
0		10. RIGS		200
0		11. Hunterian 2007 fund		0
0		12. T N George Celebrity Lecture		0
0		13. Society's 150th anniversary celebration	**5**	625
289		14. Affiliation fees	**6**	313
		15. Admin costs – postage, stationery, telephone etc		
645		Membership Sec		406
104		Chairman		119
54		Treasurer		9
0		16. AGM expenditure (net)		0
10		17. Geology Festival		16
8573		18. Write off - overstock unsaleable publications		0
19,322		**Total expenditure**		**12642**
-8983		**Profit/loss**		**-840**

Balance Sheet as at 30th September 2008

Session 149 2006-07			**note #**	**Session 150 2007-08**	
		Members' Funds			
	63190	Balance as at 30/09/2007		64013	
	-8984	Surplus/deficit for the year		-840	
	9807	Revised valuation fund for investments	**7**	-3167	
64013		**Balance as at 30th September 2008**			**60006**
		Restricted Funds			
	380	T.N.George Fund		380	
1380	1000	Hunterian fund	**8**	1000	**1380**
65393		**Total Funds**			**61386**
		Represented by			
		Current assets			
		Cash at Bank:			
	4945	Royal Bank of Scotland Account		2927	
41495	36550	National Savings		35187	38114
		Cash in hand:			
	50	Publications Sales Officer		85	
	200	Membership Secretary		0	
	0	Secretary		0	
285	35	Meetings Secretary		0	85

12000		National Savings Income Bond		12,000
10833		Current Valuation of Charifund investment	**7**	7666
31		Debtors - Publications at 30/9/07		0
0		- 150th Anniversary day surplus	**5**	104
0		- Gift Aid	**2**	1054
2092		Stock of Publications (incl new Madeira Guide)	**9**	4647
66736		**Current assets**		**63670**
		LESS LIABILITIES		
	-300	Subscriptions paid in advance	-41	
	-1043	Moneys due by Society (Room hire Session 149)	-1043	
-1343	0	Moneys due by Society (Room hire Session 150)	-1200	**-2284**
65393		**Net assets**		**61386**

Signed as approved by the Trustees: …….
Dr Alan Owen President and Trustee on behalf of all the Trustees

Signed by the Independent Examiner …….
Beth Diamond (Mrs)

Other relevant figures

Year end 30/09/2007, Bank opening and closing balances

From Bank statements

Cash at Bank 30/09/2006	£4171.88
Cash at Bank 30/09/2007	£5436.10 bottom line
	£5083.80 Subtracting unpresented chqs from final balance
Increase over the year	**£911.92**

From Income and Expenditure report

Total income during year	£18001.68
Total expenditure during year	£17089.76 Includes unpresented cheques and carried forward chqs from last year
Surplus on the year	**£911.92**

Notes to the accounts

1. A £3500 transfer from the Savings account into the Bank was needed to cater for excess expenditure during the year.

2. Application has been made to the Inland Revenue for Gift Aid repayment. The figure of £1054 quoted is our assessment which should be accurate.
3. A £1000 top up from ConocoPhillips was received during the year.
4. The library cost covers the provision to all members of a free copy of "Down to Earth" and subscription for the "Geological Magazine".
5. The Societies 150th Anniversary symposium was organised by DACE and they handled all income and costs realising a surplus of £104. The Council authorised the payment of dinner for the speakers, photographs, reception and production of the Special Proceedings.
6. Affiliation fees are payable to The Geologists' Association, The Palaeontological Association, and The Palaeontographical Society.
7. To allow for potential Stock Market losses, an allowance of £3000 was deducted from the book value of the investments last year. This was prudent since the value fell by around that amount. A further £2000 has been deducted this year which if proved correct will result in a drop of 50% in the value over two years.
8. The Hunterian Fund has reached its target of £1000 and will be kept in the restricted funds until called for.
9. The cost of producing the Madeira Guide was £2910 and this is not shown in the Income & Expenditure account but has been added to the Publication stock.

Michael J. Pell

MEETINGS

Our Sesquicentennial Session was somewhat different from the norm. Our President, Alan Owen, had taken several initiatives, including setting up Joint Lectures with no fewer than three other societies. In addition, he was largely responsible for the "Local Heroes and Characters" Conference held on Saturday 23 February which was well attended, a great success and subject of a special issue of the Proceedings.

For our opening lecture in October, the highly-acclaimed Professor Richard Fortey (Natural History Museum) gave the Professor George Memorial Lecture (jointly with the Glasgow Natural History Society) in which he gave an overview of our subject "Forward into the Past" with predictions about future directions. In November, local hero Geoff Tanner presented his view of the current understanding of a controversial subject – "The Highland Boundary Fault Zone".

2009 got off to a flying start with another Joint Lecture, this time with the Glasgow Astronomical Society, when the charismatic Professor Monica Grady (Open University) gave a lucid and entertaining account of "The Search for Life beyond Earth". The problems of early life on Earth were addressed by a relative newcomer to the Glasgow Department, Vern Phoenix, in "Precambrian suntan lotion: UV screening". It's taken humans a while to catch up with nature!

Spring saw the return of an old friend Dave McGarvie (Open University) who gave a lecture beautifully illustrated with shots of his work in Iceland on "Volcanic eruptions into glaciers". Our last lecture was also our third Joint Lecture, this time with the Scottish Hellenic Society – an apparently unlikely pairing! Our speaker described work involving collaboration with an archaeologist which started with a 'Google by Diggle' (the said archaeologist). In it he showed how ancient Ithaca of Homerian times was probably not modern Ithaca, but the present western peninsula of Kefalonia, subsequently made part of that island by rockfalls.

The Session closed as usual with Members' Night, but with fewer talks than usual, your Meetings Secretary overcoming his natural reticence to provide two out of four talks. Come on Comrades – You can do better in May 2009!

Jim M. Morrison

.....

Thursday 11th October 2007

Joint Lecture with Glasgow Natural History Society

After the following citation delivered by Professor Trevor Hoey, University of Glasgow, the **Professor Thomas Neville George Memorial Medal** was presented by Dr Alan Owen to:

Professor Richard A. Fortey

The Natural History Museum, London

The Professor T. N. George Medal is awarded "for excellence in palaeontology and/or stratigraphy". Professor Richard Fortey excels on the international stage in both of these fields and he is also one of the foremost writers on Earth Science for the general public.

Richard Fortey is the world's leading authority on trilobites. He has described trilobite faunas from almost every corner of the globe and has produced a succession of benchmark papers interpreting their evolution, their biology and their changing distribution patterns in space and in time. His work on Ordovician trilobite palaeobiogeography is one of the key elements in our understanding of the plate tectonic history of that very dynamic period of earth history.

Richard Fortey is also an acknowledged expert on Ordovician graptolites, early arthropod evolution and the so-called 'Cambrian explosion'. In addition he is one of the leading lights on Ordovician stratigraphy and is currently the longest serving member of the International Ordovician Subcommission.

His scientific achievements led to Richard Fortey becoming a Fellow of the Royal Society in 1997 and he was recently awarded its Michael Faraday Prize for Public Communication of Science. A succession of books from 'The Hidden Landscape' in 1993 through to 'The Earth: An Intimate Landscape' in 2004, including a best seller on his beloved trilobites published in 2002 have brought Earth Science in general and palaeontology in particular to an ever widening public. These popular books are both erudite and accessible and have received justifiable plaudits including the Natural World Book of the Year (for The Hidden Landscape) and The Lewis Thomas Prize for Science Writing.

Richard Fortey is, rightly, no stranger to awards; he has received the Lyell Medal from the Geological Society of London, the Senior Medal of the Zoological Society of London and an Honorary Degree from the University of St Andrews. He is currently the President of the Geological Society of London which is celebrating its 200th Anniversary and so it is especially fitting that he is here to receive the Professor T. N. George Medal at the start of the Geological Society of Glasgow's 150th Session.
I call upon the President of the Society, Dr Alan Owen, to make the presentation.

Professor Fortey then addressed the Society on

FORWARD INTO THE PAST

Where is the study of geology going in the next fifty years? Gazing into the crystal ball is a dangerous occupation, but some predictions are plausible. The changes to the world's climate are going to project the study of ice sheet dynamics into the forefront of the research agenda – global warming will be coupled with global melting! Nor are the demands for energy simply going to go away – but demands for 'cleaner' resources will stretch the technology in new directions. Engineering geologists will experience their heyday in disaster mitigation. Meanwhile, the exploitation of neglected resources like tar sands will rise higher on the political agenda. Fortunately, palaeontology will continue to fascinate for its own sake, and the marriage between molecular studies and that of the fossil record will yield new rewards. While we will probably understand the genesis of major volcanic eruptions more completely, with saving of potential loss-of-life, the future of earthquake catastrophe prevention will probably lie in simple improvements in building techniques rather than in predicting when a particular fault will 'give'. Nonetheless, theoretical and practical knowledge will increase thanks to in situ studies of earthquake movement. Knowledge of deep processes at core/mantle level will be increased thanks to modelling and experiment –
even the understanding of the earth's core will be transformed. We hope that field work will still be necessary to marry advances in theory with real observation. All of us hope that the hammer will not become obsolete.

▪▪▪▪▪▪▪▪

Thursday 8th November 2007
Dr Geoff Tanner, University of Glasgow.

THE HIGHLAND BOUNDARY FAULT ZONE, SCOTLAND

The HBFZ is marked by a major topographic break that runs NE – SW across Scotland from Arran to Stonehaven, and is associated with local seismic activity. The fault zone, which is > 300 km long and 1 – 3 km wide, is centred upon the 'Highland Border Complex', with Dalradian rocks to the NW, and Devonian and Lower Carboniferous strata mostly to the SE. Although it is generally accepted as being a profound, long-lived, fracture in the Earth's crust, there is no consensus as to where precisely the fault plane is located and what type of displacement has taken place. Is

it a terrane boundary, a major transcurrent fault, a rift fault defining the northern margin of the Midland Valley, or just a plexus of small partially-linked fault segments? In order to find an answer to this question, new, detailed maps of the geology at key locations along the fault zone have been prepared, and used to draw serial cross-sections and simple 3-D models of the structure of the rocks within, and on either side of, the fault zone. An intriguing set of rocks is found within the fault zone, and this opportunity will be taken to illustrate many of their interesting features, as well as trying to demonstrate the true nature of the boundary between the Highlands and Lowlands of Scotland.

▪▪▪▪▪▪▪▪

Thursday 13th December 2007

ANNUAL GENERAL MEETING

Thanks were expressed to:

Retiring members of Council Miss Margaret Donnelly – Proceedings Editor, and Dr Neil Clark – Publicity Officer (web) for their contribution to the work of the Society over the past three years;

The Editors of the Scottish Journal of Geology, Dr C.J.R. Braithwaite and Dr R.M. Ellam, who are elected annually;

David McCulloch who ended his term as an Ordinary Member but was willing to continue in his role, and was elected as, Excursion Secretary (Residential);

Dr Ben Browne and Miss Sally Rowan who retire after many years as Auditors. The Office of the Scottish Charities now requires an Independent Examiner.

Especial thanks were due to Roy Smart, retiring after 14 years as Publications Officer. We wished him well following his sterling service to the Society over such a long period of time. His is, arguably, the best known public face of the Society as he offered his bookshop not just to members following indoor Meetings but also to members of Adult and Continuing Education courses as well as to local bookshops and tourist outlets in the west of Scotland.

This year (2007) is the bicentenary of the Hunterian Museum and to mark this event the two curators of the geology collections kindly agreed to give short talks on their respective collections – Dr Neil Clark, Curator of Palaeontology, and Dr John Faithfull, Curator of Mineralogy/Petrology.

Broken bones, famous fossils and curious curios Dr Neil Clark

This was an entertaining and informative introduction to some of the collectors who have contributed over the years, from John Young of Campsie to Ian Rolfe, and to the important fossils accumulated such as early amphibians and reptiles, fish, shrimps, sharks, trilobites and dinosaurs, trace fossils e.g. footprints, and plants. Only lately, a fossil hidden in a drawer for years had been ‘found’ and beautifully exposed by

scientists at Cambridge. The Hunterian display, 'new' after recent refurbishment was clearly detailed.

250 years of mineral collecting at the Hunterian Museum Dr John Faithfull

This was a fascinating account of the numerous mineral specimens, including meteorites, housed in the Museum and of the many personalities involved in their assembly, from 1756 – 2007. Hunter himself provided abundant examples, and with much documentary evidence. Specimens from Alva Silver Mine, opened in 1779 at the dawn of chemistry, and gold from Wanlockhead, 1878, form part of the collection.

The business of the AGM was followed by our annual Christmas social including wine, soft drinks and nibbles.

.....

Thursday 10th January 2008
Amendments to the Constitution required by the Office of the Scottish Charities Regulator were approved at a Special General Meeting of the Society held immediately prior to this Meeting. The new Constitution will be available on the web site at www.geologyglasgow.org.uk. Paper copies may be obtained by application to the Hon. Secretary.

Joint Celebrity Lecture with the Edinburgh Geological Society and the Astronomical Society of Glasgow.
Professor Monica Grady, Open University

SEARCH FOR LIFE BEYOND EARTH

The question of whether we are alone in our Universe has fascinated humanity since the earliest of times. The talk explored our own planet with a look at how life first came about and the range of environments in which it has adapted to survive. Studying organisms that live in the most extreme and inhospitable habitats provides a guide to the limits of life on other planets. The lecture then moved on to consider places in our Solar System where life might be found, particularly Mars and Europa.

.....

Thursday 14th February 2008
Dr Vernon Phoenix, University of Glasgow

PRECAMBRIAN SUN TAN LOTION: UV SCREENING MECHANISMS OF EARTH'S EARLIEST LIFE FORMS

The lack of sufficient ozone ensured that the early Precambrian Earth was bathed in high levels of ultraviolet (UV) radiation, levels which were exceptionally harmful to life. How then did the life forms which inhabited the planet's surface, such as those which formed shallow water stromatolites, survive these harmful doses of UV? This

question is pertinent because the phototrophic organisms which generated oxygen (and eventually an ozone layer) must have been exposed to solar radiation to enable photosynthesis. These organisms must have developed strategies for filtering out the harmful wavebands of UV. This talk discussed the mix of geological and biological UV screening mechanisms available at the time, using data from both laboratory experiments and field expeditions.

▪▪▪▪▪▪▪▪

Thursday 13th March 2008
Dr Dave McGarvie, Open University

VOLCANIC ERUPTIONS ONTO GLACIERS

Recent Icelandic eruptions into glaciers that have broken through to the atmosphere have produced spectacular eruption columns, with pulsing uprushes of tephra, frequent lightning flashes, and vast volumes of steam. But Iceland also contains numerous older landforms produced during past eruptions into ice, and studies of these have helped to advance our understanding of ice-volcano interactions. This illustrated lecture gave an overview of ice-volcano interactions, with a focus on recent Iceland eruptions and on field-based research.

▪▪▪▪▪▪▪▪

Thursday 10th April 2008

Joint Lecture with Scottish Hellenic Society
Professor John Underhill, University of Edinburgh

WHERE WAS ODYSSEUS' HOMELAND?

The geological, geomorphological and geophysical evidence for relocating Homer's Ithaca.

Homer's Iliad and Odyssey are two of the world's oldest texts. The Iliad describes events at the end of the Trojan War, believed to have taken place in the 12th century BC during the Mycenaean era, while the Odyssey tells the story of the subsequent return of Odysseus from Troy to his palace on the island of Ithaca. The geographical description of Ithaca in the Odyssey has long provoked controversy and remains very puzzling. In the Odyssey the location of his homeland is described:

Around are many islands, close to each other,
Doulichion and Same and wooded Zacynthos.
Ithaca itself lies low, furthest to sea
Towards dusk; the rest, apart, face dawn and sun.
Odyssey 9.19-26 (trans. James Diggle)

The natural interpretation of the phrase 'towards dusk' is west-facing, while dawn is clearly east-facing. So Homer described Odysseus' Ithaca as a low-lying island that is

furthest out to sea on the west of Greece, with three other islands nearby: Doulichion, Same and Zacynthos. A glance at the map makes it clear that the island of Ithaki is not west-facing, nor is it farthest out to sea, while a digital elevation model confirms that it is mountainous rather than low-lying. Furthermore, although Zacynthos continues to exist today, and almost all experts regard Homer's Same as today's Kefalonia, the island of 'Doulichion' has never been traced: it has remained a mystery for three thousand years. One solution to this obvious contradiction is that perhaps Homer was simply a poor geographer who didn't know his east from his west, his dusk from his dawn nor the difference between low-lying and mountainous islands. Nevertheless, an explanation based on the assumption of a geographically incompetent Homer left many classicists and some archaeologists feeling very uneasy.

The main clue for an alternative location for ancient Ithaca came from the work of the geographer Strabo who also wrestled with the problem of these islands. In his 'Geography' he makes an unusual and very specific observation of Kefalonia: 'Where the island is narrowest it forms an isthmus so low-lying that it is often submerged from sea to sea'. The application of geoscience entered the picture in 2003 in an attempt to address the all-important question: could a marine channel, subsequently described by Strabo as a low-lying isthmus, have separated Paliki, the westernmost peninsula of Kefalonia, from the rest of the island during the late Bronze Age? Because if it did, then Paliki would then have been a free-standing island that precisely met Homer's description 'lies low, furthest to sea and towards dusk'. The talk will summarise the results of all the geological, geophysical and geomorphic methods that have been used over the past three years in an attempt to test the validity of Strabo's Channel as a historical reality. The results may yet provide us with an elegant solution to a 3,000 year old mystery.

.....

Thursday 10th May 2007

MEMBERS' NIGHT

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

Short talks

Recent landslip at Slackdubh on the Campsie Fells Dr Jim Morrison

New field guide to the Glenelg-Attadale Inlier Dr Simon Cuthbert

Strathclyde RIGS activities Mrs Seonaid Leishman & Mrs Margaret Greene

Magic Moments off Ardmeanach, Mull Dr Jim Morrison

Displays

Margaret Donnelly – Memories of 2007.
Charles Leslie and Robert McNicol – Selection of photographs from 2007.

EXCURSIONS

Saturday Excursions

19th April 2008	Southern Uplands: Thirlestane Score and Syart Law. Professor Euan Clarkson, Dr Cecilia Taylor, University of Edinburgh, and Dr Alan Owen, University of Glasgow.	Participants: 15
Sun 11th May 2008	East of Siccar Point. Mr Mike Browne, BGS.	Participants: 13
7th June 2008	North Berwick, Yellow Craig to Cheese Bay. Dr Colin MacFadyen, SNH.	Participants: 16
30th August 2008	The Hutton Trail: Part 2. Dr Con Gillen. University of Edinburgh.	Participants: 22

The first three excursions were well subscribed but all had last minute 'call offs', while the fourth was over subscribed and had a waiting list. All four were most enjoyable and the weather was kind to us. The Joint Excursion to the Southern Uplands was very successful with the Edinburgh Geological Society organising both the trip and High Tea in Moffat. As in previous years, early organisation, and advertising in the third (February) Billet was important and helped to ensure the success of the excursions. For all four, we used buses from DB Travel of Clydebank who charged very competitive rates. However, with the increase in the price of petrol this year, these rates will most probably go up in the future. As it was, an extra £3 – £4 was collected from each participant on the day to cover costs.

Margaret Donnelly

Residential Field Excursions

Two residential field excursions took place in 2008, both in southwest Argyll.
In June Dr. Chris Burton took 23 members to Kintyre which last formed part of our excursion programme 14 years ago. Dr. Burton took the party on a journey from the Dalradian Argyll Group up into the Southern Highland Group and then through Devonian conglomerates and Lower/Upper ORS into the Carboniferous lavas.
In September Dr. Roger Anderton led 22 members on an excursion to the isle of Islay. One of the main attractions was a study of the Rhinns Complex, formerly thought to be Lewisian but now understood to be part of a wholly separate orogenic belt and unique in Scotland. We also examined the metasediments of the overlying Colonsay Group as well as the famous Dalradian tillite.

The weather this year was generally good although not quite reaching the highs (or lows!) of 2007.

I would like to thank Dr. Burton and Dr. Anderton for all the time they put into their preparations for these excursions and for being such patient and approachable leaders. Michael Pell kindly agreed to deputise for me during the Kintyre trip for which I am very grateful and I also thank those drivers who volunteered to use their cars on the Islay trip. Finally I would make special mention of Eve, Jill, Maggie and Seonaid who agreed so willingly to write a synopsis for the Proceedings.

David McCul1och

.....

SOUTHERN UPLANDS: 19 April 2008

Leaders : Professor Euan Clarkson, Dr Cecilia Taylor, University of Edinburgh,
Dr Alan Owen, University of Glasgow.

Report by : *Charles Leslie* Participants : 15

Members of the two Societies met near Tibbie Shiel's Inn, on the A708 north of Dob's Linn and set off southeast up a track for about a mile before climbing a short distance east to the Thirlestane Score ravine at about NT 255197. This was the locality in which Charles Lapworth, while a teacher in Galashiels between 1872 and 1878, observed and recorded the graptolite fauna, and developed a Silurian stratigraphy, before later using the same techniques to demonstrate the stratigraphy and structures of the Northwest Highlands. His 1880 original map showed details of the ravine which we examined.

As in the classic Dob's Linn site, here all the graptolite zones from the Middle Ordovician to Lower Silurian were identified by Lapworth, whose original graptolite zone names became adopted 'locally' (southern Scotland) although some have since been modified by a recent global standard for the Silurian. On the east side of the ravine, beds of unaltered black Moffat Shales have been steeply tilted and inverted in places to bring Upper Ordovician rocks to the surface, although only the *anceps* zone is convincingly exposed. The Black Shales found at both sites were laid down when there was plentiful food for graptolites over a period of millions of years, but here this must have been suddenly reduced, as the Purple Shales of the Upper Llandovery on the west side of the ravine contain few graptolites. (This suggests that although the two sites are less than 3 km apart today, during deposition they were probably distant from each other and have been brought to their present positions by major strike-slip movements.) The evidence of any productivity in the Purple Shales is restricted to immediately above the whitish/yellowish bentonite bands of volcanic debris which brought elements down to the ocean floor and improved the plankton bloom. When this temporary increase in nutrients subsided, the normal unproductive environment returned, as recorded in the Purple Shales higher up. The thickest (highest) bentonite band is thought to be an extension of the broad band stretching through southern Norway and Sweden and into Estonia, associated with acidic volcanicity as island arcs were created and consumed during the Caledonian Orogeny.

The Moffat Shale Group is famous for its rich, diverse graptolite fauna but contains little else, although trilobites have been discovered at Dob's Linn and in

County Cavan in Ireland near the Ordovician/Silurian boundary. One of our leaders, Alan Owen passed around a fossil pygidium (tail shield) of a trilobite he found on the east side of this ravine, during a pre-excursion visit. From a fragment of a head, also found on this site, it was probably an unusual atheloptic (shrunken eyed) member of the *Dalmanites* Group, their small, or non-existent, eyes suggesting a deep ocean dweller – just like the Dob's Linn and County Cavan animals. Thirlestane Score is also the type locality for the deep ocean graptolite *Rastrites maximus*, which may be a reason why they survived the mass extinction induced by the ice age between the Ordovician Upper Ashgill *anceps* and *extraordinarius* zones. This almost wiped out all life.

Tail shield of trilobite. ***Charles Leslie***

Spurred on by this find, the party set about the flakes of fissile shales in the scree slopes and outcrops of the ravine, and although there were several graptolite fossils found, sadly, no trilobites this time!

Although it was sunny, a cold wind swept down the ravine and our reluctance to leave this fascinating site was tempered by the thought of the high tea promised in Moffat. This provided an opportunity for members of both Societies to exchange tales of expeditions past and to express our many thanks to our leaders and to our organisers.

EAST OF SICCAR POINT: Sun 11 May 2008
Leader : Mike Browne, British Geological Survey
Report by : David Mollison Participants : 13

As forecast, we ran into sea mist or haar as we neared the east coast, much to our disappointment. At Redheugh Farm, NT 822700, we met our leader, Mike Browne, and Dr Con Gillen who had joined us to observe and assist. We passed cottages of the old coastguard station and descended a steep track, hearing waves breaking but not seeing them until almost at sea level. The tidal shore was revealed as a wave cut platform of the Upper Old Red Sandstone with the strata gently curving round the bay. The group walked east to examine the Meikle Poo Craig structures of the Redheugh Mudstone Formation. This was an easily eroded formation as shown by the many slabs, lying at all angles, which the group had to cross. The beds are of red mudstone and various coloured sandstones, the latter being generally thinner than the mudstones. Bands of green sandstone showed reduction by ground water leaching down. The proportion of mudstone to sandstone is 3:1 with a dip of 28^0 northward. The grain size of the sandstones showed some aeolian deposition. As uplift occurred due to erosion the relief of stress caused shattering in the mudstones. Fossil fish remains of *Bothriolepis hicklingi* have been found in loose blocks on Redheugh Shore, and at Siccar and Greenheugh Points.

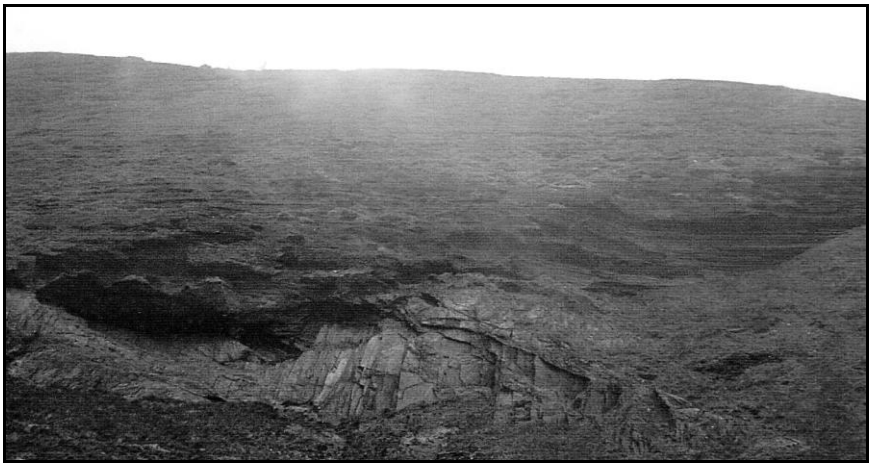
Walking further east to near Hirst Rocks, NT 830705, the group saw evidence of the unconformity between an exposure of the Siccar Point Conglomerate and breccia of Silurian greywacke. The conglomerate is poorly sorted in medium to coarse grained sandstones. Palaeocurrent flow in a south to southeast direction has been deduced from pebble deposits and strata. An example seen showed scree type material which had travelled a short distance. Mike suggested that this might be the edge of a wadi. The intrusion of sandstone dykes into the greywacke breccia was caused by movement of post Devonian tectonic activity.

After lunch, the visit along the shore to Lansey Bank was abandoned due to lack of time and the very poor visibility, but happily we had been given a large print of the site demonstrating clearly the unconformity between the vertical greywacke and the horizontal sandstone on top. The group then set off for the east side of Siccar Point. The passage of the rocky Redheugh Shore was avoided by retracing our descent route. Part way up some stopped for breath and to inspect a developing grassy landslip. The route lay across fields, and very steeply down a track to the shore at Marly Brae, NT 813708. Unfortunately, not all members made this descent. On the shore a possible channel was seen in a block of sandstone but this was explained as collapsed strata. Approaching Siccar Point to see the famous unconformity we scrambled over layers of conglomerate and pebbly sandstone. In the corner of the bay near high-water mark, the vertical Silurian greywacke overlain by 5 m of conglomerate could clearly be seen, where the unconformity has been has downthrown by faulting to near sea level. A very impressive exposure, our party concluded that it was even better than the 'official' Hutton's Unconformity on the west side of the cliff!!

As we returned along the shore we looked back at the Point through the mist which very briefly lifted, allowing those fast with a camera to secure their own

personal trophy photograph of the unconformity high in the cliff. These would supplement the excellent sunny print we had been given of the bay and Siccar Point. Consideration was given to driving east to view the unconformity along the shore at Lansey Bank but this was ruled out due to lack of time. Back at Redheugh Farm, Alison Drummond thanked our leaders for a most interesting and enjoyable day.

The 'alternative Hutton's Unconformity', up close. ***Margaret Donnelly***



The 'alternative Hutton's Unconformity', from afar. ***Margaret Donnelly***

NORTH BERWICK, YELLOW CRAIG TO CHEESE BAY: 7 June 2008
Leader : Dr Colin MacFadyen, Scottish Natural Heritage
Report by : *Bob Diamond* Participants : 16

Although few in numbers, we had an excellent day out with Colin exploring the Permo-Carboniferous volcanics of East Lothian. Although erupted at about the same time as the Campsies and Renfrewshire Hills in the west, these sequences are quite a bit different. More detail of this excursion can be found in *Lothian Geology: an excursion guide,* (pp 103 – 108).

Our first location was at Yellow Craig itself, NT 520860. This roche moutonnee is a volcanic plug which lies within the Yellow Craig Vent; with a diameter of about 500 m, it dates from the Tournaisian (*ca*. 342 Ma). The plug consists of an olivine rich basalt, whilst the vent seems to be filled with a brownish grey tuff agglomerate, full of angular blocks deriving from the sedimentary and volcanic layers through which the volcano has punched its way. The tuff is unusual in that it forms a ring around the vent (a so called tuff-ring, see *Geology of Scotland 4th Edition*, Nigel Trewin [ed], p. 291 for details). It is also indicative of the lava being extruded into a swampy/shallow water environment, a so called phreatic explosion.

Columnar basalt at Longskelly Point. ***Charles Leslie***

We then made our way across an extensive raised beach, evidence that sea levels relative to the land, had changed during recent times – further confirmed by the sea arch above water on the island of Fidra. At our next location of Longskelly Point, NT 522862, we found columnar jointed basalt which was poorly formed and sub-horizontal. It is part of the Garleton Hill lava flow and consists of markle basalt

which has many large feldspar crystals within it, and forms the lowest of the Carboniferous volcanic sequence of this section. Punched through this lava flow was a very small *ca*. 50 m basalt plug dating from later Permian (*ca*. 264 Ma) times.

As we progressed along the shore we came to Marine Villa where we met the next in the lava sequence – mugearite. This lava contained concentric iron-banding, giving a purplish streak to much of the rock. Above this flow was a reddish ash layer, the trachytic tuffs. The absence of any indication of a palaeosol seems to indicate that the tuffs were deposited soon after the lavas had cooled. The tuffs are quite strongly flow banded in places, showing alternating fine and coarse banding. Could this indicate airborne vs. waterborne deposition, or a change in the explosive force of the source volcano? Who knows, but as usual it was fun to speculate.

Our next location was Weaklaw Vent, NT 501861, which had a well exposed tuff-ring of dolomitic tuffs containing trachyte clasts. This gave the rock a mottled 'wallpaper' effect which was very attractive and distinctive. There is a possibility that this site represents the remains of a collapsed caldera. Interestingly there were fragments of fossilised carbonised wood within these deposits, a good indication that the ash fell upon vegetation – as you would expect in Carboniferous times. We continued to Hanging Rocks where a NE – SW fault brings down the top of the Garleton Hill sedimentary sequence to sea level. The fault is filled with a dolomitic breccia which also has shaley clasts within it. Because of the fault, the next sequences we met were cementstone facies sediments consisting of reddish-grey cementstones within which were some silty grey nodules. Nearby was a collapsed asymmetric synclinal structure, picked out by harder dolomitic bands.

Between here and our last locality at Cheese Bay was an intrusive Permian basaltic sill. At Cheese Bay we came to oil bearing shale beds, within which were the famous 'shrimp beds'. We did manage to find a few specimens of *Tealliocaris woodwardii* which had kindly been left for us by the JCB driver who has decimated the site. All in all a very rewarding day, finally ended by a much appreciated ice cream at Gullane. Our leader was sincerely thanked by Barbara Balfour for a truly interesting and enjoyable expedition.

▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪▪

SOUTHERN KINTYRE: 20 – 23 June 2008
Leader : Dr Chris Burton, University of Glasgow
Report by : *Eve Gilmore, Gillian Hornibrook, Margaret Donnelly.* Participants : 21

Friday 20 June

We left the Gregory Building by bus, collected some members on Loch Lomondside and continued to Kintyre, stopping for a coffee break at Invereray. Southern Kintyre lies to the north of the Highland Boundary Fault Zone and is of special interest in part because of the large outcrops of Palaeozoic rocks preserved over the Dalradian. We were based in the Hunting Lodge Hotel, Ballochantuy on the west side of Kintyre, and were treated from the hotel to wonderful views of Jura, Islay and Northern Ireland. Locally we admired raised shoreline features of the late

Devensian Glaciation. Indeed one room of the hotel featured a wall of a sea stack formed about 20,000 years ago.

After arriving in the early afternoon, we had lunch and then began the geology on the hill and shore at sites local to Bellochantuy. We were north of the Kilchenzie Fault, in the Dalradian, and so made a first aquaintance on the shore at Port nan Clachan (NR 658319) with the Stonefield Schists of the Dalradian Argyll Group, their impressive complex folding and the red potassium feldspar within quartz veins. We then moved only a very short distance (NR 661324) to see much younger Permo – Triassic breccia. The rounded and angular clasts of vein quartz, schist, quartzite and epidiorite were local, and of all sizes up to about 25 cm. We could visualise the debris from an alluvial fan laid down over part of the very irregular underlying topography. The junction between the Dalradian pelitic schists and the breccias, a palaeovalley, was clearly seen to be a sedimentary unconformity and the term 'Buried Landscape' became more real for us!

In the evening our leader delivered a talk – a clear and thorough general description of the geological history of Southern Kintyre, and supplied us with a detailed printed excursion guide to the area. He and his students have done much research on the location of faults, the ages of dykes and the sources of clasts in the breccias.

Saturday 21 June

We started on the eastern side of Kintyre, just north of Campbeltown where we looked at rocks of the Dalradian Southern Highland Group, from Kildonald Bay to Black Bay, NR 780278 – 775268. After examining the local blocks of pelitic schists, schistose grits, epidote-chlorite schists, marble and epidiorite used to construct Kildonan Dun, we descended to the shore and the turbiditic Beinn Bheula Schists with way-up evidence. To the south we crossed the hard, grey epidiorite sheets which extend to form the headland. A highlight was being shown the finely crystalline black marble of the Loch Tay Limestone. We drove south to Penniver, NR 759248, where, on the beach, we were again able to examine a junction of breccias lying over (reddened) Stonefield Schists. These are the basal breccias of the Glenramskill Formation, with abundant angular clasts of quartz, a few of finely crystalline black marble and of quartzite, and many imbricated schist and schistose grit fragments indicating the direction of current, all enclosed in a red sandstone matrix. The breccias are infilling a palaeovalley and reminded us not to linger in the dry wadis of the Lower Devonian! After lunch we went to Machrihanish, NR 640208, moving on in time to the Carboniferous – the Clyde Plateau Volcanic Formation, the Kirkwood Formation and the Lower Limestone Formation exposed on the beach. Apparently there are 27 different lava flows along the coastline. Our bus driver was 'taken' with part of the mugearite flow, which showed a crude polygonal jointing, a part of which to him resembled Queen Victoria! The agglomerate with pink barite in some of the interstices between the agglomerate clasts was particularly interesting and attractive. Just at the water's edge our leader showed us dark shales which shattered easily to let us get excited about the abundant fossil plant remains. It was comforting in the cold winds to imagine the tropical forests of the Carboniferous.

Further south on the shore at Uisead, NR 625210, we crossed a large headland composed of an ankaramite flow, a late Carboniferous monchiquite dyke and a number of basaltic lavas, before coming to the most spectacular cliffs of the day here in the bay at Galdrings, NR 625200. Carboniferous lavas overlie part of the pale cliffs of sandstones and thick cornstone horizons of the Kinnesswood Formation. Two obvious dykes cut through the layers. The larger, a 15 m thick verical dyke of Carboniferous olivine dolerite forms a prominent buttress in the cliff but is only about 2 m wide at the shoreline. Just south of this dyke is a large normal fault, downthrowing to the north and bringing up to the south the pelitic rocks of the Stonefield Schists. At the end of the second day these rocks brought us back again into the Argyll Group, back to the older landscapes of the Dalradian.

Carboniferous dyke through Kinnesswood Formation at Galdrings.
Charles Leslie

Sunday, 22 June

The weather forecast was grim and our first stop near Killellan, NR 680166, in the hilly trap topography to view a complex of Carboniferous vents and lavas was marred by mist. The Killellan intrusions (Upper Carboniferous – Lower Permian) to the east cut the Upper Old Red Sandstone (UORS) and Lower Carboniferous sediments and lavas. To the northwest, we were told, were more Carboniferous lavas, UORS sediments and the alkaline dolerite sill of Tirfergus Hill. A fault to the east brought up the Dalradian schists, cut by an alkaline olivine dolerite intrusion, Croc nan Gabhar. It was emphasised that, uniquely, the lava series is complete in Kintyre and that the lavas differ isotopically from those in the Midland Valley.

Then towards and beyond Southend by the bus, we noted the vent on the right and the abandoned Art Deco hotel at Kiel. First studied on the beach beside Kiel Point, NR 670077, was a hard black unweathered dyke 2 – 3 m wide which, on a previous visit by a study group from the Geological Society of Glasgow fourteen years ago, was determined by magnetometry to be Carboniferous, not Tertiary. This crinanite dyke cut across the Upper Glenramskill Formation of the Lower Old Red

Sandstone (LORS) in a NW – SE direction. The Upper Glenramskill Formation had pale, gritty, cross-bedded sandstone with thin inter-bedded marls and large rip-up clasts of marl in the sandstone. Rip-up clasts are composed of sediment laid down in the previous flow but ripped up as clasts by, and incorporated into, the next flow. From Kiel Point, we saw Sanda and Sheep Islands. The Highland Boundary Fault is said to pass between where we stood and Sanda. The "mess" of igneous rocks on the foreshore and the cliff behind us was formed by the Kiel Point LORS vent. It then began to rain heavily, but fortunately we were due to visit the Kiel Point caves in the vent. The caves stand on the same shore platform (Eastern Irish Platform) as our hotel, which has a sea stack built into one of its walls. At the cave entrance was a marine erosion notch. The vent penetrated along the bedding of the sandstone and was full of boulders of varying size (20 mm upwards) with quartzitic conglomerates and sandstone of the underlying Glenramskill Formation. This was an explosive vent, possibly choked with siltstone.

Rip-up clasts in the sandstone. ***Charles Leslie***

We then walked eastwards to St Columba's "footsteps", one a natural erosion feature and the other cut by a mason in the1860's, and saw the ivy-clad remains of St Columba's church and St Columba's well. The well had the St Columba's or Chapel vent agglomerate above it with the water dripping into the well via fractures in the agglomerate. The St Columba's vent (again LORS) was recognised by the disordered sedimentary rocks. Both vents had gathered evidence of rocks there previously. Miraculously, the weather had improved and we returned to the beach to study the chaotic conglomerate of the Southend section of the New Orleans (named after a local house!) Conglomerate. Tuff was also seen on the beach. The New Orleans Conglomerate here had boulders of rounded quartzite, quartz and lava clasts. The

beds represented fining up sequences from alluvial fans to floodplains, the fan deposits having the coarse conglomerates. Using a small, braided stream on the beach, Dr Burton demonstrated how the formation may have occurred in the past.

A sunny stop for lunch was spent by some of us in a small bay, watching the incoming tide and hearing the waves breaking on the rocks.

We walked across Dunaverty Bay to the Point (NR 689076), up a grassy slope graced with a mass of pale purple orchids, to view, across Bull's Head chasm, an amazing 800 m thick exposure of the top of the LORS. Fine conglomerates of lava clasts, quartzitic grit and greywacke interbedded with red/white sandstone were seen. Nothing remained of Dunaverty Castle – site of a massacre in 1647 of Royalist supporters who had been besieged and had surrendered. A walk back to beach level brought us to the narrow Roaring Cove, not, thankfully, roaring, but displaying the top of the LORS, a coarse conglomerate of big quartzite clasts, a bit of veined quartz, schistose grit and a few lavas. The direction of bedding was from the north but the boulders probably originated in the south. A good discussion about this ensued.

Then back to the path and over the Conieglen Water to the golf course, guarded by a gate to prevent the brown and white cows jostling there from crossing. We had earlier watched, entranced, as there was a "stand-off" across the stream between the black and white cows of the golf course and the hopeful brown and white ones on the other side. We crossed the sward and went down to Brunerican Bay, NR 695076, and noting the rocks getting redder, we came to the outcrop Little Clet (a clet being a clint or upstanding rough rock). Here was the base of the UORS, with cross-bedded red sandstone and conglomerates with fairly large clasts (up to 100 mm), veined quartz, quartzite, red sandstone schist but no volcanic clasts, indicating a filled basin with a provenance from the north. Again, the incoming tide brought crashing wave sounds and along the beach, a series of noisy agitated oyster catchers haunted us, presumably suspecting us as nest robbers. On to Big Clet, showing classical fining upwards, with fewer and smaller (5 – 10 mm) clast types: mostly veined quartz and cross-bedded sandstone. These were better sorted, suggesting a flattened topography of the source, and rivers losing strength. The rest of Big Clet was formed of nearly vertical beds of red and green sandstone with reduction spots. On to the far point, below Dun Duirn, noting an increase in grain size again with cross-bedded red and green sandstone and veined quartz conglomerates, indicating an alluvial fan coming from the back beach area with minor uplift to give bigger clasts. Time ran out, so it was agreed to finish the section the next day and we returned across the grass and golf course to the bus and back to the hotel.

A farewell dinner was held that evening, when all were thanked: Dr Chris Burton, as an enthusiastic tour leader; David McCulloch as organiser, though unable to attend; Michael Pell as his competent substitute; our committed driver, Raymond and others.

Monday, 23 June

A glorious sunny day, chilly to start then warm. We returned to Brunerican Bay to below Dun Duirn. As we moved east, the sandstone and conglomerate size diminished, indicating that the Dalradian mountains to the north had eroded to a peneplain, with no further quartzite clast erosion. After the point, Rubha

MacShannaich, the Kinnesswood Formation reappeared, with red sandstone and caliche horizons. Then came an area of very red sandstones where the intrusions into the otherwise beige desert must have held iron containing minerals which were oxidised by the falling rain. These upthrown Upper Devonian beds contained many reduction spots. Given that reduction needs decomposing vegetation to provide the correct chemicals, we were told "think thorny desert". We continued along the beach, noting the rhythm of the parallel depositions of conglomerate, siltstone/mudstone, conglomerate, siltstone/mudstone etc. which indicated seasonal rains (conglomerate) and dry seasons (mudstone). Another headland (topography again) indicated uplift and harder rocks, but the succession was still younging up to the UORS. What, we were asked, would be round the next headland? Logically, it would be caliche and Carboniferous lava. And it was! Round into Innean Bay was the UORS and siltstone (soft!). Thick caliche was seen on the beach and down the cliff and then a wonderful flow of Carboniferous lava on top of the caliche – a lava flow with a bubbly base and a dramatic outline. Finally, we stood on the promontory of the Rat Stane, NR 704073, where the basalt lay unconformably on the Kinnesswood Formation.

Our group just east of Rubha MacShannaich. ***Margaret Donnelly***

So, in our four fascinating days, we studied rocks from the Dalradian to the Carboniferous. Dr Burton had provided us with excellent handouts and tuition and shown an impressive knowledge of the tides. We returned to the hotel via a minor road along the picturesque east coast, past Polliwilline Bay, the conical Bastard hill, Balnabraid Glen and Davaar Island, for a very late picnic lunch, and then back by bus to the Gregory Building.

THE HUTTON TRAIL, PART 2 : 30 August 2008
Leader : Dr Con Gillen, University of Edinburgh
Report by : *Margaret Donnelly* Participants : 22

We arrived by coach at the large car park beside Jedburgh Abbey (NT 648205) on a very cloudy but dry morning. Dr Gillen gave us an introduction to the geology of the day, in which we hoped to finish off the Hutton Trail begun last year.

We set off over the bridge on the Jed Water and followed a path back along the river bank to Hutton's 'Other Unconformity'. Mr Mike Browne of Lothian RIGS explained that this site has lost its SSSI status because it had become very overgrown and was too expensive to keep clear. It became a RIGS site, and this group arranged for the local Council to remove the vegetation, but now, unfortunately, it is back to its former state. Additionally, the dangerous possibility of landslides required that the bank under the road be strengthened with concrete etc. The result is that viewers can see very much less than Hutton, who probably viewed the unconformity from across the river at Allar's Mill (Inchbonny), NT 650199, and from where his friend John Clerk made the beautiful and famous drawing which appears in so many textbooks. Approaching the site in single file and in small groups, we could see the Mill with difficulty through the trees on the far side. The lower section is Silurian greywacke (from the German meaning 'grey rock'), with vertical beds of sandstone metamorphosed almost to schist, and more massive than the intervening beds of shale.

Hutton's 'Other Unconformity'. ***Margaret Donnelly***

They form tight isoclinal folds, and sitting on top are the sub-horizontal basal UORS beds, 365 Ma. It is an angular unconformity and represents a long time gap

(recognised by Hutton) of 55 Ma. The UORS has pebbles, up to 3 cm in diameter and coated with haematite. This is possibly diagenetic, although the process can be seen happening nowadays in South Africa. The beds fine up to medium-grained sandstone and bedding structures can be clearly seen. The Silurian rock formed the valley floor, while rivers brought material down, possibly in flash floods, in a desert environment lacking land vegetation.

We returned to the car park. RIGS had arranged to obtain £40,000 from the European Union to build a viewing platform; however, the local Council took charge and could not get a tender for less than £10,000 – £15,000 more than this, so they decided to commission an 'unconformity wall' sculpture, by Max Nowell, instead. Initially they proposed to construct it of basalt and cream sandstone (!!) but were eventually persuaded to change the basalt to greywacke. However……..even the artist wanted red sandstone but the cream sandstone was cheap and available locally and so was used. Two placards have been erected explaining the geology.

'Unconformity Wall' sculpture. ***Margaret Donnelly***

We drove south and up a steep road to Dunion Hill, NT 626191. Leaving the bus we started up the slope, pausing halfway to survey the landscape of rolling countryside with intermittent hills sticking up. Most of these are volcanic – plugs, necks and intrusions. They are very early Carboniferous, and earlier than Arthur's Seat. A Monument to Waterloo, a castle, and the coast on a clear day can be seen in the distance, as well as the three Eildon Hills. We continued up to a disused quarry (for road aggregate) of blue black dolerite intruding through UORS. The presence of iron, even in small amounts, gives the typical brown weathering surface colour. The dolerite was fine-grained with feldspar phenocrysts and had extremely good columnar

jointing, seen almost end on. Hexagonal columns form as the rock cools because these require least energy, and are the most efficient shape with the lowest surface/volume ratio. The process may be aided by rain or water penetration: the water follows an original crack/joint and then increases it as the intrusion cools. It also helps the cooling process. On one side of the quarry the contact with UORS was obvious – some of it very messed up with the bedding lost. Gases, fluids and possibly water had penetrated the sedimentary rocks, disturbing the bedding and creating a sandy volcanic 'gouge'. The dolerite is fine-grained near the contact but coarser further over, indicating a chilled margin. We then settled down here for lunch.

We drove back to Jedburgh and to the rear of the old railway station – when Jedburgh still had a railway, NT 655225. We walked along the old track to the bank of the Jed Water where, across the river, was a massive cliff face of fairly uniform red sandstone bedding, with a rather small, gentle anticline and fault. This is the Redheugh Formation also found at Siccar Point. Fossil freshwater fish scales have been found in these beds, deposited in a desert landscape of rivers and lakes.

Driving north towards St Boswells, and east along the B6404, we stopped at Mertoun Bridge, NT 610320, over the River Tweed, which was teeming with anglers! We walked down the track to the river, past glacial till and sandstone, and in one place a large anticline, and made our way precariously along the edge of a cliff beside the river. The Redheugh Formation comprises the lower part of the cliff, with abundant ripple marks and rip-up clasts, showing that the area had dried out repeatedly in ancient times. Higher up was an erosional base with glacial till on top – a dramatic formation of boulders/cobbles/clasts of mainly greywacke up to 30 cm in diameter. This boulder clay was matrix supported – a large amount of matrix – and the clasts were somewhat rounded suggesting that they may have been reworked.

Leaving the Tweed, we drove up to Scott's View (NT 594343), passing a red sandstone quarry which had been used for some of the abbeys. Dryburgh and Melrose Abbeys were built with red sandstone from Dumfriesshire while Jedburgh was built using local cream sandstone, and with volcanic agglomerate filling. Because of the low cloud our view at the top was limited, but the Eildon Hills laccolith and agglomerate plug dominated the landscape. A laccolith is a domelike concordant body of intrusive rock, which arches overlying rocks and sediment like a mushroom, and has an almost flat floor. This one is rather felsic, composed of trachytes and riebeckite rhyolites. Riebeckite is a purplish/dark blue amphibole, also found in Ailsa Craig granite, and gives curling stones their characteristic bluish/purple tint. The top of the laccolith and overlying volcano has now been completely removed by erosion. Lack of time prevented us from visiting any of its quarries, but our leader produced a specimen from near Melrose – a silica-rich agglomerate.

We thanked Dr Con Gillen and Mike Browne enthusiastically for a truly fascinating and enjoyable day in which we had walked in the footsteps of Hutton, and set off for home.

.....

ISLAY : Thursday 18 Sept – Monday 22 Sept 2008
Leader : Dr Roger Anderton
Report by : *Margaret Donnelly, Seonaid Leishman, David McCulloch.*
Participants : 22

Thursday 18 Sept

Our party met up in Kennacraig, caught the ferry to Port Askaig and then drove to the Machrie Hotel, south of Bowmore. In the evening our leader gave us an introductiion to the geology of Islay – a unique place with four main 'chunks' of geology :–

1. The Appin and Argyll Groups, 750 – 600 Ma, of the late Precambrian Dalradian Supergroup, occur on the east of the island as far south as the Mull of Oa, and include the highly significant Port Askaig Tillite. Dr Anderton used dates from dykes in Canada to date the Tayviallich Lavas at ~ 600 Ma (now the accepted date is 601 Ma!!) and from this he surmised that the Tillite was Varangian and 650 Ma. However, recent research suggests an age of 720 Ma.
2. The Bowmore Sandstone, a thick pile of lightly metamorphosed arkosic sandstone, is found on the isthmus of the island. Its age is uncertain and it may be Torridonian, Moine, or even perhaps Grampian!!
3. A major fault runs through Loch Gruinart and separates the west of the island with the Rinns Complex (all signposts have now reverted to this original spelling). Recently dated at 1.8 Ga, this is new, juvenile crust from the mantle and is part of the Ketilidian Orogenic Belt found in Greenland. It contains pinkish syenite and metagabbro intrusions.
4. The Colonsay Group, a metasedimentary assemblage, lies on top and to the north of the Rinns. The contact is sheared, but probably an unconformity. It is Precambrian, but younger than 1.8 Ma, and does not correlate with other rocks. It is similar to Torridonian and to Dalradian but may even be Moine – it therefore has a wide possible age range!!

Finally there are extensive Quaternary deposits – eskers, erratics, shore platforms, raised beaches, moraines etc

Friday 19 Sept

We set off from the Machrie Hotel in five cars on a rather overcast morning under threatening clouds, and drove across the isthmus to the west.

Having parked in Bruidladdich near the old pier, NR 265608, we followed a grassy path down onto the beach to a large outcrop of greenish, low to medium grade metamorphic basic rock with patches of 'pistacchio green' epidote, chlorite and a substantial quantity of hornblende (the most common type of amphibole). Some specimens contain crystalline green feldspar (with inclusions) indicating that it has been 'cooked up a bit'. Originally a gabbro, it has a marked schistosity. A little further on there was a large, blocky mass – a coarse-grained gabbro intrusion, now metamorphosed into hornblende. This is a metagabbro or 'amphibolite', previously called 'epidiorite', a traditional name originating in Scotland. It is one of a number of extensive basic igneous intrusions, usually hundreds of metres wide and up to several kms long, probably emplaced as dykes. Walking on, we found a very pink/red

granitic intrusion with feldspars – a syenite, with little or no quartz, and the dominant igneous rock in the Rinns Complex, which is made up of 60% syenite, 35% gabbro and 5% minor intrusions.

Previously, the Rinns Complex was considered to be Lewisian, but in the 1990's the age of emplacement of the syenite was dated at ca. 1.79 Ga, using U/Pb on zircons, and the amphibolite facies metamorphism dated at ca. 1.71 Ga. Its geochemistry revealed that it formed from mantle melting and so was new crust, unlike the Lewisian. The whole Rinns Complex is classic calc alkaline – an island arc, and now recognised as the root of an igneous complex which has been deformed, metamorphosed and retrogressed. It is therefore significantly different from the Lewisian, having similar ages to the Ketilidian Belt of Greenland and the Svecofennian Belt of the Baltic, and thought to be part of a whole orogenic 'belt' accreted onto the 'northern' continent, in a major crust-forming episode at the edge of the Laurentian-Baltic plate at 1.9 – 1.7 Ga, contemporaneous with the Laxfordian reworking of older crust in northwest Scotland.

The accretion process was repeated ca. 1.2 Ga, during the Grenvillian Orogeny (the Rockall Bank is 1.2 Ma), and again in the Caledonian Orogeny, ca. 400 Ma, so that over time a series of 'orogenic belts' of new and reworked crust have been added on to existing crust – plate tectonics have been constantly creating a 'scum' of crust, and the continents have been getting gradually bigger. This area in Islay is extemely significant because it is the only place in Scotland where evidence for juvenile crust of the Ketilidian – Svecofennian Orogeny is found. The Rinns of Islay, part of the Colonsay – West Islay block, are caught in a splay of the Great Glen Fault, between the latter and the Loch Gruinart Fault. They are thought to form part of a large platform of basement rocks, originally juvenile Palaeoproterozoic crust, which extends northwest to the Great Glen Fault, and southwest to Inishtrahull in Northern Ireland. Intriguingly, isotopic signatures from xenoliths in Caledonian granites, and inclusions in Tertiary dykes suggest that this platform may also lie under the Dalradian, and may be quite extensive – approximately 100 km wide and 600 km long, on the southeast side of the Great Glen Fault. Sinistral movement occurred later on this fault bringing the platform to its present position, and it was still active into the Permian and Tertiary. At this point our leader entertained us with the *aide memoir* – the two main types of rock in this vicinity, the syenite and the amphibolite, are just like red and green apples!

We drove south to Port Charlotte, NR 255586, and walked onto the beach, to find a greenschist mudstone, with bedding. To the northeast was a large outcrop of this metasedimentary pile – the Colonsay Group, which occupies the whole area north of the Rinns, extending onto Colonsay. It is typically of low grade greenschist facies, with thinly bedded coarse and fine layers, and here dips steeply to the sea and the east-south-east. It occurs in slivers within the Rinns all the way down this coast, extending out under the sea; the contact runs southwest, and the soft sedimentary rocks have been eroded out to produce the bay.

We came to a Tertiary dolerite dyke, with erosional features of deeply cut sinuous channels and potholes which are all at just one level (above present SL), and at right angles to the sea, demonstrating that they have not been created by marine erosion. Glacial striations are seen on the surface and along the inside walls of the

channels. These are known as 'P forms' and are found on hard rock. They may have been created by water flowing under high pressure under a kilometre of ice – a combination of ice and glaciofluvial action ~18 ka. The height of the ice can be traced on the Paps of Jura, which were nunataks standing above ~ 600 m of ice. The whole area is a raised beach, of complex origin, possibly prior to the last glaciation.

We continued round the lighthouse, struggled over a wall, and scrambled along the beach to the northwest, to where we found the contact (not an easy task!) between the Rinns Complex and the Colonsay Group. The latter sit on top of the Rinns – the contact is sheared but may be unconformable, and extends across Islay from Port Charlotte to Kilchiaran. The age of deposition is uncertain and it has been correlated with both the Torridonian and the Dalradian. Although researchers have disagreed on the detailed stratigraphy and mapping, the consensus is that the base was laid down in shallow water which deepened upwards, before shallowing again towards top as the basin filled. The source for the lower part was the Rinns Complex; for the upper, high grade gneiss with sedimentary cover, and the sediments have a general 'northern continent' provenance. There is an early, flat-lying cleavage (best developed on Colonsay) but not found in the Dalradian, and a later steep cleavage which is comparable to that axial-planar to the Islay Anticline. We returned to the cars for lunch, and some of the party 'indulged' themselves in the local cafe!

We drove south to the tip of the island at Port Portnahaven, NR 165522, and walked across a flat outcrop of strongly foliated rock – an acidic, syenitic gneiss, of pink feldspar, quartz and chlorite, typical of the Rinns Complex and superficially looking very 'Lewisian'. However, here we are dealing with an andesitic island arc (similar to the Aleutian Islands) made up of metasediments, basic pods and syenite. The deformation pressure had been directed from the northeast and southwest to produce the foliation, and there were glacial striations and P forms. There is evidence that ~ 500 m of ice flowed to the northwest, as the glacier, wet based, moved down from its origin in a concentric pattern. The sea channel between here and the nearby islands of Eilean Mhic Coinnich and Orsay is gouged out by ice. We set off along the shore towards Port Wemyss and the Rinns of Islay lighthouse, to a large outcrop of low grade metasediments of calcareous mudstones with quartz veins. The carbonate was produced by single celled pelagic algae which, seemingly, get everywhere! This is part of the Rinns but is not metamorphosed as much as the gneiss – rocks need the correct minerals for metamorphism – and raises questions about all of the Colonsay Group. However, these sediments could have been deposited on top of the Rinns gneiss and then the whole lot remetamorphosed. Further along, we came upon cleaved metagabbro, and a contact between syenite and amphibolite.

Our leader reviewed the order of formation of the Complex: first, intrusion of the syenite which was converted to gneiss. This was then cut by the gabbro and minor basic intrusions, volcanic and other sediments were deposited, and finally the whole package was metamorphosed to amphibolite facies between 1.8 and 1.7 Ga. Basic intrusions and dykes would have been emplaced throughout the process, in the expected and typical history of an island arc with back arc basins. We returned to the cars and followed a minor road north to Kilchiaran.

After parking, NR 202599, we climbed the grassy slope of a raised beach, an erosional platform and prior to the last glaciation. Most of the ground was covered by

boulder clay but we found an exposure of feldspar-rich, foliated syenite. We were above Kilchiaran Bay, with its slate of the Colonsay Group on the beach. As we crossed the slope we saw intercalation with sedimentary rock which, before erosion, went up and over us towards the east, and came to a greenish outcrop of amphibolite and a conglomerate with small pebbles of amphibolite sand. Finally, we found a quartzite, the first real sedimentary rock here, and pure with little feldspar, indicating shallow marine. This is a typical unconformity – we were once again at the contact between the Rinns Complex and the Colonsay Group – and its line could be seen running along the hillside. It is slightly sheared, as elsewhere on the island, and the original sediments immediately on top had been washed away.

We returned to the road where there was a large quartzite which had been cracked throughout. It looked like breccia, but, like a jigsaw, could all be fitted back together. Compression had been from above and below, so that the rock was forced to move outwards – the competent quartzite would not be deformed. We continued down towards the beach passing a large black striated face of Colonsay phyllite and a slate quarry. Boulder clay was all around. We made our way along the beach, crossing a wide and rather deep stream twice (!), and examining cleavage and bedding in various outcrops. At the far end was a particularly fascinating exposure of sandstone/mudstone with small mullion structures, rods and lineations, and our leader explained in detail how these were formed. Small sand dykes crosscut the rock – produced after the sediments had been buried under pressure, but still had water present and had not lithified. When the water was removed, possibly by a seismic event, jets of the sand moved rapidly through newly created spaces in the surrounding material. Apparently, this is commonly seen in cores from the North Sea, and can occur in fairly deep rocks. The dykes are now parallel to cleavage and have rotated from their original position.

By now it was late afternoon, and so we returned, exhausted, to the cars, and then to the Machrie Hotel for a well earned rest and meal.

Saturday 20 Sept

Having had a fascinating day on Friday we set off to discover more about the complex geology of Islay. We were not to be disappointed. We were to discover plenty more rocks with an uncertain past.

Our first stop was near Blackrock on the isthmus at the head of Loch Indaal, NR 300628, where the Bowmore Sandstone dips south under the bay. It consists of 1.5 km thickness of arkosic-feldspathic sandstone interspersed with a few phyllites/slates, indicating that the depositional environment was shallow marine. The puzzle is – how did this depth accumulate? The average depositional rate in actively subsiding basins today is 200 m per million years – a rate of 1 km is rapid while 10 m per million years is slow, and the Bowmore Sandstone must have taken at least 1.5 million years to accumulate, while keeping the sedimentary surface at roughly the same level for this length of time. However, in the Precambrian there was nothing to bind the soil as there were no plants, and such massive sandstone deposits are a WORLD-WIDE phenomenon, of which the Assynt Cambrian 'Quartzite' was the last in these huge events. There is little evidence with which to date the Bowmore Sandstone, and its source is not known. However, it does contain some pebbles

which are similar to those in the Jura Quartzite (Dalradian) and in the Torridon Group. These contain oolitic ironstones aged at 2.5 Ga, confirmed by U/Pb dates, and originating from Northern Canada and Greenland, and so the Bowmore Sandstone could have had the same source. It might be of Grampian age (i.e. Moine-like) as it has a faulted contact with the Dalradian Supergroup. Of which more later…..

In the Archaean the oxygen concentration was low enough to allow the transport of iron, resulting in purple sandstones such as the Torridon Group. The Lower ORS is a darker red than the Upper, and the Permian sandstones are almost orange, reflecting the effect of the changing concentration of atmospheric oxygen on iron ions.

We could see almost vertical graded bedding which gave the younging direction (to the east), but there was no cleavage because no mica is present, and so the rock fractures instead of folding and is a relatively competent rock. At this point we had a detailed discussion on the 'competency of rocks'!!

To the west of Blackrock, NR 290637, we admired an impressive Quaternary esker which runs alongside the road for some distance.

We drove west to Machir Bay, NR 200637, where, on the shore, we again found the Colonsay Group of low grade metasediments sitting on the Rinns Complex. The latter could be the source of the lower Colonsay sediments as the palaeocurrent is from the south. Walking northwest along the sand, we came to the Kilchoman Phyllite and Coull Grit – a muddy and sandy deposition. Both have gone through the same deformation event/s (same stress, pressure and temperatures) BUT here the phyllites are less competent than the grits and the result is disharmonic folding i.e. a MESS. The mud collapses, the sand buckles and the mud flows around, while quartz migrates to the nose of the fold. As the clay minerals heat up, water and silica are released. If there was sandstone above, the water would rise and cement it, but if there is clay above, the minerals grow. If the silica cannot escape, it moves into the nose of the fold or into the cleavage plane. Further on were excellent examples of ice-cut platforms – plus three of the four choughs that are known to frequent this beach.

We were now deep within the rocks when, rounding a bend, we came upon an amazing boulder bed in the rock face, a new find by our leader. It appears to be about 4 – 5 m thick and probably 40 – 400 m across, and this is the only location where it is found. It is clast-supported with sizes ranging from 15 x 5 cm to 30 x 15 cm; the clast shape is angular and blocky as if fractured and not far travelled. The composition range of the clasts is narrow – mainly metapsammite, and the laminations (cleavage) indicate an earlier deformation, but the whole bed has been further deformed in the Caledonian Orogeny. The matrix (~ 10%) is sandy-muddy, while one bed is matrix-rich and does not show metamorphism or deformation. What were the process(es) that gave rise to this outcrop? Imbrication gives the direction of a flow of water pressing down into the beds (to the southwest), and so it is not a surface debris flow (apart from the matrix-rich bed) but occurred in a deep water environment with fast flow. It could be a channel-fill – the exposure is not extensive and so it cannot be a sheet. Perhaps it was a fluvial fan in a fast flowing braided-stream giving a migrating sequence, or even a sub-marine canyon. The angular clasts may have already been broken into a scree and then moved in a seismic event or

during a very high rainfall. Or, as at Portgower near Helmsdale, it might be the result of an avalanche from a fault scarp. One final question: was the original psammite laid down on top of the Rinns complex? As we puzzled over all this, our leader 'helped' with his three rules of geology:

1. There *are* no rules.
2. If it *has* happened it *can* happen.
3. Everything has got to be *some* place – but only has to be in *one* place.

The amazing debris flow. ***Charles Leslie***

A little further on we came to the Coull Grit – an arkosic quartzite which alternates with the Kilchoman phyllite. The beds dip 30^0 to the southeast, younging to Machir Bay. In the next bay to the west we could see the phyllite again and so we were in the core a fold. The grit however does not fold but has many joints. Cross-bedding was evident where a grit bed joined a mudstone, and where the grit bed was blanketed by mud the original large ripples giving the current direction could still be seen. At this point we settled down on the rocks for lunch.

After a visit to an RSPB Visitor's Centre and seeing some early arrivals of barnacle geese from Greenland we found ourselves in the Dalradian Supergroup at Carraigh Dubh, on east side of Loch Gruinart, NR 295693, and looking at the Jura Quartzite of the Argyll Group, a quartz-cemented feldspathic low grade metamorphosed sandstone (greenschist facies). It was laid down as a VERY thick shallow marine sediment (> 5 km) – we couldn't even see any bedding! There was no evidence of imbricate thrusts (i.e. repetition) so this was the real thickness, and was the start of a long period of syndepositional rifting and faulting. About 50 m to the south we found a quartz-mica schist with quartz bulbs/lenses and a strong tectonic

fabric indicating stretching. This was a phyllonite – formed by cataclasis during shearing and was in fact a tectonised outcrop of Bowmore Sandstone. The Bowmore had more mud than the quartzite, was therefore less competent and so took up the strain in the shear zone. A few metres further on there was another outcrop of the Jura Quartzite with tectonic lineation on the bedding plane. So this was a 'thrust package' or thrust zone – the Loch Skerrols Thrust of Caledonian age with a NW – SE direction. The Dalradian Argyll Group (Jura Quartzite) was thrust over the probable Grampian Group (Bowmore Sandstone) i.e. younger over older. But….does this not indicate a normal fault? The explanation is a two-stage process: originally this was a normal fault; later, Caledonian thrusting occurred in the reverse direction, but the rocks were not taken the whole way back to their initial position.

The Paps of Jura from Port Askaig. ***Margaret Donnelly***

We continued to Port Askaig on the Sound of Islay, NR 432694. Here is a huge exposure (thanks to ferry terminal new car park) of Precambrian glacial till (of Snowball Earth fame) underneath quartzite beds, and topped by more tillite. The marine tillite was deposited on an inter-tidal shelf – the previous sea bed during the interglacial periods, during which the ice melted and very shallow marine conditions returned, when the quartzite was again deposited. In one place the sandstone beds have been eroded and another bed laid down unconformably just before the next glaciation. The tillite has a matrix of sandy mud with a few clasts – a typical boulder clay. The clasts are unlikely to be drop stones on the sea bed because the matrix is not marine. The date is now thought to be 720 Ma (Sturtian) and is of great stratigraphic value in the Dalradian along with the Tayviallich volcanics (601 Ma – the start of Iapetus opening). The first tillite member has clasts of dolomite (Appin

Limestone), the second dolomite and granite (extra-basinal), and the third granite only, indicating the un-roofing order (i.e. inverted stratigraphy). The tillite is 750 m thick and consists of 20 – 30 individual glacial advance/retreats representing about 10 Ma. The area was on the equator at the time – there are limestone deposits above and below indicating a warm environment. However these glacial events were world-wide – certainly more wide-spread than the glacial periods of the Ordovician, Permian and Recent.

Driving north we arrived at Bunnahabhainn, NR 423733, where after walking through the distillery we noted that a fault dropped down Jura Quartzite to the north against the Bonahaven Dolomite (Islay Subgroup of Argyll Group) which consisted of beds of pale quartz-rich siltstone, rusty coloured dolomite and brown carbonated sandy mudstone. The dolomite is formed when Mg replaces Ca in calcite (if Ca is removed by precipitating gypsum the Mg/Ca ratio increases. The Fe can then be substituted by Mg because the Mg and Fe ions are the same size. Weathering then produces the rusty colour). We noted channel fills – shrinkage cracks in the dolomite filled in by sandy mud indicating serious global warming during the late Precambrian. We also saw very good examples of cushion-like stromatolites, formed in warm water by cyanobacteria secreting carbonate, another indication of warm conditions.

While returning to our hotel we stopped at Knocklearoch and Dun Nosebridge, on the road down the middle of Islay, NR 403627 and 390605. Here we had excellent views of the Islay Anticline looking along axis and up plunge with the older Appin Group limestones in the middle and the Jura Quartzite (Argyll Group) forming the higher hills to the west – a fitting end to a fascinating day.

Sunday 21 Sept

We drove south to the car park at the end of the long single track road on the Mull of Oa (pronounced 'Oh'), and then followed the path past the farm to reach the edge of the high ground overlooking the cliffs and the sea far below. Dr. Anderton explained that the highest ground on the Mull of Oa is formed from the Jura Quartzite; however it is much thinner here compared to the substantial thicknesses in other parts of Islay and Jura. Could this be due to extensional faults, or has it always been thinner here? It is probably the latter and represents beds laid down near the shallow periphery of the subsiding basin in which the sands accumulated. Conversely, the overlying Easdale slates are thin on Islay but thicker on Easdale. From the cliff top we looked down to a spectacular tall rock face on the east side of a promontory called Cleit a' Ghlaisrig, NR 276412, about half a kilometre to the west. Even from that distance we could clearly see many obvious boulders in the tillite, in fact much more visually impressive than the section at Port Askaig itself. Below the tillite was a sequence of thinly bedded sediments including limestone, slate and phyllite, which had been folded and thrust. This was interpreted as deformation caused by movement of the glacier over the soft sediment.

We scrambled down a very steep grassy slope to the foreshore, past an outcrop of the Ballygrant Limestone, and walked to the base of the rock face which we had first studied from a distance. There were many large boulders of tillite on the foreshore. Dr. Anderton demonstrated how the pattern of folding and thrusting in the rock face showed that the ice had flowed roughly towards the northwest. Some

researchers had interpreted it as of tectonic origin rather than soft sediment deformation because the thrusting was in the same direction as the tectonic thrusting on the Loch Skerrols Fault. However it is now accepted that the similar direction and appearance are just coincidental.

While explaining this, Dr. Anderton suddenly fell backwards from his precarious perch on top of a fallen boulder and was lucky not to injure himself as he finally came to rest at the top of a steep drop just above the boulder beach. One of our party, Ben Browne, gallantly dived to grab hold of Dr. Anderton's ankle to prevent him tumbling even further down the slope, and is hereby 'mentioned in dispatches'. Rapidly recovering his composure, Dr. Anderton explained that the igneous boulders within the tillite are the same age as the Rinns Complex but do not have the same geochemistry. This suggests that they are derived from another part of the same Ketilidian – Svecofennian Belt. The source in Sweden and Finland shows that the opening of the Iapetus Ocean must postdate the formation of the tillite. As the tide was high we tried to climb over an intervening promontory to reach Port nan Gallan, but the scouts sent out ahead of the main party reported a sheer drop on the far side so we headed back up to the cars instead.

Port Askaig Tillite at the Mull of Oa. ***Margaret Donnelly***

We drove to the old cemetery at Kilnaughton Bay, NR 343452, and walked southwards from there towards the lighthouse. On the way we found cross-bedding in the ubiquitous Jura Quartzite. In places, cross-bedding in opposite directions indicates bipolar currents. Further south we looked at the slates lying above the

quartzite. The grey colour indicates organic matter deposited in a deep anoxic environment. This shows that the basin has subsided quite quickly from the shallow tidal current environment of the quartzite (about 50 metres deep) to about 200 metres with no currents, and was probably due to regional tectonic extension which was a precursor to the eventual opening of the Iapetus.

At Carraig Fhada lighthouse, NR 349443, a pervasive cleavage had developed, in stark contrast to the regular quartzite with which we had become familiar, indicating a muddy content within the psammite, but not quite a slate. The cleavage was spaced forming layers about one centimetre thick showing that the mud content was not continuous. We also found turbidites with pebbles the size of pigeons' eggs. These turbidites, called the Scarba Conglomerate, flowed down the steep fans formed at the edge of the rapidly subsiding basin. We followed a small path over a low rise to reach a secluded beach known as Traigh Bhan (NR 345441). Although once a very common sight on the islands, we were surprised to find that we had to share the beach with a herd of sturdy cattle but, undaunted, we settled down for lunch, before resuming the serious business of rocks. Here, the cleavage and bedding were almost at right angles. A series of dykes cutting across the beach culminated in the reappearance of the quartzite at the west end due to the presence of a fault.

We then headed to the metropolis of Port Ellen. On the beach near the midpoint of the perfectly circular bay we found the eponymous Port Ellen Phyllites. These overlie the Scarba Conglomerate and dip to the southeast at about 30°. The bay owes its very existence to the erosion of the soft phyllites. They comprise interbedded layers of cleaved sandstones and mudstones. Two different cleavages can be found, a high angle cleavage in the sandstones and a later low angle one in the mudstones. The first cleavage was formed during mountain building while the later one resulted from the subsequent orogenic collapse. Normally cleavages are overprinted so it is unusual to see them as distinct units. The presence of shallow water phyllites indicates that extension had stopped and the basin had filled up. It is known that a series of deep/shallow sequences preceded more persistent extension and the opening of the Iapetus Ocean. As we walked round to the south side of the bay we saw ripple lamination in sandy beds within the phyllite. These were undeformed compared to the first locality indicating proximity to the solid epidiorite sill which forms the headland of The Ard. (A small stripey cat decided to take an interest in geology and followed the party for a short distance, playfully scampering over the rock face as Dr. Anderton tried to maintain a scholarly disposition.) The low hill at the end of the road, NR 363448, is formed of metagabbro, traditionally called epidiorite in Argyll. There are many sills in this part of the Dalradian sequence. Their MORB chemistry indicates rifting and precedes the appearance of the Tayviallich volcanics and the Iapatus Ocean. As light rain began to dampen our spirits, Dr. Anderton described a similar environment in present day Baja California where a mid-ocean ridge is developing underneath sediments, not yet fully formed as an ocean.

It was now late in the day and so we returned to the hotel for our last night, and thanked Dr Anderton sincerely and enthusiastically for leading us on such a truly fascinating and enjoyable weekend excursion

GENERAL INFORMATION

As part of the commemorations for our 150th Anniversary, extracts from the first Constitution and from Minutes of Meetings of the Society in 1858 were published in this year's Billets. Electronic distribution of the Billets was introduced this Session.

The cost of room hire for the monthly Meetings rose substantially at the beginning of this Session. After investigating the cost of other venues, it was decided that the Gregory Building remained the most appropriate. A small charge was introduced for tea/coffee following the Meetings to help offset the increase.

Scottish Geological Societies-ConocoPhillips Awards.
These were awarded to pupils with the highest score in Scottish Higher Grade Geology, Intermediate II Geology and Standard Grade Geology from Arbroath High School, for the second time, Westhills Academy (Aberdeen), Golspie High School and Plockton High School ,and included two at Intermediate II Geology.

Scottish Festival of Geology. 1st to 30th September 2008. www.scottishgeology.com. This is now held annually. Our Society organised two events:
Saturday 13th September
At the Glasgow Science Centre, 10am to 4pm:
A display of rocks, minerals, fossils, maps and photos relating to Glasgow and its surroundings. Membership packs were also available.
Sunday 14th September.
Silver panning at Silver Glen, Alva with Dr Neil Clark.
Saturday 27th September.
BGS Open Day, 10 am to 5 pm, at Murchison House, West Mains Road, Edinburgh.

Expedition Funding.
A grant was awarded to member, Neil Smith, to provide field equipment for a group of 12 young people on a 5-week BSES Expedition to Svalbard. Neil will be a Science Leader for one of two geology groups as part of a large expedition with seventy-two 17-20 year olds and some twenty leaders.

Rock Kits
An award of £1000 was made to the Scottish Earth Science Education Forum (SESEF) which disseminates educational advice concerning geology to a large number of schools.

Front cover photograph – Carpet bedding display provided by Glasgow City Council in Victoria Park, showing the Society's logo. *(Roy Smart)*

Edited by M. Donnelly,. Published by the Geological Society of Glasgow, c/o Department of Geographical and Earth Sciences, Gregory Building, University of Glasgow, G12 8QQ. www.geologyglasgow.org.uk/. **I.S.S.N. 0141 1839**

Printed by **Pandaprint**, Block 2, Unit 1, Oakbank Ind. Estate, Garscube Road, Glasgow, G20 7LU. www.panda-print.co.uk. March 2009.