PROCEEDINGS OF

THE GEOLOGICAL SOCIETY

OF GLASGOW

Session 151 **2008 – 09**

SESSION 151 (2008 – 2009)

SESSION 151 (2008– 2009)

Members of Council

President	Dr Alan W. Owen
Vice Presidents	Dr Chris J. Burton
	Mr Mervyn H. Aiken
	vacancy
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 Jim 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	Mr Jim Martin (Saturdays)
	Mr David McCulloch (Residential)
Strathclyde RIGS Chairperson	Mr Stuart Fairley
Rockwatch Representative	Ms Katerina Braun
Junior Member	Mr. Robert Jamieson
Journal Editors	Dr Colin J.R. Braithwaite
	Dr Brian Bell
Ordinary Members	Mrs Barbara Balfour
	Dr Simon Cuthbert
	Dr Tim Dempster
	Mr Charles M. Leslie
	Mr Robert McNicol
	Mrs Margaret Rollo
Independent Examiner	Mrs Beth Diamond

PRESIDENT

Membership of the Society has shown an encouraging rise to 390, reversing the trend of recent years. The eight evening meetings of the Society were well attended as were the five Saturday field trips, an evening excursion and a residential excursion on the Isle of Gigha. In addition, the Astronomical Society of Glasgow kindly held a joint lecture meeting with the Society.

The long established Strathclyde RIGS (Regionally Important Geological and Geomorphological Sites) group, a subcommittee of the Society's Council, has continued to be very active in promoting geology in the wider community. During Session 151, they produced a leaflet on Balmaha in conjunction with the Loch Lomond & Trossachs National Park, and a reprint of the RIGS leaflet on Fossil Grove was funded by Glasgow City Council's Land and Environmental Services department. Two other RIGS/Geodiversity groups, based in Argyll and in Dumfries & Galloway, have now come under the Society's umbrella and Council have agreed a set of policies and procedures for the administration, representation and reporting by all such subcommittees.

Two parts of the Scottish Journal of Geology were published in Session 151 along with an edition of the Proceedings. As noted in previous reports, the rise in cost of publishing the Scottish Journal of Geology, coupled with the reduction in advertising revenue, has resulted in the need to use funds from reserves for the past five years. A new publishing agreement has now been signed with the Geological Society of London Publishing House to publish the Journal on behalf of ourselves and the Edinburgh Geological Society, both in hard copy and electronically from 2010. The Journal is one of the core elements of the Society's Constitution for which a minor amendment was agreed at a Special General Meeting in January 2009. The new arrangement will bring to an end the drain on the Society's reserves as the GSPH will take on all responsibilities for the costs of producing, printing and distributing the Journal. The arrangement 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'. Thanks to the hard efforts of members of Council, the entire back contents of the Journal were audited prior to scanning by the GSPH. These electronic versions will be available on line from January 2010. The Society's librarian has undertaken an assessment of our holdings of the Transactions of the Society in anticipation of their digitisation and inclusion in the Lyell collection. This will be an extremely valuable archive of geological research from 1860 to 1963 including papers of fundamental importance in the history of our science.

This year brings to an end my term of office as President of the Geological Society of Glasgow. It has been a privilege to serve in this capacity and my sincere thanks go to the members of the Council whose hard work and expertise have ensured the smooth running of all the Society's activities and its continued success in achieving its aims.

Alan W. Owen

MEMBERSHIP

	At end 151 30 Sep., 2009	At end 150 30 Sep., 2008
Honorary Members	4	5
Ordinary Members	294	281
Associate Members	68	66
Junior Members	24	22
TOTAL Members	390	374
New Members	40	31
Memberships Closed	24	49

There was a steady growth in overall membership numbers in Session 151 due both to an increase in the number of new joiners and a decrease in the number of members who resigned or whose payments became overdue. (The memberships closed category rolls up the numbers resigning and the terminations due to non payment of subscriptions.)

R. A. Painter

LIBRARY

Much of the reorganisation of the Society's library has been finished during this Session, although developments within the Gregory Building have meant further relocations of some of the stock.

Relocations and reorganisations. The journal library and the map library have been relocated to Room 516, and the British Geological Survey publications to the Society's normal library (Conference Room – Gregory Building). To make room for transferred and newly acquired stock Council have approved the policy of offering the Society's out of date journals to the membership. These journals will be offered free of charge to members at the first meeting of the new Session.

Book Accessions. Thanks to the generosity of professional members of the Society and others who have been downsizing their personal libraries, and to donations by generous Society members we have accessioned 146 books in the current Session. All of these books have been chosen for their current relevance and many are new. They cover an extraordinary range of subjects within geology and include geological guides to many areas of the world. Further key acquisitions include 71 BGS Sheet Memoirs from the latest (and last!) editions of these valuable volumes (10 sheet memoirs – Scotland; 61 sheet memoirs – England/Wales). The Society now has almost complete coverage of British geology via these memoirs. Also acquired have been volumes 2 – 27 of the Reviews in Mineralogy – which cover all groups of minerals comprehensively.

Map Collection. Ten new BGS maps have been added to the collection, plus 16 geological maps from elsewhere in the world, including several from the Czech Republic and Slovakia and two geological atlases of China.

Library Use. A number of new users have been tempted into the library thanks to the advertising campaign run by the Assistant Librarian; they join the stalwart company of regular users who find much of value in our stock – whether they are studying in particular courses, or looking for interesting areas to visit, or simply widening their knowledge of the subject. The Librarian or the Assistant Librarian will always be present on Meeting nights to help locate books or to fetch maps and journals.

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

SCOTTISH JOURNAL OF GEOLOGY

There have been two changes in the Editorial Board in the last year, relating to specialist editors in palaeontology and structural geology. The flow of manuscripts submitted has been steady and both issues have been published on time and at full length. Although this has been a pleasing change in comparison to some previous years we have managed to keep the process of review and the time to publication short, with an undoubted benefit to authors.

A major change in the publication of the Journal now in progress may not initially be noticed by members but represents an important step forward. The Councils of the Edinburgh and Glasgow Societies, that jointly own the Journal, met with representatives of the Geological Society of London to discuss a new publishing Agreement. The Geological Society Publishing House (GSPH) have been publishing the SJG for a number of years and members will have noted changes in format and presentation that have modernised and improved the appearance of the Journal. More recently, through the electronic publishing company Ingenta, current issues of the Journal have been available on the web. As a result of the new and generous agreement reached with GSPH the Journal will now appear as part of the Lyell Collection, a major online database hosted by the London Society. As part of this we will also be listed on Geoscience World (GSW), the largest online reference source in North America. Although this facility will not formally come online until January 2010, we are already listed in Geological Society publication lists and as 'about to be available' on GSW. It is important to appreciate the full extent of this new venture. GSPH undertook to scan all of the back issues of SJG from its inception. This process is rather more than simply copying. Optical character recognition means that all of these documents will be fully searchable by engines such as Google, so that present and all past authors will have their work available online where it can be identified by keyword searches even if the SJG is not known to the searcher. This will undoubtedly increase the attractiveness of the Journal to would-be authors. New authors will also find that their diagrams and photographs can be in colour in the online version, at no charge. However, it has been a tedious and lengthy operation. It was necessary to find copies of the Journal that could be sacrificed and to audit their entire contents. This task was undertaken by a small number of members who devoted many hours of their valuable time, and we thank especially Charles Leslie and Mervyn Aiken. Their help was greatly appreciated. As the scanning was in progress it was necessary to check the quality of each individual page and Colin Braithwaite undertook this task on behalf of the Editors. In general this can be

described as excellent and the few, typically old, cases where print is less than clear are entirely the result of the poor quality of the original diagrams or photographs. A test version of the completed work is already online in order to undergo any necessary "tweaking". Once this is up and running, members will be notified of the procedure to access the Journal. Our next task will be to add the entire body of the Transactions of the two Societies.

C.J.R. Braithwaite

WEBSITE

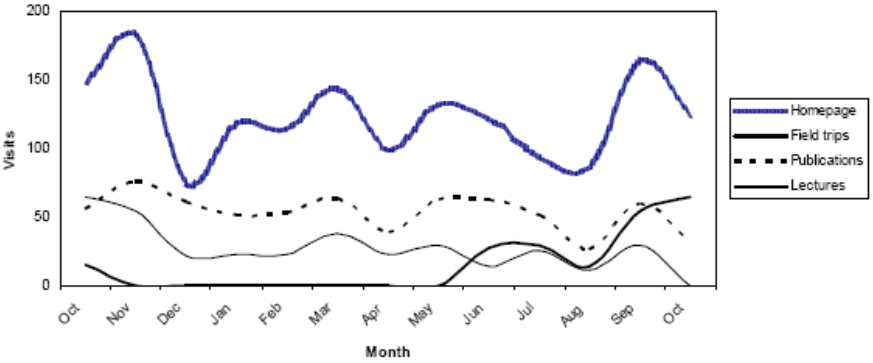
Map of towns in the UK where visitors to the website originate.

Since the introduction of Google analytics in December 2007, it has been possible to draw better comparisons between previous data and data for the present year. There are still a few problems with regard to changes in the designation of websites, but this has been largely standardised. For the year between the 2nd of November 2008 and 2009, there have been 1,432 visits from 57 countries. If we compare an equivalent period from the previous year (January 2008/2009 to September 2008/2009) there has been an increase in visitors to our website of about 8%. The most popular webpages, as expected, are the homepage (increase of 17%), the publications page (with a decrease of 20%) and the excursions (with an increase of 72% from July to September). The lectures webpage has changed name a couple of times and therefore is not included here although it does show a healthy increase in visits since September, perhaps as a result of the Scottish Geology Festival that runs during that month (despite the Society not being able to take part this year). The year did not go without its problems as some pages of the website were unavailable for sometime due to server problems (see excursion profile in graph). Overall the website was successful in informing visitors to the site on the activities of the GSG.

55% of visitors looked at only one page (compared to 56% last year), 13% looked at two pages (compared to 19% last year) and 11% looked at 3 pages (compared with 8.5% last year) tailing off to a maximum number of pages viewed to 14 for 0.66% of visitors. Visitors from around the Globe have come to the GSG website including one in Mongolia! However, the vast majority of visitors are from the UK, accounting for 1,015 of the 1,432 total visits. Of these, 260 come from Glasgow (not including Cumbernauld and other nearby towns), 265 from London, and even 1 from Gateshead, who visited 14 pages. Some improvements to the pages have been

undertaken throughout the year, and news items have been added occasionally, but plans are afoot to revamp the website to make it more efficient to run and update. A subcommittee comprising Jim Martin, Seonaid Leishman and Neil Clark was formed to look into the redevelopment of the website.
Comments and suggestions for the webpages are always welcome, but the content is reliant on information being provided by members.

Graph showing the number of visits each month to the website from 2008 to 2009. http://www.geologyglasgow.org.uk/.



Neil D.L. Clark

PUBLICATIONS

As always the bookshop has been a popular stopping point for members on Society lecture nights. We have held a stock of 56 titles ranging from serious geology to light reading and from excursion guides to maps, some of which have been specially requested by members. Sales have been good and once again the publications section has shown a profit for the Society. The present stock value is £4300 which includes our holding of the Madeira Guides. They have brought in orders from booksellers abroad and in the UK, as well as personal sales. Some new titles have been added to our stock, in particular the Field Guide to Bute and the BGS/SNH Landscapes series of South West Scotland.
I thank our members, students and DACE classes for their continued support and particularly thank those who help with the books on lecture nights.

Muriel Alexander

STRATHCLYDE RIGS GROUP

The Third Scottish RIGS Workshop was held at the end of May. All the RIGS Groups in Scotland were represented, plus Lochaber and North West Highlands Geoparks. The main issue of concern was the lack of a geodiversity duty statement in Scottish Local and Central Government Planning Policies and Advice Notes. As a result a Petition was raised, with over 300 signatures, which was heard by the Scottish Parliament Public Petitions Committee on 3 November. Consideration is continuing. In the meantime some Local Authorities are responding. East Dunbartonshire Draft Local Plan 2 includes reference to the geodiversity review by BGS supported by

Strathclyde RIGS which identifies over 30 Local Geodiversity Sites or RIGS. Lothian and Borders RIGS have carried out a review of sites for Edinburgh City and Glasgow City Council will now be approached.
Promotion and outreach is a prime objective and guidance has been given by SNH. Funding sources for leaflet production have included LLTNP for Balmaha, Glasgow City Council for a re-print of Fossil Grove and GSG itself for Campsie Glen to celebrate 150 years since the Society's inaugural excursion.
Strathclyde RIGS Group members are all volunteers. Of the 16 members, an average of 6 is able to attend each meeting or site visit. With increasing case work it would be great if some more of the Society members could come along and share their experience and enthusiasm for the geology of West of Scotland
The past year's efforts have produced the Balmaha leaflet and an event is planned with SESEF for Rangers and teachers. As well as Campsie Glen, a leaflet on the geology of the Rouken Glen is being used by the Friends of Rouken Glen, the geology of Waulkmill Glen is highlighted in the Dams to Darnley Country Park Plan, and the leaflet on Portencross is almost ready. GSG members will have seen the interpretation potential of the collaborative project with Scottish Coal at Spireslack Open Cast Mine, Muirkirk, now designated Glenbuck RIGS. Fossil Grove did open during the summer but plans for its future are uncertain. The Society and RIGS Group will continue to monitor the situation.
During the year Stuart Fairley had to hand over the Chair duties to Margaret Greene who is standing for election at this AGM. Luckily for the Group Stuart will still be involved. His enthusiasm, local knowledge and wide contacts among Scottish geologists have strengthened Strathclyde RIGS efforts to conserve and promote our geology. There are many more projects and sites in the pipeline. Please let the Group know if you have suggestions and would like to make a contribution by coming along to meetings or evaluating a favourite site. You will be very welcome. Just contact any member of the Group or e-mail strathrigs@tiscali.co.uk.

Seonaid Leishman and Margaret Greene

GeoD - Geodiversity in Dumfries & Galloway. Report for 2008-09

Recording
In the first year, 11 RIGS sites in Dumfries & Galloway (D&G) were documented and submitted to SNH who allocated some funding for the expenses of the work. Funding has been continued for a second year and a further 10 sites will be surveyed and submitted.
Projects
A ‘geodial’, a circular paved ‘patio’ in a public area, was constructed in Moniaive, using local rocks, with the assistance of a grant towards preparing the stone and construction of the structure. It will be formally opened on 28 November 2009.
Field trips
4 April 2009 D&G Wildlife Festival, visit to Dalbeattie Quarry
2 May 2009 Field trip to Grey Mare’s Tail and Dob’s Linn
23 May 2009 Field trip to Wanlockhead

Display events

13 – 14 June 2009 Display and talk at Solway Firth Partnership event, Port William

17 Oct 2009 Display of local geology, Wildlife Recording event, Lockerbie

Dr Jim Floyd

DRAFT Minutes of the First AGM of The Geodiversity Argyll and the Islands Group

Thursday 12 November 2009 at the Oban Library

Present: Alastair Fleming (Isle of Luing, Oban), James Westland (Tobermory, Mull), Julian Overnell (Kilmore by Oban), Zoë Fleming (Isle of Luing). Minutes recorded by ZF.

1. Apologies for absence: John Faithfull (Glasgow Hunterian & Ross of Mull), John Sedgwick (Isle of Seil)
2. Minutes of Steering Group 10 April 2009. These were distributed by email in April 2009. The Minutes were accepted as a true record of the meeting. A printed copy was signed by AF and filed by ZF.
3. Adoption of Rules. The draft copy was distributed by email in October. Several minor amendments were made to clarify the distinction between RIGS sites in the field and the GA&I Group of people. The final document was adopted unanimously and a copy attached to these Minutes.
4. Steering Committee:

(i) Election of Officers. At the inaugural meeting in April 2009 it was decided to propose the following Officers – Chairman: Alastair Fleming, Secretary: Zoë Fleming, Treasurer: Julian Overnell, Data Manager: James Westland.

(ii) Membership subscription. A nominal membership fee of £5 per year, to cover incidentals like website domain name. The Treasurer is opening a bank account for the Group and will now accept the fees. Please arrange to pay your subscription promptly.

(iii) Accounts. The Treasurer proposes to ask John Wilson of Kilmore by Oban to check the accounts for the forthcoming year. If John is unable to accept, the Treasurer will invite another suitable person. The end of the financial year is 30 September.

5. Resolutions. None
6. AOB (i) AF to contact the relevant A&B council person again, now that the AGM has been held.

(ii) JW requested more material for the Group's new website www.argyllgeology.co.uk. Contact names and addresses for the Officers would be added. A single email for contact only, would be managed by JW, to reduce SPAM and other related problems.

(iii) A standard procedure to be followed for the Group to assess a particular site as being worthy of the title "RIGS site of GA&I", based on the Geoconservation UK assessment procedures. At first a draft procedure will develop as we explore a few initial field-sites, and eventually this could be presented as a flowchart.

(iv) Discussion about the Kilmore waterfall site assessed at the field meeting on 5 June by 6 members of Group. The Kilmore follow-up needs to be completed by: AF finalising the forms, JW providing a base map from EDINA online maps, JO checking the research literature.
(v) Next stage is for each volunteer to select a potential site in Argyll, complete the assessment forms, request a base map from JW and then invite another volunteer to assess the site with them to thrash out a consensus of results! If the site is passed worthy the pair will alert the committee to that fact.
Meeting closed at 1pm promptly.

Zoë Fleming

PROCEEDINGS

The Proceedings for Session 150 (2007 – 2008) were printed in March 2009, again by Pandaprint, of Garscube Road, Glasgow, who continue to provide an excellent service at very competitive rates. About 70 copies were distributed at the April Meeting, leaving the remainder of about 315 to be delivered by post.

Margaret Donnelly

TREASURER

Income and Expenditure Account for Year Ended 30th September 2009

(Scottish Charity Number SCOO7013)

		2007-08			**2008-09**
Income			**note #**		
1. Subscriptions					
Received by Bankers Order	4,171			4,018	
Received by payment to Memb Sec	1,792			2,454	
Deduct paid in advance this year	-41			-61	
Add received in advance last year	300	6,222		41	6,452
2. Investment Income					
Dividends	592			594	
National Savings	2,137	2,729	**1**	1,747	2,341
3. Tax refund (Gift Aid) (payment awaited)		1,054	**2**		1,000
Under accrual on 2008 gift aid					16
4. ConocoPhillips prize		1,050			133
5. Net surplus Publications sales		149			313
6. Saturday excursions income	880			1,300	
expenditure	843	37		1,290	10
7. Weekend excursions income	6,931			840	
expenditure	6,897	54		823	17
8. Donations (coffee collections)		150			251
Total income		**£11,445**			**£10,533**

Expenditure	**2007-08**	**note #**	**2008-09**
1. Scottish Journal of Geology	4,500		5,088
2. Meetings incl speakers, meals, etc	873		535
Room hire session 151a	0		713
Room hire session 151b	0		1,189
Room hire session 149b	0		0
(1,043 accrued in session 150)			
Room hire session 150a	668		0
Room hire session 150b (accrual)	1,171		0
3. Publication of Proceedings	418		541
4. Billets, production incl Hon Sec's expenses	406		568
5. Sponsorship grants	1,500		600
6. Library	583		635
7. Insurance	139		166
8. ConocoPhillips prizes	350		400
9. RIGS	200		480
10. Society's 150th anniversary celebration	625		0
11. Affiliation fees	313	**3**	328
12. Admin costs – postage, stationery, telephone etc			
Membership Sec	406		433
Chairman	119		112
Treasurer	9		75
13. Geology festival	16		0
Total expenditure	**£12,296**		**£11,863**
Profit/loss	**-£851**		**-£1330**

Balance Sheet as at 30th September 2009

	2007-08			**2008-09**	
Members' Funds			**note#**		
Balance as at 30/09/2007	£64,013			£60,035	
Add back unpres. chq last year now cancelled	40			60	
Surplus/deficit for the year	-£851			-£1,330	
Revised valuation fund for investments	-£3,167		**4**	£689	
Balance as at 30th September 2008		**£60,035**			**£59,454**
Restricted Funds					
TN George fund	380			380	
Hunterian fund	1000	1380	**5**	0	380

Total Funds		**£61,415**			**£59,834**
Represented by	**2007-08**			**2008-09**	
Current assets			**note#**		
Cash at Bank:					
Royal Bank of Scotland Account	2,927			2,661	
National Savings Investment Account	35,187	38,114		33,892	36,553
Cash in hand:					
Publications Sales Officer	85			63	
Membership Secretary	0			0	
Secretary	0			0	
Meetings Secretary	0	85		0	63
National Savings Income Bond		12,000			12,000
Current Valuation of Charifund investment		7,666	**4**		8,355
Debtors – Publications at 30/9/07		0			0
– 150th Anniversary day surplus		104			0
– Gift Aid		1054	**2**		1016
Stock of Publications		4,647			4,140
Current assets		**£63,670**			**£62,127**
LESS LIABILITIES					
Subscriptions paid in advance	-41				-61
Moneys due by Society (room hire Sessions 149b)	-1,043				-1,043
Moneys due by Society (room hire Sessions 150b)	-1,171	**-2,255**			-1,189
Net assets		**£61,415**			**£59,834**

Signed as approved by the Trustees: …….
Dr Alan Owen President and Trustee on behalf of all the Trustees
Signed by the Independent Examiner …….
Mrs Beth Diamond

Notes to the Financial Statements
For the Year Ended 30th Sept 2009

Accounting Policies

Accounting convention: The financial statements have been prepared under the historical cost convention, and in accordance with applicable accounting standards. The accounts are also set out to comply with guidance from OSCR.
The principal accounting policies adopted in the preparation of the financial statements are as follows:

All income from membership subscriptions, excursions, publications, bank interest and donations is accounted for on an accruals basis.
Resources expended are accounted for on an accruals basis and are recognised when there is a legal or constructive obligation to pay for expenditure.
All costs have been directly attributable to one of the functional categories of resources defined in the Statement of Financial Activities.
Expenditure on equipment is charged to Revenue in the year of purchase.

Notes on entries.

1. A £3000 transfer from the National 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 £1000 quoted is our assessment of the payment expected.

3. Affiliation fees are payable to The Geologists' Association, The Palaeontological Association and the Palaeontographical Society.

4. To allow for potential Stock Market losses, an allowance of £3167 was deducted from the book value of the investments last year to allow for further falls in the market. Thanks to an improvement in the market it has been possible to restore £689 of this bringing the Balance Sheet value of the investments to £8355 whilst still understating it by 11%.

5. The Hunterian fund, having reached its target of £1000, has been disbursed to the intended project.

Michael Pell

MEETINGS

Our 151st Session opened in October 2008 with local girl Maggie Cusack describing how the study of fossil brachiopods can give information on past environmental conditions. In November, Rob Butler from Aberdeen told a large audience about the discovery and study of the Moine Thrust and how it still has importance for world geology today. On the evening of the AGM, we heard talks by Neil Smith on the BSES expedition to Svalbard in summer 2008 and Iain Allison on the BSES expedition to East Greenland 2006.

January 2009 brought John Gordon from Scottish Natural Heritage to give a highly individualistic talk entitled "Stone Voices" which discussed geodiversity, 'geopoetics' and reading the landscape. Tony Prave of St Andrews enlivened February with an entertaining and informative talk on his interpretation of the Neoproterozoic history of the Scottish-Irish Highlands. Old friend Roger Anderton continued the historical theme in March with "Rocks, Landscape and Man – reading the geological history of mid-Argyll". Paul Bishop was unable to attend in April and, at very short notice the President and Meetings Secretary stepped in with short talks on Trilobites and Shetland Geology respectively. Members' Night closed the season with the usual interesting and varied programme of contributions including a sequel to his talk by Roger Anderton on the epidiorite grave slabs of Argyll.

Jim M. Morrison

Thursday 9th October 2008
Professor Maggie Cusack, University of Glasgow

BRACHIOPODS – RECORDING ENVIRONMENTAL CONDITIONS WHILE UNDER BIOLOGICAL CONTROL

With their long geological history and stable low magnesium calcite, Rhynchonelliform brachiopods are attractive sources of environmental data such as past seawater temperature. The outer primary layer of acicular calcite is isotopically light in both $\delta^{18}O$ and $\delta^{13}C$ while the secondary layer calcite fibres are in oxygen isotope equilibrium with ambient seawater. The calcite fibres of the secondary layer are parallel to the shell exterior. Electron backscatter diffraction (EBSD) reveals that the fibres are effectively single crystals with the calcite c-axis perpendicular to the fibre axis. The granular nature of the fibres is evident in Atomic Force Microscopy (AFM) where the addition of bands of calcite granules to the growing fibre is clear. These bands of granules are thus added over the duration of fibre growth with crystallographic orientation being maintained throughout. Although there remains much to be understood about how this precise biological control is achieved, the attainment of isotope equilibrium under such strict biological influence is counter-intuitive.

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Thursday 13th November 2008
Professor Rob Butler, University of Aberdeen

THE MOINE THRUST – DISCOVERY, RESEARCH AND IMPORTANCE TODAY

The Moine Thrust Belt is one of the great sites for world tectonics. The NW Highlands are visited by structural geologists from all over the world each year and generations of students have learnt how to map and understand mountain building processes. Some of this importance arises as an accident of history: the thrusts in NW Scotland were amongst the first to be so recognised anywhere. Additionally – the first systematic approaches to describing the processes and products of faulting come from Moine thrust sites. But research has continued since these roots in the late nineteenth century. Much of our understanding of grain scale deformation, critical for understanding how rocks flow, was derived from samples from NW Scotland. This talk outlined these scientific discoveries, and then explored how they have been applied around the world to active mountain belts and continental tectonics, through to exploring for oil and gas in the deep oceans.

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Thursday 20th November 2008

Special Joint Meeting with the Astronomical Society of Glasgow, University of Strathclyde

Dr Dave Rothery, Open University

MERCURY – NEW INSIGHTS INTO THE GEOLOGY & EVOLUTION OF THE SUN'S INNERMOST PLANET

Dr David Rothery is a volcanologist and planetary scientist and a senior lecturer at the Open University, and prior to that he was at the University of Glasgow. In May 2006 David was appointed UK Chief Scientist on MIXS (Mercury Imaging X-ray Spectrometer), which is the only UK Principal Investigator instrument on BepiColombo, the European Space Agency mission to Mercury to be launched in 2013. David's research interests centre on the study of volcanic activity by means of remote sensing, and volcanology and geoscience in general on other planets.

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Thursday 11th December 2008

ANNUAL GENERAL MEETING

Thanks were expressed to:
Retiring members of Council Mr Charles Leslie – Vice President, Dr Jim Morrison – Meetings Secretary, Dr Robin Painter – Membership Secretary and Publicity Officer (meetings etc), and Mrs Seonaid Leishman – Assistant Librarian/Archivist, 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 Brian Bell, who are elected annually.

This was followed by the Election of Office Bearers.

Short Talks

The President then invited Neil Smith and Iain Allison to give two short talks. Neil Smith had received funding from the Society for a trip he took part in with BSES Expeditions to Svalbard in summer 2008. He explained that BSES Expeditions is a youth development charity that organises challenging scientific expeditions to remote wilderness environments. He outlined his part in this expedition and the challenges that were given to the young people, not just scientifically, but also how to survive in the harsh environment in Svalbard. Iain Allison had been part of a similar expedition to East Greenland in 2006. Both talks were illustrated with amazing photos of the young people and the terrain in which they worked and slept for the five weeks.

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

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Thursday 8th January 2009

Special General Meeting

The lecture was preceded by a Special General Meeting to consider a change to the Constitution necessitated by a forthcoming change in the publication arrangements for the Scottish Journal of Geology. The proposed change is to the last date given in Article 29 such that it will read:

"The Society shall support the publication of the Scottish Journal of Geology according to the Minute of Agreement between the Edinburgh Geological Society and the Geological Society of Glasgow, dated 8th October 1964, and registered in the Books of Council and Session of the Registers of Scotland, and the Publishing Agreement made between the Edinburgh Geological Society, Geological Society of Glasgow and the Geological Society Publishing House, dated 10th December 2008."

Professor John Gordon, Scottish Natural Heritage

'STONE VOICES': GEODIVERSITY, GEOPOETICS AND READING THE LANDSCAPE

This talk explored the close links of geodiversity with landscape, history, archaeology, art, poetry, literature and the development of tourism in Scotland. These links provide opportunities for creative ways of 'reading the landscape', complementing more traditional didactic approaches to raising awareness and interpreting geodiversity. The Geoparks initiative is one example of a framework that can help to promote better integration of Earth heritage, landscape history, archaeology and local culture, and at the same time support sustainable economic development, particularly in rural areas.

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Thursday 12th February 2009
Professor Tony Prave, University of St Andrews

NEOPROTEROZOIC EARTH HISTORY AS WRITTEN IN THE SCOTTISH-IRISH HIGHLANDS

At the dawn of the 20th Century, the stratigraphic framework synthesised by the original workers who mapped the Highlands was that a "belt of complication", namely the Moine Thrust, separated rock units (Torridonian and Moine) that had experienced different degrees of metamorphism but were nonetheless broadly correlative; as Ben Peach and John Horne stated explicitly in 1930: "The difference…on either side of the Moine Thrust plane…is one of degree not of kind." Likewise, relatedness, or at least compatibility, of units on either side of the Great Glen Fault was implied by the use of the terms 'older' and 'younger' Moines. However, by the end of the 20th Century that view had been largely discarded and replaced by one in which originally widely separated and disparate crustal blocks (i.e. terranes) became juxtaposed during early Palaeozoic Caledonian orogenesis. This fundamental shift in thinking led to the

inference that each of the three major supracrustal groups of rocks in the Highlands, the Torridonian, Moine and Dalradian, was deposited in genetically unrelated and temporally distinct basins.
It is not surprising that such contrasting interpretations were reached because it is frustratingly difficult to establish robust stratigraphic correlations in rocks like those of the Highlands; they are unfossiliferous, have experienced polyphase tectonothermal histories, and lack widespread marker horizons. Two techniques, though, C-isotope chemostratigraphy and U-Pb dating of detrital zircons, have gained recent prominence in efforts to understand better the profound events of Neoproterozoic time. It was then (1000 – 543 Ma) that animals evolved, oceans became oxic, the global C cycle underwent unprecedented perturbations, supercontinental assembly and break-up occurred, climatic extremes (Snowball Earths) shocked the Earth system and, pertinent to us, many of the rocks in the Highlands were deposited. Professor Prave and his colleagues have used these techniques to redefine the stratigraphic framework of the Highlands and our data reveal a striking compatibility between units across the Highlands and an even more striking correlation to the hallmark geological events of Neoproterozoic Earth history. This new view of the geological evolution of the Highlands was presented and offered for discussion, comment and criticism.

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Thursday12th March 2009
Dr Roger Anderton, Consultant, formerly with BP Aberdeen

ROCKS, LANDSCAPE AND MAN – READING THE GEOLOGICAL HISTORY OF MID-ARGYLL

The landscape of Mid-Argyll is made up of an attractive patchwork of hills, valleys, lochs, lowlands, peninsulas and islands. Clearly, in a general sense, this reflects the distribution of relatively hard and soft units within the Neoproterozoic Dalradian bedrock. This comprises metasedimentary and metavolcanic rocks that vary in structural character from areas with consistent gentle dips to those with tight and complex folding. The talk first examined how far the landscape is a consequence of this bedrock stratigraphy and structure and how far one can relate depositional facies changes, basin architecture and structural style to the subtleties of the landscape.
The evolution of the Dalradian bedrock was essentially complete by the end of the early Palaeozoic Caledonian orogeny. Since then, the area has been positive, although near to areas of late Palaeozoic and Mesozoic subsidence and deposition. During the Tertiary it was cut by a dyke swarm feeding fissure eruptions and underwent significant uplift and erosion before glacial erosion, fluvioglacial deposition and shoreline processes added a final imprint to the area. Also, from Neolithic times onwards, Man has exploited the landscape by quarrying, building and farming. The contribution of all these post-Caledonian processes to the present character of the landscape was discussed.

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Thursday 9th April 2009
Dr Alan Owen, University of Glasgow

TRILOBITES

The Ordovician was a period of major biodiversity; there were more species of trilobites than at any other time, and they existed in a wide range of forms. Notably, they had a large variety of intricate and elaborate eyes, from huge ones that encircled the front of the head, to no eyes at all (atheloptic). Many of those found in Scotland are identical to those of America, such as at Pye Mountain in Maine, where, satisfyingly, the outcrop is poorer than some Scottish ones, and the Girvan exposures are far superior! They occupied all levels in the water column – pelagic, mesopelagic and hemipelagic (nearer the surface). A very elegant method of determining water depth is employed – in rocks formed of shallow water sediments, only surface trilobite fossils occur, in rocks of deeper water sediments both surface and deeper trilobites, in rocks of still deeper water sediments all three species occur etc. Towards the end of the Ordovician there were very high sea levels; this was followed by a short-lived but distinct glaciation when sea levels dropped. In the 'End Ordovician Extinction', all pelagic trilobites died out, and these species never recovered.

Dr Jim Morrison, University of Glasgow

ASPECTS OF THE GEOLOGY OF SHETLAND

Shetland has a fascinating mix of geology with Lewisian, Mid Devonian, Moine and Dalradian rocks, and the Ophiolite on Unst and Fetlar. Devonian volcanics outcrop in the northwest and there is a distinctive red granite. Two major faults extend the length of the islands from south to north – the Nesting Fault, and the Walls Boundary Fault which is an extension of the Great Glen Fault. Movement on the latter could be 200 km or 1000 km! Granites on either side of this fault have different dates – to the west they are Devonian, ~ 360 Ma, while to the east they are the 'Younger Granites' of the Dalradian, ~ 430 – 420 Ma. The Dalradian rocks are similar to the Grampian Group but were deposited in a different basin from those of the Highlands; the Moine rocks to the east of the Walls Fault are thought to be akin to the Glenfinnan Group.

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Thursday 14th May 2009

MEMBERS' NIGHT

Once again we had a good range of talks and displays, and we acknowledge with thanks the contribution of our members noted below to the success of this evening.

Short talks

The Moon: a Virtual Field Trip.	David Degan
Geology of the Jabal Akhdar (Green Mountains) in Oman.	Dr Ben Browne
Darwin's Concretionary Action and its Explanation.	Julian Jocelyn
Photos from the Excursions of Summer 2008.	Charles Leslie
Geoarchaeaology at Kilmartin.	Dr Roger Anderton

Displays

Ben Browne – the Geology of the Jabal Akhdar (Green Mountains) in Oman
David Hollis – Rouken Glen and Spireslack
Julian Jocelyn – Darwin's concretionary action
Charles Leslie – Photographs from the excursions of summer 2008
Margaret Donnelly – Memories of 2008
Robert McNicol – the BGS Open Day and our outreach event at the Glasgow Science Centre
Carolyn Mills – Photographs from the Civic Dinner during our 150th year

EXCURSIONS

Evening and Saturday Excursions Report

This year we had one evening excursion and five Saturday excursions, all of which were well attended:

25th April 2009. Joint Excursion with Edinburgh Geological Society. Spireslack/Garpel Burn followed by high tea in Abington. Drs Chris Burton and Alan Owen, University of Glasgow. Hosted by David Booth and the staff of Scottish Coal who kindly gave up their Saturday. Participants: 20

7th May (Thursday evening) 2009. Rouken Glen. Dr John Faithfull, Hunterian Museum. Participants: 18

16th May 2009 Bathgate Hills. Drs Rona McGill & Allan Hall, University of Glasgow. Participants: 15

6th June 2009 Highland Slate Quarries. Dr Joan Walsh. Participants: 25

11th July 2009 Ballantrae Metamorphics. Dr Simon Cuthbert. Participants: 22

15th August 2009 Isle of Bute. Dr Julian Hill. Participants: 16

This was my first year in organising the logistics associated with the day trips. I am grateful to Margaret Donnelly for her guidance and Dr Iain Allison for recruiting our leaders.
A few words about our leaders; I can think of few other professions where such highly qualified professionals are prepared to give so freely of their time in agreeing both to lead us and the associate preparation. We are, I am sure, both indebted and grateful.
Financially the day trips broke even although it was necessary to ask attendees for a contribution of 3 or 4 pounds on each of the excursions.
Finally thanks to everyone who supported the programme.

Jim Martin

Residential Field Excursions

In September, Dr Jim MacDonald let a party of 23 members to the island of Gigha. We enjoyed generally good weather and learned much about the evolution of the crust before the opening of the Iapetus Ocean. The highlight was the discovery of an extensive exposure of volcanic bombs embedded in tuff which does not appear to be recorded in any of the geological literature about the island. Due to personal commitments I was only able to organise one excursion this year; however I intend to return to the usual format of two excursions in 2010.

David McCul1och

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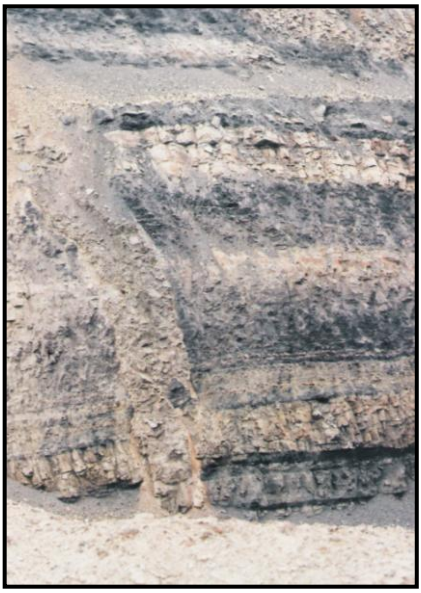
SPIRESLACK AND GARPEL BURN : 25 April 2009
Leaders : Dr Chris Burton and Dr Alan Owen, University of Glasgow
Report by : *David Hollis* Participants : 20

The purpose of today's visit was to study exposures of the Strathclyde and Clackmannan succession of the Lower Carboniferous strata in the vicinity of the old mining village of Muirkirk. The strata extended from the Johnstone Shell Beds to the Index Limestone of the Limestone Coal Formation at Spireslack Open Cast Mine in Glenbuck (NS 750300), and from the Blue Tour Limestone down strata to the Index Limestone in the Garpel water (NS 690250).

Our group left Glasgow at 08.30 and met a similar group from Edinburgh, at Spireslack at around 10.30. We spent about two hours on site before returning to the coaches. The Spireslack site is designated as a RIGS, and is part of the proposed Glenbuck Geopark. A short drive into the workings by landrover led us to a spectacular sight for which most of us were totally unprepared. A face about 30 m high, dipping approximately east at about 45 degrees, showed six cycles of deposition, from the Six Foot Coal to the Ell Coal. On the opposite side of the excavation, the sloping surface of the Johnstone Shell Beds was visible, but the McDonald Coal, which lies beneath the Shell Beds, was not visible. A number of

northwest-southeast striking Permo-Carboniferous quartz-dolerite dykes have cut through the coal beds, turning the coal into coke, which, in turn, has turned the dykes from quartz into "trap". Several of these made vertical fissures through the sedimentary strata. During the nineteenth century, several shallow mines were developed in the locality. In the valley surrounding Muirkirk, the remains of the railway lines to several of these mines, and the main line to Cumnock (another mining area) were visible. It was possible to see collapsed pillar and stall workings of one of these mines in the coal seams at Spireslack. Although most of the coal which was extracted at Spireslack was of the bituminous variety, the top of one seam was "cannel" (candle) coal. This substance contains a high proportion of wax and burns easily, with a bright yellow flame. Dr. Burton reports that he was able to light some of it directly from a cigarette lighter. The samples we found were remarkably lightweight compared to similar pieces of the bituminous coal.



A quartz dolerite dyke
David Hollis

***Lepidodendron* fossil bark in limestone**
David Hollis

Our leaders took us across the workings to a row of dumps. There were impressions of *Lepidodendron* bark and branches in many pieces of sandstone. No leaves were found but there were some clusters of productids and gastropod shells. These made excellent photographic material. Pieces of the upper layers of the Johnstone Shell Beds showed ironstone, which is solidified bog iron ore. This material is heavy because it contains up to 40% iron. In former times, it was mined and processed at several foundries in the locality, one of which existed in

Muirkirk. In the 20th Century, the ironstone beds have been neglected in favour of bulk iron ores from, for example, Broken Hill mine in Australia. Larger foundries with blast furnaces, such as Ravenscraig near Motherwell, replaced the smaller foundries. There are now few reminders of the former extent of industry around Muirkirk. Beneath the ironstone, a mudstone layer revealed worm trails in profusion. Several spectacular "sheets" of this stone were on view. We left the open-cast somewhat heavier, with specimens, than we were on arrival!

Plunging fold in the Limestone Coal Group
Charles Leslie

After a lunch on the grass in Muirkirk, we walked on a farm track to the place on Garpel water where, in former times, one of the mine railways crossed the burn. Here we saw the Blue Tour Limestone. Following the burn upstream, we came to a remarkable face of channel sandstone. A discussion ensued as to whether the cut into the mudstone beneath was evidence of an "evulsion" – that is a "break out" of a river from its normal channel. Further upstream, we arrived at the Orchard Beds. These are an SSSI, because of ostracod, orthocone, and trilobite fauna which exist in some of the mudstone strata. Just downstream of Tibbie Pagan's Bridge (NS 689258) is an ideal exposure of a cyclothem: seat earth, coal seam, and, above that, sandstone. Upstream of the bridge, the Tibbie Pagan Limestone is visible in the river. It is possible to reach the Index Limestone by walking further upstream, but lack of time and some rather ugly weather (thunder, and intermittent rain) were against us. We headed to the coaches, which were waiting for us at the Miner's Institute in Muirkirk.

Tibbie Pagan was a well known poet and folk singer, who was a contemporary of Robert Burns. She lived in a cottage near the bridge of her name, from which she sold beer and other refreshments to the passing traffic. Upstream, near the Index Limestone, is a cairn which was erected by the people of Muirkirk, in memory of John Macadam, who mined coal nearby for the Scottish Tar Company. The tar was produced by the destructive distillation of coal, and sent to the shipyards for tarring ship's hulls. Later, Macadam moved to London, and was placed in charge of the roads. Subsequently, he developed the idea of using tar as a binder of the road surface, to give good run off of rain water, and resist the grinding action of horses' hooves on the surface.

By this time, we were hungry! The High Tea at Abingdon was most welcome. Apart from a cooked meal, we had scones, cakes… "Forget about the calories and enjoy life!" came to mind. A vote of thanks was well justified after the excellent printed notes and verbal descriptions of the sites given by our two leaders, and the smooth organisation by Jim Martin. Our hosts at the Abingdon Hotel were also praised for the magnificent spread which they prepared for us. After a convivial meal, the two groups went their separate ways. We arrived tired but happy, in Glasgow at around 7 p.m.

The references given below are from Dr. Burton's notes.

1) Cossey, P.J. et al. 2004. British Lower Carboniferous Stratigraphy. *GCR review series*, **29**: Garpel Water, East Ayrshire, 100 – 102.
2) Davies, A. 1972. Carboniferous rocks of the Muirkirk, Gasswater, and Glenmuir areas of Ayrshire. *Bulletin of the British Geological survey*, **40**.
3) Eyles, V.A. et al. 1930. *The Economic Geology of the Ayrshire Coalfields area*, **111**: Ayr, Prestwick, Mauchline, Cumnock, and Muirkirk. Geological Survey Scotland H.M.S.O. Edinburgh.
4) Smith, R.A. 1999. *Geology of the New Cumnock district – a brief explanation of the geological map.* Sheet explanation of the Geological survey 1:50,000 Sheet 15W New Cumnock Scotland. Keyworth Nottingham British Geological Survey.
5) Smith, R.A., Bide, T., Hyslop, E.K., Smith, N.J.P., and McMillan, A.A., 2008. North Ayrshire, East Ayrshire, and South Ayrshire. Map scale 1:100,000 *Mineral Resources. Mineral Resource Information for Sustainable Communities.* British Geological Survey.

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ROUKEN GLEN : 7 May 2009
Leader : Dr John Faithfull, Hunterian Museum
Report by : *Margaret Greene* Participants : 18

Our group met John Faithfull at the boating pond in Rouken Glen (NS 550580) on a wild and windy May evening. John started by giving a background to the rocks in the park and pointing out that the glen is an SSSI. This site is of national importance as it is virtually the only place in the west of Scotland where the Orchard Beds of the Upper Limestone Group of the Carboniferous can be seen. Unfortunately some of the best exposures have been covered by a landslip, and John, with the backing of Strathclyde RIGS, is hoping to persuade the Council to clear this site. As the group walked round the pond John pointed out some blocks of limestone in the bank of the pond. These rocks are not lying *in situ* but may have been dug out when the pond was created as they are similar to the limestone one would expect to find in the park. At the side of the pond there are some large, fairly flat lying blocks of sandstone; these show signs of striae from the last glaciation with the ice flowing in a southerly direction.

After leaving the pond and passing over the waterfall we came to a large outcrop of the Giffnock Sandstone. The site is locally known as the 'picnic rocks' for obvious reasons as in the summer you can hardly see it for people! John drew our

attention to the fact that this outcrop has a steeper dip than beds next to the pond and pointed out some examples of cross-bedding. This sandstone can also be seen in the steps down into the glen, and on the bank opposite the steps where you can see the layers becoming thinner as the Carboniferous environment changes. Beyond the picnic rocks John led us into a small valley where there is an impression of fossilised wood in an overhang in the sandstone.

We then descended the stairs into the glen. At the foot of the steps on the opposite bank there are a number of interesting layers which John pointed out. There is a small seam of coal without any evidence of roots and he explained that this was probably from a raft of peat which had floated into a river channel. There is also a layer of siderite nodules in the bank and layers of siltstone, all indicating a mixture of floodplain and swamp environments. John had hoped to retrieve some examples of *Locheia* but the river was running too high. *Locheia* represent feeding burrows of small burrowing creatures and are found in shallow marine conditions indicating marine inundation of the floodplain. Further down the river we encountered an area where a number of large trees have fallen across the stream, and on the opposite bank there is an area of landslip which covers the previously excellent exposures of the Orchard Limestone. Some lumps of shale retrieved from the river had numerous fossils in them, including bivalves, goniatites, brachiopods and crinoids. Just before this section John had pointed out where a small stream came into the Auldhouse Burn; at this point there is a rib of hard fine-grained limestone which is of the "Lower Orchard Limestone" and had been 'lost' since 1908 until he and Chris Burton found it in March 2007. We carried on downstream, past the level where there is a large overhang of sandstone indicating that we were now out of the marine succession and back to the big rivers advancing to the sea. Following this we made our way up from the river and back to the beginning.

Bill Gray concluded our excursion by extending our thanks to John for guiding us along this very interesting and accessible section of Carboniferous geology.

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BATHGATE HILLS : 16 May 2009
Leaders : Dr Allan Hall, Dr Rona McGill & Dr W.D.I. (Ian) Rolfe.
Report by : *Charles Leslie* Participants : 15

The East Kirkton Quarry near Bathgate (NS 990690) has yielded a rich fossil record of terrestrial organisms dating from just before the major marine transgression which produced the Early Carboniferous Lower Limestone Formation rocks. Elsewhere in the world, environments in which these early organisms lived have been eroded away along with their remains, but here, a lava capping has preserved them. Scientific interest in the quarry site, which fortunately had not been used for landfill after operations ceased in 1844, was rekindled by the discovery of the remains of an air breathing reptilomorph, *Westlothiana lizziae*, 'Lizzie', by Stan Wood in 1984. The National Museums of Scotland then initiated a major systematic study of the individual strata in the quarry, led by W.D.I. (Ian) Rolfe, whom we were fortunate to have as one of our leaders. Three major groups and six quite distinct

species were identified during the study from 1985 to 1992 in which at least forty-five world-wide experts and numerous volunteers participated. Detailed logs of rock types and fossil finds in a 1 metre section through the southwest of the quarry were published in the Transactions of the Royal Society of Edinburgh in 1994. 'Lizzie' was found near the bottom of the section but all the lower layers are dominated by air-breathing, lung-bearing scorpion-like amphibians, with fossil fish and bivalves only appearing in the later Geikie Tuff and Little Cliff Shales, as brackish conditions were established on the edges of what had been a fresh water lake.

At the nrthern end of the quarry, limestone layers are interlaced with black organic laminae which contain mm diameter calcite spherules of algal filaments. These cool water organisms accumulated as mats on the lake floor while others built into stromatolites. Close by are fine textured localised layers of pure silica, estimated, from stable isotope analysis, to have been precipitated at 65^0 C when hot silica rich fluid, perhaps from a hot spring on the flank of the Bathgate volcano, met the cool waters of the lake. The picture that emerges is of an essentially fresh cool water lake into which organic rich debris was brought, while hot springs introduced silica rich fluids from nearby volcanoes. Air breathing organisms lived around this lake, with its algal mats producing limestones. However, the land was finally overtaken by a shallow sea which introduced 'marine limestone forming' life.

On the drained Petershill Reservoir site (NS 985696) beds of *Gigantoproductus* were examined, amongst the broken remains of both colonial *Lithostrotion* and solitary *Caninia* corals, which form the Petershill Limestones, stratigraphically equivalent to the Hurlet Limestone in the west at the base of the Lower Limestone Formation. Locally beds generally dip to the west, so the next set of rocks examined to the NNW, towards Cairnpapple Hill, were younger and equivalent to the Hosie Limestones. Although sea levels fluctuated, they were never very high in this area which then sat on the Burntisland High, so wave disturbed limestones are common. At times, the area was even subaerial with karst weathering of exposed limestones and infilling of grikes with sandstones in which rootlets formed. The heat of the nearby volcanoes forced fluids through the fractured limestones causing dolomitisation but even this impure limestone was good enough for use as a soil improver.

At the northern end of the workings, the limestone exposure is cut off by a NNW – SSE Late Carboniferous dolerite dyke, while an overburden of lava, erupted at the end of the Lower Limestone Formation, restricted quarrying to the west. However, collapsed audits indicated that mining of limestone had continued in that direction. The dyke is interrupted at about NS 995718, where a stream runs through a small valley, the site of the Hilderston Silver Mine. Vein deposits were emplaced as hot fluids from the Early Carboniferous volcanicity mobilised minerals, but here, the silver, deposited as a rich pod, was quickly exhausted in the early 17^{th} Century. Lower grade veins were worked throughout the 17^{th} and 18^{th} Centuries but by the 19^{th} Century most of the activity was in processing what had earlier been gangue minerals, barite, galena and nicollite. Time did not permit a visit to the exposure of the Petershill Limestone on the east side of the dyke (and road) and the site of its 19^{th} C processing plant, but from the maps supplied and the easy access, personal visits should be possible later.

The leaders were thanked for their enthusiasm and patience in answering the many questions and for the detailed list of references supplied.

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HIGHLAND BORDER SLATE QUARRIES : 6 June 2009
Leader : Dr Joan Walsh
Report by : *Muriel Alexander* Participants : 25

On a bright, sunny but chilly morning we visited the slate quarries at Aberfoyle with Dr Joan Walsh who is a specialist in all things slate. After a quick stop at the David Marshall Lodge we continued up the Trossachs road until we branched off onto a track at a cottage on the left (NN 515031). We set off on foot up the track and our first stop was to investigate slate spoil at the trackside. Here Joan told us about the history of the slate industry in Scotland. Records from the 17th Century indicate that slate was used to roof Stirling Castle in 1625 along with Glasgow and St Andrew's Cathedrals and the industry peaked in the 19th Century as cities grew and housing developed. There were four main slate localities – Easdale, Ballachulish, Aberfoyle and Aberdeenshire (near Huntly), with the first two benefitting originally from their closeness to the sea and thus having ease of transport to markets. At the Aberfoyle quarries, transportation problems limited production until the introduction of a railway to Aberfoyle in 1882. However all quarries were finally closed by 1960.

Further up the track we were fascinated by the different colours of the broken slate which varied from shiny greens to purples and silvery grey. Joan explained that slate and grits were formed from marine muds and silts which flowed as turbidity currents from the continental shelf into subsiding basins and were later metamorphosed at low grade, greenschist facies, by the heat and pressure of deformation during an orogeny, in this case the Grampian Phase of the Caledonian Orogeny. The mineral chlorite is produced during low grade metamorphism giving the slate its green colour, while in an oxidising environment the presence of haematite gives it a purple-red colour. Joan compared the fine, colourful slates of the well oxidised basins of the Aberfoyle area with the black Ballachulish and Easdale slates where the sediments were laid down in stagnant, anoxic basins. In the latter, carbon was not oxidised but formed dark graphite, and bacteria used the sulphur to form cubic, pyrite crystals in the slate. The Aberfoyle quarries are part of the Highland Boundary Slate Quarries which outcrop along the line from Arran to Dunkeld. They are part of the Southern Highland Group of the Dalradian Supergroup, the main structure involved being the metamorphosed fold of the Tay Nappe.

As we climbed further we came to the first of several quarries that we explored. We were told that the quarries were worked on three levels, the oldest being further back and nearest the top so this was one of the last worked on the lowest third level. The quarries were not originally worked systematically, although after 1947 mechanism improved this. The slate was worked by about twenty men in units of four, two cutting and two dressing, and each team worked independently on an area they leased for a year, early transport being supplied by animals and later a tramway. Spoil heaps were seen dumped near the quarry being worked and dressing areas were

found where the slates were split along cleavage planes and trimmed to irregular dimensions, but there was 90% wastage. Earlier buildings seen by Joan were now demolished but after a scramble to the oldest top area a low, stone, emergency shelter was still standing. Triangular holes in the slate were found where poles had been hammered in and turned to break the rock. Barrow runs for tipping waste rock and the rail remains of the old tramway were also found.

Having lunch in a slate quarry ***Margaret Donnelly***

As we visited the various quarries we noted how the seams were worked and examined the cleavage/bedding intersection in the slate. The latter requires to be close to parallel to provide good quality slate; it was also an indication of how near we were to the nose of a fold. On the handout provided, a geological sketch showed the Aberfoyle Slates bounded by grits. We were therefore delighted to find rocky crags near the quarry area with an outcrop of the grits, and inspection of the graded bedding revealed the direction of dip and that they younged upwards. These were the Leny Grits, which have been equated with the Ben Ledi Grits to the northwest which young downwards. We were standing on one limb of the recumbent Tay Nappe

On walking back to the bus we looked down towards the road to where the small community of quarriers' cottages, including a school, had once stood. Joan had enthused us, not only with the geology of the area, but also with the history of slate quarrying in Scotland and with the life and times of the quarrymen whose work roofed so many buildings still around us today. We had had a really enjoyable day, learned a great deal and our thanks go to her for taking the time to share her knowledge and expertise with us.

BALLANTRAE – METAMORPHICS : 11 July 2009
Leader : Dr Simon Cuthbert
Report by : *Margaret Donnelly* Participants : 22

We left Glasgow on a lovely morning, despite dire forecasts, and headed south for the Ayrshire coast where the views were stunning in the blue sky and sunshine. We parked in a large lay-by on the A77 just south of Pinbain Hill, about one km north of Lendalfoot, and our leader gave us an introduction.

The Ballantrae Ophiolite Complex (BOC) lies south of the Midland Valley block, a Palaeozoic volcanic arc complex possibly founded on old metamorphic basement[2], but north of the Stinchar Valley Fault, a branch of the Southern Upland Fault. It was formed during the Early Ordovician, as were the Highland Border Complex and Shetland Ophiolite, and contains a wide variety of lithologies, originating from mid-ocean ridge, island arc, subduction zone and sub-oceanic mantle. It has all the elements of a classical ophiolite, commonly found in orogenic belts, and is thought to represent "obducted" slices of oceanic crust marking the "suture" between two continental masses, following the subduction of an ocean. The BOC lay at the edge of Lower Palaeozoic Laurentia, and is now generally believed to have developed in a supra-subduction zone. It is tectonically disrupted – most of its elements are fault-bounded, or occur as isolated blocks in olistostrome melanges (mud-matrix conglomerates and breccias which can include enormous blocks). Metamorphic grade varies from prehnite-pumpellyite through greenschist, blueschist, amphibolite, granulite and possibly eclogite facies, with some metamorphic dates at around 480 and 465 Ma. The BOC has implications for understanding the Caledonian Orogeny in the British Isles – its obduction may have played a part in the cause of the Grampian Phase in the Scottish Highlands, and so this is an extremely important area of Scotland[2, 3, 5, 7].

We went down onto the shore to explore the dark green rocks – serpentinites, formed by low temperature hydration of olivine, enclosing pale gold-brown grains of bronzite (partially serpentinised enstatite, an orthopyroxene). They were originally harzburgite, from a depth of around 10 – 30 km, the residue left after basaltic melt (as pillow lavas) had been extracted from a more fertile clinopyroxene-, Al- and Ca-rich lherzolite peridotite. Intruded through these was a spectacular coarse-grained pegmatitic gabbro – Bonney's Dyke (NX 135911) containing augite and feldspar, and xenoliths of the host serpentinite rock in its margins. This was cut by a series of strike-slip faults with some ductile shearing – it had 'slid over itself', the gabbro had been streaked out and there were slickensides. Ductile deformation, about 1m wide, along the northern margin had occurred before the crossfaults. A tough, white rock with a "flinty" fracture occurred within this shear zone and in narrow shears within the gabbro. This is "rodingite", made up mainly of calcium-rich silicates such as hydrogrossular garnet, prehnite and pumpellyite, and is the result of calcium metasomatism ("rodingitisation") of the gabbro, when it was flushed through with minerals and fluids escaping from the serpentinites. This process had also severely altered the minerals of the gabbro, but in the absence of deformation, so that they are "pseudomorphed" (replaced *in situ*) by calcic silicates, giving the cloudy white colour.

Pale greyish/green veins of very coarse-grained pyroxenite, mainly diopside and now serpentinised, had been injected through the darker (olivine) harzburgite – a 'flow through' of clinopyroxene which was refertilising the depleted mantle. These are similar to veins found in mantle xenoliths from kimberlites (up to 200 km deep) and in other ophiolites such as that of the Lower Ordovician Bay of Islands in Newfoundland. They are associated with the generation of boninites – unusual, high silica lavas, rich in magnesium, nickel and chromium, and derived from the partial melting of depleted mantle in a wedge, aided by fluids from a subducting slab. Boninites often occur in modern subduction zones, and they are also found among the lavas of the Balchreuchan Group of the Ballantrae Complex[6].

Our group examining Bonney's Dyke ***Charles Leslie***

We had lunch on the beach and on the grass, looking out to brilliant views of the Ailsa Craig, Arran and Kintyre. Some of the company claimed they could even see Ireland! We then drove south to Lendalfoot, and turned left along a minor road (for about 5 km) to a small quarry (NX 170917) near Knocklaugh Lodge. Our leader gave us a further introduction.

This area is crucial to understanding Highland Geology of about 470 Ma. Within a few tens of metres, we can traverse structurally upwards through the obduction plane of the Ballantrae Ophiolite, from the sedimentary cover of the Balchreuchan Group (upper oceanic crust in the footwall) to the lower parts of the overthrust, hot oceanic mantle peridotite. Ascending the hill, the metamorphic grade of the rocks increases upwards, implying a heat source from above – a large, hot mass of mantle peridotite and pyroxenite (the serpentinites of the upper slope) lying over cold, shallow spilites and black mudstones. The rocks also have a very well-developed tectonite fabric (foliation and gneissosity), indicating that they have

experienced intense deformation during heating – 'dynamothermal metamorphism', forming a 'dynamothermal aureole' or 'metamorphic sole'. Similar 'soles' occur at the mantle base of other ophiolites, and are thought to represent the obduction surface. Notably, there is an extreme temperature gradient over a small distance into the footwall below the sole thrust, and the recorded pressure range in the rocks is at least 10 kilobars over less than 200 metres (the lithostatic gradient is 1 kbar for every three kilometres). Some "retrogressive metamorphism" linked to shearing has occurred, but high-grade minerals have survived. The evidence suggests that thrust faults or shear zones, difficult to locate under the soil, have cut the section, excising large parts of the crust, and possibly mantle, and placing together slices of rocks originally from very different depths. This was, then, a process of accretion in which blocks from the hanging wall and from the footwall were piled on top of each other during obduction.

We set off up the path to the first outcrop, of bituminous black shale faulted against rotten serpentinite (an outlier of the main Northern Serpentinite), and then on to the quarry face – a carbonised melange of organic rich claystones formed in an anoxic environment. This was interfingered with well-weathered blocks of spilite – a low grade metamophic basalt, formed at 900^0 C – 1000^0 C, about 15 kms depth. Further up we came to an unfoliated grey-brown weathering, fractured spilite with phenocrysts of plagioclase, possibly an olistolith. Pillow shapes suggested eruption into a semi fluid mud. We walked back left above the bracken to the streambed and found shattered black shale, with metabasalts and then unfoliated metagabbro. As we moved upstream, shearing became apparent; the well-exposed rocks were now platy, porphyroclastic, mylonitic amphibolites (actinolitic hornblende), with epidote filling curved laminations. This epidote mylonite rock formed at 450 – 500^0 C, and low pressure of about 4 – 5 kbar. On the east bank, some 15 m higher up, was a coarser-grained amphibolite (with plagioclase) which, on the opposite bank, was well foliated and gneissic, and beyond it was a tough, mafic, gneissic mylonitic amphibolite. We continued up the slope to the right and to scattered outcrops of hornblende-garnet-granulites with significant garnet and plagioclase. Returning to the stream, we found, across the streambed, a pale brown rib of finely laminated mylonitic serpentinite (possibly a tectonised harzburgite), veined with pale, creamy green tremolite and serpentine smears. We had just crossed the Moho!! These rocks show very high shearing and are extreme high temperature tectonites. Some of the group continued further upwards to scattered exposures of clino- and orthopyroxenite, extensively altered to tremolite and serpentine – rocks of the mantle, and at the transition between granulite/eclogite facies. Garnets (the high temperature pyrope) are present, but this is a rare lithology should not be sampled. Treloar *et al*. (1980) estimated at least 10 – 11 kbars (possibly up to 15 kbars) of pressure at about 900^0 C, corresponding to depths of 35 – 45 km. A prominent crag across the hillside to the west is of layered olivine websterite, apparently lacking garnet, while the flatter ground exposes abundant layered harzburgitic serpentinites; the layering here is oblique to the strike of the metamorphic sole. Struggling to take in all this evidence, we made our way back down to the bus where our leader provided a summary.

The obduction of this unit marked the start of the Grampian Orogeny in Scotland, and may have contributed to the deformation and metamorphism in the Dalradian rocks on the far side of the Midland Valley in an 'island arc – continent'

collision. However, the base of the section has suffered only low-grade metamorphism, indicating that the overriding nappe was fairly thin – it may have been eroded as it emerged. This suggests that the Ballantrae Ophiolite Complex itself could probably not have been thrust to the north over the Dalradian, and so the rock units around Ballantrae could not directly have caused the Grampian deformation and metamorphism. However, it is still possible that a large northern section of the Midland Valley arc terrane was thrust onto the Dalradian, and that the BOC represents the rearward thrust slices of a much larger nappe complex (an imbricated arc/back-arc system) that now underlies much of the Midland Valley.

Our last stop was back on the shore near Pinbain Hill to examine the olistostrome melanges (breccia-conglomerates) of the Balchreudhan Group. Some were clast-supported, consisting mainly of spilite, with recognisable pillow structures, while one large boulder had a dark argillaceous matrix and a variety of clasts – spilite, gabbro, granulite ("beerbachite"), trondhjemite, diorite, limestone (probably carbonated dunite) and serpentinite. Amphibolite, blueschist and greenschist clasts may also be found. These clasts have come from a range of sources: lavas, the subducting slab, the deep ocean section, the mantle and the base of a related arc island complex. Mechanisms for exhumation may have included detachment and motion of slab fragments back up the subduction channel, diapers of serpentine and mud rising vertically through the fore-arc, and thrusting together with erosion during obduction of the ophiolite. The lavas and tuffs in the melange indicate active volcanism, and throughout all this time a significant mountain range may have been rising.

We returned to the bus and thanked our leader enthusiastically and sincerely for such a fascinating excursion and a truly enjoyable day.

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ISLE OF BUTE: EAST COAST : 15 August 2009
Leader : Julian Hill
Report by : *Marion Ballantyne* Participants : 16

The weather was not promising when we met at Wemyss Bay, but on arriving at Rothesay the sky cleared. We were met by Elsa Henderson at Ascog, (NS 110630) who gave us a short talk on her most recent discoveries from Ascog beach. Many fragments of fossilised wood could be found on the beach, including a six foot log which at time of tide was just too far out for us to inspect. Some fragments of the trees have also been found within volcanic tuff. Elsa's collection included many fine examples of silicified sections of trees which she herself polished, one in particular revealing a radial formation. This would indicate a forest of Carboniferous age lying beyond the Ascog shore.

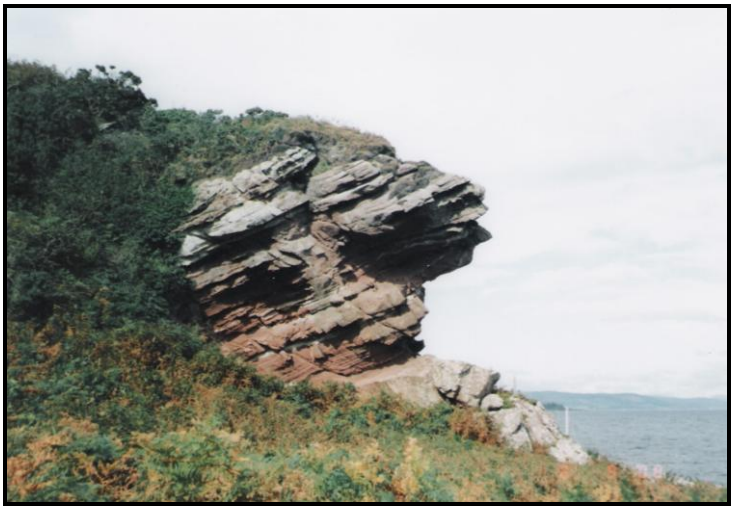
Upper Old Red sandstone is a typical combination of brown sandstones and coarse conglomerate. When bedding is found it tells of river-deposits of sand and pebble beds in a sequence of advancing deltas. Research has shown that the Upper Old Red Sandstone was laid down by seasonal rivers draining east and northeast, away from the high Caledonian Mountains to the west and southwest. The pebble beds are dominated by clasts of grey-green schists and quartz, all derived from Dalradian rocks. Ascog Hill is formed of a thick series of lava flows. Along the shore within the proximity of the hill, a sequence of lava, shale, sandstone and coal are exposed. This coal seam was utilised at one time. This site shows rapidly changing environments of Lower Carboniferous lagoons and river deltas.

We proceeded to Kilchattan Bay and by this time the weather had much improved. We went down on to the beach and sitting beside the Columnar Sandstone Formation we enjoyed lunch (NS 110540). This is one of the most famous rocks in Scotland, the highly unusual Columnar Sandstone first described by Glen in 1877 and in greater detail by Buist 1980. The rock, unique in Britain in respect of the perfection of the columns, was produced by thermal metamorphism of Upper Old Red Sandstones. The columns developed probably as a result of emplacement of a basic dyke via a fissure, with steam and other volatiles from the hot magma injected through the fissure. Columns result from contraction of heated bedrock on cooling. The metamorphic effects are considerable, extending well into the sandstone – north, south and west, with the columns extending into the cliff. The resulting 'cooked' sandstone is very pale coloured, brown iron oxide lost in the metamorphism. The heat source is not visible – the gap in the outcrop is where the dyke has been removed by marine erosion. The columns fade out further from the heat source into normal Old Red Sandstone.

The next rocks of interest were the glacial erratics sitting on a bedrock of Old Red Sandstone – schists carried by ice from their outcrop and left stranded.

These rocks have travelled in a distinct north-south trend down the east coast of Bute. Erratics can travel tens of kilometres. Tough rocks like Dalradian schists and grit, dolerite or basalt tend to travel better. On this trip evidence has been found of changing sea-levels and can be seen as caves within volcanic vents and raised beaches. Walking beneath the cliffs ahead we could see Cumbria showing its layers of lava which were quite distinct. These lavas have a similar petrology to the lavas of Bute.

On going down on to the beach at White Port we saw a group of Tertiary (60 Ma) dykes within Old Red Sandstone. In some cases the dykes themselves have been eroded leaving the tougher metamorphosed sandstone standing proud. This is especially true in the most southerly of the group – a wide dyke with a high upstanding edge, where the metamorphosed zone extended several metres on to the south side, with iron oxide bands mixed within the white bleached quartzite. This dyke was recently discovered (by Elsa Henderson) to have developed thin, irregular short columns in the surrounding sandstone – a columnar sandstone, not as obvious or as well developed as the one at the start of the walk, but yet another example. Back to the path and continuing south ahead of us was the impressive dark headland of Creag a' Mhara. A little to the north of the headland Carboniferous lava flows overlie the sandstone. The headland consists of a massive volcanic vent of agglomerate extending from the shore inland. Blocks of lava embedded in a matrix of ash, together with small fragments of cornstone and sandstone, all testify to the explosive phase of the vent. Much is stained by haematite, the product of a later basaltic intrusion which invaded the vent. The next prominent feature is Hawk's Neb – a most impressive undercut cliff of brown sandstone tilting inland into thick cornstone, now regarded as lowest Carboniferous. The band of cornstone is very weathered along the shore south of Hawk's Neb.



Hawk's Neb. ***Margaret Donnelly.***

Returning to the shore we came upon an upstanding mass of black rock exposed around high water mark. This is a famous Bute outcrop (NS 120530), the 'ultra-basic intrusion' which has been drilled through Lower Carboniferous sedimentary rock at a high angle (70 degrees). Buist (1953) and Matheson (1962) have provided descriptions of this rare rock. Mitchell *et al.* (1980) concluded that the intrusion is possibly unique in that it contains such a varied assemblage of ultrabasic xenoliths in a small area. This is lava enclosing angular lumps of dunite, serpentinite, pyroxenite, altered gabbro and olivine basalt. The intrusion dragged many of these rocks from depth in the crust, and possibly from the mantle. A wide age range is present and no simple interpretation is possible. However, the whole mass was intruded in late Carboniferous times around 390 Ma. The force of the intrusion can be seen a little to the north in the beach where the older Carboniferous cementstones were sheared and pulled up. Matheson also located a second smaller, ultrabasic intrusion high up in the Hawk's Neb volcanic vent 100 m to the north of the main outcrop, concluding that the two intrusions are identical in composition.

We returned to the path and proceeded back to the mini-bus where Michael Pell gave the vote of thanks, cordially thanking Elsa and Julian for a most enjoyable day.

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ISLE OF GIGHA : 18 – 21 September 2009
Leader : Dr Jim Macdonald
Report by : *David McCulloch, Margaret Donnelly* Participants : 23

Friday 18 September

After checking into the community-owned Gigha Hotel, we walked down towards the ferry slipway. At the road cutting (NR 651489) we got our first taste of one of Gigha's dominant rocks. Formerly referred to as epidiorite, amphibolites on Gigha consist of meta-igneous rock of basic composition which may have originated as sills, laccoliths or lava flows. It is older than the Tayviallich Volcanics but younger than the Easdale Slates (i.e. somewhere between 635 Ma and 600 Ma). The foliation has a general north-northeast trend and dips westwards. It tends to form ridges in the landscape, often covered in thorny scrub; onion skin weathering points to its basic composition. At the road cutting we saw quartz veining which must have postdated the intrusion and formed during the later (Ordovician) metamorphic event. The metamorphism is of greenschist facies with intense shearing locally. We examined Gigha's 'other' rock type where the road meets the shore. This is the Erins Quartzite, comprised mainly of psammitic and semi-pelitic rocks. The 'bedding' is in fact likely to be flattened fold limbs.

An excellent path led from just south of the hotel to the outcrops around the little beach at Port a Chinn Mhoir (NR 651486). We learned that over much of the island there is no sharp contact between the amphibolite masses and the Erins Quartzite. The foliation tends to wrap around the amphibolites and so varies locally from the NNE regional trend. The pods may be macro-boudins of competent amphibolite which broke apart from a larger body or bodies when subjected to shearing, whereas the less competent sedimentary rocks were folded or sheared. After

following the headland round to the south we noticed that the shearing was concentrated at the boundary between the amphibolite and the quartzite.

Later, we climbed to the summit of Crag Bhan, at 100 metres the highest point of Gigha. This allowed us to get a feel for the geography of this small island as well as enjoying views to Islay, Jura and Kintyre.

Saturday 19 September

We started our walk at the northern terminus of the road at Port Mor. After a couple of hours of rain the sun broke through to give a fine day. We walked east to the furthest point at the headland (NR 668542) before returning to the cars. We first passed an outcrop of schist where the foliation had been folded. This was likely to be a meta-igneous rock, possibly a meta-tuff. Later on we found an epidotic pod within the amphibolite, and some clear signs of glacial striae on the ice-smoothed rock. We also noticed a discontinuity caused by a shear plane cutting across the foliation. Near the east end of the first sandy bay we noted a sudden change in lithology to laminated pelite and quartzite as we crossed into the Erins Quartzite. Dr MacDonald explained that this schist appeared to have been subjected to low grade metamorphism. These rocks originated as shallow water sediments – sands with varying amounts of clay and subordinate carbonates, possibly in intertidal, lagoonal or deltaic environments. They are older than the more familiar schists of the Tay Nappe and pre-date the opening of Iapetus. Further on we could not fail to notice a marked crenulation cleavage at right angles to the main foliation. A basalt dyke prompted discussion about the relative hardness of the basalt and the country rock. Even though basalt is harder, it is more prone to chemical weathering by sea water and so has formed a dyke slot close to the shoreline.

Spectacular folding ***Margaret Greene***

We crossed a headland to the second bay which contained a beautiful beach. At the east end we spotted another dyke. This olivine dolerite is of Tertiary age but here it does not follow the typical northwest-southeast Tertiary orientation – it has been influenced by the regional north-northeast foliation trend. After passing a third bay, at the furthest point of the walk (NR 668542), we were rewarded by an outcrop of quartzite containing spectacular folding. These more competent quartzite beds resist the shearing stress and fold rather than shear. The obvious foliation in the pelitic beds within the folds allowed us to see clearly how the bedding related to the foliation.

After returning to the cars we had lunch on the beach. We then drove back along the road and walked down to the tombolo connecting the main mass of the island to Eilean Garbh. The Gaelic name means Rough Island and it certainly lived up to its name. The tide was high so we had to follow the coastline south with the aim of reaching the southern tip of Eilean Garbh. We never made it that far! Chest-high bracken, nettles and thorns hid very uneven bouldery ground which inclined steeply towards the sea. We hacked a way along the embankment but about halfway to the point we decided that enough was enough. Some in the party climbed up onto the ridge but the terrain was little easier and we returned by the outward route. We did however find an outcrop of amphibolite on the ridge containing flow textures. This could not be a migmatite due to the low grade metamorphism, and so was interpreted as a relict of original igneous textures. Anyone wishing to visit the peninsula to see the large amphibole crystals (2.5 cm in length) should choose low spring tide in the spring, when the bracken has not yet grown!

After a further drive southwards we walked down to the shoreline at An Fhang (NR 653530). A dyke formed a tall cliff bounded on both sides by gullies. As we followed the dyke to the shoreline it divided into two dykes which intersected each other in sinuous curves with a 'dragon's tail' extending out to sea. Fold noses were apparent in the country rocks being splashed by the sea. Nearby, a large quartzo-feldspathic mineral vein attracted attention. The white quartz and the brown feldspar crystals were seen to be growing into each other. The occurrence of these veins in the Dalradian of Gigha is an indication that the metamorphism was at the high end of greenschist facies.

Sunday 20 September

We set off on a sunny morning, in cars and on foot, to cover the couple of kilometres to South Pier, where we crossed a broad raised beach down to the shore at Port na Carraigh, just west of the pier (NR 643464). Erins Quarzite, striking almost N – S and dipping to the west, was interbedded with sheared phyllites. The former was less affected by the shearing, and one of our party found faint cross-bedding in a substantial outcrop, which indicated a younging direction to the west. This was confirmed by small chips from each side which showed graded bedding. The rocks are of greenschist facies with the bedding parallel to foliation; the isoclinal folding was picked out by quartzite beds. Cutting the beds was a basaltic dyke with vesicles; this suggested low pressure allowing the gases to escape, and that the dyke had come close to the surface. It curved and branched to fit the foliation which ran roughly north to south at this locality. We walked southwards past more massive beds of

quartzite with a northwesterly dip and came to a second Palaeocene dyke, this time amygdaloidal with zeolites filling the vesicles. It was also parallel to the foliation,

One view of the dyke at An Fhang ***Margaret Donnelly***

The two 'Doctors' examining the direction of the dyke
Margaret Greene

just east of N – S. Beyond this was a face of strongly foliated quartz-chlorite-schist, and then, at Port Beulan Faing (NR 636457), we passed through a gap in cliffs of massive foliated quartzites, and searched unsuccessfully for bedding structures. We arrived at Port Mor, at the southern end of Gigha, and a huge basic intrusion which occupies the southwest of this promontory together with the adjacent Eilean Leim. Its contact with the country rock was sharp and clear, and the metasediments reddened, suggesting that they were baked when this 'sill' had been intruded. We climbed high to get an overview, and then found the 'Spouting Cave' – a deep gully roofed over by fallen blocks. We could hear the waves roar deep down below and just see, through a cleft, a beach with 'super' polished and rounded cobbles, moving back and forth in the surf. With a rougher sea this cave does indeed spout!! Closeby we found a spectacular quartz vein injected through the rocks. We settled down for lunch in a sheltered spot up here on the intrusion.

We then spent time investigating the locality in more detail. The intruding amphibolite 'sill' appeared to be doleritic. It had enclosed and baked rafts of laminated sandstone, and had massive joints, some of which formed giant curves. Strong shearing had exploited weaknesses in the intrusion, and here we found bronze coloured phlogopite (a magnesium mica often found in foliated aggregates and in some ultra basic rocks), and crystals of pyrites. Scrambling over the rock we found ever more features, before climbing to the top from where we had a fine view of the coast to the northwest, and our next locality. We descended to Gròb Bagh (NR 634462), where the intrusion looks more 'gabbroic', and examined the contact at the water's edge – again clear and sharp. Along the shore were strongly folded, metamorphosed laminated sandstones, still with traces of original bedding, and interbedded with thicker, folded and dismembered beds of quartzite. The rocks were a mass of isoclinal folds and included some obvious Z-folds. Following the edge of the bay, we came to a small headland, Rudha Ban, composed of a thick and persistent quartz vein which extends for about 150 m out to sea and is roughly parallel to the foliation. This white streak of rock formed when a tension crack opened and silica was precipitated from pore water; it is clearly visible from the top of the sill. As we reached the western end of the bay, the foliated quartzite was replaced by phyllite – its shiny grey foliation planes containing chlorite, characteristic of greenschist facies metamorphism, and indicative of an original clay-rich sediment.

A dark grey cliff loomed ahead (NR 631463). Its rock had a well developed penetrative foliation, with occasional thin sheets of fairly angular quartz grains extending through it at intervals, and, in places, small, well-formed cubic crystals of pyrites. Later examination of thin sections established that this is a very fresh quartz-chlorite-schist with subordinate biotite and carbonate, and its protolith (original rock) must have been sedimentary, probably a fine-grained sandstone or siltstone, with a significant clay content. Regularly spaced indentations were spread over the surface, the result of carious weathering. The outcrop extended some distance down to the waves where a number of un-foliated inclusions (up to ~30 cm) were eroding out. Their mineralogy (largely epidote with significant amounts of carbonate) suggests that they could have originated as carbonate nodules formed during diagenesis of the sediments. All this is consistent with the evidence from the Erins Quartzite in Gròbh Bagh and elsewhere in the south of Gigha that these Dalradian sedimentary rocks

were deposited in a deltaic environment, probably in part shallow water marine or intertidal. The presence of biotite in the schist indicates that the metamorphism was at the high end of greenschist facies, fitting with the composition of the quartz-feldspar veins that we observed farther north at An Fhang. We spent some time exploring the area before heading back to the cars and the hotel. After dinner, many and enthusiastic thanks were expressed to our leader for giving of his time and expertise, and for guiding us on such a unique and interesting field trip.

The group after lunch at Port Mor ***Margaret Donnelly***

Mon 21st Sept

This was a very grey, damp morning and most of the company decided to head for an early ferry. However, some brave souls met the Director of the Gigha Heritage Trust who had kindly agreed to show us the island's working quarry, in the high ground about 2 kms south of the hotel. Large blocks lay around the base of the quarry face, while three or four heaps of broken and crushed rocks, arranged according to clast size, awaited transport to various parts of the island. Although the rock is clearly amphibolite, thin sections reveal some relict cores of pyroxene. It is used mainly for road metal and aggregate, with the fine material acting as binding agent. We finally surrendered to the weather, headed back to the hotel for coffee, and then to the ferry and mainland, after a truly fascinating weekend.

GENERAL INFORMATION

Scottish Geological Societies-ConocoPhillips Awards.
These were awarded to pupils from

Ellon Academy	Int. L 1
Portree High School	Int. L 2
Dingwall Academy and Perth High School	Higher

Scottish Festival of Geology. 1st to 30th September 2009. This is now held annually. A variety of events were held across Scotland. The BGS Open Day was on Sat 26th Sept. Details of events were available on the website: www.scottishgeology.com

Expedition Funding.
The University of Glasgow Exploration Society planned an expedition to East Iceland in 2009. These expeditions are made annually, but for the first time in at least five years, three Earth Science students were involved. They were Stephen Fullerton, Freya Marks and Kamil Swiatek, of whom two are recent members of our Society. An award of £600 was made to the expedition, with the expectation of a talk at Members' Night by one of the participating students.

INTIMATIONS

With regret we record the deaths of

Dr A.M.Hall, member since Session 113 (1970 – 71), who died in the spring of 2009.

Mr Edwin Kellock, member since Session 95 (1952 – 53), who died in early July, 2009. He lived in Port Knockie, near Buckie, and was made an Honorary Member in December 2002. All the material from his life-long geological studies including his slides, computer and two microscopes, were donated to the Kirkwall Museum, Orkney Islands, where it will be on permanent exhibition, and available for access by any geology students.

Front cover photograph – Columnar Baked Sandstone, Isle of Bute. *(Margaret Donnelly)*

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