PROCEEDINGS OF

THE GEOLOGICAL SOCIETY

OF GLASGOW

Seafield Tower and sandstone outcrop (Kircaldy)

(Photo courtesy of S.Leishman)

Session 156 **2013-2014**

SESSION 156 (2013-2014)

SESSION156 (2013-2014)
Members of Council

President	Dr. Brian Bell
Vice Presidents	Miss Margaret Donnelly
	Dr. Ben Browne
	Vacancy
Honorary Secretary	Dr. Simon Cuthbert
Treasurer	Dr. Ben Browne
Membership Secretary	Dr. Robin A. Painter
Minutes Secretary	Mrs. Margaret L. Greene
Meetings Secretary	Dr. J.M. Morrison
Publications	Mrs. Mina Cummings
Librarian	Dr. Chris J. Burton
Asst. Librarian & Hon Archivist	Mrs. Margaret Anderson
Proceedings Editor	Mrs. .Mina Cummings
Publicity	Dr. R. A. Painter (general)
Excursion Secretaries	Vacant
	Ms. Katerina Braun (Residential)
Junior Members' rep	Mr. Scott Jess
Editors of S.J.G.	Dr. Colin J.R. Braithwaite
	Dr. Brian Bell
Webmaster	Dr. Bill Gray
Website Coordinator	Miss Emma Fairley
Website Consultant	Dr. Neil Clark
Ordinary Members	Miss Alison Drummond
	Dr. Walter Semple
	Dr. David Brown
	Mr. David Webster
Independent Examiner	Mrs. Beth Diamond

President's report session 156

This session, the Society has a membership of 353. Eight evening meetings took place, normally on the second Thursday of each month from October 2013 through to May 2014. Speakers were:

Dr. Richard Bates, University of St Andrews: *Doggerland extended - submerged prehistory in Northern Scotland* [Joint lecture with Archaeological Society]; Dr. Tom Bradwell, BGS Edinburgh: *Ice streams in the British (Scottish) Ice Sheet: theory and observations – from onshore and offshore*; Dr .Jim Hansom, University of Glasgow: *What has Geodiversity ever done for us? Answers from a coast near you!* (AGM and lecture); Professor Chris Hawkesworth, University of St Andrews: *The evolution of the continental crust: the isotope legacy* (Joint Celebrity Lecture with Edinburgh Geological Society); Dr. Simon Cuthbert, University of the West of Scotland: *Geological travels in Norway;* Dr. Rob Strachan, University of Portsmouth: *New interpretations of the Caledonian geology of Shetland;* Dr. Simon Passey, University of Cambridge: *Continental flood basalts of the Faroe Islands and the opening of the North Atlantic*; Members' Night.

Our day excursions ran from April through to September 2014, and included the following day trips: April – Cononish Gold mine (Chris Sangster); June – Pentland Hills (Richard Smith); Kinghorn to Kirkcaldy (Colin Braithwaite); July – Rock around the University & Building stones of the university (Maggie Donnelly); August - Schiehallion and Strath Fionan (Ben Browne & Maggie Donnelly).

One residential field trip took place: Findochty to Fraserburgh, Leaders John Mendum & Con Gillen (Saturday 13th –Monday 15th September 2014).

The Strathclyde Geoconservation Group (SGG), a subcommittee of the Society's Council, has continued to promote geology in the wider community, investigating a number of new sites as well as continuing work on others. Members of the Council attended Steering Group meetings for the refurbishing of the Fossil Grove building in Victoria Park.

Our Society is a member of the Scottish Geodiversity Forum, which includes Geoparks, Museums, SNH, BGS, Geoconservation Groups, other Geological Societies and interested groups/individuals. The aim of the Forum is to promote Scotland's Geodiversity and its value in education, community involvement and health, tourism and the wider economy.

Sales of our new guide, on the geology of the Island of Gigha have gone well, and a new guide on the geology of Southern Kintyre is at an advanced state of preparation. Our leaflet on the *Building Stones of the University of Glasgow* has been well received and is distributed in the university free of charge. A Guide to the geology of Tenerife is being prepared for posting on the Society's website and a revised Guide to the geology of Arran is planned.

The Society's website has been further developed, to advertise our activities and to provide a platform for the promotion of geology.

Dr. B. Bell

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Membership Secretary's Report

	At end Session 156	At end Session 155
	30 Sep 2014	**30 Sep 2013**
Honorary Members	4	5
Ordinary Members	275	289
Associate Members	64	66
Junior Members	10	16
TOTAL Members	**353**	**376**
New Members	14 (joining in Session156)	24 (joining in Session155)
Memberships Closed	19	15

Overall membership numbers in Session 156 has decreased (6.1%) from the previous Session. The new members joining rate in Session 156 was a little lower than in Session 155.

There was a slightly higher number of membership closed (memberships are closed either by resignation, non-payment of fees or death) than in Session 155.

R A Painter

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Library Report 2013-2014

The Society's Library has continued to grow and diversify over the session with a large number of accessions notably from a former student (Mr. A. M. Jack) of the Department of Geology. The Society's considerable collection of geological maps has now been

catalogued and the catalogue will shortly be placed on the website. Details of how to borrow maps will be forthcoming (currently - ask the Librarian on meeting nights!).

Acquisitions

The Jack Donation is very wide-ranging and consists of a core of mining and engineering geological works, notably of Precambrian gold deposits worldwide, but including the geology of diamond, tin and silver deposits as well as Mississippi Valley (Lead/Zinc) deposits. In addition from this acquisition we now have a long run of the Journals and Bulletins of the Chamber of Mines of South Africa - dealing primarily with the Namaqua and Damara metamorphic Belts of South Africa and Namibia.
Other acquisitions include Neil Clark's latest book on Scottish Gold and a new Geology of Egypt.

Maps

The British Geological Survey continues to provide the Society with the latest geological maps for the whole of Britain, and we have also acquired sheets from the older "one inch" series:

Scotland
4 Miles to one inch:
Sheet 14. West Central Scotland. Solid.

One inch to one mile:
Sheet 23. Hamilton. Solid.
Sheets 30, 31, 22, 23 (partim). Glasgow District. Solid.
Sheets 30, 31, 22, 23 (partim). Glasgow District. Drift.
Sheet 30. Glasgow. Solid.
Sheet 30. Glasgow. Drift.
Sheet 31. Airdrie. Solid.
Sheet 31. Airdrie. Drift.
Sheet 38. Loch Lomond. Solid and Drift.
Sheet 39. Stirling. Solid.
Sheet 39. Stirling. Drift.

1: 50 000:
Sheet 46W. Crianlarich. Bedrock.
Sheet 46E. Killin. Bedrock.

England and Wales:
Special 1: 50 000

Fforest Fawr. Geology and Landscape.
Isle of Wight. Bedrock and Superficial.

Special 10 miles to one inch
William Smith 1815 Geological Map (Facsimile).

C. J. Burton,
Librarian.

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Scottish Journal of Geology: Editors' Report 2014

Following what seemed to have become a recurrent decrease in submissions, 2014 has been a good year and for the moment we have a satisfying number of papers on diverse topics 'In House' and progressing towards publication. For most of our authors this means that, subject to review, their work is likely to appear in print within months of submission. Members may not be aware that papers accepted for publication and processed ready for the printers now appear online some time before the print edition is ready, providing an additional incentive to intending authors.

The journal continues to hold a modest place in the citation index competition, comparing favourably with similar journals published elsewhere. Our collaboration with the London Geological Society's (GSL) Publishing House has continued to bear fruit and the SJG has been widely publicised at conferences and in materials circulated by them on our behalf. The complete archive of the Journal is now available in the GSL Lyell Collection, one of the largest online repositories of geological materials in the World. It is important to remind Members that, if they have a broadband connection, they can access the SJG anywhere in the world from this site. The Lyell Collection now also contains the entire archive of the Transactions of both the Edinburgh and Glasgow Societies from their inception in the 1860s. Through the good offices of the GSL, these materials are now also available from GeoScience World, the premier repository in the United States, hosted by HighWire Press in California. These associations have already generated a satisfying number of references to the SJG and exposure for our authors. We can reasonably expect that these will raise the status of the journal and encourage more submissions.

Over previous decades the Journal has seen a number of changes, from the quarto style of the 1960s, with text run across the page, to the A4 double column format beginning in 1990. A new format will appear in 2015 with alterations to the text and layout that we hope will improve the appearance. Illustrations have improved significantly from simple black and white to high quality photographic images and the potential for colour. We do not have the resources to finance full colour for all but

authors can contribute to the costs of publication of colour images and even if they cannot their images will appear in full colour online at no cost to them.

Dr. C. Braithwaite
Dr. B. Bell

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Publication Report session 156

It has been a busy year at the book shop. Muriel Alexander came to the end of a very successful and much appreciated six year term of office at the December 2013 AGM and my term of office began in January 2014.
I had a lot to learn and am very grateful to Muriel for her continuing advice and assistance while I have been learning the ropes. Interest in the books on offer has continued to be lively and between the two of us we have accumulated a profit of more than £500. Much of this has come from postal sales of the Madeira and Gigha guides ordered via the website. Bill Gray has been an essential part of this by handling the correspondence and payments. His assistance has been much appreciated
A few new titles have been added to our stock including the excellent' Scottish Gold' book by Neil Clark. Barbara Balfour and Alison Drummond have continued to assist with the management of the bookshop on lecture evenings and we have been joined by Bob Diamond. I give them all my heartfelt thanks for their invaluable support.

Mina Cummings
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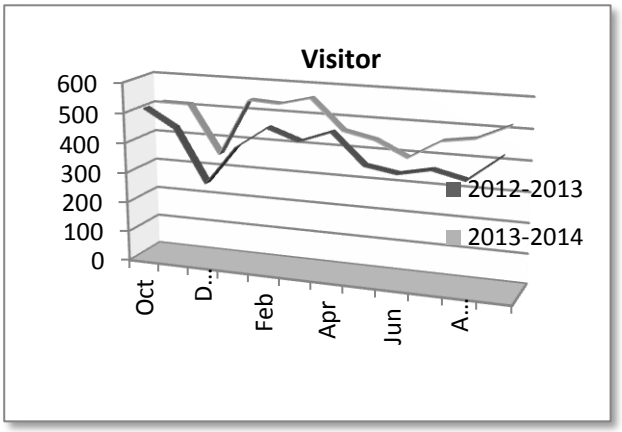
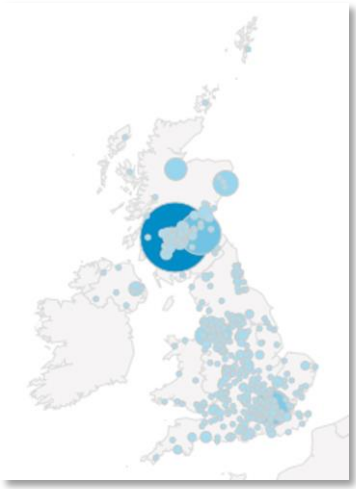
Website Report for Session 156

The website has been running since January 2011, and during the sessions since then the number of visits has steadily increased. In Session 156 there were 7385 visits to the site, an increase of 6.6% over the total for the previous session (6928). The number of visitors, as opposed to visits, was 5244, an increase of



17.2% over the previous session's total (4474). The chart shows the number of visitors each month for Sessions 156 (2013-2014) and 155 (2012-2013).



The increase in visits was the result of increased traffic from abroad, as the number of visits from the UK for Session 156 (5548) was almost identical to the number for the previous session (5547). The three most productive countries were the USA with 389 visits (376 in the previous session), Brazil with 137 (29) and Australia with 131 (96). Within the UK, Scotland accounted for 3142 visits (3012 in Session 155), England for 2298 (2278) Northern Ireland for 59 (207) and Wales for 45 (45).

The map shows the amount of traffic from cities within the UK. Glasgow was the most productive city, with 1461 visits (1527 in the previous session), followed by London with 814 (900) and Edinburgh with 489 (616). There was a marked increase in the number of visits from Inverness, from 28 in Session 155 to 161 in Session 156.

Apart from the homepage, the most popular pages were the Excursions page (3.9% of pageviews) and the Lectures page (3.4%). The Events, Strathclyde Geoconservation and Bookshop pages all had over 2% of pageviews. By far the most productive source of traffic to the website was Google, which was responsible for 3948 visits (3462 in the previous session), but the next most productive was direct logons to the website, which produced 1789 (1961) visits. The majority of the remaining visits resulted from referrals from other websites. The referrals from scottishgeology.com were up slightly (136 this session compared to 132 last session), but those from the Edinburgh Geological Society website (96 compared to 153) and the Geological Society of London website (48 compared to 51) were both down. However, the most productive source of referrals was visitscotland.com, which produced 231 visits, up dramatically from the 27 referrals in the previous session. Facebook produced 194 referrals, considerably fewer than the 283 in the previous session.

The society's Facebook group now has over 162 members, which implies that any Facebook posts have a potential audience of over 700 people. The reason for the decrease in direct traffic from the Facebook page to the society's website is probably that there have recently been fewer postings on the website pages because of the effort being put into the site's upgrade (see below). It is expected that the number of referrals will increase when the upgrade has been completed and more new articles are being generated.

As Webmaster, I am responsible for the day-to-day running of the website. However, decisions about its content and long-term direction are taken by the website group,

which consists of Neil Clark (Web Consultant), Emma Fairley (Website Coordinator), Maggie Donnelly (Society Vice President) and me. The group recently decided that, after running for more than three years with its original structure, the website would benefit from an upgrade, and the society's council agreed to provide the required funding. The upgrade is currently being carried out on a test version of the website by the company who developed the original website, Red Paint, and the new version should be ready to go live by the beginning of December 2014. There will be numerous improvements to the layout of the site, but the main change will be the addition of a new section on the rocks of the Glasgow area, which will contain a detailed geological map of the area, prepared by Emma. This map will contain links to descriptions of 12 of the best geological sites in the area, and these descriptions will eventually contain links to excursion itineraries for the sites. In addition, there will be new pages on minerals, rocks and fossils.

The website requires a continuing input of news items and event details to keep it fresh and topical. I am grateful to society members who have provided such material in the past and encourage all members to continue to send relevant articles and information to: web@gsocg.org.

Bill Gray

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STRATHCLYDE GEOCONSERVATION GROUP ANNUAL REPORT 2013-2014

East Dunbartonshire Council:- Geology information boards, one at Twecher and two at Crow Road car park are now in place and there was a successful launch at Twecher attended by representatives of East Dunbartonshire Council, local press, school children and SGG members in April 2014.

North Ayrshire Council: - SGG were approached by North Ayrshire Council NAC to supply sites of geological interest to link into a biodiversity audit. 22 sites described in great detail by Dr Chris Burton have been passed to NAC.

North Lanarkshire Council:- Members of the North Lanarkshire Group have handed over details of 15 geological sites to NLC Biodiversity Officer as part of an audit.

Scottish Geodiversity Forum: - Margaret Greene continues to take an active part in the Forum.

Leaflets:- A new booklet, The Building Stones of Glasgow " Glasgow Rocks" produced by Margaret Greene, has been printed and distributed.

A new leaflet entitled "Cumbernauld Rocks" has been produced by Paul Carter of the North Lanarkshire Group.

A second print run of 5000 Dumbarton Rock leaflets has been completed and distributed.

Fossil Grove: - Representatives of SGG have been active in following the progress of the refurbishment/rebuilding of the Fossil Grove area and continue to liaise with the two FG rangers.

SGG Members:- Rachael Ellen had to resign from the Group as she was relocating to Edinburgh. Her position as Website Manager has been filled by Maggie McCallum. Seonaid Leishman has stood down from Archivist and the position is now filled by Margaret Anderson. Mina Cummings has stood down as Secretary and the position is now filled by Barbara Balfour.

Activities: - Over the last year SGG members have been involved with giving a talk to Kilmarnock Community Trust, providing geology input into a walk organised by Woodlands Community Garden, walks organised as part of the John Muir Festival including part of the John Muir Way and a loop walk from Twechar and in connection with the Great Outdoor Festival, a walk round Strathblane. Another geology themed walk was led in Rouken Glen. SGG was also represented at Ardmore Point Volunteer Day as part of a path clearance and vegetation management. At Fossil Grove for Doors Open weekend 20/21st September, SGG had a marquee in which they had organised geology linked activities. Leaflets were also dispersed at other Glasgow Doors Open locations. SGG propaganda was also available at Doors Open day at BGS, Edinburgh.

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Geoconservation: Argyll and the Islands; Annual report 2013- 2014

The AGM of the group was held on 29 November 2013 at the Ocean Explorer Centre on the campus of the Scottish Association for Marine Sciences (SAMS) Centre, part of UHI, at Dunstaffnage. The committee and officers remain unchanged for this year.
The principle of creating a roadside geology trail was agreed at the AGM. Some preliminary work has been done, but progress is slow. It remains on the group's agenda.

Field trips for the U3A group this year included a re-run of the local trip around Oban Bay, and a new trip to Gigha based on the new field guide. Demand was such that two Gigha trips were planned, but the second one had to be postponed until next year due to unforeseen circumstances.
The main activity this year has been work done by the Oban U3A Geology group to create a Town Trail in Oban for the building stones. The group has already done considerable groundwork, though one aspect is proving difficult – there are few pointers to the actual quarries from which many of the building stones came. We suspect that some of these came from the same quarries as similar buildings in Glasgow. We are researching, but if any GSG member has 'inside information', please let us know.

The GAI group will be cross-checking the material produced by the U3A group, so that in due course one or more publications may result. Perhaps at some stage, GAI may request help in securing funding for that purpose.

The AGM of the group will held on Monday 8 December 2014 in Oban. The committee and officers are likely to remain unchanged for the coming year.

Alastair Fleming

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Proceedings editor's report

The proceedings for session 155 reflect another successful and enjoyable year. The evening lectures were very interesting and well attended and the synopses reflect the variety of topics to which we were treated. As always a large part of the proceedings is given over to the reports of day and weekend trips for which many thanks are due to those who took so much trouble to produce lively and detailed accounts of the trips together with excellent photographs. This year's issue was larger than usual because of the superb reports of the trip to Norway and the many photographs used to illustrate it.

As the printed version of these reports is necessarily in monochrome the reports are also reproduced in colour on the website and I would urge those who have access to the website to log on and enjoy the full colour versions.

They can be found at http://geologyglasgow.org.uk. Once in the website select **excursions** from the menu bar at the top and then **excursion reports**. Here you will find the day trip reports from session 153,154, and 155 together with the residential (Norway) report for session 155. My thanks go to Bill Gray for uploading and managing my pdfs on the site.

Mina Cummings

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THE GEOLOGICAL SOCIETY OF GLASGOW

Income and Expenditure Account for year ending 30th September 2014

			Session 156 2013 - 2014		Session 155 2012 - 2013	
Income						
1. Subscriptions						
Received by Bankers Order			4,588.50		*4619*	
Received by payment to Memb Sec.			1,377.50		*1470*	
Deduct paid in advance this year			-120.00		*-80*	
Add received in advance last year			80.00	5,926.00	*40*	*6049*
2. Investment Income						
Dividends			557.67		*525*	
National Savings			398.61	956.28	*377*	*902*
3. Gift aid		re GSG	963.92		*900*	
Note 3		re Betsy	102.00			
Extra to accrual on 2013 gift aid			37.05	1,102.97	*-9*	*891*
4. Conoco-Phillips prizes	ConocoPhillips 5yr contribution		1,250.00			
Note 1	Edin. GS paid in adv last year		83.33			
	Aberdeen GS		83.33	1,416.66		
5. Publications	In house	net profit	502.61		*761*	
Note 2	Moine Guide	net profit	257.00	759.61	*200*	*1935*
6. Saturday excursions		income	1,453.00			
		expenditure	1,479.05	-26.05		*16*
7. Week end excursions	Ben Lawers	income	1,500.00			
		expenditure	1,492.00	8.00		*0*
	Cullen	income	524.00			
		expenditure	488.00	36.00		*-300*
8. Donations (coffee collections)				280.43		*280*
9. Collection for Voyage of the Betsey project		Note 3		408.00		
10. Miscellaneous income				25.05		*58*
Total income				**10,892.95**		***8940***
Expenditure						
1. Meetings incl speakers expenses, etc			499.80		*645*	
Meeting Secretary expenses			676.00		*514*	
Room hire session 155		Note 5	3,132.00	4,307.80	*1159*	*2318*
2. Publication and postage of Proceedings				577.99		*1044*
3. Sponsorship	Building Stones of Glasgow Leaflet		350.00			
	Gold Book		500.00			
Note 3	Betsey Project		500.00			
	Members collection re Betsey		408.00			
	Gift Aid on Betsy collection		102.00	1,860.00		*0*
4. Library and Down to Earth				115.00	*112*	
5. Insurance				196.78	*187*	
6. Conoco-Philips prizes				0.00	*800*	
7. Website	Maintainance		318.46		*826*	
Note 4	Upgrade		1,186.80	1,505.26		
8. Affiliation fees				405.00	*350*	
9. Admin costs - postage, stationery, etc						
Hon Secretary expenses			216.70		*500*	
Membership Secretary			514.24		*332*	
President & VP			54.12		*122*	
Treasurer			24.00	809.06	*93*	
10 Miscellaneous expenditure (bank Charges)				4.00	*62*	
11Transfer of funds to Conoco Phillips Fund		Note 1		1,500.00		
Total expenditure				**11,280.89**		***8500***
Loss				**-387.94**	***Profit***	***440***

THE GEOLOGICAL SOCIETY OF GLASGOW

Balance Sheet as at 30th September 2014

			Session 156 2013 - 2014		Session 155 2012 - 2013	
Members' Funds						
Balance as at 30/09/2013			62,897.77		*62457*	
Surplus/(deficit) for the year			-387.94		*440*	
Devaluation of Book Stock		In House	-262.17			
Note 2		Moine	-673.00		*0*	
Balance as at 30th September 2014				**61,574.66**		*62897*
Restricted Funds	TN George fund			380.00		*380*
Note 1	ConocoPhillips fund			1,500.00		*0*
Total Funds				**63,454.66**		***63277***
Represented by						
Current assets						
Cash at Bank						
Royal Bank of Scotland			4,971.84		*2,884*	
National Savings		Note 6	3,438.01	8,409.85	*33,039*	*35,923*
Cash in hand						
Publications sales officer			0.00		*0*	
Membership Secretary			485.76		*200*	
Hon Secretary			-121.70		*95*	
Meetings Secretary			-5.00		*0*	
President/VP			307.12	666.18	*161*	*456*
National Savings Income Bond			12,000.00		*12,000*	
Current Valuation of investments		Note 6	38,355.00		*8,355*	
Debtors -						
Gift Aid			0.00		*900*	
Ben Lawers hotel deposits			0.00		*270*	
Gigha sales not paid yet			0.00	50,355.00	*210*	*21,735*
Stock of Publications	In house		3,915.63		*4,593*	
	Moine Guide		228.00	4,143.63	*1,146*	*5,739*
		Total Assets		**63,574.66**		
LESS LIABILITIES						
Subscriptions paid in advance			120.00		*-80*	
Conoco Phillips prizes			0.00		*-83*	
Ben Lawers paid in advance			0.00	120.00	*-413*	*-576*
		Total Liabilities		**120.00**		
Net assets				**63,454.66**		***63277***

These financial statements are prepared in accordance with the special provisions of part VII of the Companies Act 1985 relating to small companies.
The financial statements were approved on ..... by the Trustees and signed on their behalf by

Signed as approved by the Trustees .....
President Dr B Bell

Signed by the Independent Examiner .....
Prof Chris Morris

Note to the Financial Statement
For year ending 30th September 2014

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. During the course of the year money was collected to fund the ConocoPhillips prize. ConocoPhilllips contributed £1250 to fund prizes for the five years 2014-2018. Our Sister societies of Edinburgh and Aberdeen each contributed £83.33 to fund the prize For 2014, yet to be awarded, to this we added £83.34 and the sum of £1500 has been allocated to a restricted fund making £500 available for the 2014 prizes

2. The publishing costs for the Moine Guide were shared among the National Museums of Scotland, Edinburgh Geological Society and the Geological Society of Glasgow on a 50%/25%/25% basis and profits are shared accordingly. The GSG have no control over most sales or stock so accurate reporting has been difficult and the stock value ascribed to the Society at 30th September 2013 was only an estimate. This year we have a more reliable estimate of stock necessitating a substantial devaluation of stock value. Similarly a thorough stock taking of our in house publications has necessitated a significant devaluation both shown as a deduction from the Members' fund.

Moine Guide	**£**	**In House Publications**	**£**
Closing stock value(155)	1146.00	Closing stock (155)	4592.72
Deduct Stock Devaluation	**673.00**	**Deduct Stock Devaluation**	**262.17**
Opening stock value (156)	473.00		4330.55
Closing stock	228.00	Add publications purchased	572.07
Value of stock sold	245.00	Stock available for sale	4902.62
Income	502.00	Deduct Closing stock (156)	3915.63

Profit	**257.00**	Stock assumed sold	986.63
		Receipts	1578.59
		Gross profit	591.61
		Less Expenses	88.99
		Net Profit	**502.61**

3. Society funds were used to sponsor the publication of a leaflet by the Strathclyde Geoconservation Group, a book by the Huntarian Museum to accompany their Scottish Gold exhibition and also to support an educational expedition to commemorate The Voyage of the Betsy as described by Hugh Millar. A further £408 was collected by members to support the latter to which was added the Gift Aid reclaimed on this sum.

4. Half the cost of upgrading the website was born this year with the remainder to be paid next year. This exercise may need supplementing every three years or so.

5. Room hire for lectures has been inflated and will need renegotiating.

6. In June £30,000 was transferred from National Savings to a portfolio of investments managed by Speirs & Jeffrey. By year end there had been little change in the value of either this or our other investments so the previous valuation was retained for the balance sheet

B. Browne

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Meetings Secretary's Report

The session started with a lecture rather different from our usual talk by Richard Bates of St Andrews University. He told us about Doggerland, inundated by the North Sea several thousand years ago and extensions of this period into Northern Scotland.
Some archaeologists joined us for this event.

In November, Tom Bradwell from BGS Edinburgh, who had been unable to give his talk in November 2012 because of jury duty returned to tell us about ice streams from the British Ice Sheet. He concentrated on the Minch and the North coast and showed us the great detail on the sea bed which can now be observed with sideways sonar images.

On the night of our AGM on 12 December, local man Jim Hansom of the Department of Geography and Topographic Science delighted our geodiversity buffs with an entertaining talk "What has geodiversity ever done for us? Answers from a coast near you!".

2014 opened with a bang when Prof Chris Hawkesworth of St Andrews gave the Joint Celebrity Lecture on 9th January. He was commemorating the centenary of Frederick Soddie's description of isotopes and gave a clear and interesting exposition of how the

understanding of isotopes has aided the dissection of the evolution of continental crust. The Joint Lecture was attended by a larger than usual contingent from Edinburgh.

As if to remind us that 'extreme weather' is becoming more of an issue, on 13 February, Dr. Peter Treloar was unable to leave the Home Counties because of flooding. Our Hon. Secretary, Simon Cuthbert, manfully stepped into the breach with a talk on various aspects of his geological research.

Old friend Rob Strachan – expert on the Northern Highland Moine – came from Portsmouth to update us on the recent developments in Shetland geology and tectonics, including the discovery of a whole new set of metamorphic rocks aged around 900 Ma on Westing, Unst and elsewhere.

Glasgow graduate Simon Passey, now at Cambridge University, gave the latest in our series of lectures on North Atlantic opening when he talked about the continental flood basalts of the dramatic Faroe Islands. The season closed with Members' Night and its customary interesting and varied programme of talks and demonstrations.

J.M.Morrison

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Meetings

10th October 2013
Dr Richard Bates, University of St Andrews
Doggerland extended - submerged prehistory in Northern Scotland
[Joint lecture with Archaeological Society]

The rising sea levels at the end of the last Ice Age inundated vast landscapes of the North Sea that had once been home to thousands of people. Investigations of these landscapes in the south on an area known as Doggerland are providing new insight on the environments and the people who lived on the drowned lands in key period of pre-history. Lessons learned from these investigations are now being applied to Scotland's coastal zones where recent discoveries could herald a reinterpretation of our past.

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14th November 2013
Dr. Tom Bradwell BGS, Edinburgh
Ice streams in the British (Scottish) ice sheet, theory and observations – from onshore and offshore

Recent advances in geological data acquisition onshore and offshore, combined with the increased complexity of coupled ice-sheet-ocean-climate models have resulted in a better understanding of Pleistocene ice sheets. These advances have revised ideas of a largely

terrestrial, relatively small, British Ice Sheet to a much larger ice sheet covering around 75% of the British Isles, the continental shelves and most of the North Sea Basin at its maximum. More importantly, perhaps, is the recent identification of ice streams – largely transient fast flowing corridors- within the last British Ice Sheet. Ice streams are prone to non-linear behaviour and are responsible for governing the large scale geometry of ice sheets. In this talk Dr. Bradwell outlined the onshore and offshore glacial geomorphology of Northern Scotland, focusing on the evidence for ice streaming. These findings are then used to elucidate the pattern and style of British Ice Sheet retreat from the UK continental shelf edge back to the Highlands of northern Scotland. Aspects of this work are still in progress, however, these new results form an exciting, controversial, new interpretation of event in Scotland at the close of the last glaciation.

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12th December 2013
AGM and Presidential Address
Dr. Jim Hansom, University of Glasgow
What has geodiversity ever done for us? Answers from a coast near you.

Geodiversity is a relatively new term which has not captured the recognition which Biodiversity currently enjoys. Ask in the street about geodiversity and you are likely to get a blank response at best, and an 'aye right' at worst. The myriad ways in which a healthy biodiversity supports us is well understood, yet without geodiversity there would be no biodiversity, since all life depends on the variety of surface environments provided by rocks, landforms and the processes that form them. With an enhanced rate of climate change now upon us and surface processes and ecosytems increasingly in a state of flux, we need to publicise the value of geodiversity to science and society. Using examples from the coastal zone, this presentation aimed to show how an understanding of coastal geodiversity can help society better adapt to changes which are underway and may increase in the future.

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9th January 2014
Joint Celebrity Lecture with Edinburgh Geological Society
Professor Chris Hawkesworth – University of St. Andrews
The Evolution of the Continental Crust – the Isotope Legacy

The discovery of radioactivity changed our understanding of the thermal evolution of the Earth, and provided ways to determine the age of the Earth and time scales of geological change. Isotopes were first described by Soddy in 1913, and much later the high precision measurement of radiogenic isotope ratios markedly changed the study of the continental crust. The discussions shifted from the movement of the continents, and how they once

fitted together, to models for when and how the continents formed and the evolution of the Earth's crust and mantle. The continental crust is characterised by peaks in the distribution of U-Pb crystallization ages and these coincide with the ages of super-continents. Such peaks may reflect periods of high magmatic activity or, as argued here, the preservation potential of magmatic rocks in different tectonic settings. The peaks marked times of increased preservation within the crust, rather than times of anomalously high volumes of magmatic generation. Even though <5% of present continental crust is older than 3 Ga, there is increasing evidence that ~60-70% of the present volume of the continental crust had been generated by that time.

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13th February 2014
Dr. Simon Cuthbert
University of the West of Scotland
Geological travels in Norway

Dr. Peter Treloar had planned to give this evening's lecture but was unable to travel to Glasgow because of the prevailing weather conditions. Dr. Cuthbert stepped in at short notice to deliver an excellent talk on Eclogites

Eclogites are spectacular red and green garnet + clinopyroxene rocks formed by metamorphism of basaltic rocks at pressures normally experienced in the mantle. First described by Hauy in the 18th century they are now known from subduction and collision zones and mantle-derived xenoliths in kimberlites. Eclogites and related high-pressure metamorphic rocks preserve abundant information about processes at destructive plate margins. Mafic oceanic crust undergoes wholesale conversion to eclogite during subduction but, paradoxically, eclogites are often found within continental gneiss terrains whose low density might be expected to prevent subduction. These will be the main focus of the presentation. Some of these rocks contain metamorphic diamond and other unusually dense minerals such as coesite, indicating burial to depths in excess of 150km. Frequently found outcropping beside eclogites are garnet-bearing peridotites – bodies of sub-continental mantle that have been introduced tectonically into the eclogite-bearing crust. Such "ultra-high pressure" eclogite-bearing terrains tell us that continental crust can be subducted quite deep into the mantle when continental margins follow oceanic lithosphere into a subduction zone. Their return to the surface also presents us with some interesting tectonic challenges. We will explore these fascinating rocks with examples from around the world, and with some recently published computer models of collision tectonics. For the skeptic of all this grandiose story-telling, just come and look, because eclogites are, quite simply, very beautiful rocks found in beautiful places!

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13th March 2014

Dr. Rob Strachan- University of Cambridge

New interpretations of the Caledonian geology of Shetland

The Caledonian belt in Shetland comprises a superb west-east section from the supposed equivalent of the Moine Thrust to the Unst-Fetlar ophiolite; all documented in detail by the work of Derek Flinn and his research students. However, understanding of this northernmost part of the Scottish Caledonides has lagged behind in recent years in comparison with mainland Scotland. New geochronological studies have placed constraints on the depositional ages of major metasedimentary units and timing of orogenic events with implications for regional tectonic models

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10th April 2014

Dr. Simon Passey- University of Cambridge

Continental flood basalts of the Faroe Islands and the opening of the North Atlantic.

The Paleogene Faroe Islands Basalt Group (FIBG) comprises four eruptive sequences or formations, emplaced in a dominantly subaerial environment during the development of the extensive continental flood basalt province which stretches from East Greenland through the Faroe Islands and into the Faroe-Shetland Basin. The Lopra and Beinisvørð formations consist of lava fed hyaloclastite deltas and fissure fed simple lava flows which represent the filling and levelling of the pre-existing irregular topography and the progradation of the lava field basinward. A regional hiatus in the lava flow volcanism is marked by Prestfjall Formation consisting of coals and sandstones deposited in mainly lake and swamp environments. Volcanism resumed with airfall tuffs of the Hvannhagi Formation which were subsequently reworked by rivers and mass flows and deposited in localized basins. Lava flow volcanism resumed with the point-sourced shield volcanoes of the Malinstindur Formation consisting of compound lava flows. The final phase of volcanism recorded on the islands is the Enni Formation which consists of a mixture of shield volcanism and simple flows which tend to fill the accommodation space between the volcanoes. The Malinstindur and Enni formations are punctuated by sedimentary deposits marking pauses in the volcanism, aiding regional correlations and helping us to understand the volcanic evolution prior to and during the opening of the North Atlantic Ocean.

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15th May 2014
Members Night

Oral presentations (15 minutes each):

Neil Clark "A photo from the 1869 Scottish Gold Rush"

David Webster talk "Islay field guide"

David Jarman "Mull of Kintyre - a remarkable failed coastline, discovered via "Google Earth"

Maggie Donnelly "Fun in Norway - Geol. Soc. Field Trip June 2013"

Bench displays:
Simon Cuthbert - "kiosk" PP slideshow on "The Bedrock Walk"
Neil Clark - "A photo from the 1869 Scottish Gold Rush"
Margaret Greene - Strathclyde Geoconservation Group
Seonaid Leishman - Launch of the SGG East Dunbarton interpretation boards
Maggie Donnelly – "Fun in Norway + Part 2"
Bill Gray - photos from Provence, France, May 2014

Thanks go to all who contributed to a very enjoyable end to the indoor lecture season.

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Excursions Secretaries Reports

Saturday Excursions report

12/4/2014 *Cononosh Gold Mine & Glen Orchy,*
Chris Sangster, Maggie Donnelly; 16 participants

21/6/2014 *Pentland Hills Regional Park*
Dr. Richard Smith; 13 participants from Glasgow ,~20 participants from Edinburgh.

5/7/2014 *East Coast , Kinghorn to Kirkaldy*
Dr. Colin Braithwaite,University of Glasgow; 34 participants

19/7/2014 *"Rock around the University" +" Building Stones of the University of Glasgow"*
Maggie Donnelly; 21 participants
9/8/2014 Loch Ardinning
Dr. Simon Cuthbert; 16 participants (this trip was cancelled)

23/8/2014 *Schiehallion and Strath Fionan*
Ben Browne, Maggie Donnelly; 19 participants

These trips were all mostly successful, probably due to early organisation and advertising in the third (February) newsletter. All excursions were well attended ~20 participants are needed to make an excursion break even financially. A maximum of 16 could attend the Gold Mine; unfortunately three people cancelled within two days of the trip and replacements could not be found, however three members joined us in the afternoon for Glen Orchy. The Pentland Hills Regional Park was the joint excursion with the Edinburgh Society who organised it. This was a gentle walk on a lovely day finishing with High Tea in Flotterstone Inn – a very successful excursion. Our Kinghorn to Kirkaldy trip was excellent with exposures of volcanic and sedimentary rocks along the coastal section. The fourth excursion followed the "Rock around the University" exercise devised by Dr. Tim Dempster of GU and the new publication" Building Stones of the University of Glasgow". Unfortunately our leader had to cancel the Loch Ardinning excursion at short notice due to unforeseen family circumstances. The last trip to Strath Fionan was intensely researched by Ben Browne who provided us all with a comprehensive insight into the geology. Due to a paucity of leaders trips 1,4 and 6 were led by myself and Ben Browne but they seemed to work well. We again used Essbee Coaches for excursions 2,3 and 6;we required off road vehicles for excursion 1 and so travelled to Tyndrum in private cars and then used two Land Rovers, one belonging to Scotgold and one to an obliging friend, to take us up to the mine.

Residential Excursion;
Banffshire Coastal Section, Friday 12th September – Monday 15th September 2014

Our residential excursion was a study of the Banffshire coastal section led by Dr. John Mendum of BGS and Dr. Con Gillen, recently of Edinburgh University. Twenty of us plus the two leaders travelled north by private car to Cullen where we divided our accommodation among three hotels. Over the course of the four days we visited localities on the foreshore at Portknockie, Cullen, Sandend Bay, Portsoy, Boyne Bay, Old Hythe, Whitehills and MacDuff and inland at the Boggierow Quarries into Portsoy Granite, The Grampian, Appin, Argyll and Sutherland Highland Groups outcrop along this coast but the geology is complicated by the Boyne Line and the Portsoy Lineament. Many of the rocks are intensely folded and more than once, so that the amazing structures on occasion included superb interference patterns. The outcrops are also intensely sheared in places leading to very steep dips and thus to steep grassy and rocky shores. More difficult for some than others! We were introduced to the 'Portsoy marble', which is in fact serpentinite, and had the pleasure of finding spectacular metamorphic minerals-kyanite, staurolite, andalusite and cordierite. The weather was mostly kind to us. Our leaders were excellent, explaining the intricacies of the local rocks with great patience and fortitude….and they were good company too…so that altogether we had a very enjoyable and successful weekend

Margaret Donnelly

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Cononish Gold Mine and Glen Orchy
Sat 12/4/14
Report by Maggie Donnelly *Participants: 13*

On a somewhat damp and overcast day we met Chris Sangster, CEO of Scotgold, at 10 am at the Dal Righ car park (NN 285292) south of Tyndrum, and, as last year, were transported the two and a half miles up to the mine in two 'off road' vehicles, driven by Chris and an 'obliging friend', Rob Barbour of OUGS EoS. We were divided into groups of eight, kitted out with safety gear and given an introduction by Chris.

This is the most important precious metal deposit discovered so far in Scotland this century. The mineralisation (450,000 tonnes at a cut and diluted grade of 11.3 g/t Au and 60.1 g/t Ag) is hosted by a steeply-dipping breccia zone, the Eas Anie vein, silicified and haematised by the hydrothermal solutions which carried the minerals, and penetrated the rocks of psammite, pelite, amphibolite and impure limestone of the Grampian and Appin Groups. These same Dalradian rocks extend from Canada through Ireland and Scotland to Scandinavia where gold is also found. The vein extends for more than 1 km along strike and 500 m down dip. It is up to 8.3m wide, has an average width of about 2 m and fills a structure considered to have formed during left-lateral movement of the early Tyndrum Fault (Treagus *et al.* 1999) during the Caledonian orogeny.

The adit went into the side of the hill and the quartz breccia vein outcropped on top, marked with posts, about 800 m above. There were also lamprophyre dykes. Wearing wellingtons, hard hats and carrying several safety torches, we were led inside. The diameter of the adit was about that of a Glasgow subway tunnel; it was dark, very wet, and rough underfoot as the ground, though essentially flattish, was strewn with coarse pebbles and cobbles from blasting operations.

We came to the 'leaking borehole', drilled for samples which demonstrated that the quartz breccia here was not a good enough quality for extraction, and then the Eas Anie Fault, a large vertical area of shearing which had shown left lateral movement similar to the Tyndrum Fault. This fault (and related others) had provided the conduit for the thermal silica fluids to emplace the gold. From here on, the Eas Anie Vein, now named the 'Cononish Main Vein' was very obvious, running along the roof of the tunnel, and as wide – a sheet cutting through the hill at an angle of approximately 45^0.

About 200 m further on was another 'leaking borehole', and beyond this, a quartzite marker bed cut off by a fault. We passed the large black lamprophyre dyke which had displaced the vein, so that the adit took a left turn, and continued for about 400 m until it was back into the vein. Finally, here, was good quality ore with abundant pyrite

and minerals in the quartz breccia vein on the roof. Another indent in the wall was discoloured to a deep brownish, reddish pink by iron, an indication of thermal fluids bringing in the gold, and its particularly deep colour here suggested good quality gold-bearing rock. The gold occurs as flecks in the quartz, around the margins of the pyrite, in cracks within the pyrite and within the crystal structure of the pyrite itself.

In the process of mining, pipes about 20 or 30 cm diameter are drilled and explosively blasted. The broken rock is removed, crushed to a small size on site, treated by 'gravity separation' and then a frothing process, during which the 'pyrite with gold', as tiny particles, will sink to the bottom. In this way 25% of the gold is recovered. The remaining ore is sent off to a processing plant in Holland for the final extraction, and the resulting gold returned to Scotgold. One tonne of rock is required for 10 gm gold……..i.e. 2 gold rings!! Over time, a gallery of tunnels, with stoping, will be created throughout the vein, until all the 'gold rock' has been extracted. On our return journey out of the adit Chris pointed out the abundant minerals, especially of galena (lead sulphide), present in the quartz in the roof; however, there was not enough for commercial viability.

Back at the Dal Righ car park Chris attempted to provide us with more information about the background geology, and the methods and history of mining precious metals in the British Isles. Unfortunately the rain came on and our 'briefing' was cut short!! One little gem gleaned last year was that Dr Geoff Tanner had produced a map of plots predicting where the vein would be found. Scotgold had followed this carefully in their prospecting and proved Geoff to be almost ***exactly*** right every time!! We gave Chris, and our 'obliging friend', a 'great big thanks' for a marvellous experience, and settled down for lunch.

After a short introduction to the geology of Glen Orchy we drove north, and turned west into the Glen Orchy road, B8074, about I mile south of Bridge of Orchy. The geology of Glen Orchy is complex and has only recently been reinterpreted (Tanner & Thomas, 2010). The Glen Orchy/Beinn Udlaidh/Glen Lochy area is bound to the northwest by the Ericht-Laidon Fault, to the southeast by the Tyndrum Fault and to the west by the Glen Etive Granite. The rocks belong to the Meall Garbh Psammitic Formation (top of the Grampian Group) underlying the Beinn Udlaidh Quartzite Formation and then the Coire Daimh Pelite Formation (bottom of the Lochaber Subgroup of the Appin Group), and all belong to the Neoproterozoic–Lower Ordovician Dalradian Supergroup. The region is dominated by two major recumbent folds, the Beinn Udlaidh Syncline and the underlying complementary Glen Lochy Anticline; the rocks show a sedimentary transition from the Grampian Group to the overlying Appin Group. They achieved their maximum deformation during D2, subsequent to the regional metamorphic peak, and are part of a stack of larger SE-facing recumbent folds created during the Grampian Orogeny, ~ 470 Ma. The core of the south-facing Beinn Udlaidh Syncline contains the Appin Group and, together with the underlying Glen Lochy Anticline, it is gently folded by an elongate, east-west regional structure, the Orchy Dome. There is an early fabric (S1), which is mainly destroyed by the D2 imprint, but *does* survive as inclusion trails in regional metamorphic garnets, which are highly oblique to S2. Dalradian rocks from below the Iltay Boundary Slide nearby are now believed to be in structural continuity with those of the Tay Nappe above, and the Slide is reinterpreted as a

structurally-modified disconformity between the Leven Schist (Appin Group) and the overlying Ben Lui Schist (Argyll Group). There are also a number of later minor intrusions and explosion vents of the lamprophyre suite in the area, whose spatial distribution was probably influenced by the Orchy Dome.

As we drove along, abundant glacial features of drumlins, breached moraines, kames and kettle holes were obvious on either side, while directly ahead of us loomed the Orchy Dome, and Beinn Udlaidh. After about 2 miles, locality 1, ~ NN 286373, we squeezed into a parking place for a closer view – the fold axis of the dome ran approximately northeast – southwest, the pelite beds were on the northwest side of the crag while the semi-pelite-psammite was dipping off the northeast side. There is a prominent quartz breccia dyke running through the Beinn in a northeast – southwest direction, an area of quartz-breccia, and a small knob at the end formed by an explosion breccia pipe. Unfortunately these features were difficult to discern through the mist high on the Beinn!! At about 1.7 miles further, locality 2, ~ NN 286373, below the Easan Dubha waterfall, there was a sizeable parking space beside the river…which, as a result of snow melt and recent heavy rain, was a raging torrent!! However, the Grampian psammite rocks on the banks could be clearly seen dipping to the northwest, and on the opposite bank, the upper half of a circular area of broken up material – one of the numerous explosive breccia pipes. We were fortunate to have Dr John Mendum of BGS in the party; he helped us in our attempts to find convincing evidence of the 'way up' of the rocks.

At locality 3, a further two miles on, there was another large parking area beside a sizeable expanse of water in the river below a set of rapids, NN 246326. We walked upstream along the bank through overgrown vegetation. It was ***very*** wet underfoot and the going was not easy, but the rocks were amazing!

We stopped numerous times to examine them on the bank, in the river and on the far side – they were composed of large, isoclinally folded beds of Beinn Udlaidh Quartzite. We were in the core of a major recumbent fold (considered to be the best-exposed example in the British Isles), which has itself been folded by the regional Orchy Dome. After about 400 m we arrived at our target…… fabulous 'fold mullions', so called because the beds continue around them and are not broken into separate rods ……*and* we were in the nose of the fold!! Thankfully the mullions were not submerged, as I had feared, and the company was suitably impressed. We spent a considerable time examining the rocks from every angle and taking photos. Our final bonus was cross-bedding in the quartzite which indicated that

the beds were younging downstream, and that we were on the lower, right-way-up limb of the Beinn Udlaidh Syncline..
We made our way back to the cars, and drove further southwest to Locality 4, Iron Bridge and the Falls of Orchy, NN 243321, where there were amazing structures, and potholes, in the bed of the river.

We continued about another 200m downstream to a weir or dam where we hoped to find 'z vergence' in the bed of the river. However the water level was too high and the river broad; nevertheless some of the company were satisfied that the elusive 'z vergence' could be seen on the opposite bank. Altogether we had had a marvellous day of fascinating geology, and it was time to head for home. Many thanks are due to Dr John Mendum who was ***not intended*** to be a 'leader' but whose expertise and enormous assistance enabled us to interpret lots of the 'little details' hidden in the rocks.

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Excursion to the Pentland Hills

21st June 2014

Joint Field Trip arranged by The Geological Society of Edinburgh
Leader: Dr. Richard Smith
Report*:* Allison Drummond *Participants: 12 from GSG*

The aim of the excursion was to study the geomorphology and glacial features to be found in the Pentland Hills.
In the main we were following the locations set out in the Pentland Rocks leaflet produced by Lothian and Borders Conservation, a committee of the Edinburgh Geological Society We had arranged to meet our Edinburgh colleagues at Threipmuir where we also met our leader Dr. Richard Smith who gave us an introduction to the area.
The Pentland Hills form an area of high ground which rises above the surrounding Carboniferous rocks. Most of the rock that forms these hills is igneous, created from molten magma. Close to the end of the Devensian glaciation, ice retreat had left the summits of the Pentland Hills free of ice but with high level meltwater channels draining eastwards through the hills. So this was a glacial drainage area. The grinding of the ice sheets gave the Pentland Hills their rounded profile which can be seen today. The oldest rocks are sedimentary i.e. mudstones and siltstones of Silurian age. The youngest surviving rocks are red sandstone (~370 Ma). When the ice retreated it produced a vast amount of water with the hills acting as a dam. Eventually the water broke through creating deep valleys leaving the landscape much as it is today. Other remains from this period are mounds of sand and gravel which were left behind after the ice melted and is now used in road workings.

We left the car park and proceeded to our first location which was a small exposure of the Bavelaw inlier. This is of Silurian age and had been pushed up due to the Caledonian orogeny. Devonian dykes cut through the sediments. From here we could see meltwater channels formed at the end of the last ice age. They drain eastwards and in some places the channel goes uphill due to the meltwater flowing at pressure under the ice.

We then carried along the path to our next location (location 2) which was a narrow gully on the right hand side of the path and is the site of a fault line. The rocks to the left hand side of the gully are red sandstone of the Carboniferous period which have dropped down during the faulting process to become level with the older rocks of the Silurian period. These older rocks can be seen on the right hand side of the gully. After climbing up towards the gully and examining the different rocks we continued along the path to the next location.

Black Hill (location 3) which is the remains of a viscous dome of magma and is composed of a rock called microgranite (formerly known as felsite) which is very hard and slow to break up. It forms sharp edged fragments called clinker and weathers to a light pink colour. Black Hill shows how rock type can affect vegetation. The rock is rich in silica and makes acidic soil with heather being one of the few plants which can survive in these conditions.

Continuing along the path we entered Green Cleugh which is a narrow valley and thought to have been a glacial drainage channel carrying meltwater eastwards to what is now the Loganlea reservoir. Here (location 4) we found fallen blocks of Devonian conglomerate which originated from The Pinnacle, an area which lies above the path through Green Cleugh. The conglomerate includes pebbles of sandstone, lava and chert all of which are derived from rocks older than the conglomerate.

Further along the path near the "The Howe" farmhouse almost vertical beds of sedimentary rocks could be seen (location 5). These are sandstones, siltstones and mudstones which would have originally formed as horizontal beds on the floor of the Iapetus Ocean. The present day vertical nature of the beds shows the compression associated with colliding continents as the ocean disappeared.

Flute marks could be seen on the soles of some of the beds indicating an environment where turbidities had been common.

We continued along the tarmac road and could see on the left hand side intercalcated sandstone and lavas with tuff sitting on top of the basaltic lava (location 6).
This was the last of the locations from the Pentland Rocks leaflet that we were to see but we continued along the tarmac road towards what is now the Glencorse reservoir.

Here we were passing through Devonian rhyolite and we could see flow banding and gas bubbles in the rock (location 7).

Finally a short distance from the road side we could see mounds of sand and gravel, now grass covered, which had been dumped by the glacier as the ice retreated.

This was the end of the geological trail and we continued along the road to the Flotterstone Inn where we had a tasty high tea. After a vote of thanks and a presentation to Dr. Richard Smith for giving us a clear and informative explanation for all we had seen, we returned to Glasgow having had a most enjoyable excursion.

The Fife Coastal Path from Kinghorn to Kirkcaldy,
5th July 2014
Leader- Dr. Colin Braithwaite.
Report Barbara Balfour. *Participants 24*

We started on the coastal path at Kinghorn, overlooking a sandy bay and the Firth of Forth. After a short walk in a north easterly direction, we made our way down to the shore to study volcanic rocks of the Lower Carboniferous. Geikie referred to the lavas we examined on the shore, as 'pillow structures' suggesting that they had formed under water, but they were not as the classical pillow lavas at Girvan. These 'pillow structures' looked as though they had tumbled into the muddy ash and cooled.

The lava was rich in vesicles, suggesting that they formed in shallow water where the gas could have escaped which wouldn't happen at depth. Some of these vesicles were infilled with calcite, originating from hot ground water, forming amygdales. Nearby we saw the effect of cooling and contraction of the lava which had superimposed a pattern of polygonal fractures on the pillow

Pillow structures with vesicles, and ash below it

Polygonal fractures marked by calcite veins

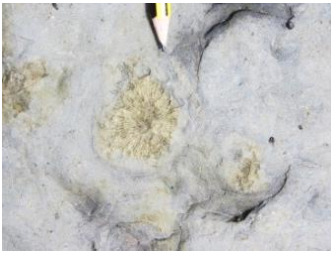
The volcanism in this area probably happened following the Caledonian orogeny when the area was in tension.

As we moved along the shore of the bay, we observed large blocks of limestone with shell fossils and also ones with crinoids indicating a marine environment. Although we could not be sure these were in situ, we could see the source ahead, the First Abden Limestone. This is an excellent cross section, as the beds are dipping 22^0 NE, allowing us to see that underneath the limestone lay shelly grey shale, and below that, grey green tuffs showing graded bedding. Above the limestone, there was calcareous shale contorted under the lava flow with basaltic lava on top. However this was not the same lava flow as we had seen previousl

Shelly grey shale and grey green tuffs with the First Abden Limestone and lavas on top.

On the foreshore, solitary cup corals and brachiopods were found, which again suggest shallow, oxygenated water, probably relatively warm in the Lower Carboniferous.

Cross sections (2-3cms diameter) of solitary cup corals



We also saw recent weathering of the limestone which exhibited "lapié". This looked as though grooves had been cut in a downwards direction in the limestone. Colin explained that this had happened in the recent past, caused by exposure to rain water reacting with the limestone in the presence of carbonic acid i.e. possibly formed from emissions of carbon dioxide from earlier industries in the area.

Continuing a short distance along the footpath, another large basalt flow was observed on the shore below. Colin pointed out that the undercut was a wave-cut notch in the old sea cliff. In the notch was fossilised, red, lateritic soil, called bole, which has formed on tuff. This red bole or laterite is indicative of weathering and soil formation under tropical conditions in the Early Carboniferous and, as the lava flow lies on the bole it must have erupted on dry land.

Down on the shore again, we could clearly see the exposed succession – from the path, going seawards, roughly west to east, basalt lavas with pillow structure, tuffs passing into red laterite, dark grey fossiliferous calcareous shale and the Second Abden Limestone dipping about 22^0E, a series of limestone beds separated by irregular muddy parting.

The Second Abden Limestone in background, then shales, and red laterite covered in green seaweed.

The laterite had taken at least 10,000 years to form in dry conditions before there was a marine incursion forming the shales and limestone on top of it. This marine area gave rise to many fossils including bivalves, brachiopods, crinoids, corals and bryozoan.

Solitary coral

Naiadites crassa

Crinoid 'debris'

Back onto the path north and then down to the shore again to see some 'lumpy' limestone. This was a result of limestone forming which is not all cemented, so there is some limestone of muddy consistency present.

When this mixture is overburdened the 'muddy' part is squeezed out from the more cemented yielding the 'lumpy' limestone or 'discontinuous cementation nodular rocks'. Digenesis is common near the Carbonate Compensation Depth (CCD), usually about 4 kilometres depth, as below this depth calcium carbonate will dissolve, thus limestone will not form.

Discontinuous cementation nodular rocks

Still moving north-east along the shore, we came upon a fault which had caused the ridge of the limestone, which runs along the shore, to be breached. The affected limestone has been turned at right angles to the dip. It was best viewed from the path.

Quartz-dolerite sill

It is worth mentioning that this photograph shows the exposures of the rocks of the Lower Carboniferous dipping approximately 20^0NE, caused by the Burntisland Anticline which disappears under the Forth and becomes the Fife Coalfield Syncline.
Although we missed the way back up to the path we quickly retraced our steps along the shore and made our way to the Seafield Tower via the footpath, where we were able to look down on some seals basking in the sunshine.
By the shore at the Tower, Colin showed us very good examples of burrows of Zoophytes 'Coda di Gallo', so named as it resembles the plumes of a (Italian?) cockerel's tail. We also saw lots of crinoid 'debris'. However the main attraction here was a wonderful example of current bedded sandstone, reddish in colour. A discussion ensued as to the source of the quartz. The grains, although fine, were angular and not rounded. It was thought to have been a high energy river system flowing north to south with braided streams or a deltaic system.

Seafield Tower and sandstone outcrop
Photo courtesy of S.Leishman

Cross- bedded sandstone

Zoophytes 'Coda di Gallo'

Our last stop of the day was next to the Tyrie breakwater. Here we saw a quartz-dolerite sill that is exposed further south, but in this area it has been buried in sand for about 25 metres until it makes a reappearance. This sill, which has a dip of 20-25^0 eastward, intruded into the Limestone Coal Formation. The sill margins are fine grained and bleached. It contains a large raft of sandstone, now baked to quartzite and with its bedding perpendicular to the sill margins.

Quartz-dolerite sill

Stigmaria

As we walked along the shore to the car park at Kirkcaldy to rendezvous with the bus, we came across examples of Stigmaria, root stocks of lycopod trees. It is hardly surprising to find evidence of these trees, which grew in deltaic swamp conditions and finally became the Limestone Coal Formation, 259 metres in thickness (including 15metres of coal) at Kirkcaldy.

It was a splendid day, both weather and geology. What a treat it was to easily follow successions, to see volcanics contemporaneous with sediments *and* a plethora of fossils. Colin was clear with his explanations, patiently answered questions and was still smiling at the end of the excursion!

References: Fife and Angus Geology by A.R. MacGregor 1996
Teachers' Guide: Higher & Intermediate2 Kinghorn,Fife.

Rock Around + Building Stones of the University of Glasgow
19th July 2014
Leader: Maggie Donnelly
Report: Isabel Collins *participants 21*

We met outside the Gregory building armed with our coloured pencils, hand lenses and compass clinometers, all set for our mapping exercise on what turned out to be a very wet but thoroughly enjoyable Saturday afternoon.
This was a two part excursion combining Tim Dempster's 'Rock around the University' project with the excellent publication 'Building Stones of the University of Glasgow – A Geological Trail round the campus' recently updated by Barbara and Allison from Chris Burton's original leaflet.
'Rock around the University' is a project designed as a teaching aid to provide an accessible on campus field exercise. The rocks to be studied do not represent the 'actual' geology of Gilmorehill as all the stone was imported from various sites across Scotland with the intention of representing key chapters of the geological history of Scotland. 16 boulders were positioned in strategic locations around the west side of the University Campus and the plan is that they represent outcrops.
The 'Buildings Stones of the University' trail is dominated by stones from the Devonian and the Carboniferous periods, taken from quarries in both Scotland and England, with limestone and sandstones being the most prolific.
In all there were 18 buildings/monuments/architectural features around the campus trail to examine and we managed to take a close look at the majority in between studying the rocks from the 'Rock around the University' project.

Before heading off to find the first outcrop we took a look at the Gregory Building which was originally built to house the Geology and Applied Geology department but was ironically made of brick. The building was closed so we didn't get the opportunity to study the mural inside but we did take a look at the stone monument just outside. We identified the rock of the redundant culvert as being a granodiorite in origin with clearly visible xenoliths which we were informed were of Ballachulish Slate.

The Boyd Orr Building, like many of the post war buildings of the University, is constructed in concrete and partly clad with stone panels. This particular cladding had flint pebbles with chatter marks from the action of the sea turning the pebbles on the beach. We then paused at the cobbled area in front of the entrance of the Queen Margaret Union.
This had just about every type of rock including Sandstones with migrating ripples.
There were several highlights across the road starting at the main building which, incidentally, is made mainly of Gilmorehill Sandstone. This is poor quality sandstone as it

erodes easily due to its thinner beds and course texture. The builders must have been aware of this at the time as they used better quality smooth sandstone which is less prone to erosion on the important structural features like the corners and the window cases of the building.

Beautiful, polished, pink Granite pillars can be found at several of the doorways. The pink feldspars are potassium feldspars that readily take in iron; the iron ion is small enough to fit into the potassium feldspar crystal which results in the pink colour. Outside, Lord Kelvin's sundial carved from Carboniferous Sandstone was placed on top of Dolerite setts quarried in North Ayrshire; these setts were traditionally used to pave the streets of Glasgow. The Gable end of the lower section of the James Watt Engineering Buildings was clad in yellow Permian Sandstone with the upper portion clad in an oolitic Portland Limestone which contained an abundance of brachiopod shells.

The magnificent Gilbert Scott Building incorporated the original 1690 staircase taken from the old college building on the high street with its remarkably preserved carved sandstone Lion and Unicorn. The sandstone of the staircase showed signs of ripple marks.

The Permian Sandstone of the Davidson Building was a dune bedded aeolian sandstone. You could work out the direction of travel by following the asymptotic curve of the bedding planes.

There was also fossiliferous Portland Stone of the Kelvin building with its beds of fossil bivalve shells. I imagine all of us viewed parts of the university campus that we would never have noticed before taking this tour.

A pdf version of the 'Building Stones of the University of Glasgow' leaflet can be downloaded from the following web link:

http://geologyglasgow.org.uk/geoconservation/rigs/building-s/

Rock Around Outcrops

Maggie provided us with a contoured map of the campus showing the positions of the 16 outcrops. We took a look at each outcrop in detail, rocks were classified as either being Igneous, Sedimentary or Metamorphic; their lithology was studied to further aid in their identification and to interpret their geological history; heights were estimated using the contours on the map provided; the strike and dip of the rocks were also recorded; with all the information gathered we were then able to determine the nature of the geological boundaries which helped us construct a colourful theoretical geological map.

The majority of the outcrops were straightforward to find with the exception of number 11. Also the location for outcrops 2 and 3 was not so easy to reach – access was via a precarious slope made more difficult by the wet weather. At this point we were reminded to use the law of superposition as we came across two outcrops one on top of the other. We made the assumption the younger rock was sitting on top of the older rock as we could not see any evidence of folding or faulting.

The first schist outcrop we came across showed evidence of sheering and the foliations showed signs of 3 separate deformation events which ultimately resulted in crenulation cleavage. The first deformation squashed the rocks to produce the cleavage, leaving shiny flattened micaceous schist. The second deformation folded this cleavage to produce asymmetric folds probably in association with a mountain building event. The third deformation happened when the rock was squashed in the opposite direction, producing the crenulation cleavage. These deformations were not caused by a *number* of orogenic events, in fact the deformation and metamorphism of these rocks all occurred in association with the Caledonian orogeny.

One particular limestone outcrop rich in Crinoids, brachiopods, sea urchin spines had a determinable palaeocurrent, as you could clearly see the direction of flow from the alignment of these fossils. Where bedding surfaces could be seen on the limestones, grey patches could be found, this reflected higher concentrations of mud in the sediment.

Above the limestone fossiliferous Sandstone was found, and on top of this we identified a Basalt lava flow.

At the highest point we found a Granite Intrusion. We did not find any evidence of heating on the surrounding sedimentary rocks indicating that the granite had been faulted against them. The black shiny biotite showed alignment indicating that the granite had been deformed during a metamorphic event; this alignment suggested that the granite was probably deformed by one or more of the deformation periods that affected the schist. So the Granite must have been intruded, eroded and then the sedimentary rock was laid down on top.

We deduced there must be a transcurrent fault running along University Avenue as there was a significant drop in height in the outcrops on the south side of the road and the Schist, Limestone, Sandstone and Basalt had shifted to the left.

For more detailed information on the ‘Rock around the University’ project follow the link below:

http://www.gla.ac.uk/schools/ges/rockaround/

Real Geology of the Area

Maggie finished the day by giving a description with the aid of various printed illustrations of the real geology of the local area, highlighting that Glasgow was built on a succession of drumlins, Gilmorehill itself being a drumlin on top of carboniferous strata. Carboniferous limestone, sandstone and coal measures have been extracted from numerous local quarries. The strata dips slightly to the south east which of course would have meant that a large proportion of the coal measures would have been inaccessible had it not been laid down during a period of extension in the carboniferous, which resulted in a large number of faults. In fact the midland valley consists of a series of fault blocks and each fault brought a coal seam back up again, avoiding the need for extraction at any great depth.

A special thanks once again to Maggie for all her hard work in the organisation of this excursion, transforming a wet summer's day in Glasgow into an interesting and informative day of geological discovery.

Strath Fionan & Schiehallion
Sat 23rd Aug 2014

Leaders: Ben Browne, Maggie Donnelly
Reporter; Maggie Donnelly *Participants: 19*

Fifteen of us set off by coach on a damp morning, driving up the A9 (and getting caught in heavy traffic north of Perth!) to Ballinluig. We turned west along the A827 to Aberfeldy, took the B846 towards Tummel Bridge, and then a minor road NW through Strath Fionan to the Braes of Foss car park where we met another six participants. We planned to visit some of the localities from The Geologists' Association Guide No. 67: The Dalradian of Scotland, by Jack Treagus (2009), indicated by bold numbers in brackets below. We had been told that the coach company had double booked us for this evening, so that we would have to be back in Glasgow for 6 pm instead of the anticipated 6.30 pm – this meant that our trip would be rushed if not a little curtailed!! Ben began by giving us an excellent introduction to, and explanation of, the geology

The rocks of the Dalradian Supergroup lie between the Great Glen Fault and the Highland Boundary Fault. They were deposited mainly in shallow water in a subsiding basin within the supercontinent of Rodinia from about 750 Ma ago. This crustal extension finally culminated in the eruption of the Tayviallich volcanics, 603 Ma, and the opening of the Iapetus Ocean which would separate the Laurentian plate to the NW from the Gondwanan plate to the SE. The rocks were later folded and metamorphosed during the closure of the Iapetus (locally the Grampian Event, *ca* 470 – 460 Ma). Roughly from NW to SE the Dalradian is divided into the Grampian, Appin, Argyll & Southern Highland Groups, younging from the NW to SE. The metamorphic grade increases from SW, where sedimentary structures are best seen, to NE where higher grade metamorphic minerals occur; the metamorphic grade in the Schiehallion area is in the region of kyanite grade. The Dalradian Supergroup can be traced for 1300 km from Connemara to Shetland with some very persistent beds. Strath Fionan to the north of Schiehallion offers exposures of a

continuous succession within the Islay Subgroup, Argyll Group, down through the Appin and Grampian Groups. Today with one walk of 1.5 km on a good track and well grazed grass, and three walks of up to 300 m on rough grazing we would view the upper nine beds, from the Schiehallion Quartzite down to the Meall Dubh Graphitic Schist. The rocks are deformed by two major folds as well as by the broad swing of the Bohespic Antiform, and there are spectacular metamorphic minerals. We would have the opportunity to examine the Schiehallion Boulder Bed, deposited during the late Neoproterozoic Glaciations, and to discuss the controversial theories associated with the latter.

We drove NW and parked in a layby (*locality 4*) at NN 740 563 where there was a good view of the stratigraphy as revealed by the topography. The strath and road follow the softer beds of the Strath Fionan Limestone and the Strath Fionan Banded Formation; the ridges and high ground to the north are composed of Meall Dubh Quartzite, Meall Dubh Graphitic Schist and then Grampian psammites, while to the south lies the impressive mountain of Schiehallion Quartzite. We passed through a gate and followed a feint path over a narrow deep burn and uphill to NN 742 565 where, at the base of a crag line, was an exposure of Meal Dubh Graphitic Schist with numerous superb black kyanites. There were further exposures about 35 m to the east. We then drove on to an old quarry at NN 726 566 (**locality 7b**), and made our way 200 m SSE across tussock grass and a burn to tree lined crags. The lower beds to the east of the crags (NN 728 563) were of dramatic white dolomitic Strath Fionan Limestone with an extensive outcrop of spectacular tremolite rosettes. Above lay the contact with Strath Fionan Dark Graphitic Schist. We returned to the coach and on to a quarry in the Strath Fionan Dark Schist and Limestone at NN 715 574 (*locality 8a*). This comprised three alternating strata of dark limestone and of dark graphitic schist. A dramatic clear, clean limestone pavement above the quarry displayed tight D2 folds, also exposed in the quarry face, and very well developed clints and grykes. We spent some time examining the folds and the myriad features, before driving further up the glen to park in a forest road entry, next to an exposure of Banded Semipelite at NN 701 578.

Clints, grykes & folding in limestone pavement above the quarry
Bill Gray

We crossed to the north side of the road and found, just over a gate, a large and impressive erratic boulder of the Schiehallion Boulder Bed (*locality 9)* with granite, quartzite and schist clasts of various shapes and sizes set in a mudstone matrix, and typical of the upper beds of the Boulder Bed – the lower beds are predominantly of dolomitic clasts.

Erratic boulder of Schiehallion Boulder Bed at *locality 9*

Maggie Donnelly

We started up a track from East Tempar Farm, NN 690 575, (*locality 9a)*……..Lunch!!! Because we were pressed for time, many of us had started eating on the coach and on the hoof, but at this point a few of us rebelled and sat down on the grassy slope – the sun had come out – and relaxed with our pieces. The rest of the party turned south after the first wall to clean exposures of Schiehallion Quartzite in the Tempar Burn, NN 691 570, where they confirmed a NNW strike and steep ***NE*** dip, younging SW, because these beds are inverted locally by the Bohespic Antiform. A little further upstream, just before a wire fence, there were Dolomitic Beds with small scale graded bedding younging westwards. Upstream from this, were conglomerates – difficult to find in this overgrown gorge, so the group regained the track and met up with the lunchtime rebels. We continued uphill looking out for exposures of the Boulder Bed in and near the track, and began to find isolated outcrops. At last we came upon a particularly good exposure almost hidden in the bracken, ~ NN 696 565. It contained grey and pink granite, pink and white quartzite, dolomitic limestone and schist clasts, in a great variety of shapes and sizes (up to 4 cm here), widely spaced, not sorted and considerably deformed. The carbonate clasts were most deformed and strongly weathered so that they were mainly identified as distinctive ellipsoidal cavities; the least deformed granite and schist clasts retained their irregular and angular shapes. The matrix was gritty and highly feldspathic, and the cleavage clearly defined, curving round each clast. This curving cleavage can be mistaken for a sedimentary feature, indicating that the clast is a 'dropstone', and has fallen from an ice floe into mud. While it is agreed that some of the global Neoproterozoic Glaciation deposits are the result of the latter process, here it would appear that we are dealing with a deformational and not a sedimentary feature.

Because these Neoproterozoic glaciogenic sediments occur on most continents, it has been suggested that they represent the repeated spreading of ice sheets from pole to pole; this would lead to run-away cooling and create a totally ice-bound Earth – the "Snowball Earth Hypothesis". Unsurprisingly, many workers do not agree with these extreme views, finding it difficult to reconcile a totally frigid planet with the survival of any life forms. While they agree that the glaciations were widespread, a model of a "Slushball Earth" is preferred. In addition, it is difficult to obtain precise dates for rocks as old as these – the margins of error ***do*** allow for diachronistic glaciations. The "Snowball Earth Hypothesis" is generally considered to be too dramatic, sensationalistic, and lacking in solutions to some key issues.

We headed back to the coach and set off for home – heavy traffic on the A9 again! – but managed to get back to the Gregory Building for 6.10 pm…….amazing, considering all that we had accomplished today!!

References

Excursion Notes by Ben Browne and by Maggie Donnelly
Jack Treagus. 2009. The Dalradian of Scotland, Geologists' Association Guide No 67
Stephenson, D, and Gould, D. (1995). The Grampian Highlands, British Regional Geology, BGS

Residential excursion

Glasgow Geological Society Banffshire Coast Excursion
September 2014

Leaders John Mendrun and Con Gillan

Friday 12th September 2014
Report by Bob Diamond *participants 22*

After a lengthy journey North from the Central Belt to the North East 22 adventurous souls arrived in dribs and drabs at Cullen, Morayshire, eagerly anticipating a good field trip amongst the Grampian Dalradian. John Mendrum and Con Gillen are well known to us, and did not let us down. We had a great time despite the haar coming down at times, and one of us managing to lock himself out of his car.
Our first stop was at Portnockie Harbour, where we started at the lowest part of the stratigraphy the Cullen Quartzite Formation. Although at the base of the sequence (in amphibolites fascies) there was a remarkable amount of structure still visible.
There were massive psammitic beds, showing crossbedding, interbedded with thinner pelitic beds indicating a deltaic/intertidal depositional environment. Other sedimentary features such as slumping and channels could be seen. All these structures had been steeply folded, so that there was evidence of brittle fracture in some of the quartzites
On closer inspection of some of the pelites there was evidence of crenulations cleavage, indicating secondary cleavage (from secondary deformation) of an existing fold
Our second stop was at the Pet Cemetery at Cullen. Right on the shore is this cemetery for pets. Very unusual, and remarkable for the evident love and affection people had for their pets.
We were still in the Cullen quartzites, but this time there were garnets in the rocks. There was some debate as to whether the rocks were 'right way up' or slightly overturned. What was evident was that we were looking at a monocline dipping c65o to the North, and younging to the North
As previously we were still in a deltaic environment, but at this location the crossbedding was at a low angle.

The only other feature was that some of the silica around the quartz grains had been replaced by carbonate during diagenesis.
So after a gentle introduction to the complexities awaiting us we retired to our respective Hotels, were the writer at least enjoyed a good bowl of Cullen Skink.

Saturday 13th September 2014 am.
Report by Elisabeth Davenport
Unfortunately technical problems have prevented me from getting this report at this time. If it can be recovered later I will add it to the website version of the reports.
My apologies to Dr. Davenport

Saturday 13th September pm.
Report by Bill Gray

After our morning among the rocks of the Lochaber and Ballachulish Subgroups of the Appin Group, we now moved east to study the rocks of the younger Blair Atholl Subgroup and the overlying Argyll Group. Our first stop was at the Glenglassaugh Distillery visitor centre at the east side of Sandend Bay, from which we walked down the path to the shore. On the way, we passed an outcrop of Devonian rock in the form of a small hill, an example of the many Devonian outliers that are found across the Northeast Grampians. The rock was a breccia/conglomerate with till on the top and it displayed surface weathering. The rocks exposed at the shore were metalimestones and semipelites of the Fordyce Limestone Formation of the Blair Atholl Subgroup, and we found a sheltered spot next to them for our lunch. Those of us with access to binoculars had a good view of a pair of Brent Geese swimming in the bay.
After our lunch, we walked eastwards along the shore. The main features here were deformed limestones that displayed folds, distorted bedding and boudinage.

Boudinage in metalimestone at Sandend East

The sun now emerged from behind the clouds (it stayed out for the rest of the afternoon) and illuminated a stretch of limestone with a beautiful striped structure. We then encountered a red outcrop of fine-grained pelite with crenulation cleavage, indicating two

stages of deformation – D1 and D3, and limestone with folded folds, which are examples of interference structures.

We also saw further examples of Devonian inliers within the Dalradian, the most spectacular of which, at the furthest point our walk, was a large outcrop that had been created by the infilling of a Dalradian pothole.

The surrounding country rock displayed karstic weathering and calcite veining. We now retraced our steps to the car park.
In a change to the planned order of events, we now drove further east to Portsoy, where we parked on a cliff top to the west of the town. From here we walked to the derelict swimming pool and studied the rocks on the foreshore next to it. These rocks belong to the Argyll Group, specifically to the Portsoy Limestone Formation of the Easdale Subgroup. They are part of the Portsoy Shear Zone, an area which gas been the focus of intense interest to the geological community, as its interpretation is critical in understanding the geological history of the Northeast Grampians. One striking feature of the rocks near the swimming pool is the presence of the metamorphic minerals andalusite, kyanite and sillimanite; knowledge of the order in which the kyanite and sillimanite were formed from the lower grade andalusite is important in determining the tectonic history of the area. (Sillimanite forms at high temperatures and kyanite at high pressures.) We saw several clusters of sillimanite crystals, and also mica pseudomorphs of sillimanite and kyanite pseudomorphs of chiastolite (andalusite with carbon crosses). At the headland to the west side of the pool we saw a spectacular asymmetrical fold structure in the rocks and to the east side of the pool we saw tension gashes in a competent bed with sillimanite crystals occupying the gash spaces.

We now walked eastwards past the old harbour and further along the shore, where we saw tightly folded limestone, reflecting the activity within the Portsoy Shear Zone.

We also saw a gabbro intrusion that had been formed between 473 and 471 Ma, a short time by geological standards. Slightly further on, we saw boulders of 'Portsoy Marble' (actually serpentinite) and then came to the probable source of these boulders, large serpentinised ultramafic bodies intercalated within the metasedimentary rocks. These bodies, which are very Mg rich, were intruded in the Early Ordovician, around the same time as the gabbro intrusion we had seen earlier. They contain grains of iddingsite, a red microcrystalline rock derived from the alteration of olivine. This point marked the end of our traverse, and we now wended our weary way back to the cars.

Sunday 14th September 2014
Report by S Leishman

On Saturday afternoon we had been introduced to the 2 km-wide Portsoy Shear Zone which marks the western edge of the Buchan Block. To the South it is bounded by gabbroic plutons. Dalradian structural timing and basement of the Block have very different histories from the South and West Grampians. Research on this has been continuing for almost 100 years. Put VERY simply, was it horizontal shearing from the east pushing the beds up OR the effect of gabbro intrusions?
Portsoy is famous for 'portsoy marble', which is not marble at all! The source is a vein of serpentinite, a metamorphosed ultra basic peridotite with olivine and pyroxene. These magnesium silicates are prone to hydration thus altering to steatite which is relatively easy to carve. The varied colours are due to iron, chromite also iddingsite for the red. John made it clear that this outcrop is not the result of MOR volcanism. It had been an intrusion linked to the gabbro, which can also be seen at Insch and Huntly.
In the coastal 'marble' quarry just east of the old Portsoy swimming pool we found a block on the beach measuring ~ 70 x 70. This clearly shows how they were broken up using the Cornish system.

Metal 'feathers' are inserted into each drilled hole and a tapered plug hammered in until the ringing tone indicates the correct depth and tightness.

Marble Block

The exposures on this beach from West to East range through mafic intrusions - quartzite - 'marble' - pelite - quartzite. A real tectonic melange.
Could this be caused by crustal/mantle weakness followed by Grampian deformation at 470 MY? The deformation would all have been at depth – any shallower and the rocks

are not plastic and mobile enough. John also noted that the mantle is not the same composition - or age - everywhere on the planet.
After this comprehensive discourse we discovered that from the middle of the bay to the east, igneous outcrops give way to quartzite, limestone and semi-pelite of the Portsoy Limestone Formation, Easdale sub-Group. An exposure of the calc-silicate quartzite has been greatly sheared to produce rodding or mini-mullions.
A stand-alone stack of dolomitic limestone allowed us to study steeply plunging folds in 3D – with a great deal of help from John and Con!

mini mullions

Then a 'novelty item'; a pod of meta-anorthosite, also ribbed and altered, with sheared boundaries.
The next locality was the Portsoy rubbish tip where it is possible to see the relationship between the older fine-grained folded and foliated amphibolite intruded by the coarse younger metagabbro, which is itself cut by shear zones.
Portsoy New Harbour was our pleasant stop for lunch. Some of us were sitting on two gabbros – one of which is foliated, the other not. This indicates that magma intrusion and deformation were contemporary.

Then over the harbour wall and traversing east along the foreshore is the expected sequence of Easdale sub-group meta limestones, calc/silicate and semi-pelites. However these are cut by huge veins/pods of leucasome pegmatitic granites of the 470 MY age.

Easdale sub-group cut by pegmatitic granites

We drove to the car park at the east end of Links Bay - the eastern edge of the Portsoy shear Zone. By then we were in a new sequence – the Cowhythe psammitic formation (equivalent in age to Crinan sub-group)
The rocks appear very complex indeed. In addition to the full range of meta-sedimentaries there are enclaves of highly deformed migmatic igneous rocks. These have recently been zircon-dated at 1004 MY, the time of the Grenville orogeny. Does this mean that basement has been caught up in the 'shuffle zone'? An intriguing question!

Migmatic igneous (basement?) dated 104 Ma

The Portsoy Shear Zone then ends and we were in the Cowhythe Formation Rosehall Croft Member. Reaching East Point we found ultra-mafic pods of gneiss with anthopholite and cummingtonite (orthorhombic and monoclinic amphiboles) the pods are like a bubble and because they are anhydrous, suck in alteration minerals and become slightly serpentinised.
So we completed another day of fantastic geology and views of the rocks of the North East coast - all in good company and amazing sunshine.

Monday 15th September 2014
Report M. Alexander

The final morning of our excursion arrived and the weather was disappointing-dull and threatening to rain. However most of the group met in the square and, after receiving directions from our leader, we set off in good spirits to the first location of the day.

We drove east through Portsoy turning left down the narrow B9139 until we parked at the top of a lane leading to the Boyne Limestone Quarry. A walk down the lane past the quarry entrance led us to Boyne Bay where, as we had now moved up the succession, the rocks were in the Tayvallach Subgroup of the Argyll Group and we were encountering rocks of the Boyne Limestone Formation.

The first outcrops encountered on the east side of the bay were of much deformed and folded greenish-grey rocks with fine granitic veins through them. They were formed by thin beds of calc-silicate, metalimestone and semipelite rocks which were interbedded, compressed, folded and refolded showing cleavage and giving step folding. These outstanding folds were F1 refolded by F3.

We next walked across the bay to the west where we encountered the challenge of wading across a fast flowing, shallow stream and climbing the grassy bank opposite (gaiters were a great help but some people must have had very wet feet).We were now looking across Old Hythe Ba. Here , in the bay, we first examined the impressive, finely banded exposures of the Boyne Castle Limestone Member where the folding (F1) and refolding (F3) of metalimestone and calc-silicate bands showed the light coloured surfaces with wonderful interference patterns of dark lines through the pale grey rock (we could even imagine the shape of a bear). The thin banding indicated that perhaps some of these layers may have been algal and have formed in warm water on a shallow, marine shelf in lagoons or on algal reefs. Folded outcrops of darker semipelite interbedded with metalimestones and calc-silicates were also found within the bay area.

Lastly, we walked across the beach to the cliff at the west end of the bay which formed the boundary between the Boyne Limestone Formation and the Cowhythe Psammite Formation. This cliff face is the position of the Boyne Line which is thought to be a shear zone as it showed mylonitic recrystallization and possible faulting.

As we returned to the cars the rain began and, as some of the group were leaving early, we decided, while still all together, to express our thanks and appreciation to our leaders. Fortunately the farm was nearby and the silky tongue of our leader persuaded the farmer to allow us to shelter in the barn. After a lively discussion and some chat, including mention of the reported find of the single microfossil arcritarch in the area, we thanked John and Con most sincerely for giving up so much of their time to be with us for the weekend and for all the effort, preparation, patience and enthusiasm the showed to give us a clear, fascinating insight into what is indeed a very complex area.

After saying our farewells we set off , past Whyntle , to Whitehills and on to the car park at Red Well for lunch. We had now moved up the stratigraphic succession from the Argyll Group into the Macduff Formation of the Southern Highland Group near the top of the Knock Head Grit Member. Fortunately the rain had stopped as we walked along the shore to the east where we soon found bands of rocks which were exposed on the foreshore. These were from turbidite fans flowing down off the subsiding continental shelf and were arenites (or psammites), semipelites and pelites indicating that they were formed from sediments in a much deeper water environment. These rocks were typical of Buchan Metamorphism and had been metamorphosed to amphibolite facies. We could clearly see many large, grey andalusite prophyroblasts scattered on the surface of some pelitic layers. Folds and cleavage could perhaps be found here and the folds around the growth structure of the porphyroblasts showed that metamorphism occurred between the D1 and D3 deformations. As we searched around looking at the pelitic bands we found other metamorphic minerals in the form of black, rounded spots which were cordierites and small, brown staurolite porphyroblasts.

Our final stop involved a drive eastward through Banff and Macduff to the Howe of Tarlair where we parked beside the old swimming pool. Here we saw some of the youngest rocks at the highest structural levels of the Macduff Formation, mainly arenites, greywackes and pelites deposited by turbidite flows. We looked at the sedimentary structures and identified bedding, grading in the psammites and ripple marks indicating that the rocks were right way up . We also found rip-up clasts, flame structures, mud flakes and calcareous blocks left by the turbidite actions. The rock outcrops and cliff faces

showed large scale, upright folding with only one (D1) deformation. Here metamorphism was lower grade at green schist facies giving the rocks a slatey cleavage. The high cliffs at the back of the bay formed an upright, F1, syncline-anticline pair of folds which were upward facing. The relationship of the cleavage to the bedding could be seen. After viewing the large outcrops at the east end of the bay and finding possible dewatering structures we made our way back to our cars where we once again thanked our leaders for a great field trip and wished everyone a safe journey before finally setting off for home.

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Intimations

With regret we record the passing of

Mr. .Julian Jocelyn member since session 102(1960-1961) who died in June 2014
Mr. Jocelyn was a much respected Honorary Member with a special interest in Agates. He is remembered with pleasure by many members who greatly regret his passing.

Miss Dorothea Blake member since session 126(1984-1985) who died on 1st July 2014
Miss Blake was a past treasurer of the Society and the sister of Rosemary McCusker. Both sisters rendered invaluable service to the Society and are missed by all who knew them.

Dr. Bruce. A. Woodger member since session 133(1991-1992) who died in 2014

Dr. Graham Jardine member since session 102(1960-1961) who died in 2014

Mr. William. Primrose member since session 116(1974-1975) who died in 1024.