PROCEEDINGS OF

THE GEOLOGICAL SOCIETY

OF GLASGOW

Session 149 **2006 – 07**

SESSION 149 (2006 – 2007)

SESSION 149 (2006– 2007)

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	vacancy
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MEMBERSHIP

	At end 149 30 Sep., 2007	At end 148 30 Sep., 2006
Honorary Members	5	5
Ordinary Members	306	300
Associate Members	62	67
Junior Members	19	23
TOTAL Members	392	395
New Members	34	23
Memberships Closed	24	10

Overall membership numbers have remained fairly static, with the increase in memberships closed being more or less counter-balanced by the increase in new members joining in the 149 Session. (The memberships closed category rolls up the numbers resigning and the terminations due to non payment of subscriptions.)

R. A. Painter

LIBRARY

The Society's Library has been reorganised and updated during the session, thanks to the efforts of the Assistant Librarian and a small but dedicated team of helpers. The reorganisation has been effected as follows:

Reorganisation of the Journal Library. The journal library was rapidly running out of space, and a number of back runs of weekly and monthly journals, plus unused runs/dead runs were disposed of – having been offered to the University Library and to members. In addition, reorganisation of space in the book library allowed the transfer into this library of the Geological Survey Memoir collection. This collection covers the whole of the UK and is now available for borrowing and consultation.

A number of older journal runs in the book library remain to be disposed of.

Acquisitions. Over one hundred new books have been acquired by the library this Session – these books being in large part via gifts and bequests. The vast majority are up to date publications ranging from introductory works to specialist studies.

Book Library Reorganisation. The influx of new books has meant that the library has had to be reorganised and redundant volumes weeded out. In addition the locations of all the books are being noted by relabelling their spine numbers, as a prelude to the production of a new catalogue – the last catalogue being over twenty years old. It is hoped to finalise this catalogue within the next session.

Map Library. The Society's map library has benefited from a stream of new UK (onshore and offshore) geological maps provided free under our arrangement with the British Geological Survey. This library forms part of the departmental collection, housed in the Honours labs. in the Gregory Building, and is to be reorganised within the next Session to provide more space for the new maps.

Library Usage. Usage of the library has been at a low level for some time, despite successive efforts at drawing its facilities and scope to the attention of members. A fresh publicity effort has been made during this session, including the exhibition of new acquisitions at post-meeting coffee, the prominent signposting of the route to the library, and drawing the attention of DACE students to its existence. A small increase in users has resulted, but many members still need to be convinced of the value of what the Society possesses.

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

SCOTTISH JOURNAL OF GEOLOGY

The full 192 pages for volume 43 were published in 2007. Hardcopy uptake via libraries and trade subscriptions continues to be an issue, although data suggest that the Journal suffers slightly less from this than some comparable publications. Online use continues to grow and it is gratifying to see the continuing increase in full text downloads. These raise the profile of the Journal and should eventually influence our impact factor. Discussions are in progress regarding a wider electronic exposure. The trade subscription is £140 (2006 price) and the subvention from the Society for volume 44 has been held at the same figure as last Session.

C.J.R. Braithwaite

PUBLICATIONS

The year showed a profit of £246 thanks to the generosity of members and adult classes. We now have very few commercial sales. Five new titles were made available to members during the year, making the total titles 50 plus maps. The book value of our stock is £10,600. Seventy percent of this amount is represented by the Glasgow and Girvan Guide and 10% by the Building Stones of Glasgow. Council is currently considering the implications of these stock values.

Roy Smart

WEBSITE

The website continues to be well used. This session it is proving to be more difficult to derive statistics about usage due to a change in the University's web systems. It is hoped to have more information at the AGM.

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

STRATHCLYDE RIGS GROUP

In February we visited the Muirshiel Barite mine… but no exposures could be seen because of deep snow! We'll be back.

In April the Group was instrumental in arranging the first Scottish Geodiversity Workshop, chaired by Mike Browne of UKRIGS. Delegates from all over Scotland heard speakers from SNH, BGS and Midlothian Biodiversity Partnership. Items covered were audits, action plans, funding, promotion, setting up a RIGS group plus learning from each others' experiences. We were encouraged to respond to consultations with national bodies to promote local public interest in geoconservation.

As the Scottish planning system favours biodiversity, efforts to promote geodiversity will be more effective if the bio and geo aspects are linked.
We have had input on issues such as the Scottish Mineral Information Policy, the Fossil Code, geodiversity for planning officers, and ensuring geology is included in the Dams to Darnley Country Park Biodiversity Integration. We are supporting the bid for a RIGS Development Officer in Scotland.
The Workshop led to a proposal, by the Scottish Coal Group to retain a section of the Spireslack opencast mine as a RIGS. Following a site visit, a meeting on this major project will be held with Scottish Coal and East Ayrshire Council. Also in Ayrshire, the rocks on the shore at Portencross are being proposed for RIGS designation and promotion.
We and Stirling RIGS Group are partners with BGS in a grant bid "to deliver geodiversity knowledge and data to the Loch Lomond and Trossachs National Park". This would include a geodiversity audit of the whole Park, but in the meantime we want to produce an interim leaflet on Balmaha as the Park's main geological attraction for the casual visitor. Funding has been requested from LLTNP/SNH.
A RIGS initiative within the City of Glasgow started with Fossil Grove in Victoria Park. Read all about it in the December issue of Earth Heritage Magazine. We are preparing a leaflet for distribution in 2008, and will be working with the City Council and SNH to develop and promote this world-class site. A number of other areas in the city are being investigated, as Glasgow's geodiversity deserves a much higher profile.
The Campsie Glen RIGS designation is being progressed through East Dunbartonshire's Local Plan and we hope to have the leaflet ready for Spring 2008. The Council are reviewing their Local Nature Conservation Sites (LNCS) and we may be involved. Craigen Glen, South Hill could be nominated – it was the locality of the Society's first ever excursion in May 1858!
See - www.geologyglasgow.org.uk – for all our leaflet details.

Stuart Fairley

TREASURER

Income and Expenditure Account for Year Ended 30th September 2007

(Scottish Charity Number SCOO7013)

	2005-06		2006-07	
Income				
1. Subscriptions				
Received by Bankers Order	6,540		3,979	
Received by payment to Memb Sec	incl		2,355	
Deduct paid in advance this year	-120		-300	
Add received in advance last year	0	6,420	120	6,154
2. Investment Income				
Dividends	572		546	
National Savings	1,871	2,443	1,956	
Revaluation of Charifund investment		0	9,807	12,309

3. Tax refund (Gift Aid)		1,075		1,048
4. ConocoPhillips prize		233		117
5. Net surplus Publications sales		308		246
2005-06 liab				
6. Saturday excursions income	netted		1,175	
expenditure	netted		1,160	15
7. Weekend excursions income	netted		2,070	
expenditure	netted	129	2,013	57
8. Donations		0		200
9. Float refund		20		0
Total income		**£10,628**		**£20,145**

Expenditure

1. Scottish Journal of Geology	4,500		4,500
2. Meetings incl speakers, meals, etc	1,865		658
Room hire extra (£632 accrued for Spring 2006, total cost £977)			345
Room hire Autumn 2006			365
Room hire Spring 2007 (provision – to be invoiced)			1,043
3. Publication of Proceedings	1,998		440
4. Billets, production incl Hon Sec's expenses	1,228		389
5. Sponsorship grants	2,150		500
6. Library	851		535
7. Insurance	520		522
8. ConocoPhillips prizes	300		350
9. Mull Guide survey	260		0
10. RIGS	40		0
11. Hunterian 2007 fund	250		0
12. T N George Celebrity Lecture	20		0
13. Society's website	0		0
14. Affiliation fees	32		289
15. Admin costs – postage, stationery, telephone etc			
Membership Sec 2006-07	0		645
Chairman	0		104
Treasurer 2006-07	0		54
16. AGM expenditure (net)	35		0
17. Donations			10
18. Write off - overstock unsaleable publications			8,573
Total expenditure	**£14,049**		**£19,322**
Profit/loss	**-£3,421**		**£823**

Balance Sheet as at 30th September 2007

Members' Funds	**2005-06**			**2006-07**
Balance as at 30/09/2006	£66,610 at 30/09/05			£63,190
Surplus/deficit for the year	-£3,421 up to Sep 06			£823
Balance as at 30th September 2007	**£63,190 bal at Sep 06**			**£64,013**
Represented by				
ASSETS				
Current assets				
Cash at Bank:				
Royal Bank of Scotland Account	3,295		4,945	
National Savings Investment Account	39,594	42,889	36,550	41,495
Cash in hand:				
Publications Sales Officer		33	50	
Membership Secretary		0	200	
Secretary		0	0	
Meetings Secretary		0	35	285
National Savings Income Bond		12,000		12,000
Investments at Cost		1,026		1,026
Revised valuation of Charifund investment		0		10,833
Debtors for Publications at 30/9/07		30		31
Stock of Publications		10,768		2,092
Current assets		**£66,745**		**£66,736**
LESS LIABILITIES				
Subscriptions paid in advance	- 120		-300	
Moneys due by Society (room hire Spring 07)	-2,056		-1,043	-1,343
Restricted Funds				
T.N.George Fund	- 380		- 380	
Hunterian fund	- 1,000	**- £3,556**	- 1,000	**- £1,380**

2006 Net Assets	**£63,190**	**2007 Net Assets**	**£64,013**

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

Signed by the Independent Examiners …….
Dr Ben H Browne and Miss Sally Rowan

PROCEEDINGS

After a gap of some 6 years, the Proceedings for Sessions 142 – 145 (1999 – 2002) were printed and distributed during Session 148, in two booklets with 2 Sessions in each, using Pandaprint, of Garscube Road, Glasgow. Sessions 146 and 147 were subsequently printed in separate booklets and distributed in April (2006) of Session 148, while those for Session 148 were distributed in April (2007) of Session 149. The booklets were distributed by hand where possible, at Society Meetings, Excursions etc to save on costs, and the remainder by post. Proceedings for Session 149 are presently being collated and it is hoped to have them ready for early in the new year of 2008.

Margaret Donnelly

MEETINGS

Our 149th Session opened with Mike Benton from Bristol University giving his T N George Medal Lecture, describing new evidence from Russia on the end-Permian mass extinction whose root cause was probably massive volcanic eruptions in Siberia leading to acid rain, soil stripping, global warming and anoxia. In November, Godfrey Fitton from Edinburgh University told us about the origin of the submarine Ontong Java Plateau which is by far the largest known magmatic event on Earth. On the evening of the AGM, retiring President Chris Burton gave his Presidential Address entitled "The Geology of the Island of Madeira", that island being the youngest product of the evolution of a mantle plume, the Madeira hotspot.
January 2006 saw Paul Barrett of the Natural History Museum give his postponed talk describing the series of dazzling discoveries of feathered dinosaurs that have been made in the quarries of Liaoning Province, China. Your Meetings Secretary mounted the podium in February to illustrate the use of the sea kayak in geological study. Dinosaurs were again on the agenda in March when our own Neil Clark had us "Tracking dinosaurs from Scotland to Wyoming" and discovering that the same dinosaurs probably roamed both locations. Stuart Archer from ConocoPhillips in Aberdeen gave a talk on "Landscape evolution in rifted terrains" using the Basin and Range Province of the southwestern USA to illustrate his subject. Members' Night closed the season with the usual interesting and mixed programme of contributions.

Jim M. Morrison

Thursday 12th October 2006

After the following citation delivered by Dr Alan Owen, the **Professor Thomas Neville George Memorial Medal** was presented by Dr Michael Keen to

Professor Mike Benton, University of Bristol.

Mike Benton started his academic career as a zoologist, graduating with a B.Sc. in that subject from Aberdeen University but even as an undergraduate he saw the palaeontological light and he went on to undertake a PhD at Newcastle University on the functional morphology and relationships of a reptile species from the Triassic of Elgin. Following spells at the Nature Conservancy Council, the University of Oxford and Queen's University Belfast, he took a lectureship in the Department of Earth Sciences at the University of Bristol in 1989 where he was awarded a professorship in 1997 and since 2001 he has been its very effective and highly respected Head of Department.

Mike's publication record is staggering. His first papers were written whilst he was still an undergraduate and whilst the core of his work is in vertebrate palaeontology – including writing what has become the standard textbook on the subject, now in its Third Edition – his work includes substantial contributions on trace fossils, evolutionary theory, biodiversity change, mass extinction (including a highly acclaimed book on the end-Permian extinction), taxonomic procedures and the conservation of palaeontological sites. He has written text books, edited mighty tomes – including the 845 page compilation on the Fossil Record – and provided insightful reviews of more books on palaeobiology and evolution than many a university library holds on it shelves.

In addition to the multitude of research papers and books, Mike has made a major contribution to communicating palaeontology to the wider public, ranging from articles in New Scientist, through entries in encyclopaedias and chapters in the Guinness Book of Records to a huge number of popular books on dinosaurs – so if you (or your offspring) have a copy of 'The Giant Book of Dinosaurs', 'The Best-Ever Book of Dinosaurs' or The Encyclopaedia of Awesome Dinosaurs' to name but a few, then the author is sitting right here with us tonight. Furthermore, this skill at engaging the general public is also manifested in appearances in numerous TV documentaries and a major role in putting together the highly successful 'Walking with dinosaurs' series a few years ago.

The T.N. George Medal is awarded "for excellence in palaeontology and/or stratigraphy". For his considerable contribution to the science of palaeontology and the communication of that science to the wider public, Professor Mike Benton is a more than worthy recipient of the award and I am pleased to call on our Vice President, Dr Mike Keen, to make the award.

Professor Mike Benton then addressed the Society on

THE END-PERMIAN MASS EXTINCTION: NEW FIELD WORK IN RUSSIA

The end-Permian crisis was the biggest mass extinction of all time and life came close to total annihilation. Most previous research has been on marine sections in China

and elsewhere, but the impact on continental settings has been little studied. New field work on terrestrial successions in Russia reveals the devastation caused to vertebrate ecosystems, and provides evidence about the nature of the physical environmental changes. Sepkoski's graph (1990) of total numbers of marine animal families through the Phanerozoic identifies five major mass extinctions, with a loss of 52% at the end-Permian, but only of (11 – 12) % during the other four. Block diagrams from China show a rich, complex life before the Permo/Triassic Boundary (PTB), thriving in a bioclastic limestone, but this changed abruptly to black muds having only a few shelly species – an (80 – 95) % loss of species. Volcanic ash bands provide dates: Band A, 251.4 Ma, is followed by a 90% drop in species; there is then rapid origination and extinction of 'weedy species' followed by a 5% drop at band B, 250.7 Ma. This is much more instantaneous than the K/T extinction. The only other 'PTB terrestrial section' is in the Karoo in Africa, which reveals extinctions through 60 metres, starting below the PTB – but is this real, or the Signor-Lipps effect, i.e. is it an artefact of fossil collecting and/or preservation?

The current view of the cause of the disaster supports an Earth-bound model, such as that produced by Wignall (2001) for the Siberian Trap eruptions, long linked to the PTB. Outgassed sulphur dioxide, chlorine and fluorine would lead to acid rain and increased continental weathering due to the loss of plants, while carbon dioxide would promote global warming and anoxic oceans. The $\delta\ ^{13}C$ value shifted far towards $\delta\ ^{12}C$, possibly aggravated by dissociation of gas hydrates from the sea bed.

An extra-terrestrial impact theory is supported by increased values of iridium reported from China, and shocked quartz from some sites, but these claims are disputed. The subsurface Bedout crater in Australia has been suggested as a candidate, but this does not appear circular from all aspects, and so has not found general acceptance.

The Permian Period was named by Sir Roderick Murchison after the Russian town of Perm where, in 1839, he found marine beds between Carboniferous and Triassic rocks. He had travelled widely, trying to link the UK marine beds across Europe, and to establish an international stratigraphic succession. Our speaker described his own journey into the Urals, via St Petersburg and Moscow to Saraktash and Kulchomova where Upper Permian beds were deposited in lacustrine and fluvial settings. These cyclical sediments become fine grained upwards to the PTB, then change to massive conglomerates, an indication of dramatic change in the rate of runoff from the Urals, also seen in the Karoo. The Urals were rising at the time, but this change in rate was due to loss of plant cover and not to local tectonics. Russian geologists did much work here in the 1950's looking for natural resources. They identified five huge alluvial fans on the west side of the Urals, around Tverdokhlobov, and traced their sources back into the mountains. There are enormous gas fields and detailed maps were made, but only about 100 copies of each exist and these are kept in security by the State. Unfortunately, the researchers did not keep their notes!! During current digging huge footprints of the reptile *Scutosaurus* were found. Below the PTB there is an abundance of animals, including the reptile *Lystrosaurus*; but above, there is only *Lystrosaurus* – is he the great survivor?

This was a real apocalypse with global temperature rise, superanoxia, a productivity crash, heavy rainfall and stripping of the soil: a major extinction on both land and sea.

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Thursday 9th November 2006
Professor Godfrey Fitton, (University of Edinburgh)

ORIGIN OF THE SUBMARINE ONTONG JAVA PLATEAU: THE WORLD'S LARGEST IGNEOUS PROVINCE

The Cretaceous submarine Ontong Java Plateau (OJP), in the western Pacific Ocean NE of Papua New Guinea, represents by far the largest known magmatic event on Earth. Large igneous provinces, (LIPs), of which the OJP is one, represent rapid eruption of basaltic magma on a huge scale. In the Pacific their occurrence suddenly peaks at ~ 120 Ma and they cover 1% of Earth's surface. Around this time the poles stopped reversing. Boreholes drilled near the Solomon Islands have provided an age of 122 Ma, erupted over not > 10 Ma. The OJP eruption was much larger than that of Laki fissure, and the Plateau is much bigger than Olympus Mons, on Mars. It would have caused serious environmental damage, releasing sulphur and carbon dioxide. LIPs have been linked to mass extinctions – the Siberian Traps to the Permian/Triassic Boundary and the Deccan Traps to the K/T, but others do not connect as well.

Plate Tectonic reconstruction of the southwest Pacific shows that the OJP formed far out in the ocean and then moved close to the Solomon Islands. In the Ocean Drilling Program of deep basins, beneath 1 km water, each hole is labelled so that it can be relocated with GPS. The cores contain pelagic sediment, pillow lavas and pillow breccia of olivine/plagioclase basalt – a volcanoclastic sequence with accretionary lapilli, and fossil wood. Site 1184, on the edge of the plateau and thought to be ~ 5km from the eruption site, reveals very thick volcanic eruptions, and interaction with water, but no large bombs, or clasts. The remarkably uniform composition of the OJP basalt has recently been demonstrated – it is more like Hawaiian than MORBs, and plots below the alkali/tholeiite line. This suggests that it came straight from the mantle without much evolution, requiring around 30% melting of the mantle, with very high temperatures (probably 1600 ºC, >250ºC hotter than normal), and provides compelling evidence for a mantle-plume origin. However, such vigorous upwelling should have raised the plateau well above sea level and yet most of it formed in deep water (~ 1000 m), followed by subsidence and low volcanicity beneath the plateau. This paradox has led to alternative hypotheses for the formation of the OJP:

EITHER: The mantle was fertile and melted to basalt. If eclogite was present, it would melt more easily, i.e. it was mixed with subducted oceanic crust

OR: The mantle was hydrous – but the OJP glasses are very dry.

OR: A massive asteroid impact – presently fashionable – plunged deep into the asthenosphere so that all the lava formed at once, like the mare on the Moon. But this would have produced a 20 km diameter crater and there is no impact evidence in the Aptian record. Also, if only the upper mantle was involved, then the basalts should be similar to MORB, but they are in fact distinct from Pacific MORB.

The currently favoured theory is the rapid decompression and melting of anomalously hot mantle in the head of newly ascended mantle plumes. However, this does not explain the slim evidence for sub aerial eruptions. And so the origin of the OJP remains enigmatic.

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Thursday 14th December 2006

ANNUAL GENERAL MEETING

Thanks were expressed to retiring members of Council: President – Dr C.J. Burton, Vice Presidents – Dr C.J.R Braithwaite and Dr M.C. Keen, Hon. Secretary – Dr Iain Allison, Excursion Secretary – Mrs C. Mills, Librarian – Dr C.J. Burton, Minutes Secretary – Mrs M. Greene, Treasurer – Mr M.H. Aiken and Ordinary members – Dr B.J. Hamill, Mrs N.G. Hornibrook, Mrs R. McCusker and Dr A.W. Owen for their contribution to the work of the Society over the past three years. Thanks were also due to the editors of the Scottish Journal of Geology, Dr C.J.R. Braithwaite and Dr R.M. Ellam, who are elected annually and who are willing to stand for another year,
The business of the AGM was followed by the Presidential address, before our annual Christmas social including wine, soft drinks and nibbles.

Dr Chris Burton (University of Glasgow)
Presidential Address:

THE GEOLOGY OF THE ISLAND OF MADEIRA

Madeira, a geologically young island (its oldest rocks are 5.2 Ma – 16 Ma) is the youngest product of the evolution of a mantle plume, the Madeira hotspot, which can be traced from Madeira north to the Azores – Gibraltar Fracture Zone. With the Canaries and Azores, it forms Macronesia. Madeira's Tertiary and Quaternary geology is complex, with violent volcanicity and quieter episodes of sedimentation. Life flourished on the island, leaving a rich fossil record of tropical marine life and unique land flora and fauna. Discovered and settled by the Portuguese in 1420, it has central mountains, 5000 to 6000 feet high, coastal cliffs up to 750 m, and one beach of black sand. There are two sets of active rift systems, N – S, E – W, and strongly sodic alkaline basalts; only the dykes are fractionally distilled. Intrusions are uncommon but there is gabbro and one essexite. Deep magma chambers are not seen.
The Basal Complex Stage of massive eruptions is seen in the steep central mountains and footpaths on the east side of the island. Dominated by pyroclastics, there are scoria cones and a few lavas, tunnels and laterite horizons. The land then subsided close to sea level and erosion occurred at an enormous rate. A small limestone reef half way up one cliff has abundant tropical shallow marine coral and microfossils which are older than 5 Ma and may be 12 – 15 Ma.
Most of the island's rock formed during the Main Shield Building Stage. There are lava flows with columnar jointing containing mantle xenoliths of harzburgites, and gabbros with deep tropical erosion – the Quaternary climate was much warmer than at present. Point bars, fluvial sediments, flood plains and plant deposits, developed at marine lowstand, are exposed by a large, ancient river valley which extended far out to sea when sea levels were lower. The island is repeatedly moving up and down.
During the Mature Stage, 0.7 – 0.5 Ma, activity waned and there were fewer lavas, but high level plateaux (5000 feet) with peat bogs and heather 2 m high (similar to Scotland) developed. This stage was fissure fed, with NE – SW rifts, and copious cedar charcoal was created.

The Late Stage saw activity wane further with very few lava flows filling the valleys from cones and lava tunnels, now cut through by a modern river. The scoria and pyroclastic deposits are unconsolidated, but buildings have been constructed on top of them! There is a very fast rate of erosion, and rain creates massive mud slides. Huge swarms of large trachyte and phonolyte dykes were produced at every stage. In the far west, near Pranha, there are aeolian sediments – fossil sand dunes of 300 ka – 4.5 ka; climate indicators include fossil land snails which allow dating. There was grassland, scrub and forest but this is now at high altitude because the island is still rising. Finally, the impact of cultivation and the Portuguese, who cut and burned all the wood, led to numerous extinctions.
This was an informative and fascinating account of the latest work on the geology of Madeira.

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Thursday 11th January 2007
Dr Paul Barrett, Natural History Museum, London

FEATHERED DINOSAURS FROM CHINA

Over the past 10 years, dazzling discoveries of feathered dinosaurs have been made in the building stone quarries of Liaoning Province, near Beijing, People's Republic of China, revolutionising our views on the evolution of birds, feathers and flight. These go back to the discovery in 1861, in the Late Jurassic of Solnhofen, of *Archaeopteryx*, a mixture of bird and reptile, which seemed to fit one of Darwin's intermediates and created a major controversy. It had flight feathers, but also the reptile features of clawed fingers, toothed jaws, and a bony tail, and is descended, possibly, from crocodilians. In the late 1960's and 1970's, meat eating dinosaurs which shared features with birds were found in the Lower Cretaceous of North America. Today, most palaeontologists agree that birds are flying dinosaurs, but there is less consensus among ornithologists! The Chinese fossils were discovered by peasant farmers, who removed large numbers, selling them and producing spectacular high profile forgeries for considerable amounts of money. The fossil deposits, in the Yixian Formation, are intercalated lacustrine and volcanic sediments, where zircons have provided an Ar – Ar age of 128.4 – 121.6 Ma (Aptian). The frequent eruptions of local Jehol volcanism produced huge ash flows and mass mortality events, with exceptional preservation of soft tissue, gut contents and large skeletons. This was a flourishing and diverse ecosystem with many different animals – insects, molluscs, fish, crustaceans, pterosaurs, other reptiles, amphibians, many early birds, mammals and plants.
The finds include:
A theropod dinosaur, with 'protofeathers' of long conical filaments, but not scales, colour banding and a 'stripey tail', but a lizard's skeleton. Were the feathers for thermoregulation, display or …….
Caudipteryx (oviraptorosaurs). This has real feathers, but not for flight, on its stumpy arms and tail; they would be very good for display, insulation or incubating eggs
An oviraptor with 'bird brooding' behaviour: it had a clutch of eggs with embryos, in a nest, exactly like birds.

Troodontis (therapods) – a complete, sleeping animal, just like a living bird, preserved in its behavioural stance.
Sinornithosaurus, known as 'Dave' or Fuzzy raptor', covered in bird-like feathers, but still not flight feathers.
Microraptor, with huge feathers on its arms, tail and legs. It may have used them as a parachute!
In one species, half the skeletons have very long tail feathers, suggesting male/female differences. Birds evidently evolved gradually from previous features in a classic transformation series. The robin is a direct descendant of *T Rex*!
A herd of dinosaurs was found, indicating that they were social (between 1 and 3 years old, and ~ 1m across), as well as many other dinosaurs, most less than 3 m.
Several Jehol 'firsts' include the first placental mammal, first flowering plant, first mammal, first pterosaur eggs and its embryos. There is an unusual mix of animals – 'relict' taxa, early reptiles, endemic taxa and cosmopolitan taxa. At the time of the Lower Cretaceous, China was an island but the Mongolian Okhotsk Sea has since closed. Some species of birds and invertebrates are represented by thousands of specimens, allowing palaeontologists to reconstruct their habits and ecology at unprecedented levels of detail. Unsurprisingly, there is still much excavation and work to be done; this was a fascinating lecture raising many intriguing questions.

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Thursday 8th February 2007
Dr Jim Morrison, Geological Society of Glasgow.

GEOLOGY BY SEA KAYAK

Coastlines present many magnificent rock exposures, which are, however, often difficult of access on foot, whereas kayaks allow close approach to these otherwise prohibited rocks. The sea kayak is light and almost unsinkable (like the Titanic!) and can be operated by one person in shallow waters that are challenging for larger craft. It has a hollow hull, and abundant space in three compartments to carry camping equipment sufficient for expeditions of several days' duration. The long kayak travels easily in a straight line, the short kayak does not and is used inland. The sea kayaker is the captain, navigator and power unit, all in one. Our speaker began kayaking when he was assisting Dr Brian Bell with the new Field Guide of Mull, after meeting some committed lifelong kayakers while leading an OUGS trip to the island in 2003. He gave a hilarious account of getting started, using an old sea kayak, with the University of Glasgow Students Club. Loch Lomond was easy, but Machrihanish quite a different story! He missed the arranged meeting place, and so went out alone and got a major fright! However, he subsequently began learning with an expert and sailed round the Summer Isles, Skye and the Torridonian coast.
Advantages of the kayak include the ability to reach inaccessible rocks, to see rocks from a different perspective, to approach close to wild life such as ospreys, otters and seals, and to meet other kayakers. Disadvantages include unsuitable weather, ending up in remote camping places, the difficulty of controlling the boat while trying to see rocks **and** use a camera, and camera splash.

Our speaker described taking the kayak on a trolley on the ferry to Arran, before setting off up the east coast round the Cock of Arran, and completing a figure of eight round the Big and Wee Cumbraes, with spectacular basalt columns on the latter. His slides included Loch Lomond with its four islands on the Highland Boundary Fault, other islands on its northern branch and rocks at low water revealing serpentinite and Upper and Lower ORS conglomerate. Near one island, the loch was seen from an unusual angle as two ospreys circled above Inchconachan.

We viewed Loch Melfort, at the southern edge of the Lorn lavas, in which kelp forests, and urchins and starfish grazing on algae could be seen through the clear water, as well as otters at play near Degnish Point. The lava field along the southeast coast of Mull extends far under the sea to the northwest and a little to the southeast, while the Moine underlies the area and outcrops on Ardnamurchan. Mull is a 'triple-decker' of Moine, Mesozoic and Tertiary Palaeogene. The numerous exposures of the Mesozoic are mainly Jurassic, as on the Laggan peninsula; it is very thick towards the western corner, and often contorted by intrusions. There are abundant dykes, some displaced by small faults. We saw pictures from Loch Sunart and Ardnamurchan, and from where our 'kayaker' had to squeeze through gaps between the islands where high water is a requisite, as well as some interesting campsites in tiny isolated coves; the south coasts of Mull and Ardnamurchan, Ben Hiant and Maclean's Nose all appeared from a different perspective.

This was a very interesting, entertaining and humourous lecture, and certainly provided the audience with an alternative view of geology.

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Thursday 8th March 2007

Dr Neil Clark, Hunterian Museum, University of Glasgow

TRACKING DINOSAURS FROM SCOTLAND TO WYOMING

Dr Clark delivered a very entertaining talk about the history of dinosaur discovery in Scotland, where dinosaurs are a rarity. Although they have been known in England and elsewhere for over 300 years, it was only in the last 23 years that dinosaurs began to appear in Scotland. The first discovery was that of a single 49 cm long ornithopod track discovered in 1982 from the Lealt Shale Formation, on the Isle of Skye. Since then, other tracks, and bones, have been found on Skye, mostly on the Trotternish peninsula, although bone and footprints have also been found in Elgol. The footprints and trackways occur in the Middle Jurassic Valtos Sandstone Formation, Duntulm Formation and the Kilmaluag Formation, while dinosaur skeletal remains have been found in the Broadford Beds Formation (Hettangian), the Bearreraig Sandstone Formation (Bajocian) and the Valtos Sandstone Formation. Recent discoveries in Wyoming of dinosaur footprints of the same age as those from Scotland, suggest that similar animals were roaming the hot dry plains of North America. The environment in the Middle Jurassic of Scotland was wetter than Wyoming, as it is today, but the dinosaurs seem to have been just as abundant at both sites. Dr Clark described his trip to Wyoming to compare the Scottish footprints with those of Wyoming: some were very similar, despite having been 5,000 miles apart in the Mid Jurassic. He had a

little difficulty in getting permission to visit the sites because the Wyoming authorities are very protective of their treasures. No Mid Jurassic bones have as yet been found in Wyoming – so one up to Scotland! He explained how footprints are attributed to particular species: herbivores have rounded toes, carnivores pointed ones with claws; the dimensions of the toes – angle of the point, distance between the two outer toes etc. – are measured and, amazingly, species can be identified from this! The lecture was illustrated with photographs, moulds of two tailbones, one from a small carnivore and the other, 100 times bigger, from a sauropod, and some rubber models of dinosaurs – very useful to the uninitiated! The Isle of Skye can be regarded as one of the foremost Middle Jurassic sites for dinosaur remains worldwide and continues to reveal its secrets about dinosaur life in Scotland, more and more every year. Dr Clark concluded by announcing that the refurbishment of the Hunterian Museum was almost complete and the Museum will be open in May.

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Thursday 12th April 2007
Dr Stuart Archer, ConocoPhillips, Aberdeen

LANDSCAPE EVOLUTION IN RIFTED TERRAINS

The Basin and Range Province of the south western USA is a striking desert landscape. The combination of extensional tectonic forces and changing climate has created a distinctive geomorphology that has been a playground for earth scientists for over a century. From the top of the mountains to the valley floors, there is a relief of 11,200 feet, with Death Valley at – 282 feet extreme and unique, 'the biggest hole in North America'. The area is a series of long linear mountain ranges and basins with playas and salt pans in an intracontinental rift setting; sediment eroding from the heights fills the basins, and alluvial fans coalesce to form 'bajadas'. This topography results from the meeting of the Pacific Plate with North America, creating the San Andreas Fault complex; the Pacific Plate is moving north producing shearing, a tearing apart of the crust. There is also the gravitational collapse of the ancient Sevier orogenic belt which started in the Oligocene ~ 35 Ma and continues today, as evidenced by earthquakes and geothermal activity. The major faults may be high angle normal, or listric, and all form very regular half grabens, about 40 km apart with more than 160 tilt blocks. The climate is arid to semi arid (commonly found at 30^0 N around the world), and water collects in the basins, from rivers on the Colorado Plateau and surrounding wetter regions. One basin may have a river flowing through it and so has a large salt pan, while its neighbour without a river has only a small salt pan. It is a very variable environment, with an average 5 – 10 inches of rain per year, and temperature of 85^0 F. Some parts are quite wet because of high mountains; some mountains have their own climate and generate rain – these are relict climates of the Pleistocene Ice Age, when the area was much wetter; around 18 ka there was the huge Lake Lahontan. Climate, tectonic activity and base level determine the type of landscape formed, and can be plotted on a triangular diagram. Normally base level would be sea level but here it is the floor of the valley, dictating the potential energy of the sediment and water. At the beginning of the 20th Century, William Morris

Davis published a very simple 'Theory of Landscape Evolution' which envisaged high rugged mountains (young) gradually eroding to lower rounded hills (mature) and then to flat land (old), but currently the idea of straightforward peneplaining is not widely accepted because we now know that there is much variability. This traditional model has been revisited using quantitative observations from satellite imagery, seeking to bridge the gap between geomorphologists and geologists, and highlighting the links between landscape maturity models and rift evolution models in which the syn-rift landscapes evolve into post-rift landscapes with the formation of inselbergs (alluvial fan nunataks). In the study area, there is a recent active range front, and range front variability; faults are seen to have 'jumped' their positions. The Ruby Range is young with high mountains towering over low valleys and alluvial fans starting to form, while the San Antonio Range is old – its low mountains peer over a wide plain into which major alluvial fans have already transported all the sediment and filled in the depressions. In some places the fan captures sediment not from the nearest range but from the larger one beyond, and the flow finds a way through, possibly along a fault. An understanding of these processes can deliver possible modern landscape analogues for use in the exploration for and the production of oil and gas reservoirs. The Basin and Range Province is one of the best places to try to understand the subsurface of the North Sea, which was at 30^0 N in the Triassic, with probably the same arid climate and extensional regime, mountains in the background, and a river which flowed north to the arboreal sea, or to south to the Tethys Ocean. This was an informative and fascinating lecture, illustrated with a selection of stunning slides.

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Thursday 10th May 2007

MEMBERS' NIGHT

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

Short talks

Plume-textured (Cocos) geodes Julian Jocelyn

This was an illuminating account of the latest theories of the formation of geodes by the deposition of chalcedony, a cryptocrystalline variety of silica, from colloidal solution or silica gel. This replaces the rim of the calcite pebble, and is followed by oscillations of growth between chalcedony and quartz.

Strathclyde RIGS: Report of Activities Margaret Greene

Our speaker outlined the work of the RIGS Group and presented an update of sites considered. Ardmore Point is now established as a RIGS site and an information leaflet has been produced, while progress is being made with Campsie Glen. Other

sites receiving attention are the barite mine at Muirshiel Park, which is quite dangerous just now, Portencross with its interesting ORS and conglomerates, and Fossil Grove – in serious danger of neglect and closed at present. The group continue to seek out worthwhile sites, bearing in mind the two philosophies: 'Geodiversity is better than Geology', and 'Local is important'.

Welsh dinosaur tracks: a tale of theft and recovery Tom Sharpe

This was an entertaining tale about dinosaur footprints on Triassic rocks around Porthcawl, south Wales. In one locality they occur on loose slabs on the beach; another locality was on Barry Island, near Cardiff, discovered in 1974 by students who chanced upon them because the light was 'right'. These trackways, of both large and small animals, were made on the shore of an inland sea. The local museum lifted part of the pavement, leaving more tracks in situ, while others were found both to the east and west. Later, a 2005 Sale Catalogue in Christie's advertised dinosaur tracks from Nell's Point on Barry Island for £480; then in Lyme Regis, Dorset, a shop was found displaying 14 slabs. Some came from a coastal quarry near Cardiff and were provided by a collector. They also appeared on e-bay. Others had come from an SSI at Bendrick and had been stolen. In the subsequent investigation the fossils were seized, and the collector and dealers were cautioned.

Colourful Scottish garnets Julian Overnell

This was a detailed description of the many and varied Scottish garnets which our speaker has collected and examined in thin section, at both 30μ and 390μ, and included their geochemistry. Garnets conform to a general composition and formula, with various metals substituted into the crystal structure. They occur in all colours except blue. Pyrope varies from dark red to almost black and is widely used as a gem stone while the grossular series is white through golden to cinnamon. Our speaker described his homemade apparatus for measuring light absorption, and how metals such as Fe^{3+}, Ti^{3+} etc can be identified from absorption spectra. Each different ion produces a specific colour: e.g. garnets with Cr^{3+} are green.

Getting away from it all on Mull's SE coast Jim Morrison

Our speaker enthralled us with a selection of slides documenting his kayaking trip around the three lochs and peninsula of the southeast coast of Mull, including a view from space! It is not easy to get pictures of this coast, unless from the top of Dun Mor on Seil, but we were shown its rugged and dramatic cliffs rising to 400/500feet, and the geological map of the region – a colourful work of art, displaying the lavas and igneous complex, with abundant dykes. The Great Glen Fault clips the southeast of Mull; Moine rocks lie to the west and Dalradian to the east, with Jurassic round the edge. This was an entertaining tale of camping and kayaking, investigating the local geology and archaeology – lazy beds, a shieling below the cliffs and a possible silver mine.

Displays

And there was the usual wide range of displays of rocks, fossils and photographs including:
Margaret Donnelly – Memories of 2006
Julian Jocelyn – Plume-textured (Cocos) geodes
Seonaid Leishman – Some geology of the Western Cape, South Africa
Charles Leslie – Excursion photos, 2006
Julian Overnell – Colourful Scottish garnets

EXCURSIONS

Saturday Excursions Report

12th May 2007	Corrieburn and the Garrel Burn. Dr Chris Burton and Dr Jim Morrison, University of Glasgow.	Participants: 19
16th June 2007	East side of Loch Lomond. Dr J G MacDonald.	Participants: 13
21st July 2007	Siccar Point and the Hutton Trail. Dr Con Gillen., University of Edinburgh.	Participants: 25
4th August 2007	Joint Excursion with Edinburgh Geological Society. Hadrian's Wall and Haltwhistle. Dr Stuart Clark, BGS	Participants: 22
18th August 2007	Glen Orchy and Cononish Valley. Dr Geoff Tanner.	Participants: 16
8th Sept 2007	Silver Glen. Dr Neil Clark, Hunterian Museum.	Participants: 14

These were all very successful probably due to early organisation, and advertising in the third (February) Billet. Thanks are especially due to Dr Chris Burton for contacting the leaders before Christmas to arrange possible localities and dates, and well as the synopses. All excursions were well attended, and trips 3 – 6 were full with waiting lists. Unfortunately, the weather was not always on our side, unlike last year, and we had copious rain on Excursions 1, 3 and 5. However, the geology was fascinating and at the end of Excursion 3, Drs Con Gillen, Mike Browne and Colin McFadyen offered to lead trips next year – one to Jedburgh, to complete the Hutton Trail, as this year we did not have enough time. The Joint Excursion with the Edinburgh Geological Society was in fact too ambitious – we had a long distance to travel, and a joint meal locally, with the result that we were very late in returning to Glasgow. The excursion was arranged at a late date by the Edinburgh Society, while we organised the meal, and this led to a certain amount of confusion and lack of communication between the two. However, many thanks are due to Seonaid Leishman and Muriel Alexander who took over the organisation on the day, as I could not attend. The excursion to Glen Orchy and Cononish Valley was a bit challenging,

although the geology was particularly interesting. We required 'off road' vehicles and so hired a 16-seater bus with driver (volunteer minibus drivers are not forthcoming) and thanks are again due to Dr Chris Burton who kindly brought the Department's Kango, and Mr Charles Leslie who brought his car. In the event, it was pouring (!) that Saturday, and so there were a number of 'call offs'. For Excursions 1, 3 & 4 we used Essbee Coaches, for 2, DB Travel who were less expensive, for 5, A&D Travel as they could provide a small bus, and for 6, members brought their own cars as the maximum permitted on this excursion was 14.

Margaret Donnelly

Residential Field Excursions

Two residential field excursions took place in 2007 encompassing five islands.
In June Dr. Brian Bell (University of Glasgow) took 20 members to Mull, on the tenth anniversary of the society's last trip to the island. The field trip was based in the Ross of Mull and included visits to Iona and Staffa. The weather was dry and sunny in stark contrast to the rest of the summer.
In September Dr. Doug Fettes (BGS) led 24 members on an excursion over the Minch to Harris and Lewis. This was new territory for many members and highlights included an exploration of the South Harris Igneous Complex and the Mangurstadh area of west Lewis.
I would like to thank Dr. Bell and Dr. Fettes for all the hard work they put into their preparations for these excursions and for being such patient and approachable leaders. I am very grateful to the drivers who so readily volunteered to allow use of their cars on these trips due to the logistical difficulties in hiring a coach. Finally, I would like to thank Seonaid Leishman for deputising for me during the Mull trip.

David McCul1och

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GARRELL BURN AND CORRIEBURN : 12 May 2007
Leaders : Dr Jim Morrison & Dr Chris Burton
Report by : *Robin Painter* Participants : 19

This excursion was a repeat of a similar excursion held in May 2006. As well as members of the Society we were joined by representatives from the Kelvin Valley Park agency and the British Geological Survey.

The excursion was in two parts. In the morning, starting at Allenfaulds Farm above Kilsyth and ascending north towards the Campsie fault, we viewed the rocks of the Inverclyde Group of the Lower Carboniferous where they are exposed by the gorges of the Garrell Burn. In the afternoon, further west and ascending towards the Campsie Fault from Burnhead Farm above Queenzieburn, we viewed the Corrieburn Section of the Lower Carboniferous rock succession starting within the Strathclyde Group up into the Limestone Coal Formation of the Clackmannan Group. There was heavy rain for most of the morning of the excursion, though the cloud base lifted somewhat in the afternoon and the rain stopped. Rifting of the Midland Valley and the resulting faulting has produced a series of east-west trending faults which

throw southwards, so that in this area, ascending northwards across the faults is a transit from exposures of a younger formation into those of an older one.

In the morning in the lowest part of the Garrell Burn we saw exposures of crevasse splay and flood plain sandstone deposits, interbedded with some thin organic shaley layers characteristic of plant growth on the splays within cycles of repeat marine indurations. This exposure is at the entrance of a now backfilled mine adit in the Limestone Coal Formation, believed to be minor development seeking a local coal seam. Ascending north up along the bounding ridge to the east of the burn we reached an exposure of the Kinnesswood Formation in the second gorge, which lies at the bottom of the Inverclyde Group near the base of the Lower Carboniferous. Here the scale of the bedding was more massive than in the first gorge. The rocks were whitish with no obvious discoloration by any organic matter content, prompting the observation that the depositional environment was from a large river system running through a hot, otherwise arid environment. We crossed the burn up in the third gorge and then returned south downstream, climbing up to the western bounding ridge to do so. From this point we were descending towards the main Campsie Fault. There were clear views of the line of the fault as we made this descent. There are splendid narrow gorges cut by the burn descending this route. In a wide hollow above the northern entrance to the first gorge we observed an exposed cliff face with a carbonaceous shale deposit at its base, another fairly massive crevasse splay sandstone and an included lens of coal – a succession suggesting deposition in a terrestrial, marine fringing environment

At the Corrieburn location, in the afternoon, we saw the younger part of the Lower Carboniferous sequence which overlies the Inverclyde Group visited in the Garrell Burn. We ascended from Burnhead Farm, crossing the Cairnbog Fault to the Corrieburn where we observed the Kirkwood Formation which is exposed there with red horizons, from volcanic detritus of the Campsie lavas. The Corrieburn Limestone, at a younger level in this succession, is exposed at the site of old quarries running up the hillside. Samples of brachiopods, fragments of crinoids and bryozoan fossils were found in the Corrieburn sections of this part of the Hurlet Limestone. Further east, younging in the succession towards the Blackhall Limestone Formation there is a rusty brown sandstone which contains ooids apparently dumped there from an adjacent shallow marine environment where such suspended material can be generated. Further east, the most visually striking feature of this site is the 20 m black cliff of shale which overlies the Blackhall Limestone. The base of the cliff contains the Neilston Shell Bed, which is a key stratigraphic location since it contains *Crurithyris*, a spiriferid distinguished because, unlike its peers, it was adapted to the muddy conditions associated with deposition in this type of environment in the Carboniferous. Happily, unlike the previous year, we were able to find some examples of this small, otherwise undistinguished fossil.

Many thanks were given to our leaders for taking us, despite the weather, on this very interesting excursion.

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MULL AND IONA : 8 – 11 June 2007
Leader : Dr Brian Bell
Report by : *Julian Overnell, Margaret Greene* Participants : 20

The domestic arrangements for the excursion including car sharing, booking of shared rooms and the communal evening meal at the Argyll Arms Hotel, Bunessan had all been arranged beforehand by David McCulloch, who was unfortunately not able to attend. The leader was Dr. Brian Bell and the party was joined for an afternoon and a morning by Dr. John Faithfull.

Friday 8 June.

The group met on the 11:55 am Oban – Craignure ferry and went directly to the first location at the Sound of Erraid, Ross of Mull (NM 307198). Here the Ross of Mull granite (RoMG) is exposed on the foreshore. The RoMG is a pink, coarse granite with pink alkali feldspar, white plagioclase, quartz and dark mineral(s). It is an unfoliated granite with a zircon U – Pb age of 420 Ma. Its emplacement may have been controlled by the Moine Thrust which is presumed to be in the Sound of Iona, immediately to the west. At the sound of Erraid the granite is seen to have metre sized inclusions of diorite, and these inclusions were the subject of the afternoon's discussions. The inclusions were darker and finer-grained than the granite and in places they had many pink feldspars of approximately the same size as those in the granite; in other inclusions there were few or no porphyritic feldspars. It was concluded that the large feldspars in the diorite owed their origin to mixing with the granite, rather than crystallization from the diorite. The contacts were sharp with no evidence of chilling, and in places the contacts were sinuous, suggesting a liquid-liquid contact. The diorite, because of its more basic composition, must have been a product of magma differentiation rather than crustal melting, but no work has yet been done to establish whether the granite has the same geochemical signature as the diorite, but it is assumed to have the same origin. The attention of the group was drawn to curious elongate holes, up to 8 mm across, in the weathered surface of the diorite inclusions, which looked like amygdales from which secondary minerals had been weathered out. In freshly cleaved rock these were seen to be outlined by a ring of pink feldspar crystals enclosing a variable mixture of quartz, biotite and amphibole. Dr. Bell suggested that these might have been formed as gas vesicles when the molten diorite was near the surface. It subsequently cooled and sank in the granite magma. Dr. Faithfull suggested that they could be the result of mineral reaction around some unknown pre-existing phenocryst.

Saturday 9 June,

Ardalanish Bay. The beach showed exposures of Moine pelitic to psammitic rocks, with the contact with the RoMG just west of the beach. At the first location on the east end of the beach (NM 378187) the country rocks ranged from micaceous semi-pelite to psammite. The brown micaceous schists were steeply dipping and strongly foliated. A small isoclinal parasitic fold showed that the rocks were part of a larger isocline structure. For the interpretation of these fold structures Dr. Bell introduced the concept of the 'stereonet', by the use of a pointer in the sand.

Interbedded with these schists were hard white rocks with pink garnets and dark amphiboles, highly elongated in the direction of the bedding/ foliation. We were told that the white part of this rock comprised quartz and secondary plagioclase and Dr. Bell suggested that the protolith might have been a carbonate-rich sandstone. The rocks at this exposure also contained a basic intrusion which had obviously been intruded before the regional metamorphism. It now comprised a coarse amphibole, black in hand specimen, with large red garnets up to 1cm across. All the rocks here had been metamorphosed to amphibolite grade. The second location was a knoll just behind the beach (NM 375189) which was a brown pelite. One exposed plane surface had a spectacular array of prominent cm-sized kyanite crystals. These were pale blue in colour, often with pink ends. The pink colour was due to retrograde metamorphism to the lower temperature isomorph andalusite which, we were told, was in the form of smaller randomly orientated crystals pseudomorphing the kyanite. Elsewhere on the knoll, kyanite was not obvious, suggesting one (at least) very Al-rich horizon. The third location was at the west end of the beach (NM 372187) where micaceous semi-pelites were exposed. Here regional sillimanite had been partially altered to muscovite.

Fingal's Cave ***Charles Leslie***

In the afternoon the party went by boat to visit the island of Staffa. Staffa is composed mostly of a single, very thick Tertiary basalt lava flow overlying a rubbly ash stratum. Either side of Fingal's Cave the spectacular massive, vertical, hexagonal columns are capped by a chaotic zone of smaller columns called the entablature, the top of which is not preserved. The massive columns are the result of steady cooling

from the bottom upwards, which proceeded by a series of small co-ordinated fractures as the basalt solidified. These columns formed by upward solidification until they met the chaotic columns formed by downward solidification, and the meeting is now marked by a clear discontinuity. Why the entablature columns were formed chaotically was the subject of discussion. Perhaps rainwater on the surface did not allow the steady even planar cooling needed for the formation of the large parallel columns. In other places on the island the columns of the lower part of the flow are curved and some nearly horizontal, suggesting a very uneven base to the flow. The rubbly ash stratum at the base of the flow was inspected and a probable filled lava tube was identified by its radial arrangement of jointing cracks. Elsewhere in this stratum, flattened vesicular lava in the form of pancakes could be seen where pieces of presumed molten airfall lava had hit solid surfaces, preserving the round shape of the vesicles. Definitely a dangerous place 60 Ma ago, but fine and warm last June.

Curved columns on Staffa ***Julian Overnell***

Sunday 10 June

We caught the 10.00 am ferry to Iona where we were met by Fiona Menzies, who lives on Iona and has an expert knowledge of the local rocks having based her PhD on them. She led us first to the north of the island, across from the small islet of Eilean Chalbha, to an outcrop of Lewisian gneiss cross-cut by an amphibolite dyke. She pointed out a small F2 fold in the gneiss at the sand level to the left of the dyke, which was quickly being covered by the incoming tide. There was granitic material within the dyke demonstrating that this is a dyke of Lewisian age possibly Scourian. This north beach is in the mylonite zone so chemical changes are contemporaneous with the Moine Thrust, which is believed to run down the Sound of Iona. There was also another Scourie dyke cutting the gneiss further to seaward which was running parallel to the foliation of the rock.

Moving round the island in the direction of the cathedral and facing onto the Sound of Iona we were shown a section where the Lewisian rocks give way to the

Torridonian conglomerate – here there were clasts of Lewisian rocks within the conglomerate. These are of terrestrial material weathered from Lewisian by debris flow with unsorted large and small clasts. From here we continued along the shore to the next location where the Torridonian deposits were now grits, with evidence of bedding and small clasts comprised of mainly feldspar and quartz with the occasional small clast of epidote, evidence that the source rock was still Lewisian. These beds were laid down in a fluvial environment. There were also small glassy veins – pseudotachylytes – the result of rapid melting of country rock when fault movement takes place in a hot brittle rock environment. Continuing along the coast in the direction of the cathedral the Torridonian rocks were seen to change to a grey slaty rock with a coarse cleavage. Permian dykes cut through this sediment and Fiona pointed out erratics of Ross of Mull granite, and gabbro from the central complex on Mull. Lunch was had by the roadside in the village on Iona.

In the afternoon we took the ferry back to Mull and proceeded to the banks of Loch Scridian in the area of Kilunaig, to view a dolerite sill intruded into the lavas. This is characterised by large xenoliths which have been ripped off the walls of Moine rock during emplacement. Some of the xenoliths are almost pure plagioclase. Brian pointed out one of the xenoliths in which the glassy middle could be seen and within this there were needle-like crystals of Mullite – an aluminium rich mineral. The Loch Scridian dolerite sills are unique worldwide due to the xenoliths within them, some Jurassic limestone, some Moine, but the there is nothing in the basement rocks which have the same composition as the xenoliths, with the plagioclase feldspar on the outside and the isotropic glass within. Inside the glassy centres there can also be found other aluminium rich minerals such as spinel and sapphire.

Following this we drove along Loch Scridian in the direction of Bunessan to a bay in which Brian had been told he could find pillow lavas. We didn't find the pillow lavas on this occasion but there was a horizon of red laterite, the weathered top of a lava flow. The laterite forms from the breakdown of the basalt lava into clays etc and gives a sense of a timescale between the magma flows in this area. The laterite was overlain by patches of black broken-up lumps of a glassy appearance. These dark patches are evidence that a subsequent flow of lava crossed shallow pools of water in the underlying rock and cooled quickly into glassy fragments which crack up in the water; the term for this is hyaloclastic.

At the evening meal Elspeth thanked Brian on behalf of all of us for leading us around such an interesting corner of Mull as well as on added excursions to Staffa and Iona. Seonaid was thanked for being the organiser on hand and David McCulloch in his absence for being the coordinator of the whole trip.

Monday 11 June

On Monday morning we travelled to the bay which we had left the previous afternoon but this time we were accompanied by John Faithfull who pointed out, in a different section of the bay, an amygdaloidal lava flow containing breccia and some pillow lavas with a small dyke running across the top. As previously explained this was a wet site onto which the lavas flowed, with pools of water, some deeper than others so that the lava flowing into the shallow pools fragmented and the lava flowing into deeper pools formed more pillow-like shapes. John also pointed out the laterised

top of a lava flow which had a deep fissure within the flow filled with broken-up paler material; this structure can also be found on the other side of the loch. We then travelled over to Carsaig Bay and, after looking towards the white cliffs of Jurassic and Cretaceous sandstone to the west of the bay, we traversed along the coastal path in an easterly direction to Carraig Mhor.

At Carsaig Bay ***Julian Overnell***

This bay has a spectacular backdrop of cliffs topped by columnar jointed basalt lava and a foreshore of lava with a ropy-textured surface. Brian pointed out a circular event, 1-2 metres across, on the rock of the foreshore. Around the outside edges of this, the lava was amygdaloidal in texture while the inner core was solid rock. There is apparently conjecture that this could be evidence of a tree at this spot. It would first have been surrounded by lava, bubbling up on initial contact, then the tree would suddenly have been incinerated as the lava obliterated what was left.

The cliffs at the back of the bay comprise a number of interesting layers, the lowest being fine grained sediments with small intrusions cutting through the sediments. There is some folding in the sediments due to the overlying lava. In a

large cave the overhang is of fine grained basalt with carbonate staining. There is a layer of brecciated lava above the sediments and between this lava and the jointed lava flow there is a layer of very interesting rock, the Carraig Mhor Peperite. Peperite is very rare in the Hebrides. Although too high up the cliff to examine in situ, examples of the peperite can be seen in fallen blocks below the cliff. The rock is fine grained with a mixture of dark and light material and the paler element tends to be elongated. The pale material is actually basalt which has had the original minerals destroyed and replaced by carbonate, and the darker material is the sediment into which the original lava was intruded. The magma in this case was intruded into an unlithified carbonate-rich sediment.

This more or less concluded our geology for the weekend and we returned to Carsaig bay to enjoy our lunch in the continuing sunshine before returning to Craignure for the ferry back to the mainland. It was generally agreed that to have such brilliant weather on a weekend in Mull was pretty amazing equalled only by the amazing rocks and scenery to which Brian had introduced us.

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EAST SIDE OF LOCH LOMOND : 16 June 2007
Leader : Dr Jim MacDonald
Report by : *Margaret Donnelly* Participants : 13

On a rather damp morning, we drove from the Gregory Building to Sallochy car park, on the 'peaceful' east side of Loch Lomond, where our leader gave us an introduction to the geology of the day. The bedrock is mainly regionally metamorphosed sedimentary rocks of low grade greenschist facies, chlorite zone, belonging to the Southern Highland Group, the youngest division of the Dalradian Supergroup. The rocks share a common history in time and lithology – a suite of greywackes, they were deposited in a marine environment, downslope in a zone of subduction. They now form part of the Tay Nappe, a major recumbent fold structure that was emplaced during the Caledonian orogeny, and probably have a similar history to the Alpine-Himalayan orogeny. Structurally the rocks occur in the nose of the Aberfoyle anticline which has been down-turned at the SE margin of the Grampian Highlands against the Highland Boundary Fault, so that it is now a synform. The Ben Bheula schists extend from the Loch Lomond area to the Cowal Peninsula. The older Dunoon phyllites are probably equivalent to the Luss slates, which occur in the core of the intensely folded Tay Nappe, whose top limb has been eroded away, so that here, we are on the lower limb, in the 'Steep Belt'. The younger schists are seen underneath. Today we will visit localities where evidence which helps reconstruct the geological history of the area can be gathered, and will record structural data, looking for features which indicate the rocks' history – folds and associated cleavage, and sedimentary structures such as graded bedding. However, the rocks are highly sheared and difficult to interpret. There are competent and less competent rocks, with variability in grain size. The history of the area is complex – there was arc-continent collision, and continental collision, and it is now recognised that a major compressional event occurred in the Devonian (MORS) which pushed

ORS up and over the already metamorphosed Caledonian rocks, so that the last movement on the HBF was a low-angle thrust.

At our first locality on the beach beside Sallochy car park, there were vertical outcrops of strongly cleaved slate with some gentle folding, variable in orientation, and large pods of vein quartz parallel to the foliation. We were a little NNE of Luss: these slates were somewhat paler than the Luss Slates and so were probably not exactly the same. We walked north across the slates and on to schistose grit, which was more brittle and resistant to cleavage so that the rocks were broken up. They contained clasts of vein quartz, quartzite and feldspar. This lithological boundary was continuous across the nearby cove and could be seen on the opposite Ross Wood side, raising the possiblility that local faults determined the locations of the coves. A little further on was a large outcrop displaying distinct glacial features – smoothed roches moutonnees, with clear striations and a large gouge running NE to SW, indicating the direction of the ice movement. Variations in the lithology were 'picked out' by the erosion. We moved on to a small promontory where graded bedding in the schistose grit could be seen with some effort, and endeavoured to determine the younging direction. We started up the hill, passing an outcrop of fine grained, pale slaty phyllite whose dip of cleavage was 87^0 to the SE, and, further up, a coarser outcrop of arkosic grit, eroded from a granite – a process happening in the Andes today. Near the top we were overlooking Camas an Losgainn – the bay of the 'frog' or 'toad'. We scrambled up through the bracken to the abandoned slate quarry, and nearby outcrops of schistose grit with graded bedding. The quarry was fenced but some of our intrepid party penetrated for a closer look. Struggling back down to the beach, we found an abandoned stack of cut slate and much slate spoil along the shore. Traces of bedding could be seen in individual pieces – good quality slate requires the bedding and cleavage to be parallel. It seems that the slate from the quarry was transported by boat.

Here we had lunch amidst hordes of midges, before setting off up the hill again, past outcrops of chlorite-schist at the edge of the path and schistose grit near top of hill, north of the IBLS Field Station, and then back down to the shore at Rubha Fhuar a' Chos near Mill of Ross. From here we could see a submerged Crannog, and Glen Douglas across the loch. On the nearby point was 'a steeply dipping chlorite-schist with well developed strain slip cleavage, heavily veined with quartz in places'. Following the path we came to Carra and rock outcrops overlooking Loch an Maoil Dhuinne, 'the bald man', and recorded the steeply dipping foliation and its strike. We continued about 400 m along the path and then back to the shore where there was a fairly extensive outcrop of chlorite-schist with abundant shear planes, mms apart, and within these an earlier wavy 'banding' – a cleavage approximately perpendicular to the later shear planes. We were looking at isoclinal folds which had been sheared out, and isolated fold noses, displaying within them evidence of an earlier phase of deformation and associated foliation. These rocks are unique to this area and are easily recognisable – erratics from here have been found on the north side of the Old Kilpatrick Hills. A little further along the shore of the loch, was a huge lamprophyre dyke, dark pink because of potassium feldspar, which extended back into the hills and had been quarried at some time. This is one of a series of minor intrusions of late Caledonian age related to calc-alkaline volcanic activity and the late stages of

mountain building; it is post deformation and related to subduction like Ben Nevis and Glencoe, and also the Cobbler which is granitic/dioritic. The Midland Valley did not complete its docking until mid Devonian

And then we came to our last and **WOW!** Locality. About 600 m south of Rowerdennan, on the shore, was a substantial outcrop of chlorite schist enclosing well preserved fold 'pods' of the more competent schistose grit. At least one of these pods contained a fold which had been folded!! Its bedding and the base of the bedding plane, folded, could be distinctly seen, and was clear evidence of at least two deformations. We completed the remaining distance to Rowardennan, where our coach awaited us, and thanked our leader enthusiastically for such a fascinating and enjoyable field trip.

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SICCAR POINT AND THE HUTTON TRAIL : 21 July 2007
Leader : Dr Con Gillen
Report by : *Gillian Hornibrook* Participants : 25

A group of the usual friendly and chatty members set off for what turned into a rather unusual and intriguing day. And yes – it rained, but as we were off to see a classical geological site, standard rain was in order.

We arrived at the meeting point, just south of Pease Bay. Here, we were greeted by Con Gillen – our leader – who dispensed leaflets and introduced Denise Walton, the author of The Scottish Borders James Hutton Trail leaflet, Mike Browne of BGS and a Borders Foundation for Rural Sustainability (BFRS) enthusiast, and Colin MacFadyen of SNH, known to many as an excursion leader himself. Denise Walton spoke briefly before leaving; then Con Gillen spoke with humour and enthusiasm about James Hutton – a true pioneer and the Father of the Science of Geology. We were about to learn not only of Hutton's great discoveries but also of Hutton the man. So, through the new gate and up past St. Helen's Chapel built of Old Red Sandstone (ORS). This was a ruin even in Hutton's day. We overlooked Pease Bay, the rocks Devonian Upper ORS to Lower Carboniferous, the distant cement works (Dinantian rocks being worked), the Bass Rock (Carboniferous phonolyte) and the general glacial rounding of the landscape. Further up, the wave cut platform of the ORS overlying the Midland Valley sill was seen. The dry-stone walls ("dykes") around us were of greywacke – with one area, in the distance, of startling ORS. Then, after the helpful Siccar Point explanatory board – there was Siccar Point itself – familiar even to those who had not been before from the universally seen photograph. The intermittent drizzle did not prevent descent down the steep grassy slope to sea level (with cautious progress for some!)

Hutton, in 1788, had come by boat with friends, searching for, and finding the defining proof of his Theory of the Earth. Con Gillen spoke of the Silurian (greywacke and shale) deposition and compaction, the Ordovician isocline formation with subsequent uplifting and erosion of the rocks which were then covered by the Devonian Upper ORS formed, he emphasised, as iron-rich scree from the bare desert landscape. The dyke (or was it a sill?) was observed intruding the Silurian folds. Another huge, dramatic unconformity was seen in the cliff to the south.

Hutton's Unconformity ***Charles Leslie***

Back up the slope and down to the nearby worked out quarry of the greywacke – used as building material and for "dykes". Slickensides were demonstrated and the dark green and purple layers of greywacke were shown. Graptolites were discussed but none were found. The turnip factory in the quarry was a further reminder of Hutton's farming Improvements. The sheep, which had previously been slaughtered in the winter and the meat salted, were fed turnips to keep them alive. (The story of the false steel teeth for turnip-cracked sheep teeth was one of a non-successful entrepreneurial brainwave!)

By bus to the James Hutton Exhibition above Riever Farm Shop and a summary of his life and achievements. Here, one learnt more of the man himself. He studied chemistry at Edinburgh University, then medicine at Edinburgh and in Europe. But, inheriting in 1750 the family farms of Slighhouses and Moneynut in Berwickshire, he switched to agriculture. Dr Hutton was a leading figure in the Scottish Enlightenment, with friends including David Hume, Adam Smith, Joseph Black and Robert Adam. Slighhouses (set on Upper ORS overlain with glacial till) was our next visit to see the remnants of the 18th C landscape. Hutton had studied innovative farming in Norfolk and returned to improve the farm. Improvements were made with boundary banks and bog drainage; with cultivation of cereals and turnips and with keeping cattle and, perhaps, sheep. Some of the features remain. We saw the Marl pit at a distance, the farmhouse (possibly original), the changed entrance to the house and Hutton's gateway of ORS with a gatepost of greywacke.

Sloshing through the rain to the bus (and the long-suffering driver, Raymond), the group enthusiastically agreed to the final visit to see (from a lay-by) Hutton's hill farm of Nether Moneynut. From low-lying arable land, we travelled up through narrow lanes to Moneynut Valley. We saw the farm buildings high up the valley (on mainly Silurian sandstone and shale). An explanatory board in the lay-by showed how relatively little the scenery had changed since the late 18th C.

We had learnt much about Hutton the farmer, Hutton the geologist and Hutton of the Enlightenment. Dr Gillen was warmly thanked for an audible and instructive day.

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HADRIAN'S WALL AND HALTWHISTLE : 4 August 2007
Joint Field Excursion with the Edinburgh Geological Society.
Leader : S.M. Clarke, BGS, Edinburgh.
Report by : *Barbara Balfour* Glasgow Participants : 22

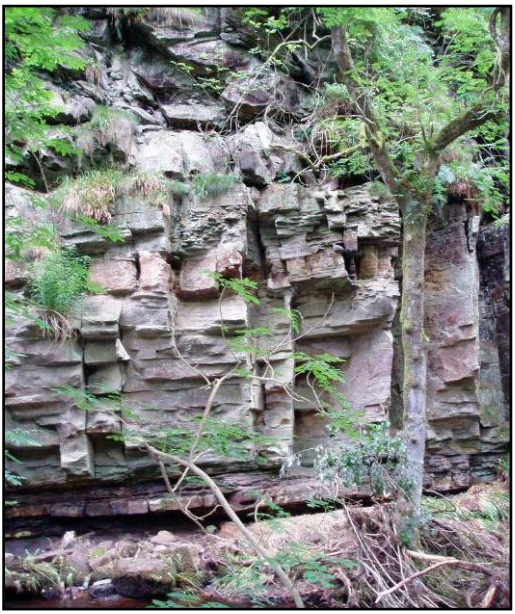
Once our Edinburgh colleagues arrived at the rendezvous at Cawfields Quarry car park, we were given an introduction by Stu Clarke to the area we would be exploring at the Haltwhistle Burn and Oaky Knowe Crags, where limestones, siltstones and sandstones of the Carboniferous succession of the Northumberland Trough were intruded by the Great Whin Sill dolerite at around the level of the Scar Limestone. The whole succession dips by up to 20° to the south into the Stublick Fault system. The quarry, now flooded, was once a source of the fine grained, black dolerite of the Great Whin Sill known to the quarrymen as 'Whinstone' which was utilised for road surfaces due to its hardness and resistance to becoming polished.

Frostilee Band ***Barbara Balfour***

After a short walk, we were on top of the Great Whin Sill where we encountered Hadrian's Wall and the ruin of Milecastle 42. This vantage point allowed us to appreciate the surrounding Carboniferous landscape, where the Alston Block, with high flat topped moorland and wide valleys contrast with the classical cuesta landscape of the Northumberland Trough, a major east – west trending, half graben. Our next stop was at the Four Fathom Limestone quarry, with typical dark fine grained limestone of the area. The even bedding contained chert nodules characteristic of the North Pennines. Onwards to the Haltwhistle Burn, itself, where we could see the Great Limestone Ridge and get some feel for the rock cycles or cyclothems, where repetitions of deposits of limestone, silt

or mudstone, sandstone and coal were discussed. These Yoredale cyclothems had a profound influence on the landscape, where the softer mudstone wore away more easily with weathering and glacial action, than the limestone and sandstone, producing the distinctive scarps and terraced hillsides of the Pennines. Continuing along the Burn, we could see siltstones overlying the Great Limestone and poorly consolidated sandstone, the 'Tuft', underlying it. Within the limestone, fossil bands containing solitary corals may be found but always within about a metre from the bottom of the limestone. About two thirds towards the top of it is a Frostilee band, or "marble", so handsome, that it was used for the pillars of Durham Cathedral.

At the next stop, we came upon the abandoned workings of the Little Limestone Coal. The chimney for the engine house of the colliery had been restored but the area was rather overgrown with trees and vegetation. This was coal of a very high calorific value and was heavily worked in the region. The coal took its name from the Little Limestone which is above it in the succession. As we continued, we could see, on the opposite side of the Burn, spectacular 'cliffs' of Firestone Sandstone which we were able to examine in detail once we reached a wooded area. Here we discussed the conditions which would have accounted for the course grains and cross-bedding of the sandstone (possibly a mid river channel) and the thin seams of coal above it.



Firestone Sandstone ***Barbara Balfour***

We speedily retraced our steps to the car park where Stu was thanked for his excellent explanations of the geology of the area. He just happened to have in the back of his car, an excellent BGS publication called "Ancient Frontiers" about the geology and the landscape of the Hadrian's Wall area, which a good number of us purchased, as word got round that it had lots of nice pictures! After a visit to the local hostelry with our Edinburgh colleagues, we got home to Glasgow after a long, but most enjoyable day.

It would be a bit remiss not to mention something about the Romans and Hadrian's Wall so imagine the scenario of two Roman sentries on the Wall.

1st sentry… "It's cold tonight"

2nd sentry…. "Yes, and we've got the Whin Sill factor to contend with!"

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GLENORCHY AND CONONISH VALLEY : 18 August 2007
Leader : Dr Geoff Tanner
Report by : *David Hollis* Glasgow Participants : 16

On a very wet morning we headed north to explore the antiform structure of Glen Orchy and the geology of Cononish Mine. Both localities can be found on map 377 (O.S. Explorer series, grid area NN), at grid reference squares (28–34–) for the quartz-breccia dyke on Beinn Udlaidh, (24–31–) to (25–35–) for the traverse across the antiform, and square (29–28–) for Cononish Mine.

First, Dr. Tanner gave us an overview of the area. The region is bound to the north by the Ericht-Laidon fault, and to the west by the Glen Etive Granite. We did not have time to go to the quarry in the Glen Etive Granite at Tainault (at the southwest end of Loch Etive), but the granite there is, in its lower region, an attractive black and white speckled (riebeckite?) granite. The overall strata of this part of Scotland follow an upward succession in the Dalradian, from the Grampian Group and the Appin Group. The major structure of the area consists of an elongate, E-W dome over which is folded the Beinn Udlaidh Syncline. The syncline is of D2 age and contains the two lowest members of the Lochaber Formation, namely the Beinn Udlaidh Quartzite and the Coire Daimh Pelite. The syncline formed at approximately 470 Ma, at the same time as the Tay Nappe above it was being transported to the SE. The age of the Orchy Dome is not known. The aim of the visit was to demonstrate firstly, the succession from the psammites of the Grampian Group to the Lochaber quartzite and pelite in the river bank on the northwest side of the Glen Orchy road, and secondly the geometry of the D2 syncline.

Above the Dalradian beds are some recent glacial deposits which show well developed examples of drumlin formation, and breached moraines. At the Bridge of Orchy entrance to Glen Orchy (NN 29–37–) there are kames and "kettle" holes. Our first stop was at the side of the road about 2 miles into Glen Orchy (~ NN 285375). We looked south through the mist to view the distinctive white quartz-breccia dyke which runs through Beinn Udlaidh in a northeast – southwest direction. The pelite beds are on the northwest side of the crag, and the fold axis of the Orchy Dome runs approximately northeast – southwest in this area. At the next stop (~ NN 268358), the semi-pelite-psammite could be seen dipping off the dome on the northeast side; there was an area

Grampian beds dipping northwest ***David Hollis***

of quartz-breccia, and a small knob at the end formed by an explosion breccia (NN 26–33–). At our third stop at the riverside (NN 266358), the Grampian Group could be seen dipping northwest near the waterfall, cut by a small breccia pipe.

'Fabulous mullions' ***Charles Leslie***

At the fourth stop, about 1 kilometre downstream of the waterfall, the party headed along the river bank upstream in an approximately east – north – east direction diagonally across the nose of the dome, to view the succession from psammite to quartzite to pelite on the lower right-way-up limb, of the Beinn Udlaidh Syncline, and in the reverse order on the top, inverted, limb. We came to a large series of outcrops, in the middle of the river, in which the rocks were intensely folded, and demonstrated that 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 a regional-scale domal structure. Near the top end of the section the quartzite contained fabulous mullions, and cross-bedding which indicated that the beds were younging downstream and that we were on the lower limb of the fold. A wet group of geologists returned to the minibus, and set off for much needed lunch and a thorough drying out at the "Green Welly", at Tyndrum (NN 32–30–).

In the afternoon, we were taken to Cononish Mine. We are grateful to our driver, who managed to take the bus up the rough access road to within sight of the mine workings. After a short introduction by Dr. Tanner, we walked the remaining half kilometre to the workings to view the core store and collect samples from the mine dumps. The country rock consists of pelite-psammite sediments which have been metamorphosed to garnet grade with quartz veins in places. The rocks proximal to the veins in this area are a pink colour produced by pink potassic orthoclase feldspar, and haematite formed when they were metasomatized.

The gold mine follows a quartz vein into the hillside in a direction approximately northeast for about 750 m until it reaches a fault. There is also a lead mine dating from about 1750 in the steep crag to the northwest of the gold mine, comparable to the well known workings for zinc and lead just west of Tyndrum (NN 320303). Certain parts of the quartz vein at Cononish are brecciated, which indicates a later phase of activity, during which gold, pyrite and galena were deposited in the orebody, named the Eas Anie vein. Good specimens of the brecciated material were found in the dumps. The pyrite contains the gold in the form of tiny particles which were too small for the early miners to detect. A piece of the pyritous material was found on the mine dumps, and is shown below.

The present estimate of the gold content over the economic part of the orebody is 10-11grammes per tonne and the total weight of gold-bearing quartz is estimated at around 750,000 tonnes. The mine is at present inactive, but following the recent hike in the price of gold, is due to commence operation in 2009-2010.

Pyritous material ***David Hollis***

A vote of thanks was given to Dr Tanner for a highly interesting day in Glen Orchy, and at Cononish Mine, and the party set off to Glasgow to dry out and enjoy home comforts. Dr Tanner is also to be sincerely thanked for his great assistance in the compilation of this report.

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SILVER GLEN : 8 Sept 2007
Leader : Dr Neil Clarke
Report by : *Allison Drummond* Glasgow Participants : 14

On a bright sunny day fourteen hopeful silver prospectors gathered at the car park near Alva before proceeding to Silver Glen. Our leader for the day, Neil Clark was laden down with all the necessary equipment including a plentiful supply of sample bottles, both large and small, for us to use to carry our silver home. We started with Neil giving us a background talk about the geology and mining which had been carried out in the area. The Ochil Hills around Alva are a pile of Devonian andesites, tuffs and agglomerates that are bound to the south by the east – west Ochil Fault. The western Ochils have a long history of copper mining and the eastern Ochils are now known for their alluvial gold. At Alva the silver seems to be associated with a north – east trending vein in andesite on the west flank of the stream

on Nesbit Hill 130 m north of a quartz-dolerite intrusion. Silver was first found in Alva in 1714 and was assayed by Sir Isaac Newton, who was Master of the Mint. It was found to be 85% silver which was said to be the purest in the United Kingdom. At its height it earned the Erskine family almost £430,000 per week. In 1758 a rich cobalt ore was found. This ore, erythrite, $[CO_2(AsO_4)_28H_2O]$ was used as blue colouring in the ceramics industry. The mines were finally abandoned in 1770.

After a pleasant but steep walk through a wooded area we came to the location where the spoils from the mine had been discarded and Neil assured us that silver was still to be found in the spoils. A large tub of rubble, hopefully containing silver, was gathered and taken to the stream where Neil then demonstrated the art of panning to us. Wellington boots were donned and with great enthusiasm we waded into the stream and attempted to copy Neil's technique. Unfortunately our efforts were not quickly rewarded and after two hours of endeavour and plenty of guidance from Neil only two out of the fourteen hopeful prospectors found small pieces of silver. Neil himself found a specimen of erythrite which has a bright red-purple colour and for this reason was called "Cobalt Bloom" by the miners. We returned to the car park having had a most enjoyable introduction into the art of panning for silver, and after a vote of thanks was given to Neil, we departed for home.

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HARRIS AND LEWIS : Thursday 13 Sept – Monday 17 Sept 2007
Leader : Dr Doug Fettes (BGS)
Report by : *Muriel Alexander, Ben Browne, Margaret Donnelly, David McCulloch*
Participants : 23

Our party assembled at Uig pier on Skye on 13 September for the evening ferry to Tarbert. The weather had turned very wet on Skye (no surprise there) but improved as we approached Harris. After checking in with our various landladies we gathered in the Harris Hotel where Dr. Doug Fettes gave us an introductory talk.

Dr. Fettes illustrated his talk with overheads which were replicated in a comprehensive guide which he issued to each member of our party. He explained that the Lewisian gneiss was part of a craton against which the Caledonian and Variscan orogenies formed. The gneiss in the Western Isles and northwest Scotland is but a small fragment of that craton stranded on the east side of the Atlantic Ocean following its opening. The gneiss was formed over a truly vast time span of 1500 million years from about 3000 Ma to 1500 Ma and has four main elements to it. Firstly, the early crust composed of relics of a sedimentary cover intruded by vast igneous intrusive suites; secondly, the Scourian tectonothermal event (2700 Ma to 2500 Ma); thirdly, intrusion of Scourie dykes (2400 Ma to 2200 Ma), sometimes referred to as the Younger Basics, during a subsequent extensional event; and fourthly, another major tectonothermal compressional event known as the Laxfordian (1860 Ma to 1630 Ma) which resulted from continental collision and subduction.

<u>Friday 14 September</u>

It was dull but dry when we gathered in the car park of the Harris Hotel, piled enthusiastically into cars and set off on our first excursion of this Outer Hebrides

trip. Our plan for the day was to explore the various elements of the South Harris Complex as well as (most important for some) stock up with enough food for our three days' packed lunches, so we headed south for Leverburgh. On the way we stopped at a lay-by (NG 087971) where we had our first introduction to two of the great attractions of Harris – wonderful scenery and the spectacular Lewisian gneiss. This rock, known as grey gneiss, was formed from huge plutonic igneous intrusions which were then compressed and metamorphosed during the Scourian and Laxfordian tectonothermal events some 2700 and 1800 million years ago and showed irregular, pink pegmatite veins of granitic origin. In some exposures dark cross-cutting igneous dykes and lenses were intruded – the Scourie dyke suite – when there was a time of extension around 2400 Ma. Suitably impressed we moved on to have a welcome stop at a surprisingly well-stocked shop in Leverburgh.

Driving on south towards Rodel we parked just before St. Clement's Church and were told that the South Harris Complex was, at least in part, an oceanic island arc of younger igneous material which, by subduction, had collided with and been compressed against the older Archaean gneisses, then buried deeply and subjected to high grade metamorphism during the Laxfordian event. The three parts of the complex were named from southwest to northeast as the Leverburgh Belt, the South Harris Igneous Complex and the Langavat Belt and we heard that we would first see rocks of the Rodel series of the Leverburgh Belt which is the most westerly band of the South Harris Complex and is formed of metasedimentary rocks.

After a walk along the cliff top and a scramble down a steep grassy slope we walked out to the Stuaidh Peninsula (NG 042831). Here we found evidence of metamorphosed oceanic sediments in the form of marble from metamorphosed limestone and convinced ourselves that we found sulphide-rich quartzite and pyrite in the brown stained pelitic rock and schist. We heard that other metasedimentary rocks such as calc-silicates and graphite schists had been found and all had originated from material eroded from the island arc and subsequently been buried, deformed and metamorphosed to granulite facies. The next challenge was to struggle back up the slope after which we were glad of a little time to visit St. Clement's church, absorb its history and climb the tower to get a wonderful view of the surrounding landscape.

Our next stop was at one of the four main intrusions of the South Harris Igneous Complex where we had lunch in a small quarry (~ NG 059849) surrounded by a startlingly white rock. This, Dr. Fettes told us, was formed by a large fold of meta-anorthosite which is almost entirely plagioclase feldspar with streaks of mafic rock through it. Later, on exploring a similar small quarry nearby (~ NG 057849), we found a patch containing garnets. These quarries, we heard, were the test quarries for the planned superquarry at Lingarabay which was subsequently rejected, the intention having been to use the rock as a reflective roadstone.

Back in the cars we headed for the next stop in our itinerary – but there was an unexpected change in plan. Is it possible to get lost on the few roads in Harris? Well we did! However the magic of the mobile phone soon put us right and we found that we were now in the Langavat Belt of metasediments, metabasic rocks and folded amphibolite sheets. From the road we tramped northeast across the peat to a ridge (Scara Ruadh, NG 056884) from which we had a spectacular view over a typically bare Lewisian landscape. However an outcrop on the ridge itself was a real puzzle –

in parts dark, shiny, slippy to touch, studded with angular crystals and with a schistose outer edge. The explanation – it was an ultrabasic pod that had been considerably metamorphosed and serpentinised.

Again, reunited with cars, we headed back towards Tarbert and to our final stop, which involved a pleasant walk across the machair in the direction of Toe Head. Here (~ NF 983912) we found several outcrops of metamorphosed pelitic gneiss and realised that we were back in the Leverburgh Belt but this time in the different metasediments of the Chiapaval Pelitic Series. Hand lenses out, we found the rocks to be full of garnets and biotite mica and, once identified, we also found much kyanite making these rocks kyanite-garnet pelitic gneisses.

We retuned to Tarbert tired but, thanks to Dr. Fettes, having enjoyed a fascinating day of geology and looking forward to a nice meal and a relaxing evening in the Harris Hotel.

Saturday 15 September

This promised to be the wettest day of the excursion and delivered its promise. We used it for the more local exposures. The morning was devoted to examining the relationships of Scourie dykes in North Harris.

At the road end at Hushinish (NA 993120) we walked up the grass slope for a view of the island of Scarp then gathered for an explanation of the local Uig Hills-Harris Granite Complex. Complex networks of granite sheets intruded the gneiss probably due to subduction during the latter stages of the Laxfordian collisional event. This dominant granite yields poor soils and any local fertility is dependent on wind blown shell sands. Driving back 4½ km we parked at the turning to Gobhaig (Govig) and walked on about 100 m to (NB 019097) where ice polished slabs just above the road showed a folded Scourie dyke cross-cutting the gneiss foliation. A pegmatite was seen to cross-cut the folds suggesting that it was late or post Laxfordian. A little lower, a grey granite cut a pegmatite, so granite intrusion had not finished before the pegmatites started to develop. Four kilometres back down the road just past Abhainnsuidhe house we parked at the road end (NB 053077) to the power station. Four hundred metres up this road is a metal gate. About 100 m after this on the left are polished slabs rising gently up to a dome (NB 055083). Here are multiple folded basic Scourie dykes, some showing boudinage, and many were cut by later granite veins. Originally it had been thought that the granites were a local melt derived from the gneiss but Dr. Fettes was able to explain that this could be excluded by considering the chemistry of the rocks.

Our soaked and bedraggled party headed back to Tarbert to dry out and assess the prospects for the afternoon. Some of us had lunch in a small but cosy cafe by the pier, before regrouping at 1.30 pm at the Harris Hotel. Here we could see that a small stream which tumbled over a grassy embankment on the other side of the road had become a frothing white torrent in a matter of only a few hours. Someone announced that the forecast was for the weather to get even worse, but Dr. Fettes politely offered to take the party out in the afternoon if anyone was interested. One small voice bravely took him up on his offer and before too long others joined in. So.....eight of us in two cars headed off on the Leverburgh road for the west coast of Harris, to examine the northern part of the South Harris Complex.

Our first stop was north of Borve Lodge around NG 035951, where we parked and walked across the field to the beautiful extensive silver beach, with a series of rocky outcrops. Walking south we examined each in turn – they were the migmatitic grey Lewisian gneisses of northern Harris, cut by abundant late Laxfordian pegmatites. The rain had gone off so we congratulated ourselves on our decision to venture forth only to have serious misgivings when we were caught by two massive squalls. Reaching the Borve river which was flowing fast and full, we had some excitement climbing the bank and over a couple of fences in order to cross by the bridge. Back down on the beach, we found a change to a mixture of quartzofeldspathic rocks and amphibolites. Early workers regarded these as part of the Langavat Belt but recently they have been reinterpreted as highly strained Lewisian grey gneisses (Mason et al 2004a). (The Langavat Belt is a mixed zone of metamorphic, ultramafic and metasedimentary rocks. The latter contain detritus from the northern Archaean grey gneisses and show no evidence of granulite-facies metamorphism, both factors distinguishing them from the 'oceanic rocks' in the southern Leverburgh Belt.) A little further on was Sta Bay (NG 029950) where we found metasediments: garnet-biotite schists, graphitic schists and calc-silicates – we had reached the contact with the Sta Series, the lowest undisputed member of the Langavat Belt. The current view is that the Langavat zone is part of a major tectonic suture between the 'island arc' rocks of the Leverburgh Belt and the meta-igneous complex, and the northern Lewisian gneisses, with the Langavat metasediments caught between, and now lying partly in an imbricate thrust zone.

We returned to the cars and drove south to Bagh Steinigie (NG 035951) near Scarista, from where we had fabulous, though intermittent, views across the white sandy beaches of South Harris to the North Harris mountains. Well-exposed on the shore was grey, unfoliated medium- to coarse-grained metadiorite, clean-washed and glaciated, and some 60 – 70 m of laminated amphibolites with subsidiary micaceous and quartzose gneisses, containing banded metalimestone and calc-silicate rock units each up to 2.5 m thick. Although originally mapped as part of the Langavat Belt, this thin septum is now considered to be a northern sliver of the Leverburgh Belt because it has undergone granulite facies metamorphism like the latter, but not the former, and the isotopic signature of the protoliths resembles Leverburgh rocks, distinct from those of the Langavat Belt. To the northeast of Bagh Steinigie we found the elongate metatonalite body (more deformed, retrograded and quartzose than the metadiorite) which was delineated by Horsley (1978).

Satisfied, enthralled and not totally drenched, we made our way back to the warm, dry haven of Tarbert and dinner.

Sunday 16 September

We drove past the Harris hills and across the boundary into the flatter lands of Lewis. Just east of Balallan we walked out on one of the peat roads to view rocks affected by the Outer Hebrides Thrust Zone. The thrusting occurred after the emplacement of the Granite Vein Complex and is therefore one of the last events in the Lewisian, starting at around 1675 Ma but subject to periodic movements ending at 425 Ma at the time of the Moine Thrust. Dr. Fettes explained that east of Loch Seaforth the thrust zone is marked by crushed and broken up rocks including

mylonites; however to the west the thrusts are more discrete structures. We passed chewed-up grey gneisses beside the road displaying low grade alteration before reaching a small crag (NB 308222) where pseudotachylyte was amply displayed. This rock has a smooth flinty appearance and a conchoidal fracture, and is sometimes called 'flinty crush'. It is formed when there is sudden movement on a thrust which causes instantaneous melting and rapid quenching. The high strain environment of pseudotachylyte formation can be contrasted with a lower strain crushing environment when mylonite is formed. We saw clear evidence that the rocks locally were dipping to the east, a reflection of the thrusting. Injections of pseudotachylyte into the surrounding rock can often be seen. Just south of Garynahine we stopped at a road cutting (NB 230299) to view some very typical migmatitic grey gneiss containing basic Scourie dykes.

Thrust Plane ***Charles Leslie***

Some careful navigation led us to the road end at the air traffic control mast on the cliffs at Mangurstadh (NB 004332). The sun was now shining and thankfully the shower clouds all seemed to pass over elsewhere. The lighthouse on the Flannan Islands could clearly be seen although St.Kilda was not visible. We climbed down to the west of the mast to see a spectacular thrust plane, much more visually impressive than outcrops of the Moine Thrust which we had seen elsewhere. Dr. Fettes pointed out that the foliation in the gneiss was vertical, yet we were standing on a rock slope dipping landward, which was formed by the thrust plane. We could see the same dipping thrust plane in the rocks on the south side of the bay. Moreover, at our feet there was a distinct layer of crushed rock (mylonite) several inches thick at the base of the cliff facing us. The green colour of the mylonite is due to epidote mineralisation.

A granite vein could be seen above the thrust but not below it showing that the thrusting post-dated the intrusion. This is one of the discrete thrusts found west of Loch Seaforth and showing that the Outer Hebrides Thrust Zone extends right across to the western seaboard of the islands. We walked along the cliffs to the southern end of the long narrow inlet (NB 002330) which was formed by erosion along the thrust plane. Lineation on the surface of the mylonite shows the direction of movement on the thrust. We could see that the mylonite reached a thickness of about 15 feet.

Sea stacks to the northeast of Aird Fenish ***Charles Leslie***

The walk out to Aird Fenish affords a spectacular view to the sea stacks in the bay to the northeast. The headland itself (NA 991293) is formed from granite injected as veins rather than a pluton. It was originally thought that the granites were closely related to the local migmatitic gneiss having been derived by partial melting of similar rocks, and intruded over only short distances. However the chemistry of the gneisses and the granites rules out this intimate connection and suggests the granites were generated at greater depths in different types of gneiss and then injected into the migmatitic gneiss as is now seen. At the western extremity of the headland we descended down over the rocks to view a section of the low cliff intruded by two Scourie dykes. The foliation just to the south is very regular whereas that to the north is very contorted. The dykes mark the edge of a late Scourian shear zone about 200 metres wide where the complex foliation has been stretched out. Shearing can be compressional or tensional and the intrusion of the dykes would suggest that this particular shear zone is tensional. Just below the dykes is a granite vein with an unusual foliated central section. This would suggest that shortly after injection, the

still molten centre was subject to deformation and is evidence that the late Laxfordian deformation and thrusting took place soon after injection of the granite vein complex.

Two Scourie dykes at Aird Fenish ***Charles Leslie***

By this time the cloud had lifted off the summit of Mealisval revealing its rugged but curvaceous silhouette. We drove back the long road to Garynahine where some in the party detoured to visit the standing stones of Callanish. The road east to Achmore afforded a superb view south over the peatlands to the distant Harris hills, a view which is under threat due to the possible construction of a massive wind farm.

On the following morning our party left Harris on the early ferry to Skye before the long drive back to the Glasgow area. Dr Fettes was thanked profoundly for a fascinating and stimulating weekend with its insight into the 'hard' geology of Harris. He is also to be thanked for his assistance in the compilation of this report.

GENERAL INFORMATION

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

Mintlaw Academy, Peterhead	Int. L 1
Portree High School	Int. L 2
Cumnock Academy	Higher

Scottish Festival of Geology. 1st to 30th September 2007. www.scottishgeology.com. This is now held annually. Our Society organised two events:

Saturday 15th September

At the Glasgow Science Centre, 10am to 4pm:

"Glasgow's Rocky Foundations"

A display of rocks, minerals, fossils, maps and photos relating to Glasgow and its surroundings. Membership packs were also available.

Sunday 16th September.

At the Fossil Grove, Victoria Park, 1pm to 3pm.

Society members and academic staff were present to explain the global significance of these unique fossil tree stumps in terms of our geodiversity and conservation of geological sites.

Saturday 8th September.

Silver panning at Silver Glen, Alva with Dr Neil Clark.

Change in format of Treasurer's Report

This was initiated by a change in the charity rules by OSCR. By the new ruling the accounts will have to be examined by an Independent Examiner, i.e. someone who is not a member of the Society.

Scottish Fossil Code.

The Nature Conservation (Scotland) Act 2004, gave Scottish Natural Heritage (SNH) the duty of preparing a code to be known as the 'Scottish Fossil Code'. Further details can be found on the website www.scottishgeology.com. The code aims to encourage responsible collecting and to promote interest in palaeontology and the appreciation of Scotland's rich heritage of fossils.

Conference Funding.

In response to a request from Dr Simon Cuthbert, the Society awarded a sum of £500 to help fund the 'Eclogite Conference' which was held in June 2007 and based in Skye and Lochalsh.

INTIMATIONS

With regret we record the deaths of

Mr. William Frame Lamb, member since Session 139 (1996 – 7).

10th August 1931 – 7th January 2007

Bill Lamb burst upon the Glasgow geological scene following his retirement, in 1996, at the age of 65. He had worked as the Deputy Director of the Cleansing Department of Glasgow Corporation and had been there for nearly 30 years. Previously he had been employed in Export/Import shipping and had worked with Playtex of Port Glasgow and Laird Portch clothing in East Kilbride.

Upon retirement he developed an enthusiastic interest in geology and began attending classes in the Extramural Department (now the Department of Adult and Continuing Education) at the University of Glasgow. I first met him at one of my evening courses, memorable in that he asked if it was O.K. to record the lecture. We soon became friends and he began a new 'career' as class 'organiser' (his phrase) for lunches and other extramural activities.

His interest in geology suited his love of travel and he undertook several overseas trips organised by the University of Nottingham; on Society Members' Nights he exhibited photographs, maps and specimens that came from these trips to the Colorado Plateau, New Zealand and Alaska. He became a Council Member of the Society and had hoped to facilitate such overseas trips from Glasgow. Although this was not to be, his inspiration led to the 2002 excursion to the USA, to Arizona and Yellowstone, led by myself, with Janey MacDougall. Unfortunately, shortly before we were to set off, he suffered a mild stroke which was to prevent his travelling. Nevertheless he contented himself with the role of base organiser from his home in Glasgow and remained very much with the party in spirit.

Subsequently he was well enough to enjoy DACE excursions to Cyprus and Spain.

In 2006, he and I were involved in the planning of a further excursion to North America, to the Canadian Rockies, Alaska, Yukon and Mount St Helens, places he knew well and was keen to visit again. However this was to be his final contribution as his deteriorating health again prevented travel.

His last task was to organise the Thursday class Christmas lunch of 2006. Although too ill to attend he ensured that all was in place on the day for his friends. Shortly afterwards he was admitted to St Margaret's Hospice where he died peacefully in early January.

Bill had three children; his youngest, David, died in his teens and Bill is survived by his daughter, Sharon, and son, Duncan. Sharon has kindly donated Bill's collection of geological books and maps to the Library of the Society.

He remains very much missed by his 'organised' friends.

Dr Michael Keen

Dr John Maguire, member since Session 138 (1995 – 6), who died on 19th October 2006. John Maguire was an enthusiastic participant in the Society, regularly attending our monthly meetings and field trips, including Tenerife and Hawaii, and was highly respected by all who knew him. A retired General Practitioner, he had a keen interest in natural history, outdoor activities and gardening. He enrolled in many of the DACE courses and held the University of Glasgow, Continuing Education Certificate in Geology and the Environment. As an active member of Sherbrook St Gilberts Church of Scotland he served faithfully for many years as an elder. His sudden death from an acute heart condition came as a great shock to us and we miss him greatly. He is survived by his wife Seona, daughter Elspeth and son Craig, to whom we extend our sincere condolences.

Mr. Alan Saunders, member since Session 136 (1993 – 4), who died in Sept 2006.

Front cover photograph – Island of Staffa. *(Charles Leslie)*

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