PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF GLASGOW

Sessions 136 and 137

1993/95

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CONTENTS

MEMBERSHIP

The membership of the Society for sessions 136 and 137 was as follows:

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Honorary Life Members	2	2
Life Members	1	1
Ordinary	394	368
Associate	54	56
Junior	12	14
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Totals	463	441
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New members	31	27
Deletions	52	49

J. Willing

LIBRARY REPORT

In **Session136** the reorganised library has now been functioning for a full session and has provided an effective service for members. The surplus material generated by the reorganisation has been catalogued thanks to the considerable help provided by one of our members - Dr R Jemileita. During the session a number of sales of books, journals and ephemera from this surplus stock were held, generating £37.44, of which a sum of £19.99 was spent on the purchase of S J Gould's "The Book of Life". The Society's holdings of old United States Geological Survey publications have been offered to an American dealer and the sale is at the moment being negotiated.

The new leaflet, explaining the library to members, has been prepared but is not yet printed.

New books purchased this session cover much of geology, with excursion guides playing rather less of a part than is usual, although guides to the Onny valley in Shropshire (P Toghill) and the Isle of Man (T D Ford) are now in stock. Regional geologies include those of the Bristol District (G A Kellaway and F B A Welch), the Precambrian of the Scottish Highlands (M J Hambrey, *et al*) and the Geology of Ontario (P C Thurston, *et al*). An introductory text on Conservation Ecology (G W Cox) leads into Global Biogeochemical Cycles (R J Orions and G V Wolfe) and Biogeochemisty (W H Schlesinger). Books on Petroleum Geology, Meteorites and Molluscs have also appeared. Of interest to the Society is a new gift to the Department from the daughter of Professor Gregory. This generous gift consists of the complete works of Gregory bound in six volumes

There were 18 borrowers this session (22 last session), borrowing between them 83 items (85 last session). A number of new borrowers began to explore the library, joining the regular band of dedicated readers. It is hoped that the forthcoming leaflet will attract further custom. Borrowing ranged widely, from the purely technical to, as always, excursion guides. An upsurge in the borrowing of books on palaeontology appears to be coincident with a rise in activity by Stan Wood.

In **Session 137** the library has functioned well during this session, members making full use of the facilities. Major users have been a dedicated group of palaeontologists (fossil identification and tracking down of fossiliferous localities) and enthusiastic excursionists seeking guides to a worldwide spectrum of locations.

Further sales of surplus stock have taken place, raising £360. However, disposal of our large remaining holdings is now becoming an urgent matter, since changes in space requirements within the Geology & Applied Geology Department at Glasgow University mean that our surplus stock must be disposed of within 6 months.
Proposals are presently being formulated to place the Society's rare books, at present in several locations, in the University Library. The books will remain the property of the Society, but will be on permanent loan to GUL, and thus will be more easily accessible to Society members than at present. The books, collected in the early years of the Society's existence, form an almost complete view of the early history of geology itself, ranging from seventeenth century mining treatises, through Playfair's *Illustration of the Huttonian Theory*, to the later nineteenth century geological classics, and comprise a valuable academic resource.
New aquisitions to the library this session include a number of guides - to Bute (J Hill & D Buist), to Tenerife and Mallorca (Geologists Association), and to Powys, Central Wales (N H Woodcock & M G Bassett). Palaeontological aquisitions include new volumes of the *Treatise on Invertebrate Palaeontology* (Introduction, Bryozoa, Arthropoda, and Conodonts), plus Maynard Smith's *Theory of Evolution* and Thomas and Cleal on *Coal Measure Forests*. A counterbalance to palaeontology is provided by Monroe and Wicanders' *Physical Geology*, *Ore Geology* by A E Evans, and in the field of Ecology/Environment, *Conservation Ecology* by G W Cox and *Environmental Change* by A Goudie.
This session 19 borrowers (18 last session) borrowed between them 96 items (85 last session). In addition numerous people used the library for consultation purposes.

C J Burton

EDITORIAL REPORT OF THE SCOTTISH JOURNAL OF GEOLOGY

Session 136

There have been no major changes in the production of the Journal in the past year. The introduction of a new typeface in volume 30 has completed our changes in format and we now look forward to a period of stability. All issues have appeared on time or ahead of time and, with a few exceptions, we have good control over the processing of new papers submitted. We are continuing our efforts to reduce the time delays between primary submissions by authors and subsequent publication but are sometimes at the mercy of both referees and the authors themselves. We will in future be able to accept manuscripts on computer discs and this should help to speed up processing and editing.
Work for volume 31 is essentially complete.
One innovation in the past year has been the introduction of book reviews. These are to be included as space permits but as a matter of policy will for the moment be restricted to works with a specific Scottish focus.
Although there has been a slight decrease in Trade subscriptions in the past year these have in general held up in the face of widespread cut-backs in library subscriptions. This relative strength can be attributed both to the quality of the Journal and to our association with the Geological Society Publishing House who have widely publicised the Scottish Journal

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The Journal has continued to attract a satisfying quality and number of papers submitted for publication. We have maintained our record of the last few years in producing issues at or before our stated publication dates and have maintained or improved the high quality of typesetting and editing. As a result of an active policy pursuing authors with long-standing unrevised manuscripts we have been able to reduce the gap between submission and

publication dates so that it is typically less than one year, although readers may note one or two papers still in the system which have slipped through what we hope is a tightening net.
The publishing house has followed an active policy of publicity for the Journal on our behalf. As examples, some 15,000 advertisements went out with a recent GSPH mailing and a further 32,000 with mailings associated with AAPG. Against this background it may be surprising that our trade subscriptions have only increased by 3 in the past year. However, published statistics show that as a result of cut-backs in spending both in Britain and North America similar scientific journals have fallen back by 4-5% in the same period so we have good cause to feel satisfied.
Discussions concerning the constitution of the Editorial Board and the adoption of recognized procedures have moved forward to the stage where formal proposals have been submitted to the Councils of the two societies.
Finally, Dr Chris Burton has recently resigned from the Board and thanks are due to him for his support for the Journal over the past years, at a time when his other commitments have increased at such an alarming rate. He is replaced by Dr Gordon Curry who brings a similar expertise in palaeontological and stratigraphical matters.

Colin Braithwaite

PUBLICATION SALES OFFICER'S REPORT

Session 136

Sales of our Publications have continued at much the same level as in the past few years, providing an income to the Society of around £1,000 per annum. The best seller is the Arran Guide followed by the Skye Guide. After the initial interest in the new edition of the Glasgow and Girvan Guide, sales have been somewhat slow. Some effort has been made to interest local booksellers to stock the Guide. This has met with some success among the principal outlets in the area.

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Sales of Publications this year generated a profit to the society of £1294. New titles added during the year included Field Guides to Yorkshire, Northumbria and the Lake District. These have proved popular with members. In all, a total of 38 titles were stocked, providing a variety of subject matter. A continuing effort was made to widen the availability of the Glasgow & Girvan Guide in booksellers and libraries in the west of Scotland and this has resulted in improved sales for the guide. The Arran Guide will go out of print probably in 1997. The council is considering its replacement which is likely to be more than a simple reprint. Sales to members during the year amounted to 22% of the value of overall sales and we are grateful for this support. Of the remainder, 11% went to Extra Mural classes and conferences while 67% went to booksellers and other outlets.

Roy Smart

EXCURSIONS 1994 (Session 136)

B.G.S. OPEN DAY: 24th April 1994
by Allan Hall

Mr John Hull, Assistant Director, went to much effort to ensure that our group was made welcome and well looked after.
Our group of 24 was welcomed by Mr Hull and Ian Hogarth, President of the Geological Society of Edinburgh. We were split into four groups and led round the exhibits by Drs. Gallagher, Stone, Mallick and Mr. Land. Sandra MacKie ensured that the visit went smoothly and that we were well provided with coffee and biscuits both before and after the tour. The exhibits included those on Scottish Geology, Marine Exploration, Earthquake Research and Earth's Magnetic Field.
Mr David Land also organised for members of the group who were interested to join a Science Festival afternoon walk on Arthur's Seat.

CORRYCHARMAIG, KILLIN: 7th May 1994
Leader: Dr A J Hall, University of Glasgow

18 people attended this excursion and the number of cars was limited to five due to access. The Corrycharmaig serpentinite is one of a number of intriguing small serpentinite bodies that occur in a linear zone extending through Middle Dalradian rocks of the Scottish Highlands from near Loch Fyne in the south west to the Moray Firth in the north east.
We examined the textures and minerals present in the serpentinite and considered how the rock originated and was modified by regional metamorphism. Relatively unusual minerals such as antigorite, chromite, talc and magnesite are found here in abundance. There are old workings here representing trials for chromium ore but both the chromite and talc-magnesite have been considered more recently for their economic potential as refractories. Other minerals of economic significance which are often associated with serpentinites are platinum, asbestos, and indirectly, gold. The serpentinite outcrops as crags on the side of Glen Lochay with Loch Tay visible in the distance and it is a particularly suitable locality for contemplating the problem of balancing man's consumption of metals and industrial minerals with the inevitable environmental consequences.
Access is easy, involving about a 1 km walk along a farm track from Corrycharmaig Farm (NN 528359) and up a gentle incline from about 150m to 250m; examination of the outcrops involves walking short distances up and down some fairly steep slopes but extending from about 250m to only 350m altitude. (OS 1:50000 sheet 51 Loch Tay).

HAGSHAW HILLS: 4th June 1994
Leaders: Dr E.N.K. Clarkson, Mrs C. Taylor, Mr C. Lovelock,
University of Edinburgh
by Roy Smart

17 members made their way by car and coach to rendezvous on the A70, a few miles east of Muirkirk at Parishholm Farm. The aim of the excursion was to study the Hagshaw Hills, one

of several Silurian inliers within the Midland Valley of Scotland. This inlier is one of a chain extending from Girvan to Scandinavia, all recording the transition from marine to terrestrial sediments, but in the Hagshaw Hills the 'marine' facies is unusual.
The excursion route went south by the Douglas Water and the Ree Burn, our leader Dr Clarkson taking the party directly to the highest point of the excursion. This had the advantage that members could enjoy the geology on the descent without any breathing problems! With the weather continuing fair, we then examined the redbeds and fish beds on the east shore of Glenbuck Loch. This loch is man-made, being constructed in 1802 to control the flow of the River Ayr to the mills at Catrine some 15 miles downstream. Our final stop was at Monksfoot Farm where, on balance, we interpreted the noise from the pig-sty as being a welcome!

CORRIEBURN: 18th June 1994
Leader: Dr G.E.Bowes, University of Glasgow
by Roy Smart

18 members travelled by car to this location, just a few miles north east of Glasgow. A coach would have been unsuitable due to the narrow roads which made even car parking difficult. The localities we visited are all in Lower Carboniferous rocks, and include sediments of the Calciferous Sandstone Series, the Lower Limestone Group and the Limestone Coal Group, and basalts of the Clyde Plateau Lavas.
Led by George Bowes we set off from Burnhead Farm in light rain following the Corrie Burn till it turned westwards, then east over rough ground to the Queenzie Burn. As we ascended towards the cloud base the rain became heavier making it necessary to curtail the excursion, though not without examining the profusion of assymetrical ironstone nodules within the shales overlying the Blackhall Limestone.

GLENSANDA QUARRY: 17th August 1994
Leaders: Mr I. MacDonald, Foster Yeoman
Miss A. Smith, Tarmac Roadstones
by David Wilkinson

Everyone turned up at the arranged time of 6.45 a.m. at the Boyd Orr car park. Dr. Alan Hall who was to lead the visit and drive the minibus was there in very good time - he thought it was a 6 a.m. start!
During the drive up Loch Lomond the weather kept changing from bright sunshine to showers and our arrival at Foster Yeoman's jetty at Rubha Garbh coincided with one of the gloomier periods. Looking down Loch Crerand towards Eriska and the Appin Peninsula however, the sea appeared silvery and smooth. As we threaded through the network of channels, past the island of Lismore and punched our way across Loch Linnhe, the sun came out and give us spectacular views in all directions. Looking across the Loch to Glensanda, the red scar of the quarry workings just above the shore line was prominent, as was the road winding up the hill out of sight. Just to the south of the quarry buildings, in rather incongruous juxtaposition, was the rectangular tower of Glensanda Castle, decorated by the Saltire. Lying just offshore was a red and green ore carrier and on the shore line was a large shed and three conical heaps of aggregate.

The quarry manager, Iain McDonald, greeted us on our arrival and was introduced by Anne Smith, who had arranged the visit. We were then shepherded into the "man transporter", which is rather akin to a Portacabin mounted on a truck with massive wheels. Inside, the seating was comfortable and as we zigzagged our way up the hill, Iain told us something about the quarry operations. Glensanda is worked continuously day and night except in exceptionally bad weather, for example in heavy mist at night, or, less frequently, after a very heavy snowfall.

When we arrived at the top, 2,000 ft. up the hill, we were able to look at the "benches" where the rock was being excavated. These slices out of the hill were several hundred metres long and about 30 metres deep along each bench. The quarry is being gradually worked further into the hill towards the boundary fence in roughly a semicircular arc. The rock was predominantly a pink granite, well shattered and cut by several dykes of black basalt. The rock is not of particularly high quality, having a Polished Stone Value (PSV) of about 55, but it has good consistency and is widely used for concrete aggregate and road foundations.

There is an ICI plant on the site who provide the explosive used for blasting. The explosive used is inactive until the two components are mixed as they are poured down the pre-drilled blasting holes. After being blasted, the rock is transported by dumper trucks to the primary crusher, which breaks it up into pieces about 20 cm cube. The crusher is somewhat like a giant pestle and mortar made of chrome steel with the mortar being in the form of an inverted cone. The crushed rock falls through a hole in the bottom of the cone. From the crusher, the rock is taken by conveyor to the "glory hole" - a 3.3 m diameter vertical shaft 300 metres deep. The shaft is kept full and the rock gradually falls as it is removed at the bottom and fed on to another conveyor. During its fall the asperities on the "clasts" are abraded away, thus reducing the amount of final crushing required. This was one of several serendipities which came about with the utilization of gravity for the transport of the rock.

Primary crusher, Glensanda Quarry. *by David Wilkinson*

A near horizontal tunnel 1.8 km. long houses the conveyor which removes the rock from the bottom of the glory hole. This conveyor is a continuous, steel cored, rubber belt about 2 m wide. This emerges to the surface where a downhill conveyor takes the rock to the final crushing plant. Secondary and tertiary crushing produce a range of final sizes from 50 mm down to 4 mm. The quarry has its own water supply, which is essential, as it is sometimes necessary to add up to 3% water by weight to the aggregate to meet the user's specifications. The final transfer of aggregate to the ship is done by remotely controlled conveyor which allows a 75,000 tonne ship to be loaded in 24 hours.

The economics of quarrying are important, just as with any other business, but Foster Yeoman seem willing to wait longer than the average company for their return on their capital investment. This may be because they are a family owned company, but they also anticipate that the quarry will have a lifetime of eighty years, and it gives them control of the product from production to the point of use. Much of the English half of the Channel Tunnel has been constructed from the Glensanda aggregate, it is exported to Germany and even to the U.S.A. Current maximum productive capacity is 5 million tonnes per annum, although the ultimate planned capacity is 15 million tonnes per annum. The company have not stinted the investment required, although the depressed state of the economy means that some of the projected development has been held back. All our party were very impressed by the scale of the quarrying and the efficiency of the operations. All quarrying operations have effects which are social, economic and environmental and Glensanda is no exception. There are arguments against disturbing an area of great scenic beauty, but compared with large quarries I have seen in Germany, France, Italy and mainland Britain, Glensanda seems a model of an attempt to minimize pollution of the environment.

Our visit was well organized, visually stunning and extremely interesting. Our thanks go out to Foster Yeoman, Iain McDonald, Anne Smith, Allan Hall and Rosemary McCusker, who made this event so rewarding.

SOUTHERN KINTYRE: 2nd - 5th September 1994

Leaders: Dr C Burton and Dr J.J. Doody, University of Glasgow

24 members attended this weekend excursion, the bulk of that number travelled to Campbeltown in two minibuses (one for people and one for the luggage and equipment). One of the minibuses had severe overheating problems and there was a delay after the 'Rest and be Thankful ' while the radiator was filled with water from a neighbouring burn using a variety of different receptacles!. The party was very comfortably accomodated in the Royal Hotel right in the centre of Campbeltown. The outward journey on the Friday was in beautiful weather showing the scenery in its full glory; unfortunately the weather deteriorated on the Saturday and the weekend was a bit damp, but not the spirit of the members! We were given full briefings and resumés in the evenings by our two leaders, this was not a weekend break you know! The mapping and the magnetic survey on the Sunday was very enjoyable and instructive. The whole weekend went very well, thanks to the instructive and detailed planning of our two leaders.

A full excursion guide as followed during the weekend is to be found at the end of the Proceedings..

EXCURSIONS 1995 (Session 137)

GOAT QUARRY (By Aberdour, Fife): 22nd April 1995
Leader: Miss A Smith, Tarmac Roadstones
by Margaret Greene

17 members travelled by car to meet up in the car park at Goat Quarry. We were then transported in two mini vans to the top of the quarry; our van was driven by the Quarry Manager, Mr Jack Marshall, who explained the working of the quarry, which has been in use for over 100 years. The rock quarried at Goat is a quartz dolerite sill and is very popular for producing a high quality aggregate of Permo Carboniferous age. The sill was intruded into sediments belonging to the Calciferous Sandstone Series, of Lower Carboniferous age. The sill is 40-60 metres thick and is upthrown by 10m, the overburden varies in depth from 4-24 metres and a significant amount of money is required to move it. The rock is blasted out 2-3 times per month using 2.5 tons of ammonium nitrate, it is necessary to ensure that the rock is in usable sized blocks for working on. The next stop was at the primary crusher having collected Joan Cameron, who had arrived late, and was brought up to join us in a dump truck! The working of the primary crusher was explained, where the rock is crushed to 9 ins and smaller blocks, then we moved down to the secondary and tertiary crushers. After the final crushing the rock is sorted, graded and coated in bitumen for the surface dressing of roads. The rock from Goat quarry is of a high Polished Stone Value (65) ensuring that there is good grip on the road surface. Anne Smith gave us an explanation of the geology of the quarry and then we were taken back up to the top of the quarry where we searched for fossils amongst the calciferous sandstone at the sill/sediment contact, examples of lepidodendron and ostracods were amongst the fossils found, there was also many good samples of pyrites in the sediments and the dolerite.
Lunch was in the site offices where a selection of rocks containing minerals including amethyst had been laid out for us by Jack Marshall, many of us went home with specimens, some much bigger than others!

Following lunch we went on the Burrowine Moor Quarry near Oakley on the A907 run by Fife Silica Sands Ltd., part of the Anglo Pacific Group, who specialise in the quarrying of industrial minerals. There, geologist Mike Allen explained the economics of silica sand. The sand in Burrowine Moor is used for container glass and the glass manufacturers demand a very high purity of sand. The sand in the quarry is from the Namurian Passage Group of the Upper Carboniferous. There are two bands of sand, designated A and B, between which there is a narrow band which includes cementstone and coal beds. The sand is so loosely cemented that it can be 'dug' out by a JCB.

ALVA SILVER GLEN: 6th May 1995
Leader : Dr A J Hall, University of Glasgow
by Dr Ben Browne

On a bright spring morning twenty-six members assembled by the old mill at the foot of Alva Glen (NS 885975) on the line of the Ochil fault.

A walk up Alva Glen alongside the old iron pipe which supplied the mill demonstrated good exposures of a coarse agglomerate of Devonian lavas intruded by a Permocarboniferous dolerite sill, an association possibly giving rise to hydrothermal systems and the mineralisation of Silver Glen. The story though is complicated by the occurence of mineralisation of Tertiary age in the same general area.
Returning from Alva Glen a traverse eastwards across a green hillside brought us to the wooded Silver Glen (at NS 892974) so named in memory of a great bonanza find of silver ore worked out in the eighteenth century.
Working upstream on the eastern bank of the burn, traces of old workings were very evident and on recrossing the burn just above a fall we came on none other than Dr Stephen Moreton sifting spoil tips for silver. Dr Moreton has made a great study of this mine and its history and has revised previous ideas on the location of the main mine. We were most fortunate to be treated to a discourse on the historical detail eagerly awaited in Dr Moretin's pending publication.
The mine was opened in 1714 on the land of Sir John Erskine. The ore was assayed by none less than Sir Isaac Newton as Master of the Mint and found to be good. Soon the greatest bonanza find of silver ever known to be found in the British Isles yielded £40-50,000 in fourteen weeks, without counting the ore stolen by miners. Sir John became incredibly rich and improved his estates, but he supported the Jacobite rebellion and so was exiled to France. It seems he was able to buy his reprieve with a promise to open his last mine. The venture proved disappointing and the bonanza was never repeated. The next to try his luck was Charles Erskine in 1759. He found not silver but cobalt ore "the colour of peach blossom". This ore was used to make a blue glaze in the Prestonpans pottery.
On picking over Dr Moreton's discarded siftings we were able to find grains of cobalt ore and pan out flakes of silver, so we were able to go home happier and wiser, if not greatly richer.

References: Dickie D.M. & Forster C. W. Mines and Minerals of the Ochils 1994 reprint.
Available from: L Corbett, Forth Naturalist and Historian, University of Stirling FK9 4LA

LARGS : 18th May 1995
Leader: Dr Judith Lawson, University of Paisley
by Evelyn Lennie

In spite of the fears of the Excursion Secretary, 18 members and friends did manage to reach the car park above Largs by the appointed time - 6.30 pm, a few more who had endured long delays due to rush hour traffic, road works etc. on the M8 joined us later.
Our first stop was the viewpoint area adjacent to the car park. Fortunately our very efficient leader, Dr Judith Lawson, had brought along a geological map of the area to replace the totally vandalised display board provided. She was able to point out with the aid of the map all the geological features including the stepped silhouettes of the Carboniferous lavas on the mainland and the Cumbraes; the volcanic peaks of Arran and the position of the Highland Boundary Fault.
After a short drive downhill we assembled on the beach below the famous Pencil monument. Dr Lawson then distributed clip-boards, clinometers and <u>un</u>completed sketch maps of the area, known as Far Bowen Craigs. Our task was to fill in the maps indicating rock type, dip of the beds and the various intrusions. As we worked our way round the headland and back again we were given much useful advice - how to tell which beds are younger, how beds had been

laid down, which dykes were first, the effect of faulting, how to tell whether the igneous material was a sill, a dyke, a plug or a lava flow.
As the tide was out we could see very clearly the contrasting beds of hard conglomerate and softer sandstone of ORS age, at least three dolerite intrusions and faults of various sizes and ages.
Before we headed back to the cars, Dr Lawson explained that the beds we'd studied had been deformed and folded during the period of strong earth movements at the end of the Carboniferous.
Arthur Pow, in proposing a vote of thanks voiced everyone's appreciation of the clarity and practicality of Dr Lawson's explanations and answers to our many questions. We all felt we'd really learnt a great deal.
As a bonus (or was it a reward ?), before we dispersed we all received a completed map of the area beautifully and correctly mapped, illustrating all the features we'd studied - a very helpful memento of an instructive and enjoyable evening.

LOMOND HILLS: 10th June 1995
Leader: Mr M.K. Browne, British Geological Survey.
by Roy Smart

17 members travelled by coach to rendezvous with our leader, Mike Browne at the car park at the South East corner of Loch Leven. Another few miles took us to the starting point on the Glen Burn (ref. 172069). A brief examination was made of the red fluvial sandstones in the stream bed. These were noted to contain clay casts. Moving upstream, the change to yellow sandstone was evident in the outcrops in particular at the Knox Pulpit Formation. Whether John Knox ever preached here is open to doubt; what was clear was that this was an aeolian sandstone of the Upper Devonian. A cave structure, extensive cross-bedding, curious shapes of weathering and pinstripe laminations all contributed to a fascinating exposure.
Continuing west and north we were into Lower Carboniferous with a cornstone outcrop, then onto the dolerite. The final ascent of West Lomond was a fair pull but at 522m we were rewarded with a view of a large area of Scotland ranging from Ben More, Ben Lawers, Schiehallion, the Sidlaws, North Berwick Law, the Pentlands and Tinto.
Descending, we examined some recrystallised limestone before viewing Craigen Gaw, a dolerite scarp with natural tower, talus slopes and quite recent debris flow. A good nesting area for the perigrine falcon which soared out from the rocks. A pleasant 2 mile descent took us to the waiting coach at Craigmead Car park.
This was very much a day of landforms and landscapes in an area often passed by many members but never explored. A most enjoyable day blessed with good dry weather, supporting our leader, Mike Browne's claim never to have led a wet excursion!

COMRIE AND GLEN LEDNOCK: 24th June 1995
Joint with Edinburgh Geological Society
Leader: Dr A R MacGregor, University of St Andrews
by Sally Rowan

Around twelve of us left the Boyd Orr Building on a hot, sunny day. We met up with the Edinburgh contingent of two dozen in good time: in fact, so early we thought we were in the wrong place!

The first part of the excursion led through the woods behind the caravan site to examine muscovite and thorite (in various localities) indicating low grade regional metamorphism. There were also good exposures of the Aberfoyle slates, displaying the differences between cleavage and bedding planes. These all suggested that we were on the outer edge of a thermal aureole. It was suggested that the diorite which caused this when it was intruded around 50 million years after the sediments were laid down would have produced some metamorphism by pressure, but mostly by heat.

Later localities showed the colour contrast between the rusty, weathered shale and its unweathered grey slate - leading your eye to 'see' it as blue or purple.

Exposures near the top of the hill showed that the diorite did not intrude cleanly, but melted and mixed around the edges with the country rock.

Spectacular views from the summit included a fence, displaced by a massive landslip decades ago: a stack further along the cliff face: the alluvial plains and closer by, a dyke sheared flat (probably by ice action)

The second part of the excursion came after lunch in a field boasting an impressive display of various wild orchids, ragged robin etc. - by now the day was so warm people were heading for shade.

An exposure of cordierite hornfels amongst the Ben Ledi grits indicated either a large, isolated xenolith or that we were very close to the dicrite intrusion. Further uphill, we investigated an attractive pink microgranite - the central part of the intrusion, the diorite being on its periphery. It would have had a domed tip.

The third and last part was to the shore of a reservoir to see large hornblende crystals, and epidote, within the epidiorite of the more outer parts of the intrusion. This gave everyone a chance to hunt for specimens, and finished off a delightful and instructive outing due to the efforts of Dr MacGregor and to both excursion secretaries.

DOBB'S LINN: 5th August 1995

Leader: Dr James D Lawson, University of Glasgow

by Monica Sharp

15 members of the Society and Dr Lawson left Glasgow by bus on a beautiful sunny day. There was a tray with graptolites for us to examine during the journey and photocopied diagrams, illustrating the subtle differences between the various faunal types. After a brief stop at Moffat to meet other members who had travelled by car, we continued the journey to Dobb's Linn. On the way Dr Lawson pointed out the Grey Mare's Tail waterfall. However we were all keen to search for graptolites and no stop was made to look at the falls.

Dobb's Linn lies in the remnants of a large isoclinal fold, with Lower Silurian greywackes on the flanks and black fossiliferous shales of Upper Ordovician and Lower Silurian age in the core. The succession of shales represent about 25 million years although it is a mere 76m thick. In 1976 it was chosen as the boundary stratotype between the Ordovician and Silurian, by the IUGS.

The first stop was made at the Main Cliff where the strata are dipping at 45^0. There was no difficulty in finding specimens but identifying them was difficult to the inexperienced eye and Dr Lawson was kept very busy examining our finds. Orthograptus and Climagraptus were very commonly found in the Lower Hartfell Shale at the base of the cliff. Further up the succession two specimens of Parakidograptus acuminatus, the zone fossil for the Ordovician/ Silurian boundary were found.

After a leisurely lunch, sitting in the sun Dr Lawson remarked that we were not seeing Dobb's Linn in it's usual glory - grey leaden sky and pouring rain!

In the afternoon we walked further up the Linn Branch burn and up the steep track to examine the Anceps bands. At this location more diplograptids and the first monograptids were found but no unusual specimens. However examination of the cliff to the right side of the waterfall at the head of the burn, revealed some good specimens of hooked monograptids and Rastrites. One member found a particularly good specimen of pyritised Rastrites.

After the dry weather the burn was at a low level and we were able to examine the almost vertical strata along the bank.

This was a most interesting and enjoyable day and when we returned to Moffat, time was available for a cup of tea or ice-cream.

THE OIL SHALES OF WEST LOTHIAN: 19th August 1995

Leader: David McAdam, British Geological Survey.

by Monica Thorp.

This well-attended excursion combined geology and industrial archaeology. We were introduced to both aspects of the once important shale-oil industry at Binny Craig, a dolerite sill, from which we had panoramic views across the eastern Midland Valley, including the characteristic red bings marking the West Lothian oil-shale field in the carboniferous sediments of the valley.

At Uphall, we saw evidence of 19th century oil-shale mining: a small bing (where the fossil fish-scales show that the oil shales were formed in freshwater lagoons), and a striking group of pits caused by subsidence into the stoop-and-room workings below. Then, at the Shale Oil Museum in the Almond Valley Heritage Centre in Livingston, we followed the story of James 'Paraffin' Young (1811-83), who heated the shale to extract oil, producing a marketable commodity - liquid lamp-oil or solid paraffin wax - thus starting the shale-oil industry which sustained West Lothian until the shales were eventually worked out in the 1960s.

After lunch, a steep scramble up the side of Faucheldean Bing was rewarded by splendid views. Because no solid substances, only fluids, were removed from the material that was mined, the process produced a huge amount of spoil. Latterly, uses have been found for this inert waste product of baked shale, and the vast, flat-topped bings are gradually disappearing from the surface of West Lothian.

At our final stop we considered, once more, the geology that made the industry possible, as we looked at the sequence of sediments of the Lower Oil-shale Group, revealed on the shore beneath the Forth Rail Bridge: Dunnet Sandstones, the Burdiehouse Limestone, the Pumpherston Oil Shale and Shell Bed. We also puzzled over rounded structures which were indeed stromatolitic, and over an intrusion of white rock into the dark sediments: a sill of 'white trap', originally dolerite but with the minerals altered by gases driven from the carbonaceous host rock by the heat of the intrusion.

Our thanks go to David McAdam of the BGS for a most interesting and satisfying excursion, illuminated by informative and well-illustrated leaflets.

ISLE OF RAASAY, 8th -11th September 1995
Leader: Dr G E Bowes
by David Wilkinson

The success of a geological expedition depends on many things and on the island of Raasay, off the east coast of Skye, they all came together. Our leader, Dr. George Bowes, has perfected the art of giving enough information to excite the curiosity and then posing questions which compel a careful examination of the rocks; the weather, particularly on the Sunday, was superb; but the essential element of an expedition - interesting geology with good exposures - was to be found on Raasay in copious amounts. Lewisian gneiss, Torridonian sandstone, Tertiary volcanics, Triassic conglomerates and highly fossiliferous Jurassic marine sediments, provided a geological layer cake of a rich complexity in an easily covered area. Those of the party who travelled with Dr. Bowes in the minibus, missed out on the exciting night voyages between Skye and Raasay in a rubber inflatable, but we were partly recompensed by being able to examine the Lower Jurassic beds on the foreshore at Broadford on Skye on Friday, as well as the granite in Glen Cluanie on the Monday.

Saturday

We started the day by visiting Eyre on the south of Raasay. Here we saw Torridonian sandstone on the foreshore, with very well marked cross bedding and liquefaction structures, cut by basic Tertiary dykes. Back from the current shoreline there were small cliffs of conglomerate on top of the Torridonian. In the conglomerate there were clasts of Torridonian sandstone, together with quartzite and limestone pebbles which are thought to be Cambrian. Field relations show this conglomerate to be Trias.

Travelling back up the west of the island to the ferry pier at Suisnish we found dark Pabba shales on the foreshore, slightly baked with occasional ammonites and belemnites - sometimes in ironstone nodules. This was overlain by a sill of granophyre, a light coloured rock, porphyritic away from the margins.

The pier at Suisnish is a large concrete structure built to serve the ironstone mines which were worked commercially during the First World War and which we were to examine on the following day. Back from the foreshore were the remains of large concrete calcining kilns formerly used to reduce the ironstone before it was shipped to the smelters in Glasgow.

Going inland up the hill we could follow the line of the inclined railway used to transport the ore from the mine down to the kilns. Here the exposures were the Liassic Broadford beds with alternating layers of siliceous limestone with abundant Gryphea (devil's toenails), alternating with thicker layers of fine grained limestone with fewer fossils. It is suggested that this alternation is due to the migration of silica and calcium carbonate in opposite directions enriching the silica and destroying the Gryphea in the process. We also looked at many samples of ironstone dropped from the ore transporters when the ore was being worked. This contained spherical ooliths and careful hammering yielded ammonites and belemnites.

Slightly further north, we examined the rocks forming the scenic Battery Point. These are composed of pale Jurassic Scalpa sandstone with igneous intrusions of granophyre. Working round the bay to the north we walked over the Oskaig Sill, a large Tertiary basic and ultrabasic sill. The sill is overlain with dolerite in which we could see the layering due to segregation of augite and feldspar crystals.

Saturday finished with a dinner at the Outdoor Centre at which the excursion secretary's birthday was celebrated with a cake smuggled onto the island.

Sunday

The day started with a some industrial archaeological investigation. The Upper Lias shales of the Jurassic occur as ironstone in Raasay and this was mined commercially from about 1914 to 1920 using the labour of German prisoners of war. The iron content averages 23%, which concentration has been achieved due to leaching of the calcium carbonate. On Raasay there are remains of many of the structures built to exploit this ironstone. The main entrance to the drift mine is still open and can be seen, although dangerous to enter. One of the most interesting remnants was a fan house on the hill above the mine entrance, built mainly of concrete with the position of the fan being obvious from the shape of the building. The party tramped around the hill to the rear entrance of the mine which was entered by the more adventurous.

In 1916 opencast mining of the ironstone using a steam dragline was in operation and we walked down the grassed-over site of these operations which dips at about 15^0 to the NW. Again we found ammonites and belemnites in the ironstone rocks to the side of the opencast area.

In the centre of the island at Brae we lunched and searched for the oil shale bands in the Middle Jurassic sandstones exposed in the banks of the burn.

Travelling to the north, past 15th Century Brochel Castle which sits on Torridonian sandstone, we reached a typical Lewisian landscape of grey gneiss, well exposed and highly deformed. Walking back south towards Brochel we found occasional patches of red sandstone intermixed with the gneiss in an apparently random fashion and we were invited to explain this by Dr. Bowes. The sandstone was fairly obviously Torridonian, but the revelation that we were looking at an unconformity in which Torridonian sandstone had been deposited on a weathered Lewisian landscape which had then been scoured clean of most of the sandstone by the Pleistocene glaciation, came as an obvious but delightfully satisfactory explanation to this writer.

The final spectacle, just a few yards away from the fairly flat Lewisian surface, was a 30m cliff of chaotic Torridonian sandstone blocks, thought to be a Triassic breccia. The development of this structure is unexplained and we engaged in the geologist's favourite occupation of hypothetising - earthquakes and flash floods were both called on to explain it - but a final say awaits further research.

The day ended with magnificent views over the blue mirror of the Inner Sound towards Applecross. A fitting conclusion to one of the most satisfying geological excursions the society has organised.

LECTURES 1993 -1994 (Session 136)

Session 136 commenced with two meetings in the month of October, the first one on Thursday 14th October 1993 was the occasion of the presentation of the T Neville George Medal to **Professor Diane Edwards** (University of Wales, Cardiff) in recognition of her work in the field of palaeobotany. Her lecture was entitled **"In the Footsteps of Kidston and Lang"** It is a fitting tribute to the enduring quality and fundamental nature of the research activities of these two Glasgow based palaeobotanists that their pioneering descriptions of early land plants are as relevant as ever to studies of terrestrialization. In this lecture Professor Edwards returned to some of their Scottish and Welsh Borderland assemblages and showed how technological developements such as scanning and transmission electron microscopy have extended their anatomical observations and very occasionally modified their assessment of affinity. She also explained how an integrated approach, involving zoologists, botanists, geologists and geochemists can provide new insights into early terrestial ecosystems.

Two weeks later on 28th October the lecture was given by **Professor Trevor Elliot** (University of Liverpool) on the topic **"High Resolution Sequence Stratigraphy of Clastic Basin-Fill Successions: A New Approach?"**

On November 11th **Dr Euan Nisbet** (Royal Holloway and Bedford New College, London) addressed the Society on the topic **"Komatiites: The Hottest Rocks"**. Komatiites are lavas with over 18% MgO. They are mostly Archaean, over 2.5 billion years old, although some relatively young examples are known. Because of their high MgO content, they must have erupted at very high temperatures, up to nearly 1600^{0}C, and probably came from deep in the Earth's mantle. This compares with modern basalts, which mostly erupt at 1250^{0}C or less. Komatiites had many odd properties. Because they were so hot, they had low viscosity, and would have been much more "runny" than modern lavas. They crystallised in flows to produce unusual mineral textures, including long crystals of "spinifex" olivine and clinopyroxene. Komatiite volcanoes were probably wide low shields and individual flows may have covered vast areas. Those komatiites that still have unaltered fresh minerals show a variety of lovely quench mineral shapes, and are visually very attractive in the microscope. The attraction of the rocks is not merely visual. They provide a "window" into the Archaean mantle. Their temperature of eruption is an important constraint on the temperature history of the Earth's mantle, and it has been suggested, although not yet proven, that the early Archaean Earth had a magma "ocean" of komatiite buried deep in the upper mantle, which slowly cooled and solidified. Because the komatiites represent high degrees of partial melting, it is possible to construct the chemistry of the Archaean mantle from their composition, and to make speculations about the growth of the continents.

The second meeting of November was on Thursday 25th. **Dr Wes Gibbons** (University of Wales, Cardiff) speaking on **"Making an Impact - Catastrophe at Sudbury, Ontario"**

The **AGM** on Thursday 9th December was followed by a **Social Evening** with games based on "Geological Excursions around Glasgow and Girvan" then refreshments and an opportunity to chat.

1994 kicked of on Thursday 13th January with a lecture by **Dr Hazel Rymer** (The Open University) on **"Volcano Plumbing and Eruption Prediction ?"**.

Every few months we hear about another volcanic eruption and yet more deaths. Could it have been predicted ?

Before we can hope.to predict eruptions, we need to understand how volcanoes work. If we can identify the plumbing system inside a volcano, and determine when and how magma moves within this system, then we are well on the way to discovering what makes volcanoes tick.

Having determined the plumbing system, the next stage is to monitor a volcano before, during and after an eruption. If we can characterise what happens at certain key volcanoes, then we can identify the precursors to activity elsewhere.

Exciting results have emerged from recent studies in Costa Rica and Sicily. The underground fizzing of magma before eruption has been detected, and enormous hollow walls have been found to exist within some volcanoes. Details of these results and their implications for hazard warning and mitigation were presented.

The first meeting in February on Thursday 10th was by **Dr Derek Briggs** (University of Bristol) on **"Extraordinary Fossils"** the second was on 24th February when **Prof Jake Hancock** addressed the Society on **"Geology of Wine".**

Of the five controls on the quality of wine before the manufacturing process (grape-variety, type of yeast ferment, amount of warmth, supply of water and nourishment), geology is the major factor for the last three in most quality vineyards. Warmth is a critical factor in northern vineyards, as in Germany, where the best vineyards are directly related to orientation and angle of slope. Water supply is more complex, but ideally a vineyard-rock has a high porosity, high mass permeability and low matrix permeability. Nourishment of vines is mostly related to availability of K^+ but it is better for the nitrogen content of the soil to be low. The lecture was illustrated by examples from a broad variety of vineyards.

This session concluded with a successful **Members Night** on Thursday 28th April 1994 - so successful that we were there till after 10 o'clock. The topics included:

Dr J G MacDonald - "Western USA - here we come"
Dr N Clark - " Time Capsule Dinosaur Eggs"
Murray Dobson and Stuart Archer - " Research on a Proglacial area, Skalafellsjokull, Iceland" (Glasgow University Exploration Society and Geographical Department)
Leo Murray - " Study at the Top of the World: Ladakh"
James M Allan - "The measuring of the axial angle 2V in a biaxial crystal"
Dr G Curry - "Living on the Edge: geohazards in New Zealand"
Bob Finney - "Earthquakes in Los Angeles."

The follow exhibits were on display:
J MacDougall - "Samples and Photographs from the Lake District Excursion, May 1993"
J Allan - "Measurement of 2V"
M Orr and A Herriot - "Samples and Thin Sections from the Bulgaria Excursion"
Dr G Todd - "Minerals with Fossils"
Dr N Clark - "Time Capsule Dinosaur Eggs"
S Rowan - "A visit to New Zealand"
There was also a video on panning for Gold by **Ian Jones**.

T NEVILLE GEORGE MEDAL

At the opening meeting of the 136th Session on 14th October 1993 the award of the **T Neville George Medal** was made.
The citation was delivered by Dr Colin D Gribble who said:
Mr President, Fellows of Glasgow Geological Society and honoured guests; it gives me great pleasure to present the citation for the award of the T Neville George Medal to Professor Diane Edwards for 1993.
Professor Edwards: you have established an international reputation as a leading worker in palaeobotany of your generation.
As a young graduate student at Aberdeen I visited the Rhynie area and I still have a specimen of the famous chert to show for it! Later on, whilst at Glasgow, Ian Rolfe and I visited the ORS deposits at Aberlemno near Forfar, and I remember with delight finding a specimen of siltstone showing both a seed pod on a plant and a small fish. As an engineering geologist I immediately indulged in a flight of fancy whereby the fish swimming along saw the seed pod and leapt out of the water to grasp it and eventually expired. You don't have to be Stephen Spielberg to have a good imagination!

Although I'm sure you have an equally good imagination, Diane, your published work on palaeobotany is the result of careful scientific study coupled to a comprehensive knowledge of botany and geology. A Swansea girl, you got your elementary education at Glanmor County School (well known I believe by that other native of Swansea - Professor Brian Bluck) and received a scholarship to Girton College Cambridge where you read botany with subsidiary geology and zoology. You were strongly influenced by Professor Harlan Banks in your final year and converted to palaeobotany although your Cambridge supervisor felt that not enough early land plants were known to enable a PhD to be undertaken on that topic. Such views of course were premature. You completed your PhD and continued your research studies as a College Fellow at Cambridge. Diane, you had married by then and when your husband went to South Wales, you attached yourself to the Botany Department of Cardiff University on arrival in South Wales. A Fellowship was followed by a Lectureship and eventually a Readership in Plant Science. You eventually joined the Geology Department there, and the completion of a Cambridge DSc was quickly followed by the award of a personal chair at Cardiff.

Your work on fossil plants and your investigations into some of the earliest land plants have made a huge contribution to the science of palaeobotany, and your career in my opinion accurately reflects the esteem in which you are held by all your fellow geological and botanical workers.

I am delighted to recommend, on behalf of the Geological Society of Glasgow and the Department of Geology & Applied Geology that this medal, commemorating the life and work of T Neville George, be awarded to you. I would ask the President of the Society, Dr Allan Hall, to make the presentation.

LECTURES 1994 - 1995 (Session 137)

Session 137 started on Thursday 13th October 1994 with a very interesting and informative talk by **Dr Robert Muir-Wood** (EQE International Limited, Warrington) on **"Tectonics versus Glacial Rebound as the Cause of British Earthquakes"** There are more earthquakes on Scotland than in the rest of the British Isles, and this gave rise in the last century to the building of the little 'earthquake house' in Comrie, Perthshire due to the amazing frequency of the occurence of the 'quakes in that area, albiet rather small ones. Those earthquakes occuring in England and Wales are on the whole larger; some areas however, notably the whole of Ireland are almost devoid of seismicity. Dr Muir-Wood discussed possible causes of this activity. Considerable variety and complexity of tectonic activity occured around and through Britain during the Tertiary, when it lay in a broad sub-plate boundary shear-zone connecting the Alpine and North Atlantic plate boundaries. A major episode of compressional deformation is also found in north-west Britain accompanying the re-invigoration of the Iceland Hot spot in the Miocene. However comparative studies in other regions of post-glacial rebound, including Fennoscandia and North America, show strong parallels with Britain and also provide an explanation for the Irish seismic paradox.
The second meeting of the month was on 27th October. This was given by **Professor Paul Ryan** (University College, Galway) on **"The Role of Eclogites in Orogenic Collapse"** Coesite-bearing crustal eclogites, that have formed at depths of 100km or more, are exposed within some orogenic belts. The rapid exhumation of these dense rocks occurs during the late extensional collapse phase, probably associated with the removal of a lithospheric root beneath the orogen.

The talk described numerical models which investigated the isostatic consequences of the transformation of crustal rocks into eclogite facies assemblages and their subsequent retrogression. Such models, which explain the uplift of these rocks, suggest that in some circumstances the MOHO can exist within the continental crust. The talk was illustrated with slides from the Western Gneiss Region of Norway, where Caledonian eclogites were exhumed by Devonian times.

On 10th November 1994 the Society welcomed **Dr David Macdonald** (University of Cambridge) whose topic **"Collapsing Slopes and Fossil forests: the Mesozoic of the Antarctic Peninsula"** was illustrated with slides of some of the spectacular features of the Antartic. The Antartic Peninsula was a long-lived volcanic arc, active from Permian until Tertiary times. During the Late Jurassic, a series of fore- and back-arc basins were established round the arc. The fore-arc basin on Alexander Island is particularly important: it contains the largest slide deposits ever seen in outcrop, and the southernmost Cretaceous fossil forests in the world.

The AGM was held on December 8th and following the business **Dr Allan J Hall** (University of Glasgow) gave his Presidential lecture entitled **"The Origin of Pyrite and its Relationship to Gold and Life"** After this most interesting and entertaining talk the members enjoyed the Christmas Social Evening.

The first meeting in the New Year was on Thursday 12th January 1995 when **Dr Dick Jemielita** (University of St Andrews) spoke on **"Prospecting in Equador: Mineral Exploraton During a Modern Gold Rush"** Alluvial gold occurs widely in placers in rivers draining the Cordillera Real of Ecuador in South America. Placer deposits are presently being mined, mostly by rudimentary methods, but the origin of the gold has never previously been satisfactorily explained. Dr Jemielita discussed a range of possible primary sources and

concluded that the most widespread potential source for the alluvial gold is mesothermal quartz-carbonate-sulphide veins and their erosional products.
On 9th February **Dr Tony Carswell** (University of Sheffield) lectured us on **"Ultra-high Pressure Metamorphism and Collision Tectonics in Central China"** The Qingling-Dabieshan mountain belt in central China marks Triassic collision between the Sino-Korean and Yangste plates. This Himalayan-type collision zone comprises a complex assemblage of thrust terranes with different tectono-metamorphic histories. Heavily retrograde eclogites in central Dabieshan occur as lenses within supracrustal gneisses (including marbles), mostly lacking evidence of earlier ultra-high pressure conditions. Conclusive evidence that the central Dabieshan terrane experienced pressures > circa 30 kilobars is limited to micro-inclusions of coesite and diamond preserved within garnets in some eclogites.
The meeting on 9th March was a **Joint Celebrity Lecture** and the occasion of the presentation of the T Neville George Medal to **Dr Peter Vail** (Rice University, Houston, Texas). His subject was **Uses of Biostratigraphy in Sequence Stratigraphy.** He described the use of microfossils to identify the age of a sequence and his methods for describing the relative reduction and increases in sea level.
He is at present coordination the work of 1100 European palaeontologists as they correlate fossils with magnetic reversals and sequence stratigraphy.
On 20th April **Professor George Matheson** of the Traffic and Road Research Laboratory, Livingston gave a very interesting and enthusiastic talk on **Rock Excavation in Scotland**. Professor Matheson described the history of rock excavation over the last century and the different methods of rock extraction. He explained the factors affecting rock stability, e.g. the natural stability of the rock - orientation of cracks, weathering, position of discontinuity planes etc, and the types of blasting that cause instability and how. Professor Matheson's preferred method of excavation was to use pre-plitting - blasting lots of holes with small charges as can be seen on Loch Lomond side - this resulted in maximum stability of slope.

The concluding meeting of session 137 was **Members Night** on April 27th
The topics covered included:
Mr Ian Jones - "The Economic Use of Sandstone from the Clyde Valley". This took the form of a video Ian had made, illustrating the various types of sandstones and their uses.
Dr Jim Buckman - "The Micro and Ultrastructure of Calcareous Tubes of the Serpulidae"
Mr Stan Wood - "Commercial Fossils from Mumbie Quarry"
Dr Neil Clarke - "Dinosaurs in Scotland."
Shona Monahan and Stephen Moran - "Iceland Expedition 1994"
Ed Ewing - "Himalayan Expedition 1993"

The following exhibits were on display:
Ian Jones - sandstone samples , maps, and literature illustrating the use of sandstone from the Clyde Valley.
Stan Wood with examples of fish, scorpion and shrimp from Mumbie quarry
Neil Clarke with three exhibitions: a velicoraptor fossil skull with a replicate of what its head would have looked like - not like the Jurrasic Park version ! ; casts of the pieces of sauropod leg bone found on Skye - our own Jurassic Park; examples of the museum internet page.
B.G.S. - Maps of the Southern Upland Regional Geological Survey.
J Jocelyn - a sample of almandine in schist from Alaska.

T NEVILLE GEORGE MEDAL

At the meeting on 9th March 1995 of the 137th Session the award of the **T Neville George Medal** was made.
The citation was delivered by Professor Brian Bluck.

Dr Vail is W. Maurice Ewing Professor of Oceanography at Rice University. Previously, he was Senior Research Scientist with Exxon Production Research Company. He has conducted research in stratigraphic mapping, well log correlation, computer applications in geology, the stratigraphic and structural interpretation of seismic data, and sequence stratigraphy. He is widely known for his pioneering efforts in seismic stratigraphy, and his ideas have formed the basis for the developement of the seismic stratigraphic techniques which are in use today. His publications on seismic stratigraphy, worldwide sea level changes and tectonics have contributed significantly to the general understanding of sedimentary processes and their influence on the generation, migration and entrapment of hydrocarbons. Dr Vail has gained many honours during his distinguished career, including the William Smith Medal of the Geological Society of London. He is a Fellow of the Geological Society of America and an Honorary Member of the American Association of Petroleum Geologists.

EXCURSION GUIDE TO THE GEOLOGY OF SOUTHERN KINTYRE

by

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This guide is based on an excursion by the Geological Society of Glasgow to Southern Kintyre in September 1994, on which many of the localities described below were visited. The excursion was aimed in particular at the stratigraphy of the area, the relationship between the Upper Palaeozoic rocks and their source areas in terms of clast provenances and tectonic movements, the igneous rocks of the area and the techniques of graphic logging and magnetic surveying.
These themes, if not the practical techniques, have been carried through to this guide.

Maps:	O.S.	1:50 000	Landranger 68 South Kintyre
		1:25 000	Sheet 453 Saddell
			Sheet 466 Campbeltown (North)
			Sheet 578 Campbeltown (South)
			Sheet 489 Mull of Kintyre & Sanda Island
	B.G.S	1:63 360	Sheet 12

Terrain: Coastal exposures: shore platforms, beaches, cliffs; Some sections require low tide for full access. Easy walking, some scrambling. Inland exposures: Many close to roads, some require rough hill-walking for access.

Access: Campbeltown is 138 miles by road from Glasgow. The most direct route is by the A82 to Tarbet on Loch Lomond, then the A83 via Inverary and Lochgilphead. Travel time approximately 3 hours.
Alternative routes by car ferry (summer only) are:

a). Ardrossan-Brodick/Loch Ranza-Clonaig (Kintyre). Ferry time 80 minutes.

b). Gourock-Dunoon/Portavadie (Cowal) - Tarbert (Kintyre).

Time: The complete excursion requires two days, but selected locations showing the main geological features can be visited in one day.

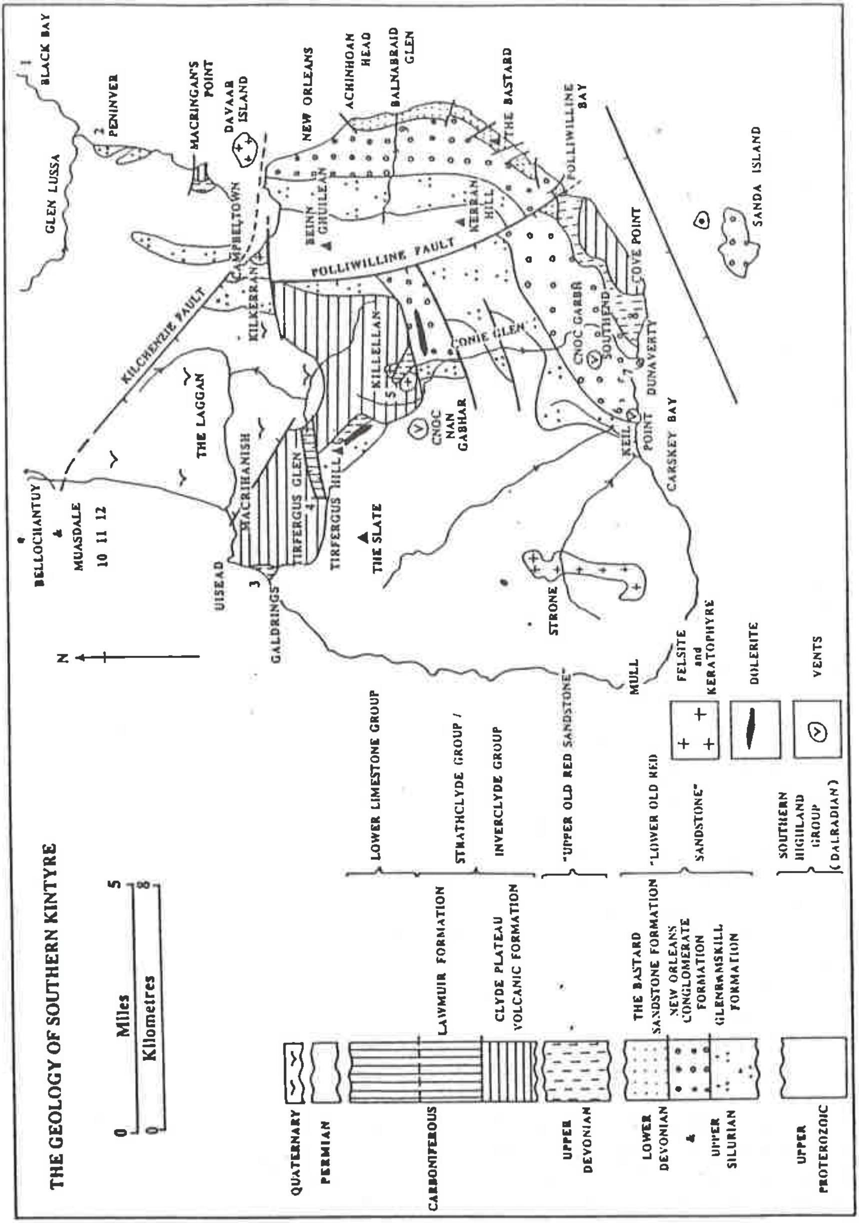

Figure 1. The geology and stratigraphy of Southern Kintyre.

Introduction

Southern Kintyre lies on the line of the Highland Boundary Fault Zone, and is related to the rocks of both Northern Ireland and the Midland Valley of Scotland.
The area was first mapped for the Geological Survey by Symes in the 1890's, but no modern written record emerged until a series of works by Gunn (1903), McCallien (1928,1929,1932) and McCallien & Anderson (1930) which laid down the major outlines of the geology of the area, dealing with all the major lithological units present, including the Dalradian basement. Later studies by Friend & Macdonald (1968) and Morton (1976) on the Old Red Sandstone filled out many details of the lithologies, environments and clast provenances, while Pringle (1952) noted that sandstones and conglomerates on the western side of the peninsula between Bellochantuy and Tayinloan were not Upper Old Red Sandstone, as previously thought, but were Permian in age. McLean *et al* (1978) demonstrated that both the Old Red Sandstone and the Permian sandstones of Southern Kintyre are at the landward edges of large basins extending eastward into the Firth of Clyde and westward into the North Channel and the Sound of Jura.

Unlike the Old Red Sandstone, the Carboniferous rocks of the area have received little attention since the nineteenth century, when Thomson (1865) described the palaeontology and stratigraphy of Tirfergus Glen. For many years the main focus of interest within the Carboniferous was the coal deposits of the Macrihanish Coalfield, where coals in the Limestone Coal Group were worked from the sixteenth century until 1927. These coals are concealed beneath the Quarternary deposits of the Laggan, the large, flat area between Macrihanish and Campbeltown. Recent work on the Quaternary by Tipping *et al.* (1994) covered an area around Carradale, a little to the north of the Southern Kintyre area.

The location of the Highland Boundary Fault and its influence on local Devonian and Carboniferous sedimentation has been a long-standing problem in Southern Kintyre, being disputed by Friend & Macdonald (1968) and Wilson & Rast (1969) and Wilson (1978). All agreed that the position of the Highland Boundary Fault was unlikely to coincide with the fault lying between Sanda Island and the mainland as suggested by George (1960), but were divided on its form and influence. Friend & Macdonald believed the fault to be represented by a zone of southward downwarping, producing southerly palaeoflows in the Old Red Sandstone rocks, whereas Wilson and Wilson & Rast believed a fault zone to be present, to underlie Southern Kintyre itself, and to be of considerable local influence on the sedimentation of the Lower Old Red Sandstone, giving north-westerly palaeoflows. Bluck (1992) noted, however, that the Lower Old Red Sandstone sequences in the north-western Midland Valley show little evidence of any fault influence, such influence being confined to Upper Devonian and Carboniferous times.

Southern Kintyre was conveniently defined by McCallien (1928) as the area lying south of a line from Campbeltown to Macrihanish, within which the majority of the Lower Palaeozoic rocks lie. However, crucial outcrops lie to the north of that line and have been included in this guide because of their relevance to Southern Kintyre geology as a whole.

Topographically Southern Kintyre begins with the flat plain of the Laggan, lying between the high moorland north of the Kilchenzie Fault (Fig.1) and the rolling upland to the south of the Drumlemble Fault. The area to the south can be divided into two halves by the Polliwilline Fault. To the east is a rectilinear and rugged hilly area underlain by Dalradian sediments between Cambeltown Loch and Kerran Hill, east of which is a much less rugged area of low hills underlain by Old Red Sandstone rocks, with the notable elevation of Davaar Island at the mouth of Cambeltown Loch. West of the Polliwilline fault and north of Killellan lies an area of hilly trap topography formed by Carboniferous lavas, culminating in a central boss at Killellan itself, where Carboniferous intrusions form the high ground. South of this lies a relatively low area of farmland along Conie Glen and around Southend, underlain by further Old Red Sandstone rocks. West of this lies the moorland leading to the Mull, underlain by further Dalradian rocks.

Geology

a. Stratigraphy. The map and stratigraphical column (Fig. 1) show the exposed rocks of Southern Kintyre. The Carboniferous of the Laggan, comprising the Limestone Coal Group, the Upper Limestone Group, the Millstone Grit and the Coal Measures is nowhere exposed and is not described further. The basement of the area is formed by Upper Proterozoic rocks of the Southern Highland Group of the Upper Dalradian. These rocks young east and include the Loch Tay (=Tayvallich) Limestone and its overlying sequence - the Glen Sluan Schists, Green Beds and the thick Beinn Bheula Schists. In Southern Kintyre the Loch Tay Limestone is a coarsely crystalline black marble, and the Green Beds are notable for chlorite-epidote schists. The Glen Sluan Schists are similar to the Beinn Bhuela Schists, the latter being formed of pelitic schists, minor calcareous schists and coarser horizons of schistose grit. Within this sequence are a series of epidiorite sheets, originally basic sills associated with the Tayvallich Lavas.
These Dalradian rocks form most of Central and North Kintyre north of the Kilchenzie Fault, and the areas in Southern Kintyre mentioned above.

The succeeding Palaeozoic rocks are everywhere unconformable on, and overstep northward onto the Dalradian, dipping generally eastward or north-eastward. The oldest of these cover rocks is the Lower Old Red Sandstone, which is relatively thin in Southern Kintyre, being only *ca.* 1200m thick and made up of three formations. The first of these is the Glenramskill Formation, which comprises two members, the Basal Breccia Member and the overlying Quartzite Conglomerate Member. The Basal Breccia Member is irregular in its distribution and sometimes absent, but where present overlies reddened Dalradian rocks and occupies a former landscape of some considerable relief (10m deep valley profiles at some locations). The breccia consists of clasts of the local Dalradian lithologies, often of very large size. Around Peninver, to the north-east of Campbeltown, the breccias occupy steep palaeovalleys cut into the Dalradian and running eastward into Kilbrannan Sound. These streamflood deposits contain clasts of Loch Tay Limestone, pelitic schists, epidiorites, schistose grits and quartzites. The breccias grade upwards into red, pebbly sandstones and finally red siltstones. The base of the Quartzite Conglomerate Member occupies channels cut into the basal Breccia Member and the underlying Dalradian and commences with 100m of quarzite conglomerate. The quartzite clasts range in size from 60mm to 1m and are well-rounded. With them are lava pebbles in a coarse matrix of fragments of vein quartz, schists, lavas and feldspars. The conglomerate is succeeded by *ca.* 200m of coarse and cross-bedded red sandstones which, at the top, contain thin mudstones, and fine sandstones with rip-up clasts of mudstones and tuffs. The formation represents proximal alluvial fan deposits and their feeders grading upwards into more distal fans and braidplain deposits. Clast types, lithologies, and palaeoflow direction all suggest a southerly derivation from the Midland Valley.

The overlying New Orleans Conglomerate Formation (named from a house on the outcrop) is *ca.* 890m thick and is highly variable along strike. To the north-east, between Davaar House and Achinhoan Head, it consists of conglomerates of andesitic lava boulders up to 1.3m diameter and reddish sandstones. On the south coast between Keil Point and Dunaverty is the Southend Conglomerate Member of the formation, which differs lithologically from the northern exposures in having, along with lava clasts, a large proportion of rounded quartzite and quartz clasts. The beds represent a series of fining-upwards sequences from alluvial fans to floodplains, the fan deposits consisting of coarse conglomerates, often in channels, of a northerly derivation. These fine upwards into sandstones with minor conglomerates. At Dunaverty is a final massive conglomerate, of possible southerly derivation, the Dunaverty Conglomerate of Morton (1976). The conglomerates of Sanda Island are lithologically similar to those around Southend, being alluvial fan and braidplain deposits, and are considered by Morton (1976) to belong to the New Orleans Conglomerate Formation.
At the base of this succession, at Keil Point, the conglomerates are cut by a Devonian vent complex.

The final formation, the Bastard Sandstone Formation, owes its rather surprising name not to geological frustration, but to a hill in the south-east of the area, and consists of *ca.* 100m of purplish, cross-bedded sandstones with regular mudstone horizons. The succession is interpreted by Morton as being deposited by sandy braided rivers coming from the south.

The Upper Old Red Sandstone crops out in three small areas only, a strip between Dunaverty and Polliwilline Bay in the extreme south, an outcrop around Killellan in the centre of the area and a tiny outcrop in the north-west at Galdrings. The succession is a classical fining-upwards sequence, such as is common elsewhere in the Midland Valley, beginning with conglomerates and proceeding with sandstones, marls and finally cornstones. The full sequence is seen only in the southern outcrop. Northwards higher and higher horizons overstep onto the older rocks until, at Galdrings, only the highest sandstones and cornstones are seen.

The Carboniferous unconformably overlies the Upper Old Red Sandstone and oversteps onto the Lower Old Red Sandstone and the Dalradian, a situation more akin to that in the Southern Highlands than the Midland Valley. Deposition commences with a terrestrial sequence of weathered cornstones followed by brown, sandy mudstones, above which are basaltic lavas, all belonging to the Clyde Plateau Volcanic Formation of the Strathclyde Group. The lavas crop out in two areas, the largest running south-east from Macrihanish towards Killellan, forming an undulating plateau and being terminated by the Polliwilline Fault. The smaller area lies to the south, along the coast from Cove Point to Polliwilline Bay and rests everywhere on the Upper Old Red Sandstone. An outlier of these lavas, overlying Upper Old Red Sandstone, occupies Macringan's Point on the northern side of Campbeltown Loch. Later deposits, of the Lower Limestone Group, occur in three small areas, along the Tirfergus Burn, around Drumlemble and along the shore south-west of the mouth of the Macrihanish Water. Much the largest of these is the Tirfergus outcrop, preserved in a small graben along Tirfergus Glen. Here the succession begins with a fluvially deposited coarse lava rubble with red and green clays developed on top of it, followed by shales and thin coals. Above these shales lies a further, heavily weathered lava flow with its own bole, followed by clays, rootlet beds, thin coals and sandstones. The top of the succession consists of coarse pale sandstones and a pale limestone with marine fossils and plant debris.

Permian rocks crop out along the west coast in a series of minor basins between Bellochantuy and Tayinloan. The sediments rest unconformably on the Dalradian and begin with coarse basal breccias of metamorphic clasts plus vein quartz, in a red to deep red matrix. These breccias were developed as proximal fan deposits, reminiscent of those of the Old Red Sandstone, in westward-running valleys. Above them lie soft red sandstones, mainly horizontally bedded, but with occasional cross-bedding.

Quaternary deposits are widespread and consist of boulder clay containing local metamorphic rocks, and igneous rocks from Arran, derived from a westward ice stream. Raised beaches exist at various levels. The most striking is the 2m beach (Gray 1978) seen at various points around the peninsula, notably on the west and south coasts.

Intrusions of various ages cut all the rocks of the area. The oldest are the vents cutting the Lower Old Red Sandstone at Keil Point and Cnoc Garbh. These vents, which appear to be explosive vents, are choked with sedimentary clasts derived from the Glenramskill Formation, in a matrix which includes andesitic and trachytic fragments and devitrified glass. The vents lie close to, if not on, the fault zone proposed by Wilson (1978) as the site of the Highland Boundary Fault Zone in Kintyre.

Carboniferous intrusives are numerous, including a few small vents as well as the felsite of Davaar Island and the trachyandesites and quartz-keratophyres of the Killellan group of intrusions lying close to the Campbeltown-Southend road at the head of Conie Glen. At Galdrings near Macrihanish a large basalt dyke and several sills of Carboniferous age cut the Upper Old Red Sandstone. At Keil Point a large crinanite dyke, running south-eastwards across the foreshore and cutting the upper part of the Glenramskill Formation, was thought by McCallien (1932) to be of Tertiary age. However a recent magnetic survey by the authors (see appendix) has shown that this dyke is probably Carboniferous.

The relatively few Tertiary intrusives of the area include, at Galdrings, a monchiquite and a dolerite, the latter cutting the same beds as the older Carboniferous dyke.

b. Geological History. Southern Kintyre, although containing a range of Phanerozoic rocks, lies to the north of the Highland Boundary Fault and its history should perhaps be considered as part of that of the Southern Highlands, rather than of the Midland Valley. It has suffered successive episodes of uplift, erosion and faulting acting upon an ancient basement, and few of its Phanerozoic rocks were laid down below sea level. The result has been copious, sequential deposition of coarse clastic sediment derived from local and distant sources.

The Lower Old Red Sandstone sediments begin with breccias derived from the immediate area, and represent a rapidly eroding Dalradian mountain region with valleys choked with massive clasts, these giving way to alluvial fan and braidplain deposits with conglomerates and sandstones. The conglomerates of these fans are a two-fold problem, since they contain few very local Dalradian clasts but do contain high-grade quartzites dissimilar to the nearby Dalradian quartzites of Jura, Morton (1976) suggested that some fans show a palaeoflow from the south, bringing in high-grade quartzites from the Midland Valley basement.

The vast number of lava clasts in the New Orleans Conglomerate Formation do, however, appear to have a northerly derivation and were probably derived from the late Silurian-early Devonian lavas of the Lorne Plateau, although clast size suggests that the lavas cropped out, on the already peneplaned Dalradian surface, further south than their modern extent. Coarse conglomerates at the very top of the formation, however, are lithologically similar to southerly derived conglomerates elsewhere in the Midland Valley and may represent a further influx from the south. The fining upwards into the Bastard Sandstone suggests a final peneplanation of the area at the end of Lower Devonian times.

Subsequent coarse conglomerates at the unconformable base of the Upper Old Red Sandstone suggest renewed downcutting, consequent on the convergence of the Dalradian block onto the Midland Valley during late Lower or Middle Devonian time. This was followed by a peneplanation during the late Upper Devonian, as demonstrated by the fining upwards sequence in the Upper Old Red Sandstone.

Renewed fault activity in the Midland Valley, produced uplift, causing significant pre-Carboniferous erosion, stripping off considerable thicknesses of Old Red Sandstone rocks and producing a flat surface covered in fine debris. The overlying Carboniferous lavas, extending across the Old Red Sandstone and on to the Dalradian, may have been fed from local vents. The lavas were subaerially eroded before distal floodplain systems laid down the coal-bearing horizons, minor downwarping allowing the occasional development of marine limestones. The thick Carboniferous deposits under the Laggan were probably accumulated in a fault-controlled basin, allowing around 400m of deposits from the Limestone Coal Group to the Middle Coal Measures. The sites of these faults are now occupied by the Kilchenzie Fault and the Drumlemble Fault.

A sharp period of uplift, probably associated with the first movements of the opening of the Atlantic in the late Permian, recreated the conditions for the production of coarser clastics, producing the Permian breccias. Later faulting associated with this movement produced the major extant faults of the area, including the Kilchenzie, Drumlemble and Polliwilline Faults.

Itinerary
The localities to be visited illustrate many of the geological features noted above, from the Dalradian to the Permian. Some Quaternary shoreline features are also included.

Day 1

1. Kildonald Bay - Black Bay (7800 2780 - 7750 2680)
Drive north from Campbeltown along the B842 for approximately 6 miles (9.6km) to the southern end of Kildonald Bay, and park at the Ballochgair forestry car park. Cross the road and follow the footpath to the *Dun* which overlooks the bay. The builders of the *Dun* used a selection of the local Dalradian rocks in their construction, providing a useful sample of lithologies. Examine, but **DO NOT HAMMER OR MOVE**, these blocks which include pelitic schists, schistose grits, epidote-chlorite schists, marble and epidiorite. Now take the steep path down to the shore and walk south towards the headland, across outcrops of the

Beinn Bheula Schists which are mainly pelitic with occasional schistose grits. Closer to the headland hard, grey epidiorite sheets begin to appear and, in large concentration, form the headland. Cross the landward side of the headland into Black Bay, walking towards the southern end of the bay, close to where a burn enters the sea. Here, among the stacks and coves of the former cliff line, are grey to whitish calcareous schists with thin bands of finely crystalline marble. A large Tertiary basaltic dyke forms the headland at the southern margin of the bay.

2. Peninver (7590 2480)
Drive back along the B842 to Peninver and park in the large car park on the sea front. Walk *ca.* 200m south along the main road and up the hill beyond the village. Here in a large cutting on the right can be seen Basal Breccia Member of the Glenramskill Formation, lying in a steep palaeovalley cut into the Beinn Bheula Schists. The junction between breccias and schists can be seen at both ends of the section. Large angular boulders with little intervening matrix form the base of the breccias, with clast size diminishing upwards, such deposits being characteristic of streamflood deposits. Red sandstones begin to appear higher in the section. Breccia clasts include epidiorite, pelitic schists, quartz and black marble from the Loch Tay Limestones. The top end of the outcrop is part of a private garden bordering the road and should not be entered. Walk back down the road and onto the beach just to the north of the caravan park, then south along the beach to the rocks. Here occur reddened Dalradian schists with pelitic and psammitic bands, the latter cross-bedded. The junction between the Lower Old Red Sandstone and the Dalradian is visible as a marked unconformity at the point (near the chalet). Breccias and sandstones dip gently east overlying a northerly dipping set of bedding planes in the Dalradian. The breccias include plentiful angular fragments of quartz, a few fragments of a pale, finely crystalline marble, a few quartzite clasts and many flat, stacked schist and schistose grit clasts, all in a red sandstone matrix. These conglomerates are at a higher level in the formation, elsewhere overlying the basal breccias of the cutting. Yellow Rock, directly offshore and accessible only at low tide, consists of the red sandstones and quartz pebble conglomerates of still higher parts of the Glenramskill Formation.

Directly north of Peninver a road leads off westwards to Glen Lussa where, on the south side of the glen, west of Glenlussa House the Loch Tay Limestone may be seen at outcrop.

3. Uisead/Galdrings (6250 2099 - 6250 2000)
Return to Campbeltown and take the A83 to Macrihanish. Go through Macrihanish following the coast until the road turns inland close to a small bay. At the first houses turn right across a cattle grid and follow the track past the fish hatchery and the lavas at Uisead until it reaches the bay at Galdrings. Park here and walk south across the lavas and the inlet of Eudan nan Gallan to the bay (6250 2000). In the bay and the cliffs behind it can be seen the unconformities between the Dalradian and the Upper Old Red Sandstone, and between the Upper Old Red Sandstone and the Carboniferous. The area can be viewed either by staying on the sands and raised beach, or by walking south along the sands, scrambling up the slope and returning along the foot of the cliffs. The latter route is described here although key points on the cliffs can also be viewed, albeit distantly, from the beach (Fig. 2).

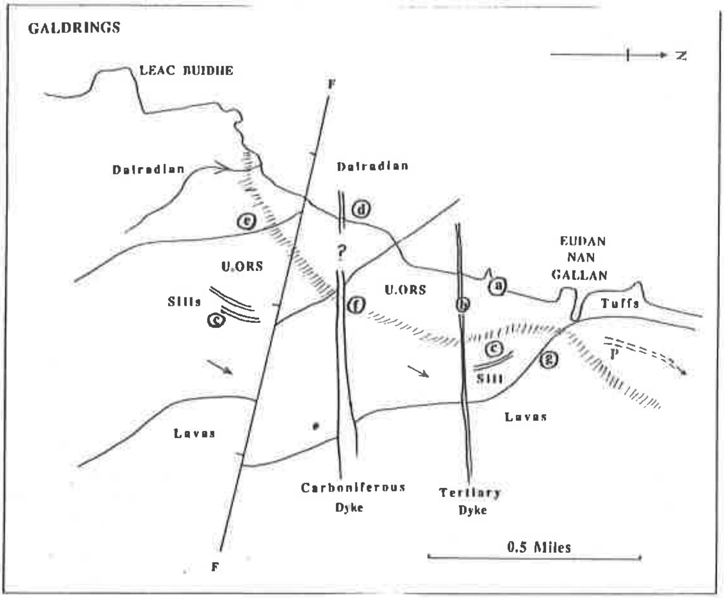

Figure 2. Geology of the Galdrings area.

a). South of Eudan nan Gallan the Upper Old Red Sandstone appears on the beach as a series of thick cornstone horizons, in which the calcareous material is in semi-continuous beds and contains fragments of red and white sandstone. The surrounding beds consist of pale, cross-bedded sandstones.

b). Crossing the shore, cutting the cornstones and rising vertically into the cliff is a 1-2m thick dolerite dyke, trending W-E and thought to be of Tertiary age (McCallien 1932).

c). Just north of this dyke and within the upper cornstones is a Carboniferous basalt sill which transgresses across the bedding and dies out upwards before reaching the dyke. Similar sills occur within the cornstones at the southern end of the bay.

d). Dalradian pelitic schists are exposed in the middle of the bay. These are reddened, suggesting close proximity to the boundary between them and the Old Red Sandstone which is concealed at this point.

e). At the south end of the beach the Dalradian schists form the sea cliffs leading south to the point at Leac Buidhe. Directly eastwards, however, the cliffs above the raised beach expose the Dalradian-Upper Old Red Sandstone unconformity. A line of springs on either side of an eroded red slip surface mark this unconformity, which is exposed 100m south of the slip surface. Vertical schists occur below the unconformity and, on a more or less planar surface above it, are purple breccias rich in quartz pebbles and flakes of schist. Above the breccias lie cross-bedded red sandstones and the basalt sills. Climb above the sills to reach a good section in which conglomerates are incised into cross-bedded white sandstone. The conglomerates contain rip-up clasts of marl. Above the conglomerates lie red marls, thin sandstones and a rubbly cornstone.

f). Walk north along the slope to a 12m thick, vertical dyke of Carboniferous basalt forming a prominent buttress in the cliff. McCallien (1928) records phenocrysts of plagioclase and augite in a similar groundmass, with patches of chlorophaeite bordered by pyrite visible in hand specimen. The dyke does not appear to be the feeder for the overlying lavas.

g). Follow the cliff line to the northern end of the bay and then scramble up a steep grassy slope to the base of the overlying Carboniferous lavas. **Care is necessary here**. Above the cornstones is a rubbly, reddish-brown deposit, followed by a brown to purple gritty and ashy sandstone, above which are the basalts forming the cliff. Lava flow has rucked up the underlying deposits and within the base of the lavas are occasional quartz pebbles. Descend the slope to the beach and return to the starting point. At the coast north of Eudan nan Gallan Carboniferous basalts and tuffs may be examined.

4. Tirfergus Glen. (6550 1840)
Drive back through Macrihanish and follow the Campbeltown road for 1.25 miles to the village of Drumlemble, turn right at the eastern end of the village taking the road and then the track up the hill. This track, passable for cars but relatively rough, leads past Torchoillean Farm up to High Tirfergus Farm. Park in the farmyard and ask permission of the farmer to enter the glen. Follow the track south from the farmyard, taking the side track leading west along the northern edge of the glen. Descend into the glen at the large waterfall which marks the faulted contact of lavas and sediments about half a mile from the farm (Fig. 3).

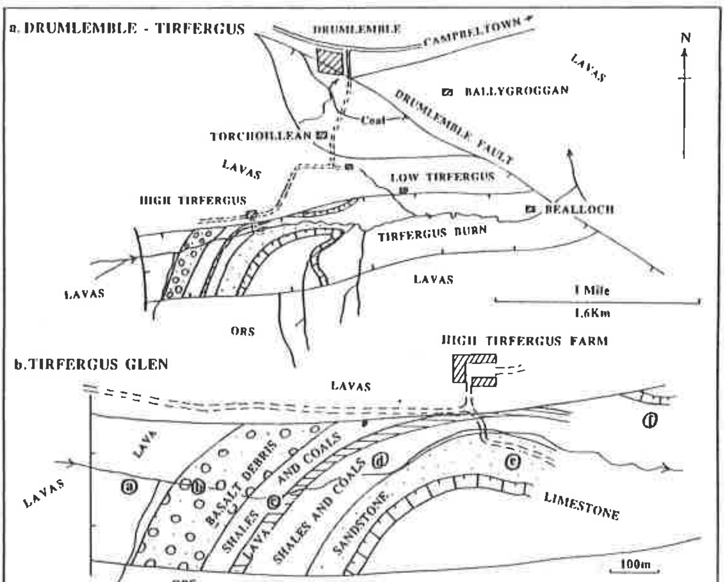

Figure 3. a. General geology of the Drumlemble-Tirfergus area. **b.** Geology and locations within Tirfergus Glen.

The fault upthrows the lavas of the underlying Clyde Plateau Lava Formation to the west, blocking the end of the Tirfergus graben. Follow the burn down to the first tributary stream from the south, walking on the Clyde Plateau Lavas which floor the graben here (Loc. a). Below the next small waterfall (east of the tributary) lavas give way to the Lower Limestone Group succession (Loc. b). Here and further downstream the lavas are overlain by a mantle of basalt debris accumulated on a floodplain. Above the lavas lie green and red shales and thin, impersistent coals. The next locality (Loc. c) is best reached by climbing out of the stream and re-entering it below the tangle of bushes. The locality is a large cliff, about 10m high, on the right bank of the burn. Here the basal lavas and their erosional debris are overlain by red and green shales and then a further heavily altered lava about 3m thick, above which lies a red bole, followed by dark clays, a rootlet bed and 2m of coals and shales to the top of the section. All these beds dip east at around 20° . 100m further downstream (Loc d) on the left bank of the burn is the best exposure of coals remaining in the glen. This is a 3m high outcrop comprising a series of thin coals and rootlet beds overlain by grey, gritty silts, and clays with plant remains. In a gully directly above these is a further 2m high of outcrop of thin coals and coaly shales culminating in a fine, white micaceous sandstone containing rootlets. The coals have been worked in the past as a supply for the local area.

Now walk 100m down to the ford and take the track on the right bank southwards for a few metres. Here (Loc e) the white sandstones become coarser forming the cliffs and slopes by the track. In the glen, directly opposite and below the farm, the thin lava underlying the coals crops out again. Descend from the track into the burn, noting stray blocks of pale, fossiliferous limestone, and follow the burn southwards for about 150m. On the slopes above the burn due east of High Tirfergus Farm (Loc. f) are outcrops of marine limestone in which Thomson (1865) noted (equivalent modern names used) *Buxtonia, Eomarginifera, Pleuropugnoides, Lingula* and spiriferids.

Return to the Campbeltown road at Drumlemble and drive east to Campbeltown.

Day 2

5. Killellan (6820 1580)

Take the A83 from Campeltown, towards Macrihanish as far as Stewarton. Turn left onto the B482 towards Southend. Drive for just over 3 miles, climbing out of the valley and stop at Killellan Park Farm. Here at the head of Conie Glen, the Killellan intrusions cut the Upper Old Red Sandstone sediments and Lower Carboniferous lavas. Together with those of Davaar Island, Kilkerran (Campbeltown) and Strone (Glenaladale), the Killellan bodies form a related series of felsites, sodic rhyolites, spilitic trachytes and trachytic porphyries scattered in a rough NE-SW line across Southern Kintyre.

a). Killellan Quarry. Ask permission for access at Killellan Park Farm, and walk up the track directly opposite the farm to the quarry. The location affords good views of the area, Kintyre weather permitting! To the north-west are the Carboniferous lavas, Upper Old Red Sandstone sediments and intrusions of Tirfergus Hill (260m), with the lower ground to the west of this, rising to The Slate (384m), formed by Dalradian schists. The prominent hill to the south-west, among the plantations, is the Carboniferous basalt intrusion of Croc nan Gabhar (239m), cutting the Dalradian schists. Within the quarry the southern part consists of a dark fine-grained basalt, together with purplish trachyandesites. The northern half of the quarry is in Upper Old Red Sándstone cornstones, having a sharp junction with the igneous rocks.

b). Killellan House Quarry, (6820 1520). This quarry is 700m south of Killellan Park Farm on the left hand side of the road. The road is narrow and only roadside parking is available. This intrusion is a sodic rhyolite (quartz keratophyre), a fine-grained rock in which occasional patches of large feldspar phenocrysts (albite) or their decomposition products can be seen. The rock is red to purplish in colour and strongly haematitic, with the well defined joint planes covered with the haematite.

6, 7, 8 Keil Point to Rubha MacShannuich (6700 0770 - 7040 0728)
Follow the road south from Killellan through Southend and westwards along the coast past the ruins of St Columba's Church. Park in the car park at the eastern end of Carskey Bay, just where the road turns north. The section between here and Rubha MacShannuich demonstrates all the formations of the Lower Old Red Sandstone, its unconformity with the Upper Old Red Sandstone, the full Upper Old Red Sandstone succession, the Devonian vents at Keil Point and the crinanite dyke at the eastern end of Carskey Bay. The Carboniferous basalts at Innean Beag (7100 0745), overlying the Upper Old Red Sandstone beyond Rubha MacShannuich may also be visited.

6. Keil Point - Dunaverty Bay.
At Keil Point walk out onto the shore platform into Carskey Bay to observe the crinanite dyke, which was the target of a magnetic survey undertaken during the preparation of this work (see appendix). The dyke is 2-3m wide and of hard, fresh black rock standing out above the surrounding sediments. It has a NW-SE trend cutting the upper part of the Glenramskill Formation which, immediately to the east, is formed of pale, gritty cross-bedded sandstones interbedded with thin marls, all of which dip steeply eastwards. The sandstones contain patches of numerous and large (up to 100mm) rip-up clasts of the marl. These sandstones grade up into the coarse conglomerates of the Southend Conglomerate Member of the New Orleans Conglomerate Formation at Keil Point (Fig. 4). The succession is interrupted here by the first of the Southend volcanic vents. This cluster of Lower Old Red Sandstone vents includes two on the section, at Keil Point and St. Columba's Church, and a third at Cnoc Garbh (6880 0905), a small hill just to the north of Southend.

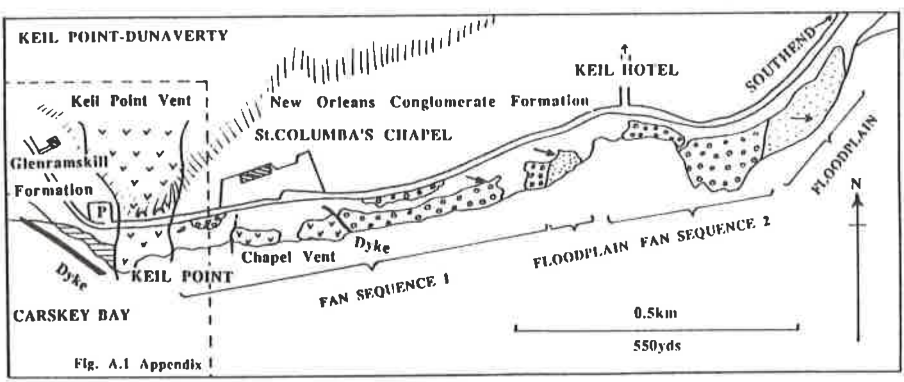

Figure 4. Geology of the Keil Point - Dunaverty section (after Morton 1976).

The Keil Point vent forms the rocky foreshore and the cliff behind it. This was clearly an explosive vent, being filled with a chaotic agglomerate of blocks of local sediments. The majority of these blocks, which vary in size from 20mm to 17 metres, are of the quartzitic conglomerates and sandstones of the underlying Glenramskill Formation. In contrast the western wall of the vent in the cliff north of the road shows huge (*ca.* 15m), partially displaced blocks of the New Orleans Conglomerate Formation formed by collapse into the vent. Friend & Macdonald (1968) noted that the matrix included fragments of andesite and possibly trachyte. A similar andesite forms the brecciated lava plug of the Cnoc Garbh vent. The cliff also shows sea caves and stacks of the 2m beach. The vent at St. Columba's Church, 150m east of Keil Point and directly opposite the cemetery, is chiefly recognisable by its destruction of the stratification in the surrounding conglomerates.

The Southend conglomerate is exposed between the vents and eastwards to Dunaverty Bay. It consists of 400m of alluvial fan and floodplain sediments in two major fining upwards sequences (Fig. 4). Clast imbrication and cross-bedding suggest a northerly derivation. The entire exposure shows a general fining upwards, maximum clast size diminishing from over 1m at the base to 200-300mm at the top. In the lower part of the succession the clasts are granule and coarse sand supported, and are dominantly of porphyritic and non-porphyritic lava material, with lesser numbers of vein quartz, quartzite and some sandstone clasts. Higher up the numbers of quartz and quartzite clasts decrease and sandstone clasts increase. Cornstones also begin to appear.

7. Dunaverty. (6890 0758)
Continue across Dunaverty Bay, where 300m of the succession is hidden under the dunes, to the old lifeboat station at Dunaverty. Here the succession reappears and consists of fine conglomerates of lava clasts, quartzitic grit and greywacke interbedded with red and white sandstones. Leave the beach here and take the path east across the base of the point to a solitary house above the river. To the seaward of this is Roaring Cove. Here the top of the Lower Old Red Sandstone appears. This is the Dunaverty Conglomerate of Morton (1976), and it consists of a coarse conglomerate with occasional tabular foreset units, containing clasts (up to 300mm diameter) of quartzite, schistose grit, quartz and lavas. It is unlike the rest of the succession, being very similar to the southerly derived sediments of similar age common around the Clyde estuary.

8. Brunerican Bay - Rubha MacShannuich (6945 0762 - 7040 0728)
Return past the house to the path and follow it to the footbridge. Cross the Conieglen Water here, skirting the golf course, and descend onto the beach, walking east into Brunerican Bay as far as the foreshore rocks halfway along. This outcrop, Big Clet, marks the base of the Upper Old Red Sandstone resting unconformably on the New Orleans Conglomerate Formation, with the Bastard Sandstone Formation missing. Big Clet is formed by cross-bedded red sandstones and conglomerates. The conglomerates vary from fine to coarse, the coarser units having rounded clasts up to 100mm. The clasts consist of quartz and quartzite with occasional schist fragments, similar to many of the northerly-derived conglomerates elsewhere in the Midland Valley. These basal conglomerates are thin compared to those of the Lower Old Red Sandstone and begin a classical fining-upwards sequence in beds which dip more gently east than the underlying sequence.

Walk to the point below *Dun Duirn,* where fine-grained, cross-bedded red sandstones contain lenticular conglomerate units. Above these along Innean A' Chromain are white sandstones and red, mottled sandstones with cornstones, followed by conglomerates. Around Rubha MacShannuich and separated from it by a fault are more or less horizontal red marly shales, overlain by thick cornstones at Innean Beg, in the form of columns surrounded by a green sandy matrix. This particular sequence suggests a relatively well-watered floodplain with caliche horizons, above which the Carboniferous lavas commence.

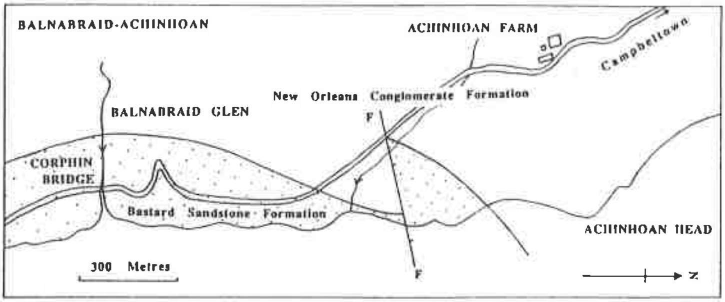

Figure 5. Geology of the Balnabraid-Achinhoan area.

9. Balnabraid Glen - Achinhoan Farm. (7682 1551 - 7662 1661)
Return to Keil Point and drive back through Southend on the B842 north for about half a mile beyond the village. Then take a right turn along the side road to Campbeltown. After crossing the bridge over the Conieglen Water at Mill Park turn left along the foot of the hills. This road eventually turns northwards just before Polliwilline Farm, going past a large conical hill (The Bastard) to the east and then through Feochaig to the sea. The road descends to Corphin Bridge, crossing Balnabraid Glen. Park here and follow the Glen to the shore. To the north (Fig. 5) between the mouth of the glen and a point on the shore opposite Achinhoan Farm the Bastard Sandstone Formation is exposed. Walk northwards and observe on the shore platform and in the low cliffs red to purplish sandstones and red mudstones. The base of the succession consists of coarse, planar cross-bedded and trough cross-bedded sandstones with planar beds in betwen them, above which is a rippled mudstone. On top of the mudstone are irregularly bedded sandstones with mudstone laminae, followed by further fine, cross-bedded sandstones. The succession is cyclical with a number of mudstone-topped cycles visible to the north. These deposits represent a sandy braidplain produced by the low sinuosity braided channels of a large river (Morton 1976). This sequence indicates a final peneplanation at the end of the Lower Devonian, with low relief on the source areas to the north and south. On the shore opposite Achinhoan Farm is the faulted contact of the Bastard Sandstone with the New Orleans Conglomerate. This formation, conformable with the Bastard Sandstone in Balnabraid Glen, is here a coarse conglomerate of lava boulders underlain to the north, towards Achinhoan Head, by reddish-purple sandstones and red siltstones. This succession differs from that of Southend in having tuffs towards the base and more sandstone towards the top.

10, 11, 12. Bellochantuy (6610 3240) and **Muasdale** (6800 4300)
These localities are well to the north of the area covered by Fig. 1 and are best visited on the journey to, or from, Campbeltown. From Campbeltown drive north along the A83 to the coast and follow the coast north to Bellochantuy. Stop at the car park by the Argyll Hotel and walk back to the south past the telephone box at the entrance to Bellochantuy Farm **(10)** to examine a large outcrop of Permian conglomerates by the roadside. The unconformity between Permian and Dalradian rocks is visible just south of the telephone box. The conglomerates contain quartz, schist, quartzites and epidiorite clasts. Fine sandstone bands interrupt the conglomerates, and at the southern end of the cutting there is a clear unconformity with Dalradian pelitic schists, showing the valley-fill nature of the deposits. Return to the car park and drive north along the main road for about half a mile to a point where the farm road, from Corputechan farm, descends south to meet the main road **(11)**. Here are fine, horizontally bedded, red Permian sandstones, which in places may be dune-bedded at the base. These sandstones fringe the road north as far as the Barr Water where they rest upon the Dalradian schists of Glencardoch Point. North of the point the sandstones can be seen again as far north as the sea stack of Sgeir Mhor, just south of Muasdale. Continue north to Muasdale **(12)** where, in and around the village, is the 2m raised beach backed by spectacular former coastal features, including a line of cliffs, offshore rocks, gullies and large sea stacks.

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APPENDIX:

A magnetic investigation of a crinanite dyke at Keil Point, Southern Kintyre.

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The metamorphic and sedimentary rocks of the Kintyre peninsula are cut by a large number of minor basic igneous intrusions. Many intrusions are assumed to be of Carboniferous age, others to be of Tertiary age. Few rocks younger than Carboniferous are present onshore in Kintyre, so cross-cutting relationships are lacking and composition has been the usual criterion for assigning a Carboniferous or Tertiary age. Other, more indirect methods are required to determine the age of an intrusion, for example, radiometric dating work and, as demonstrated below, small scale magnetic surveying. So far, all published magnetic survey work in Kintyre has been at a scale too large for this purpose (e.g. Wilson 1978).

Many intrusions in Kintyre are suitable for magnetic investigation since they have a significant magnetite content relative to the sediments (e.g. Old Red Sandstone) which they intrude. Disturbance of the geomagnetic field in the vicinity of such a body (a "magnetic anomaly") results from a magnetic field induced in the body by the global field and, if present, the effect of remanent magnetism. The remanent magnetisation exhibited by the intrusive body is of particular interest. It is most likely to have been formed by cooling through the Curie temperature (of magnetite) soon after intrusion and is controlled by the direction of the then prevailing local geomagnetic field. In the Carboniferous, Scotland was near the equator and the geomagnetic field was reversed compared to that of today, resulting in a near horizontal and southward remanence. During the time of Tertiary intrusion in Scotland the field was again reversed but steep, since Scotland was only a little south of its present latitude. Estimates of the direction of any remanent magnetisation can be obtained from the modelling of magnetic data collected across a minor basic intrusion; permitting discrimination between the two most likely times of injection.

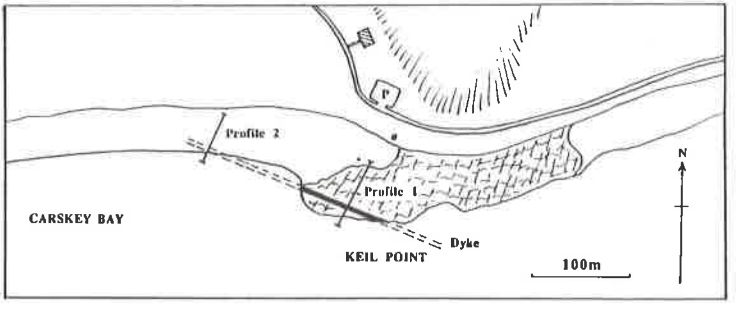

Figure A1. Location of geomagnetic profiles across the Keil Point dyke.

To this end a small magnetic survey was carried out across a 2-3m wide crinanite dyke with a trend of 124^0 across the foreshore at Keil Point (6700 0770, Fig1, main paper). The intrusion cuts the upper part of the Glenramskill Formation and was thought by McCallien (1932) to be of Tertiary age. This view is perhaps surprising since mafic intrusions as undersaturated as crinanite are rare in the Tertiary Province as a whole, but common in the Permo-Carboniferous Province of Central Scotland. However, crinanites do occur associated with the Tertiary centre in Arran as dykes and sills, probably prompting McCallien's conclusion, along with the evidence of the "Tertiary" trend, Carboniferous dykes usually trending E-W to WNW.

Total magnetic field intensity was measured along two profiles (Fig. A1) using a proton magnetometer. Profile1, some 75m in length, crossed the exposed crinanite. The height of the tide limited the length of profile to the south-west of the dyke. Carskey Bay, immediately west of Keil Point, is a low-lying area of no exposure formed of raised beach deposits, low dunes and farmland, and Profile 2 was sited about 150m to the north-west of Profile 1, crossing the predicted position of the dyke in the bay. Measurements were taken at 5m intervals along each profile, reducing to 2.5m in the vicinity of the dyke at Profile1.

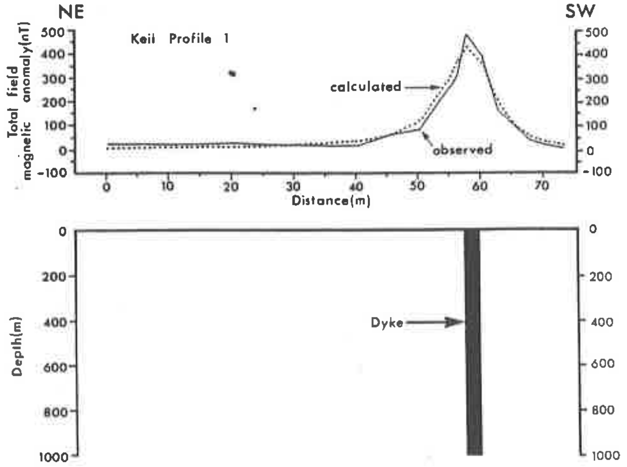

Figure A2. Magnetic modelling results for Profile 1 across the crinanite dyke exposed on the foreshore at Keil Point (see Fig. 4 Main Paper for locality). Upper figure shows the observed and calculated magnetic anomaly profiles. The latter was computed using the dyke shown in the lower figure.

Fig. A2 shows the results of Profile 1. The observed profile is shown by the solid line in the upper figure. The magnetic anomaly is positive with an amplitude of about 500 nanoTesla (nT), slightly asymmetric and centred over the dyke. A model profile was determined for Profile 1 using the GRAVMAG computer program. Models were tested for dykes with only induced magnetisation and for those with either Carboniferous or Tertiary remanent magnetisation superimposed on induced effects. The preferred model is shown in the lower part of Fig. A2 and the dotted line in the upper figure is the profile calculated from it. The model consists of a 2.5m wide vertical dyke. Most importantly, the observed data can only be modelled by a dyke which has a significant degree of Carboniferous remanent magnetisation. No other type of dyke produces a close fit to the observed data using reasonable values of magnetic properties. Modelling of Profile 2 (not illustrated) is consistent with the same dyke passing beneath the northern section of the profile with its top at a depth of about 10m.

Based on the results of this admittedly simple survey it is considered that the crinanite dyke on the Keil Point foreshore is more likely to be of Carboniferous age, rather than the Tertiary date ascribed by McCallien (1932). It should be noted that the control on rotation of the dyke after intrusion is imposed by the attitude of the Carboniferous sediments at Macrihanish, that is, the remanence cannot be a Tertiary one rotated to a lesser attitude subsequently. Further work is required to confirm this result, including laboratory measurement of the magnetic properties of the dyke and host country rock. Nevertheless, this result suggests that age attributions of Kintyre basic minor intrusions should be treated with caution where the attribution is based purely on geological field evidence other than cross-cutting relationships.

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NOTES

Frontpage - Entrance to Glensanda Quarry with Glensanda Castle. *by David Wilkinson*

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