MALTA EDITION

PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF GLASGOW

A sketch by Nora Liberi commemorating the Glasgow-Edinburgh Joint Excursion to Newbiggin Limestone Mine during the Edinburgh Geological Society's 150th anniversary celebrations.

Session 126 1983/1984

PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF GLASGOW

Session 126

1983/1984

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MEMBERSHIP REPORT

The membership of the Society for session 126 (session 125) was as follows:—

	126	(125)
Honorary Life Members	5	(3)
Life Members	3	(3)
Ordinary Members	378	(361)
Associate Members	42	(41)
Junior Members	15	(12)
Total	443	(420)
New Members	53	(36)
Deletions	30	(52)

The meeting of 13 October 1983 elected Mr Alec. Herriot and Dr. N. Holgate as Honorary Members of the Society.

Alison Lawson

LIBRARY REPORT

The 126th session of the Society saw the acquisition of 11 new books which, added to those which the department has purchased for the combined library, once again reflect the amazing range of members' tastes in geological literature. Prominent among them are those which illuminated the librarian's avowed aim to provide a geological guide for every conceivable region in Britain, if not the world, new regions covered ranging from Powys via Jersey to the French Alps. Other books deal with fossils, pyroclastic rocks, gravity, plate tectonics and, for those in need of definitions, the "Glossary of Geology" by Bates and Jackson. A recent, and unique, donation to the library is the last thirty years' run of the National Geographical Magazine — to be shelved as soon as cataloguing is completed.

While the number of borrowers remained at much the same level as last session, at 30, they read less, reading only 137 items, although the range was as wide as usual. A number of these borrowers were taking advantage of "holiday geology" advice which the librarian is always glad to provide.

A final item concerns the library itself. Despite considerable publicity over recent years, and a welcome rise in the number of users, many members seem vague about just what the library has available for them and even where the library itself is to be found! To remedy this an explanatory leaflet has been produced and will be circulated to all members. Our library has a lot to offer — use it!

C.J. Burton

THE SCOTTISH JOURNAL OF GEOLOGY

Editor's Report

Volume 19 (1983) was published in three parts totalling 414 pages (33 papers and 11 letters). The lead time from the date of acceptance of a paper to that of its publication varied through Volume 19 in the range 4-13 months. Volume 20 will be of similar size, again in three parts.

The cost to the Society of Volume 19 was just over £500. An increase of the institutional subscription (from £40 to £50) for Volume 21 (1985) should allow us

to hold down costs to well below the £1500 target. The 'surplus' is being used to generate extra parts on special themes, without holding back original research submitted in the usual way. At present we plan to publish a part largely devoted to papers presented at a meeting reviewing the Old Red 'Orcadian' basin; and the 150th anniversary of the founding of the Edinburgh Geological Society will be marked by a special part including historical reviews of Scottish geology and geologists, with state-of-the-science views and forward looks at major current aspects of Scottish geology (on- and off-shore).

J. Hall

PUBLICATION SALES OFFICER'S REPORT

The sale of publications this session was very successful. This was mainly due to the 3rd edition of the Arran Guide which was published in August 1983, and since that date 730 copies were sold. We also sold 135 extra copies of the Glasgow Guide.

I am pleased to state that the sales from the Bookshop and the Extra-Mural classes continue to be successful and so also were the sales at the conference held at the Geology Department at the beginning of September of this year.

Helen Paton

TREASURER'S REPORT

The Society's income showed an increase of £2244.17 over last year. Publication sales were up by £1877.29 largely due to the initial sales of the new 3rd edition of the Arran Guide. Additionally Britoil gave a generous donation of £500.00 towards bringing next year's celebrity lecturer, Professor Coleman, from America.

The Society's expenditure was higher this year then last by £6063.71. Whilst some items of expenditure were less, the main item was the publication and publicity costs of £6414.24 for the new Arran Guide. The larger size of the Proceedings, consisting of 36 pages against 16 last year, and additional numbers of reprints, account for the higher expenditure under this heading. This is partly offset by an income of £107.45 from the sale of reprints. Our contribution to the costs of producing the Scottish Journal of Geology has decreased, due mainly to an increase in the institutional subscription for the Journal. Council also decided to underwrite the cost of buses on some of the excursions this year to encourage more members to participate, and this accounted for an expenditure of £222.

Council is proposing to publish a number of publications over the next few years and these will require similar funding to that expended on the Arran Guide.

Tony Stevens

LECTURES 1983-84 (SESSION 126)

The first meeting of the 126th session was held on Thursday 13 October 1983, when **Professor John F. Dewey** (University of Durham) was presented with the **T. Neville George Medal.** following this Professor Dewey gave a most entertaining lecture on **"Plate Tectonics: Servant or Master?".**

Professor Leake's oration on presenting the medal is quoted in full later in these proceedings.

On 10 November **Dr Alan Gibbs** of Britoil addressed the society on the **"Structure of the North Sea".** Theoretical models of extensional basins have

shown that basin subsidence can be related to stretching of the lithosphere. Such models, however, presuppose uniform extension across the complete basin and a direct link between the elastic lid and the viscoelastic substructure of the lithosphere. Dr Gibbs used structural models and field analogues from both the Basin and Range Province of the United States and the North Sea to suggest that a more complex linkage between these components of the system may occur.

Theoretical values for extensions are often incompatible with field data:—local extensions ranging from 10 to 15% up to 200 and 300% can often be observed. Ramp and flat models of thin-skinned tectonic styles in extensional basins similar to those proposed for compressional tectonics were used to suggest how this problem may be resolved. Dr Gibbs also showed, by means of examples from the Basin and Range, how the evolution of high extension basins may have a profound effect on early basin infill history.

As usual the **Annual General Meeting** took place in December. This was accompanied by a short talk by **Dr Jeffrey Harris** of the University of Strathclyde on **"Diamonds"**. This was an illustrated exposition of modern thoughts about the genesis and subsequent evolution of this mineral and its kimberlitic host rock.

Those members who braved the elements to attend the first meeting of 1984 were treated to an address by **Professor William G. Chaloner** of Bedford College, London on **"The Land Migration"**. In a thought-provoking talk it was stated that the colonisation of the land by living organisms, which had risen and evolved in water, was perhaps the greatest single adaptive feat in the entire course of evolution. Plants pioneered this migration, apparently as a single event. Animals of several phyla (arthropods, vertebrates, molluscs) were then able to colonise the terrestrial plant communities that they formed. Particular attention was given to the early Devonian ecosystem of Rhynie in Aberdeenshire, and due credit was given to the pioneering work of Glasgow University in this context.

The annual **"Members' Night"** in February followed its usual format of short talks sandwiched between sessions viewing exhibits in the laboratory adjacent to the lecture theatre. **Dr G. Durant** of the Hunterian Museum spoke on **"Puzzuoli, Gateway to Hell in Ancient Rome and Modern Italy"**. Dr Durant showed that the present distension of this area was very similar to previous episodes which had foretold cataclysmic events. **Miss. C. Hocken** then presented the results of a Glasgow University palaeontology project on **"Chitinozoans and the age of the Margie Limestone"**. This was followed by **Dr. J. K. Ingham** of the Hunterian Museum showing both imaginative and practical **"New Homes for Fossil Grove"**. **Dr. J. G. MacDonald** of the Department of Adult and Continuing Education then spoke on **"Goatherds and Wherlite in La Gomera"**, or "How to get paid to go to the Canary Islands and get the party that you are leading to survey a previously unsurveyed island in an afternoon". Each member of the party was assigned a separate place to visit and detailed to bring back a sample of the rock there outcropping! The final talk, illustrated by slides of very spectacular country for fieldwork, was given by **Dr A. Park** who spoke on **"Himalayan molasse: or what goes up . . ."**

The following exhibits were on display:—
Dr C. J. Burton — Geological guide books from the Society's library.
Dr C. J. Burton — Basement and cover in the Channel Islands.
Mrs J. MacDougall — Teaching aids for Minerals and rocks.
Dr P. W. G. Tanner — Sheath folds from the Moine.

The following acquisitions by the Hunterian Museum were also on display:—

Dr M. Hunicken — Replica of the giant spider *Megarachne* from the Upper Carboniferous of Argentina.

Dr G. Teruzzi — Enigmatic bivalved arthropods from the Jurassic of Lake Lugano, Italy.

Dr I. Chlupac — Phyllocarid crustaceans from the Upper Silurian of Czechoslovakia.

W. M. Daniell — Aquatint engraving of Staffa, 1817.

Dr A. F. Park and Dr. N. M. Halden — Rocks from the Siilinjarvi carbonate complex, Finland.

Britoil plc — Oil from North Sea oilfields.

William Tawse & Co. Ltd. and Dr C. D. Gribble — Palygorskite from Ballochantry near Campbeltown.

In March, in a talk entitled **Unroofing the Andes,** Dr Peter Turner of Aston University described the geology of the Southern Atacama Desert in Northern Chile. Some of the problems of this classic cordilleran orogenic belt were discussed in a spectacular illustrated tour from the Coastal Cordillera through the Domeyko Mountains and the high Altiplano to the volcanoes of the Cordillera Los Andes.

The April meeting went even farther afield for its subject matter — **Dr J. Keith Ingham** of the Hunterian Museum spoke on the **"Geology and Evolution of the Solar System".** Dr Ingham, with characteristic enthusiasm, presented a summary of the results of the close examinations which have now occurred of over 40 planetary bodies in the Solar System. Their various states of crustal evolution were demonstrated and contrasted with that of the earth. Those present then had the pleasure of viewing a NASA film of time lapse footage of the Voyager mission to Jupiter and Saturn and computer animations. The commentary was supplied by Dr. Ingham.

The annual celebrity lecture was given in the Wilson Lecture Theatre of the Royal Society of Edinburgh by **Professor Daniel Bernoulli** of the University of Basle, Switzerland, who spoke on **"Mesozoic Continental Margins of the West Mediteranean".**

OBITUARY

WILLIAM G. AITKEN, BSc., Ph.D., F.I.M.M.

Dr W. G. Aitken, reader in the Department of Applied Geology, University of Strathclyde, died on May 14, 1984.

Bill Aitken graduated from Glasgow University in 1947 and went to East Africa, initially to Tanganyika, and rose to become Director of the Geological Survey of Nyasaland (now Malawi). In this position he was well versed in the techniques of exploration for metallic ores and in the exploitation of natural resources as well as the routine mapping of a survey. His particular interest was in palaeontology and stratigraphy and while in East Africa he undertook research in these fields and in 1959 was awarded his Ph.D. from his *Alma Mater.*

Bill Aitken returned to Britain in 1964 and after spending one year on the staff of University College of Swansea he was appointed Senior Lecturer in the Department of Mining Engineering (Geology Section) in the University of Strathclyde. It was with his wide-ranging expertise and drive that the Geology section had the strength to stand on its own which it did in 1967. In 1970 Dr

Aitken was appointed Reader. With his selfless bearing of a heavy load in both teaching and administration the Department grew from strength to strength.

Dr Aitken has been a member of the Geological Society of Glasgow since his graduation in 1947, but it was about the time of his return that Dr Aitken first became involved with the Society's business. In 1965 he was elected onto the Council and in 1968 he became the Honorary Secretary; a post he held until 1972. Ten years later he was to play another leading role in Council affairs when from 1979 to 1982 he was Meetings Secretary.

All who knew Bill Aitken will remember his warm personality, his concern for others and his self-effacing contribution to the Society, to his Department and for the good of geology in general.

He is survived by his wife, Evelyn, and his daughters Isabel, Jane and Catherine.

I.A.

Presentation of the 1983 Thomas Neville George Silver Medal to Professor J. F. Dewey, 13th October 1983

The following oration was delivered by Professor Leake:

Mr President, Ladies and Gentlemen:

I have exceptional pleasure in presenting Professor John Frederick Dewey for the second award of the Silver Medal named in memory of Professor Thomas Neville George.

John Dewey was born in London, educated at Bancrofts School, Woodford Green, Essex and took a first-class Honours BSc in geology in London University at Queen Mary College in 1958. He then moved to Imperial College where under the influence of Dr Gwyn Thomas he began research into the Ordovician rocks of the South Mayo trough, western Ireland. He received his PhD and DIC awards in 1960 after which he was appointed to a Lectureship in Geology at the University of Manchester where he stayed until 1964 when he moved to Cambridge as University Lecturer. He was subsequently to be approved for authentic degree of MA (Cantab) in 1965 and also to be made a Fellow of Trinity College, Cambridge which, however, he deserted in 1968 to become Fellow and Associate Dean of Darwin College. In 1970 he accepted a chair at the State University of New York at Albany which he retainied until 1980 when he was invited to become Professor of Geology at the University of Durham following the departure of Professor G. M. Brown to become Director of the Institute of Geological Sciences.

These few words convey nothing of Professor Dewey's widespread interests, energetic field work, extensive travel, numerous honours received and sparkling lectures given. His outstanding contribution has been to produce a brilliant series of plate tectonic syntheses, broad in scope, wild in imagination and comprehensive in explaining and integrating so many varied tectonic, sedimentological, magmatic and metamorphic facets of the formation of orogenic belts and sedimentary basins. It is for this very substantial and inspired contribution that we honour Professor Dewey tonight. There is no doubt that the practical application of plate

tectonic theory to unravelling the complex past history of the Earth has been enormously accelerated by Professor Dewey's pioneering and continuing syntheses.

John Dewey's modest beginnings in the west of Ireland soon spread to the volcanic rocks of SE Ireland and from them to the study of the kink bands and then to superimposed folding and then to the Appalachian-Caledonian orogen in an important synthesis published in Nature in 1969. From this, papers followed on continental margins, with J. M. Bird on the evolution of the whole Appalachian orogeny and on "Mountain belts and the new global tectonics", important papers published in 1970. A turbulent flood of syntheses followed in the 1970's; with Pankhurst on the Scottish Highlands, with Bird on geosynclines and on the ophiolites of Newfoundland, with Kevin Burke on orogeny in Africa, on Precambrian plate development, and with others on plate tectonics and the evolution of the Alpine System, on plume generated triple junctions, on Tibetan, Variscan and Precambrian basement reactivation, on hot spots and continental breakup, on the evolution of the Arctic, on aulacogens and their genetic relationship to geosynclines, on ophiolite generation and emplacement, on the displacement history of oceanic fracture zones, on suture zone complexities, on the geometry of plate tectonics, on ophiolite obduction, on the North Anatolian transform fault, on continental collision in Tibet, on the late Palaeozoic basins of the southern US continental interior, on the evolution of the Gulf of Mexico and the Caribbean region and many other similar topics. Indeed Professor Dewey has had nearly 100 papers plus over 40 abstracts published since his humble first paper "A note concerning the age of the metamorphism of the Dalradian rocks of western Ireland" in the Geological Magazine in 1961: a topic on which I would simply observe that we still do not know the answer.

Throughout these world-wide ranging studies he has repeatedly returned to the problems of the evolution of the Appalachian-Caledonide orogen, eg in his 1981 William Smith lecture to the Geological Society "Plate tectonics and the evolution of the British Isles" and in his work in Nova Scotia and Newfoundland. He is currently working on regional problems in many areas but especially in Turkey and the eastern Alps.

On the Editorial aspects of research work he has been an Associate Editor of *Geology* 1973-74 and of the *Geological Society of America Bulletin* 1974-78 and still is an Associate Editor of the *Journal of Geology*, *Structural Geology* and the *Geological Journal*, but of most importance has been his initiation, launching and editing of the new journal *Tectonics*, which is a joint publication of the American Geophysical Union and the European Geophysical Society, a new Society journal priced sufficiently modestly for individuals to be able to afford.

He has received many awards and honours including the Daniel Pidgeon Fund of the Geological Society in 1965, the Murchison Fund of the Geological Society in 1971, the 1976 Cressy Morrison award of the New York Academy of Science, the 1979 Bruce Preller award of the Royal Society of Edinburgh, Bruce Heezen Memorial Lecturer, New York Academy of Sciences, 1981 and the 1983 Lyell Medal, Geological Society.

Throughout this time of hectic and joyful activity, John has been in constant demand as an invited lecturer. He has given over 200 invited

lectures since 1967 ranging from Chicago, Cal Tech, Stanford, indeed in all parts of the United States, British Columbia, Calgary, Toronto, Orleans and Paris, Zurich, Mainz and Berlin, Germany; Norway, Madrid, Ankara, Istanbul, Moscow, South Africa, Singapore, Japan, Saudi Arabia and Australia to the 1980 Bruce Preller lecture in Edinburgh and in 1978 in Glasgow a two-day short course on plate tectonics given to BNOC which I was privileged to be invited to attend, together with a number of Glasgow students and staff. The popularity of his lectures is an impressive testimony to the value placed on his ideas and presentation throughout the world and we are exceptionally fortunate to have him here tonight to address us.

Professor Dewey, I have great pleaseure in presenting you for the award of the 1983 Thomas Neville George Medal for your distinguished contributions to our understanding and application of plate tectonics; a field involving stratigraphical synthesis which was a subject of great concern to Professor George himself.

B. E. Leake

EXCURSIONS 1984 (SESSION 126)

VISIT TO STAN WOOD'S WORKSHOP, LIVINGSTON: 26th April 1984
by Nancy MacGregor

Some 20 members of the Society attended this evening visit to Mr Wood's workshop. The material on display was very impressive and the machinery used in the preparation of fossils intrigued members. There was an interesting video of the Bearsden excavations and other places excavated. A most entertaining evening was had by all and tea was provided by Mr Wood and his wife.

NITH ESTUARY: 28th April 1984 (Leader: Dr G. F. Farrow)
by Nancy MacGregor

With the hire of a crankity old bus some 25 enthusiasts left Glasgow for the beauties of the Borders. The first stop was at Locharbriggs Quarry to view the Permian/Triassic red sandstone used in the building of the Burrell Museum. A wide variety of seed grains, airbornes and evaporites in the sandstone were noted.

As Dr Farrow is an excellent connoisseur of fine foods our lunchtime stop was arranged at New Abbey Inn. Variety was the essence and most felt in need of a sleep on returning to have a quick look at lovely Sweetheart Abbey. A group of seven had an uneventful look for amethysts and rejoined the rest of the party at a later time.

In fact there seemed to be more splinter parties looking at their own particular interests. For the stalwarts who kept with the excursion leader there was a lot of walking to Portwarren in the very low tidal estuary. They were able to see, however, future fossils in the making, salt pans, meanders, marshes, ripple marks, sand volcanoes and the underlying black layered anaerobic mud and the junction of the Greywackes by a fault.

In all, an extraordinary wide area of sedimentary and other features put over with such enthusiasm by Dr Farrow.

PARAFFIN YOUNG HERITAGE TRAIL: 12th May 1984 (Leader: Mr MacAdam)
by Nancy MacGregor

This was a glimpse of the nature and extent of the West Lothian Oil Shale Industry which flourished between 1851 and 1962. The excursion started at BP Oil, Grangemouth, with a video film of the shale miners at work. The start of the trail itself was at Dunshamstoun Works, Bathgate, where the industry started in 1851. Little apart from the house of the Manager remained. The next very scenic stop was at the Five Sisters, a collection of bings preserved as a monument to the industry, and presenting a most impressive sight at close hand. Paraffin Young's estate at Limefield House was next visited. The gardens have suffered through proximity to a housing estate, but lots of interest remains with a miniature Victoria Falls, and a fascinating bridge incorporating fossil trees, mud-cracks, cross-bedding and slump bedding. The mansion is an elegant Victorian structure. Because we were running behind time, examples of mining villages were missed out and lunch was taken at South Queensferry. In the afternoon the foreshore section at South Queensferry from the rail bridge to Hound Point was examined. The Dunnet Shale, Camps Shale, and Pumpherston Shale crop out on the shore, together with intrusive teschenite and quartz dolerite dykes. The weather was absolutely glorious and a tired but happy group of 16 members finished the excursion at Cramond.

References: Carruthers, R. G. *et al,* 1927. The Oil Shales of the Lothians.

Tulloch, W. in Mitchel *et al,* 1960. Edinburgh Geology, 188-197.

GOZO — MALTA: 22nd May-5th June 1984 (Leader: Mrs J. MacDougall, University of Glasgow)

The report for this excursion follows the reports of the local excursions.

THE TAYVALLICH AREA (KNAPDALE): 25th-28th May (Leaders: Dr I. Allison and Dr R. Anderton, University of Strathclyde)
by E. Kellock

It was a little unfortunate, if not unexpected with an alternative excursion in progress, that more members did not enjoy the superb geology weather and scenery of this excursion; however, with a small and active party (averaging eight members over the three days) Dr Allison on 26th and 27th was able to take in a large number of exposures, intervening ground being traversed fairly quickly. In an informal tutorial atmosphere the Dalradian succession and structure was demonstrated with utmost clarity; doubts and questions were not only resolved with enthusiasm but positively invited — a very stimulating two days.

On the 28th Dr Anderton took over, demonstrating very clearly the glacial features between the head of Loch Awe and Ford and Crinan; also, despite his disclaimer to having expert knowledge in the field, he gave a lively account of human prehistoric and early historic activities around Kilmartin and the significance, as far as known, of the antiquities visited. A last look over the landscape from the vantage point of the Dalradian fort at Dunadd completed a memorable weekend.

ROYAL SCOTTISH MUSEUM AND ARTHUR'S SEAT, EDINBURGH: 16th June 1984. (Leader: Dr Waterston and Royal Scottish Museum)
by Nancy MacGregor

A dozen members participated in this excursion on a most pleasant sunny day with the Holyrood Park absolutely crowded with bands, dancers and speakers for the local Miners' Gala. Although colourful, this in no way detracted from the excellent geology. The Salisbury Crags are magnificent at close quarters, showing well the cooling processes on the underlying and overlying sediments. As we walked round the complex we were able to compare the differences between the sills and adjacent lava flows, and relate them in the context of the surrounding volcanic complex and the subsequent glaciation which had a dramatic effect on this beautiful city.

The visit to the museum was undertaken with the same enthusiasm and knowledge by Dr Waterston. Further visits to the Royal Scottish Museum are a must to realise the full potential of the very excellent exhibits which are on display so artistically.

JOINT EDINBURGH EXCURSION TO BURNTISLAND: 16th June 1984 (Leaders: Mr M. A. E. Browne, Mr R. J. Gillanders and Dr A. Mackie)
by Nora Liberi (asked to write the report in Victorian style — Ed.)

A small, but select, band of members joined their brethren from Edinburgh, as part of the latter's 150th Anniversary celebrations, on an Excursion following the footsteps of the EGS in the year 1867.

The weather was most clement, a benign sun shining on what proved to be a host of people, the Edinburgh members far outnumbering the Glasgow contingent.

The first part of this interesting, and edifying, excursion consisted of an idyllic walk along the foreshore, from Aberdour to Carron Docks, Burntisland, observing exposures of the calciferous sandstone measures and associated igneous rocks, and noting, in passing, the many comfort stations provided for benighted geologists in Silver Sands Bay (most unusual on many such an excursion), and the facilities to purchase that frozen Italian Confection so beloved of the young.

Our party being of such unwieldy proportions, there were the inevitable delays whilst Mr Browne, like the proverbial sheepdog, spent an unnecessary amount of time rounding up the strays, losing his own offspring in the process, thus leading to a general tardiness. Our lunch, consisting of a cold collation (individually provided) was somewhat protracted, and took place over two venues, those in dire need of sustenance devouring their victuals before the party embarked for the afternoon session and lunch place.

The afternoon commenced with a visit to a sandstone quarry which, after a period of desuetude, is not proving to be, happily, of commercial viability, and this was followed by a two-hour descent into the stygian gloom of Newbigging Limestone Mine. This was NOT for the faint-hearted, but the writer must place on record that the members of the fair sex, wellingtonned and hard-hatted as their male brothers, proved equally capable of coping with the dark, the debris and the drips. This writer must also admit to a sense of gratifying relief when at long last our feeble lamps

were no longer needed, and with daylight at the entrance to the mine, the upper regions were safely regained.

Our perambulations for the day came to an end with a visit to what is humorously known as "The Cinema" — a huge cutting in the sandstone thought to be the commencement of a sandstone mine. The walk to this truly scenic spot was through bosky woods, and with the late afternoon sun filtering through the verdant trees, against the dramatic effect of towering sandstone cliffs, glowing golden in the sunlight, was truly a fitting end to a superb day.

The party then retired to a local hostelry, where a sumptuous repast was had by some.

THE NORTH ESK RIVER SECTION: 30th June 1984 (Leader: Dr C. D. Gribble, University of Glasgow)
by M. C. Keen

Twenty members of the Society attended the excursion to the North Esk, travelling by hired coach on the rather long journey. The weather was hot and sunny, and due to the prolonged dry spell the water in the river was very low, allowing members to examine exposures rarely visible in normal years. The first exposures examined were Old Red Sandstone conglomerates with an interesting array of clasts including granites dated as 460 Ma. At this point the geology had a rival when members discovered a salmon leap with many very large fish visible. Upstream the Lintrathen porphyry was examined, which is a red porphyritic dacitic lava flow. The next exposures visited were of the Highland Border Complex and Ordovician spilites, black shales with cherts, grits and arenites, and the Margie limestone were examined; the low water level allowed some detailed sampling. Finally, the Dalradian psammites with pelitic bands were seen, and Dr Gribble demonstrated the very narrow metamorphic zone north of the Highland Border rocks where matamorphic grade increases from chlorite to garnet within 1 km, suggesting considerable folding or faulting of the zone. This fascinating excursion ended with a discussion on the age of the Highland Border Complex; Dr Gribble distributed a table of isotopic dates related to various geological events.

ROAD CUTTINGS IN ARGYLL: 25th August 1984 (Leader: Dr J. G. MacDonald, University of Glasgow)
by C. C. Jamieson

The excursion was attended by 17 members and set out to examine roadside sections from Loch Lomondside to Loch Fyne, which exhibit various Dalradian lithologies and structures. The first stop at Culag Farm, just north of Luss, allowed the study of small-scale fold structures and the party were able to detect (after some persuasion!) evidence of two structural events. The intricacies of two sets of lineations/cleavages were discussed and the difficulty of distinguishing directly between their relative ages was resolved by relating the structures to phases of folding using the cleavage/bedding angles to indicate major folds. The members' concentration on the finer points of the inter-relationship between foliation, lineation and cleavage tended to be affected somewhat by the immediate

imperative of avoiding becoming a traffic accident statistic. The route farther north along Loch Lomondside gave a good opportunity to observe the change from the steeply dipping outcrops at Culag to the almost flat structures near Tarbet.

A short stop in Glencoe enabled members to examine the rocks in the old quarry on the slopes of Ben Luibhean. The rocks are part of the Appinite suite, a late Caledonian magmatic event, and the mode of formation was described, together with the probable tectonic setting. The rock is an alkali-rich diorite with large hornblende phenocrysts and the original magma must have been rich in sulphur since pyrite was common. Some very attractive specimens were collected at this location.

The major stop of the day was on the shore of Loch Fyne at two locations near Dundarave Castle. The Ardrishaig phyllites at this location showed good examples of fold structures and at one particularly complex exposure the members were given a sparkling dissertation on the mechanism of synedepositional tectonics. The phyllites at this location are also interesting in that they show signs of retrogressive metamorphism characterised by the occurrence of the sites of pre-existing garnets. The whole area has many features of interest, including a carbonated dyke and evidence of a diapiric structure in original quasi-viscous sediments.

The final part of the day, after a brief detour to Inveraray for ice cream and cold drinks, was spent at a road cutting in Glen Aray which showed a carbonate lithology. The limestone is now sufficiently re-crystallised to be correctly termed a marble, but shows very good examples of plastic deformation. The rock has numerous dark bands formed by carbonaceous lines of algae and again some very nice samples were obtained. The excursion was completed at this point.

Jim MacDonald led the party in his usual instructive and entertaining manner and was never at a loss to provide an explanation for any structure, even to the extent of referring to the imponderable effects of dynamite on roadside exposures! The weather all day was perfect and the potentially difficult travel arrangements were organised without any problems.

THE ESSEXITE AT LENNOXTOWN: 8th September 1984
(Leader: Mr A. Herriot)
by Alison Roberts

It was in a drizzly sou'-wester that 11 members followed Mr Herriot along the south face of the Campsie Fells to seek the famous Essexite of Lennoxtown. Erratic blocks of this distinctive rock have been found as far east as Edinburgh, indicating the direction of the final ice movement.

As we hammered our way along the hillside we were reminded not to confuse the many large fallen blocks with solid rock. We crossed a lava flow of Markle-type basalt, which contained phenocrysts of various sizes, and above us towered the cliffs of another lava flow of Jedburgh-type basalt. We could see the volcanic plug of Dunglass with its well-defined crag-and-tail, Hole Farm where specimens for the Geological Survey are deposited, and we speculated on the precise line of the Campsie Fault. We examined every exposure till we came upon the dark hornfelsed auriole of the Essexite. It contained magnetite and Mr Herriot told us that with a microscope we would also see cordierite, garnet and sphene. The Essexite

itself was very hard and required much vigorous hammering to produce a fresh unweathered sample, showing the shiny black hexagonal crystals of augite and laths of white plagioclase. We traced the extent of the intrusion but were unable to find the actual contact.

Our pockets were full of samples when Tony Stevens thanked Mr Herriot for an instructive and entertaining outing and as we walked back to the cars we speculated on what we might see if we made thin sections and examined them under the microscope.

by *Alec Herriot*

The party assembled at the car park on the Crow Road above Campsie Glen, the morning being dull but dry. A traverse eastwards along the hill face was made, generally at the level of the lowest Markle basalt flow, noting *en route* scenic points and aspects of the lava sequence and of the several landslips crossed. Some 200 metres east of a conspicuous drystone dyke, and at the 300-metre level approximately, a rocky SW-NE feature was inspected. Here two bodies running WNW-ESE show doleritic rocks, associated with what appear to be xenolithic altered sandstones, cutting Markle-type basalt lava. The lower shows a mass of "quartzite" 1.5 m wide, thinning to the west, splitting a narrow dolerite dyke of altered olivine, augite, phyric meta basalt. The upper at its eastern end shows dolerite with scattered "xenoliths": westwards the proportion of "xenoliths" increases so rapidly that the igneous matrix becomes hard to trace. These zenoliths are largely quartzose and rounded, some of them resembling the cobbles found in ORS conglomerates. The microscope shows the xenoliths are now not normal sediments.

The western end of the Essexite was visited next: it was noted that no marginal chilling could be traced, that the south-western part of the intrusion is relatively rich in biotite, and that the adjacent lavas are severely hornfelsed and veined by doleritic material probably of Essexitic parentage. Next a traverse was made uphill along the little stream which crosses the Essexite a short distance to the east, meeting the fragmental rocks which outcrop downhill of the Essexite and which become thoroughly indurated and recrystallised towards the intrusion, again the failure of the intrusion to chill, the relatively slight variations in the megascopic appearance of the Essexite and the approximate position of the uphill contact. The return walk to the car park was completed just as heavy rain arrived.

The excursion planned for the September weekend (22nd-23rd September) for the Campsie and Kilsyth Hills was cancelled due to lack of support.

EXCURSION TO GOZO, 22-29 MAY 1984

1. The Geology, by M.C. Keen

The rocks of Malta and Gozo show a simple succession of predominantly calcareous sediments ranging in age from late Oligocene to late Miocene. The total thickness of sediments is in the order of 500m, but there are tremendous variations in the thicknesses of individual formations. The structure of the islands is also simple, and on Gozo the geology is

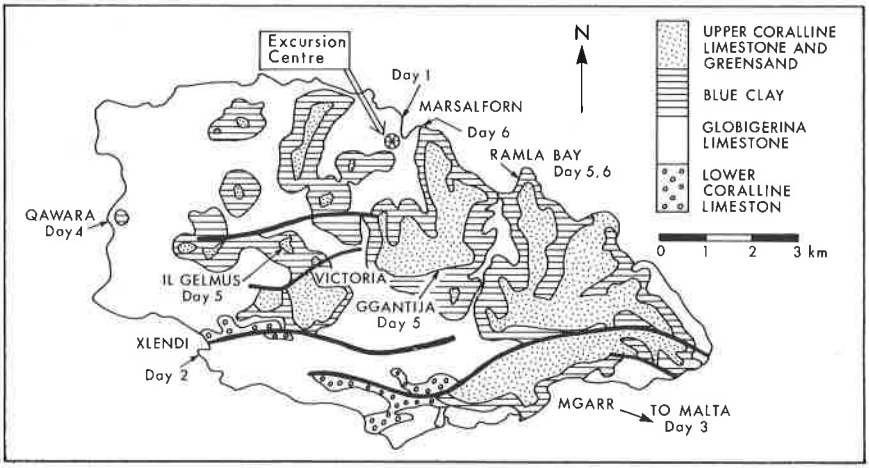

Figure 1. The Geology of Gozo (after Pedley *et al* 1976).

dominated by a very gentle north-easterly regional dip. These low dips, combined with rocks of varying durability, give rise to a landscape closely controlled by the geology. The flat topped hills of Gozo are capped by the hard upper Coralline Limestone; the steep slopes below are formed in the easily-weathered Blue Clay, while the rolling lower ground is in the Globigerina Limestone. The geological map of Gozo (Fig. 1) shows this simple relationship betwen topography and outcrop. Several E-W trending faults are present in the southern half of Gozo, but the most interesting structural features are the solution subsidence structures recently described by Pedley (1975), and discussed in more detail below. Fault movement has been active from the Miocene to the present day.

Recently published accounts of the geology of the islands can be read in Pedley et al (1976) and Zammit-Maempel (1977). The stratigraphical succession is shown on Fig. 2. The epochs and stages have been determined by studies of the microfossils, especially the Foraminifer; these are described in more detail in a report following this excursion report. The succession is drawn roughly to scale, using maximum thicknesses. Throughout much of the Miocene there was a positive depositional high in the position of the Comino Straits between Malta and Gozo, with both the Globigerina Limestone and the Blue Clay thickening away from this to the north-west and the south-east. Malta and Gozo, together with the neighbouring part of Sicily, are believed to lie a short distance behind the leading margin of the African plate. During the Miocene the islands lay near the edge of the Sicilian Platform, with deeper water to the south and west. The rapid changes in water depth seen during the Miocene probably indicate tectonically controlled basin margins.

The LOWER CORALLINE LIMESTONE is not easy to study on Gozo, being mainly exposed in inaccessible cliffs along the west coast. It is generally massive limestone, with coralline algal horizons with *Lithothamnion* and some patch reefs with corals, bivalves, and gstropods. Larger foraminifera such as *Lepidocyclina* and *Heterostegina* are present and

important for dating the rocks. Large scale cross bedding is present in the upper part of the formation, and the very top is formed by a bed rich in the sand dollar *Scutella subrotunda* (Leske) and large thalassinoidean burrow systems. The sequence suggests deposition in shallow water, well within the photic zone due to the abundance of algae, larger foraminifera, and hermatypic corals; the cross-bedded units indicate the presence of a high energy shallow water shoal. Much deeper water is indicated for the succeeding GLOBIGERINA LIMESTONE, a yellowish weathering rock composed of the planktonic foraminifera *Globigerina*. It is divided into Lower, Middle, and Upper divisions by two extensively developed phosphorite conglomerate beds referred to by Pedley *et al.* (1976) as C1 and C2. These two horizons are less than one metre thick and consist of a hard ground with associated thalassinoidean burrows containing phosphorite pebbles; body fossils such as *Chlamys, Flabellipecten,* burrowing

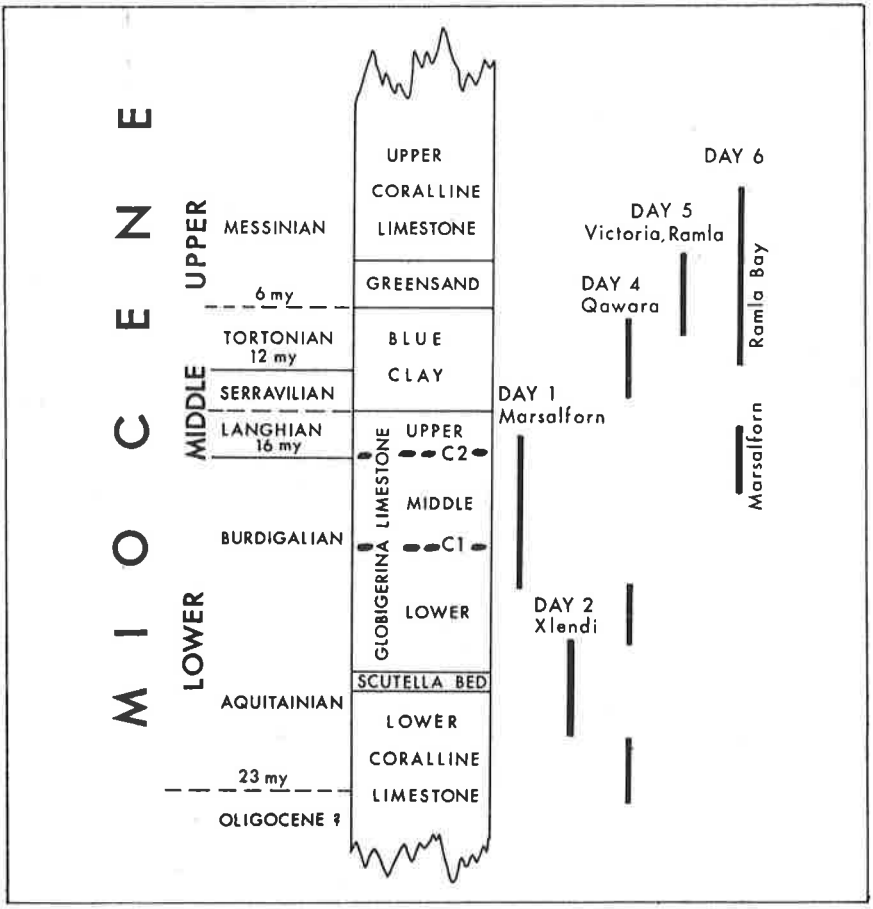

Figure 2. The stratigraphical succession of Malta and Gozo; ages of bases of stages shown in millions of years.

echinoids, and sharks teeth are abundant and often phosphatised. Macrofossils are not prominent in the main Globigerina Limestone. The Lower Globigerina Limestone is the main building stone of the islands abundant planktonic foraminifera suggest unrestricted circulation from deep water; the environment is generally considered to be deep circalittoral, i.e. 100-150m in depth. The phosphorite horizons indicate upwelling conditions, and the fact that they are now pebbles suggests increased turbulence; the associated fauna is characteristic of more shallow neritic conditions, giving an overall picture of water depths in the region of 40-80m. Thus for most of the time when the Globigerina Limestone was being deposited the area was situated on a marine platform, with much deeper water offshore from where the planktonic foraminifera were carried by currents. As the name suggests, the BLUE CLAY is an argillaceous rock, sometimes with up to 30% carbonate. It is not noticeably fossiliferous in the field, but does contain a rich microfauna dominated by planktonic foraminifera and deep water benthonic foraminifera and ostracods. It is impervious and therefore important for water supply because it underlies the Upper Coralline Linmestone aquifer. Springs are formed at the junction of these two formations, and the much "greener" landscape of Gozo compared with Malta is due to the widespred occurrence there of the Blue Clay. Digeronimo *et al* (1981) have recently studied the blue clay and its equivalents on Sicily and made some interesting observations. The molluscan and foraminiferal faunas of the lower Blue Clay indicate water depths of 150-200m while the upper Blue Clay was deposited in shallower water of about 100m depth.

The GREENSAND takes its name from the presence of glauconite in a poorly cemented and much bioturbated calcareous rock. The larger foraminiferan *Heterostegina* is prominent; echinoids, bivalves, and gastropods are common. The macrofossils and glauconite grains usually show evidence of transportation, but the microfossils appear to be *in situ.* The formation is usually 1m or less in thickness, with a maximum thickness of 11m at Il Gelmus in central Gozo. The broken shells, bioturbation, and larger foraminifera all suggest deposition in turbulent, very shallow, coastal waters. The UPPER CORALLINE LIMESTONE caps many of the hills of Gozo and western Malta. It has complex facies changes, with heavily bioturbated horizons, a coraline algal facies, with patch reefs developed in western Gozo and Malta. The common fossils are *Heterostegina,* often seen coating burrow walls, bryozoans, bivalves, echinoids, corals, and brachiopods. Deposition was probably in shallow subtidal environments up to 50m deep.

SOLUTION SUBSIDENCE STRUCTURES are the most impressive structural features seen on the islands, and are mainly developed in Western Gozo and north west Malta. They are circular in plan, up to 500m across, with vertical fault-bound margins, and closely associated with the principal faults of the islands. They have been described recently by Pedley (1975) who envisaged their formation as follows. Uplift in the early Tertiary led to subaerial erosion and the development of an extensive cavern system in the Cretaceous-Eocene limestones known to underlie Malta. In late Oligocene and Miocene times submergence occurred with

the commencement of marine sedimentation. The weight of these accumulating sediments eventually led to the collapse of the cavern roofs. Turbulent water infilled these depressions with unsorted sediments quite unlike the normal sediment accumulating on the nearby undisturbed sea floor. Tectonic movement may have aided the cavern collapses. Three episodes of collapse can be recognised, one contemporaneous with deposition of the Upper Globigerina Limestone, and two within the Upper Coralline Limestone. Post-Miocene uplift saw enlargement of the cavern systems with further subsidence and reactivation of the Miocene subsidence structures.

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2. The Excursion, by J. E. MacDougall (Excursion Leader).

Before we had even put foot on Gozo, Calypso's beautiful island where she healed and restored Ullysses after his fearful journey on the seas, there were murmerings of "WWGROT'. Interpreted, this turned out to mean "when we get rid of them" . . . and "them" referred to Jane MacDougall, the leader of the expedition, Dr Michael Keen, and his wife, Christine. Unlike the others, who had a whole fortnight in which to explore the delights of Gozo, we were free to enjoy a mere week.

After last-minute alterations to flight arrangements, and a somewhat hair-raising overnight journey by minibus through torrential rain to Manchester, we climbed aboard the plane, already rather dishevelled and just a bit weary, to take-off around 6.00am on Tuesday morning, May 22nd, 1984.

The contrast of weather conditions in Malta, a few hours later, despite our theoretical knowledge that it would be warm took us by surprise. Hot and over cast, it emphasised our tiredness, and when we were seated in the minibus which was to take us to the North end of the island, conversation, for once, seemed hard to come by.

The ferry to Gozo leaves Malta from a jetty at Cirkewwa, in the middle of nowhere. We were offloaded and doomed to a long wait in mid-day heat with no shade, no seats and no comforts. Or so it seemed, until a number of small boats, run by local entrepreneurs, appeared and solicited our custom. One chap introduced himself as one of the priests, assuring us we would be 'safe' with him. The boat we did decide to take, however, was rather larger than his and it had the added bonus of calling in at Comino, with its magnificent blue lagoon, and dramatic limestone cliffs. These cliffs

served as our first introduction to the rocks which make up the creamy-coloured Maltese Islands, and, as we slowly cruised through inlets and around stacks, we had plenty of opportunity to observe a considerable amount of detail.

Despite our early arrival at Mgarr, the magnificent port of Gozo, with its gaily coloured small boats, we met up with Paul Attard almost at once. Paul, and his wife Doreen, act as the Gozitan representatives of Victoria Holidays, the Company with whom we had made our arrangements. They are a delightful couple and proved to be staunch allies throughout our stay. In a very short time we were all transported across the Island to Marsalforn and introduced to our new homes. No one seemed to be too keen to start the geological programme that day, so after a meal and unpacking, the gang dispersed each to 'do his own thing'.

Day 1 Marsalforn area

Marsalforn is situated right in the middle of the Globigerina Limestone Formation and the cliffs rising from the horse-shoe shaped bay are perfect for its study. Somehow, it seemed a good place to begin our examination of the four main rock types which comprise Gozo, especially as, in the near distance, we could establish the change in colour which divides the creamy coloured Globigerina Limestone from the overlying Blue Clay and Upper Coralline Limestone groups.

This day established what was to become the pattern of the week — a little geology (attended to with rapt concentration); a magnificent lunch

Fig. 1. The party at Qawara. Standing: Nora Liberi, Julian Jocelyn; sitting: from left to right, Janie MacDougall (leader), Nancy MacGregor, Mike Keen, Helen Paton, Christine Keen, Molly Herriot, Dorothea Blake, Alec Herriot.

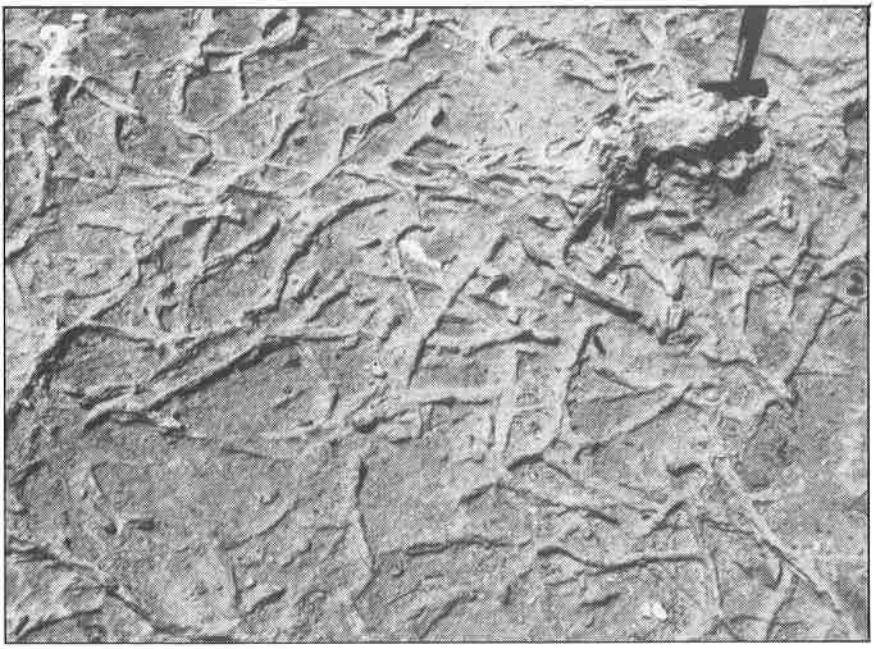

Fig. 2. Thalassinoidean burrow systems in the Scutella Bed, Xlendi.

(with meat, cheese, salads, delicious fresh bread, rich pastries, fruit and wine); and a sudden, great decline in the interest and activity shortly afterwards. Murmers of excuses . . . "och well, it IS hot" . . . "after all, it's a holiday too' . . . were interspersed with odd phrases such as 'Scutella Bed', or "silicified ooze" . . . or "shark's tooth", so the interest didn't decline completely! And we do have a photograph, taken on day one, to record for posterity the real enthusiasm shown by the group!

In the area of Marsalforn, the Globigerina ooze is punctuated by nodule beds. These are conglomeratice in appearance and weather to a dark brown. There appears to be some disagreement as to whether the concretions are *in situ*, diagenitically-produced features, or whether as pebbles, they have been incorporated into the ooze. Locally, the black-spined sea urchins have utilised the crevices formed by the weathering of these layers and have increased the overall knobbly appearance of the horizons by their slight boring activity.

The other feature which attracted our attention was the considerable evidence of fossil burrowing in the rocks. Trace fossils were abundant, and easily seen as they weathered to a completely different colour from the host rocks.

In places, thick burrows — reminiscent of tree roots — were particularly well-exposed on a marine platform which today lies some 10 feet or so above present-day sea-level.

Day 2. Xlendi

Xlendi lies almost diametrically opposite Marsalforn on the island. It is one of the few accessible areas on Gozo where the Lower Coraline Limestone can be seen. The road down to the elongate bay runs along a fault line, and dramatically shows the movement on the fault. As one approaches Xlendi, on the left are the creamy yellow horizons of the Globigerina Ooze while, at the same height, on the right hand side the rocks are a dirty grey, the colour of Coralline limestone.

It would seem that the fault is not completely inactive. It is reported that, in Januray 1693, "the sea at Xlendi withdrew more than a mile and then rushed back over the land with such fury that it swept away all the houses and fields in its path" and that "many fountains and springs dried out". It seems that the earthquake repeated itself every twenty-four hours or so, and caused the terror-stricken Gozitans to make special vows to Our Lady and to build Churches to keep the sea at bay.

Our visit to Xlendi had two main aims. The first was to see the Lower Coralline Limestone and, in particular, the Scutella Bed, which is magnificently exposed on the walkway along the southern side of the Bay. The second was to examine one of the several "collapse" structures which can be seen on Gozo. These fascinating structures, almost circular in cross-section, have formed a series of distinctive features on the Island, the most spectacular of which is known as the "Inland Sea".

At Xlendi, the subsidence, or collapse, structure is also fairly distinctive as it shows itself as a visible hollow in which the Globigerina Limestone draped at varying degrees of dip is surrounded by rising flanks of the stratigraphically underlying Lower Coralline Limestone. As pointed out already, the colour difference between these two lithologies is very distinct; so, one sees a circular, yellowish-coloured outcrop, surrounded by walls of grey limestone.

Despite the exciting geology of the day, and the strong winds, most of the party swam in the sandy-bottomed clear waters of the bay. The underwater diving in this area is excellent, though sharks do tend to hover at the mouth of this long, ribbon-shaped bay.

Day 3. Malta

With the exception of Helen, who had holidayed several times on Malta, and who decided to stay home, the rest of us headed back to join the big ferry at an early hour. Our day in Malta was planned to be a busy one and we were not disappointed. There was no slacking on day three. It was a day crammed with a host of different activities which blended well to introduce us to "the Malta Experince".

Our first port of call was to Medina, the old capital of Malta. It is a typical mediaeval town situated almost exactly in the centre of the Island. Known also as "the Silent City", it commands a magnificent view, and while fully inhabited it is a bastion of silence. The reason for our visit was to see the exhibition of the "Geology of Malta" which is housed in the National Museum of Natural History. It gave us the opportunity to see rock types which were otherwise inaccessible to us, and to study the range of fossils which have been found throughout the islands. The museum is housed in the baroque-fronted Vilhena Palace in Archbishop's Square.

From there we headed to the Megalithic monuments at Tarxien. These large stone temples, situated on high ground, are though to date back to the third millenium B.C. They are complex in plan, highly ornate and show evidence of ritual sacrifice; in one place cinerry urns, full of human ashes, were discovered some years ago. These are now housed in the Valetta Museum. The temple abounded in idols, blocks and stone balls (probably used as rollers) and, apart from their intrinsic archaeological interest, again served to let us see a variety of the rock types of the Island.

At Ghar Dalam, we visited the famous cave which has proved to be a veritable store-house of fossil remains; dwarf elephants and hippopotami; a giant dormouse; gigantic land tortoises; birds. These bones represent a Pleistocene fauna, probably some 20,000 years old, and are thought to be a concentrate from a placer deposit in a huge underground river system. The cave today stands well above sea level. It opens like a hanging valley on to a deep valley which today drains the area. Like the subsidence structures it serves to remind us of the complex tectonic upheavals which have repeatedly affected the Maltese Islands, and reflects the changing sea levels of the recent geological past. Situated near Birzebbugia in the SE of the Island, Ghar Dalem is in Globigerina ooze.

This was the turning point for our journey. From here we headed back to Valetta to attend the "Malta Experience", an extravaganza of sound and picture which details the history of these brave islands from the dawn of time. The show is housed in the Mediterranean Conference Centre which was originally part of the Holy Hospital built by the Knights of St John in 1574. It has the longest single-roofed hall in the world. An unexpected geological bonus was discovered while waiting for the minibus at the bus station just outside the city walls; the wall were built on limestone cut by several prominent normal faults with throws of a few metres. On the way back northwards to join the ferry, the driver decided to include a little detour of his own. This was to show us the Popeye Village, a wooden village designed for the setting for the film. Regrettably, erosion is taking its toll of this delightful part of the island and, as the cliffs crumble, so too is the little village being destroyed.

Our return to Gozo was marred by hearing about Helen's day. No sooner had she returned to the flat after leaving us in the morning than she had been interrupted by the arrival of the police who had questioned her regarding the cars we had hired. It turned out that there were technical problems regarding insurance about which we had been unaware.

Day 4. Qawra and the Inland Sea

The area around the Inland Sea is dominated by Lower Globigerina Limestone, with some of the underlying Lower Coraline Limestone visible as flanks to the collapse structures. This eastern end of the island has many of the finest examples of collapsed cave systems that exist; so it is almost unique in its topographical expression. The Inland Sea, itself, is one such structure. Almost circular in outcrop it is connected to the main sea by a tunnel, another remnant of the former extensive cave system. Boats — the typical brightly coloured lussos of the area — ply from the Inland Sea outwards through the tunnel. We decided it was (geologically of course) important for us all to make such a trip, and we all thoroughly enjoyed the

experience. The boat owners were insistent on telling their tales as they pointed out the colourful world of the sea anemones, set like rubies against the clear turquoise waters and the creamy white rocks. As we climbed up the path later, to view the Azure Window, a fine example of a sea-cut arch, we were approached by a BBC gentleman who was making recordings for a travel programme for the following winter. On hearing Dorothea's dulcet tones, he selected to interview her and her programme appeared on the air in due time.

The area around Dwejra is steeped in story and legend. The dramatic geological features, the presence of ancient cart ruts in the rocks, the fossils, the natural and man-made salt pans, the inland sea — all these are full of mystery to the local people. Just off-shore is a large stack known as "Fungus Rock". During the time of the Knights of St John a small shrub, "*Fungus melitensia*", was found on the rock and it appeared to have remarkable healing properties when used to treat haemorrhages, dysentery and ulcers. The Arabs called it "The Treasure of Drugs", so in 1744 it was granted a sort of conservation order against unlawful exploitation. The steepness of the cliffs makes it difficult to imagine how anyone could ever have found it in the first place. Such are the surprises of history!

The study of the geology of the area was halted when Mike discovered, using Nora's mask and snorkel, the joys of underwater biology. Everyone seemed to think it was too hot to work anyhow and there followed a time of happy splashing in the Inland Sea.

On the way back to Marsalforn one of the large building-block quarries in the Globigerina Limestone was visited and a detour from the normal road brought us round past the extensive salt pans which have been hollowed from the rocks just to the west of Marsalforn, itself.

Day 5. — Ramla Bay, Ggantija Temples and Il Gelmus

Il Gelmus is a little flat-topped hill which lies just outside the main city of Gozo, Victoria, or Rabat, as it is sometimes called. Associated with Il Gelmus is a legend of gold — of a golden calf. The calf was, apparently, a much-desired item and as various people coveted it, ill-luck befell them until, eventually, it was removed and hidden. But, says the legend, to this day specks of gold can be found on Il Gelmus. Such specks are lovingly collected each year to be used on the Christmas crib in the local church. The gold, sadly, is of course iron pyrites. And the reason it abounds on Il Gelmus is due to the presence of Blue Clay where rather anoxic conditions during deposition have led to the formation of the sulphide of iron.

On Il Gelmus the Greensand is also well-exposed and the large flakes of greeny-black glauconite were clearly visible. We were somewhat halted in our tracks as, just ahead of us, was a *real* geologist. A rather purposeful -looking young man, who appeared to be French, was perilously studying the rocks. Somehow he made even Mike's serious "collecting", seem to be a bit amateur!

The Ggantija temples were reminiscent of those we had seen in Malta. Feeling somewhat weary, we sat among the large stones looking and talking and speculating. Later we discovered we had sat where, in the past, the sacrificial virgins must have waited. A series of photographs, taken by one of the party, records the gradual diminution in the number of us left!

Ramla is a magnificent bay of golden orange, rather coarse, sand. In a way it is an enigma. One assumes the beach has weathered from the Greensand. But whence the colour? Our visit to Ramla was rather spoiled by the presence of a strong wind which made things uncomfortable. Sand was blowing everywhere. At the eastern end of the bay there are the submerged remains of a Roman villa, a 19-roomed mansion with many baths. The visit, however, was useful in that it enabled us to see the extensive land-slipping that occurs where the Blue Clay outcrops on the cliffs. It was also a good introduction for us for day 6 when we would return to the area to see the youngest of the rock types which outcrops in Gozo, the Upper Coralline Limestone.

Day 6. Ramla Bay and Xerri's Grotto and the east side of Marsalforn Bay

Before studying the Upper Coralline Limestone a visit was made to Xerri's Grotto near Xaghara. Discovered in 1923, while digging for water was being carried out, this small cave system is well worth a visit. It lies some 36 steps below a house and is rich in stalactites and stalagmites. The guardian of this cave rushed us around, pointing out "an elephant", "candles in candlesticks" and many other forms. He refused to let us linger, obviously afraid that we might be a group who would take souvenirs from the cave's bounty! This small grotto is one of many which occur in the Upper Coralline Limestone. Much of this formation now outcrops well above present-day sea -level.

The day was unpleasantly cold and windy. Later, rain came on. For the first time, cagoules were worn and we were glad of the shelter they provided. The climb to reach the limestone was, in some places, steep. Everywhere it was rather difficult as the scree was dressed in an abundance of prickly shrubs. Much of the limestone was silicified and everywhere it was burrowed and infilled. As a result the weathering produced an attractive series of sculptured forms.

Our last official visit was made to the eastern shore of Marsalforn bay. After a look at clay-like inclusions, bluish in colour, in the creamy Globerina ooze we progressed to one of the phosphatised nodule bands and hunted for shark's teeth. Most people found one.

Fossils in the islands, however, are protected by law and may not be exported without official permission. Apparently, the presence of fossils in your luggage will subject you to a fine and may delay your departure. The fossils will be impounded.

The official field trip ended by our sharing a magnificent meal at the Odyssey Bar. This lovely eating place overlooks the water of Marsalforn Bay, and is the ideal place to contemplate the wealth that is Gozo's. Somehow, it does not seem right that such a small island, only 9 miles long and 4½ miles wide, should be endowed with so much. Despite its strategic significance in history, when north fought south, or east fought west and its occupation by Phoenicians, Romans, Greeks, Arabs, Italians, Spanish and French, Gozo has maintained its individuality. Still largely untouched by the 20th century, tradition is strong. Lacemaking, fishing and agriculture are still carried out by the old methods, though often now under Government control.

George Camillari, in his book "The Realms of Fantasy" says legends

present insight into the mind of the Gozitan and the things which stimulated him in the past. They re-create for us an island world where dim knowledge and isolation mingle with a deep sense of insecurity; where caves are objects of fear, fields hide mysterious treasure; moody seas bring terror from alien shores; and springs gush magically from solid rock.

Gozo still has the magical and healing properties that Ulysses enjoyed. One leaves rested, refreshed and stimulated.

On Tuesday morning, Dr Keen, Christine and myself set sail for home. T-H-G-R-O-U. Translated . . . "they had got rid of us".

MICROFOSSILS FROM GOZO

by Michael C. Keen

Micropalaentology is one of the most important areas of palaentological study at the present day, mainly due to its application in the oil industry. There are many different types of microfossils, ranging from protozoa to vertebrates and from algae to spores and pollen. The only feature these diverse groups have in common is that you need a microscope to study them because they are small. It is this small size, generally less than 1mm which gives them their great advantage over macrofossils: you only need small rock samples in order to study them. Thus it was possible to bring back a whole fossil collection from Gozo in a few kilogrammes of sediment, enough for several years of study! Some of the characteristic species and genera are ilustrated on Plate 1. Microfossils have played an important part in understanding the Maltese succession since Jones in 1864 used the larger Foraminifera *Heterostegina* and *Lepidocyclina* to establish a Miocene age for the rocks. This was followed by the discovery of abundant planktonic foraminifera by John Murray in 1890 in the rocks he then named after them, the *Globigerina* Limestone. He was able to compare these with the Globigerina oozes of the ocean floors which he had studied in connection with the Challenger Expedition. These examples illustrate the uses to which microfossils are put: besides being interesting in their own rights, they are used firstly for dating rocks and secondly for determining conditions of deposition.

Two groups of microfossils will be considered in this report, namely the Foraminifera and the Ostracoda. The Foraminifera, more commonly abbreviated to "forams", are probably the most important microfossils. They are certainly the most important group studied to date in Malta, with published accounts by Giannelli and Salvatorini (1972-1975) and Felix (1973), which have enabled the Maltese succession to be accurately placed within the international biostratigraphical framework of biozones, stages, and epochs utilised in Fig. 2. Foraminifera are protozoans which construct a shell, more strictly called a test, and mostly range from 0.5 to 1.0mm in size. They mainly live in marine water and the majority of species are benthonic, living on seaweeds or on or within the sediment. Some, however, are planktonic, and occur in vast numbers in the surface waters of the oceans; their shells accumulate in great deposits of oozes on the ocean floors at betweeen 1000-5000m depth, and have been likened to a continual "snowfall" from the surface waters. A few of the benthonic forams belong to genera of exceptionally large size, up to 2 or 3 cm; and

are referred to rather loosely as the "larger foraminifera"; nowadays they are only found in warm 25°C summer temp.) shallow (c<50m) marine waters and it is assumed that this was also the case in the past. The ostracods are small (c.1mm) bivalved crustaceans which inhabit freshwater and brackish environments as well as the sea. A calcified bivalved carapace is only common in benthonic ostracods, so planktonic groups are very rare as fossils. They have not been described in any detail from Malta and Gozo, but a preliminary investigation has been carried out by Russo and Bossio (1976).

Biozones are based upon the appearance and disappearance of species; zonal boundaries are recognised by the first, or last, appearance of one or more species in any particular section. In general, planktonic organisms tend to be more useful for international correlation because they are more widespread than benthonic forms. The planktonic forams have additional advantages of rapid evolution so that they have short stratigraphical ranges, and being very abundand in the rocks of Malta and Gozo, they are the principal group studied. The larger forams have also proven useful for correlating the lowest (Lower Corraline Limestone) and highest (Greensand and Upper Coralline Limestone) parts of the Maltese succession. The ostracods include many stratigraphically important species found in the Mediterranean region, and in particular can be compared with the well-known faunas of the adjacent Italian mainland and Sicily. There are probably in the region of 200 ostracod species in these Maltese rocks, and the distribution of a few of them is shown in Fig. 3. It is important to understand that the stratigraphical distribution of the fossils is controlled by several factors: the type of environment, the evolution of species and genera, and their migration into any particular area. Thus, the large change evident between the Blue Clay and the Greensand is due to a fundamental environmental change from deep offshore conditions to much shallower near shore environments. Although only a few ostracods have been identified to species level, those that have vary in their usefulness for stratigraphical correlation. *Acanthocytheries hystrix* can be seen to have a long range, and only indicates a Miocene age; on the other hand *Ruggieria tetraptera tetraptera* is only found in the Upper Miocene, so its appearance in the upper part of the Blue Clay helps to locate the base of the Tortonian, the basal Upper Miocene stage. Its appearance at this level does not coincide with any obvious environmental change so it is presumably due to migration. Migration can be very rapid and within a single basin such as the Mediterranean can, to all intents, be regarded as instantaneous. Stratigraphers also use datum planes for correlation which are marked by particular biological events. One such of especial importance to Malta is the "Orbulina datum", named after a genus of planktonic foram which made its first appearance at the base of the Middle Miocene. It can be used to define this level virtually anywhere in the world where planktonic forams are present. In Malta and Gozo this datum is found at the base of the Upper Globigerina Limestone. The evolution of *Orbulina* from species of *Globigerina* has been studied in several ocean basins and appears to have been synchronous throughout the world. This poses problems concerning our understanding of evolution because new species are generally believed to arise from isolated or peripheral populations, and not to occur gradually

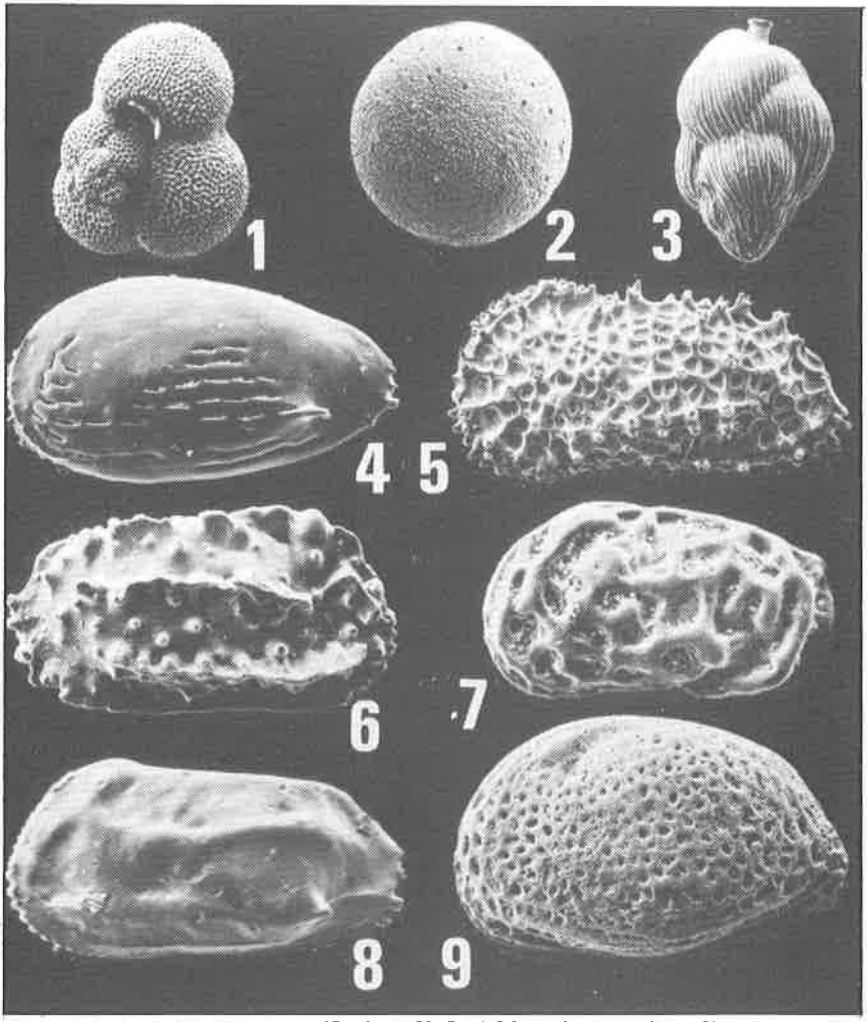

Plate 2. Microfossils from Gozo; magnification x 58; fig. 1-5 from the Lower Blue Clay, Qawara; Fig. 6-9 from the Greensand, II Gelmus.
Fig. 1. *Globigerina* sp.; **Fig. 2.** *Orbulina universa* L'Orbingy;
Fig. 3. *Uvigerina sp.;* **Fig. 4.** *Keijella punctigibba* (Capeder);
Fig. 5. *Acanthocythereis hystrix* (Reuss); **Fig. 6.** *Occlusacythereis* sp.;
Fig. 7. *Callistocythere* sp.; **Fig. 8.** *Ruggieria tetraptera tetraptera* (Seguenza); **Fig. 9.** *Aurila* sp.

over such a wide area of distribution. However, this pattern of evolution is not rare amongst planktonic foraminifera.

Turning now to the question of palaeoenvironments, the principal used is one of the basic tenets of geology: uniformitarianism. Comparitive palaeoecology uses the present as the key to the past, in other words we use our knowledge of present-day distributions to interpret fossil distribu-

tions. This can be done by considering whole faunas or individual genera and species. In order to illustrate this approach, typical samples from the Globigerina Limestone and the Greensand will be considered. In samples from the former, something between 80-95% of the forams are planktonic. It is clear from modern studies that there is a general positive relationship between increasing percentages of planktonic forams and increasing depth of water, so that the ratio of planktonic : benthonic forams offers a rough guide to water depth. However, this observation has to be used with great care because so much depends upon the local geography and oceanic circulation patterns. Thus, deep water areas may be devoid of planktonic forams if they become isolated with restricted circulation, while shelf areas may have rich planktonic faunas if currents sweep the forams over them from adjacent deep water. At this point it is useful to define some of the terms used in describing water depth. The neritic zone extends from the shore to the shelf edge and ranges from 0 to about 200m in depth; it is often subdivided into littoral (intertidal), infralittoral (0-75m) and circalittoral (75-200m). Beyond this is the continental slope, with bathyal depths (200-2000), and finally the abyssal plans (>2000m). In the case of the Globigerina Limestone, the planktonic forams taken on their own would probably indicate bathyal depths, as John Murray originally suggested. However, it is important to use evidence from as many sources as possible; for the moment then the evidence indicates an offshore environment of deep water. The composition of the benthonic foraminiferal fauna will now be examined. The dominant forams are species of *Uvigerina* and *Nonion,* genera typical of circalittoral and upper bathyal depths. It is also possible to examine the types of benthonic forams present. There is a complete absence of larger forams, which probably rules out depths of less than 50m. Benthonic forams can be divided into three major groups, depending upon the structure of the shell wall. These are hyaline, where the shell is glassy in appearance and may be transparent or translucent; porcelaneous where it is opaque and looks like shiny porcelain; and agglutinated when the shell is composed of sedimentary particles cemented together. The proportions of these different types vary according to the environment. The forams of the Globigerina Limestone are dominantly hyaline, with a few agglutinated forms. This is usually taken to indicate neritic conditions. Thus the benthonic forams suggest circalittoral depths. It is probably safer to attach more weight to evidence from benthonic fossils than planktonic, because the latter can be carried by currents to exotic environments, i.e. places where the animals did not actually live.

The ostracods are also useful for determining palaeoenvironments, and as with all fossils used for this purpose, it is important to decide whether they are *in situ* or have been transported from another environment. Because of their small size microfossils act similarly to sedimentary grains, so transportation is common. Ostracods, like all crustaceans, grow by moulting, so if larval carapaces are present as well as adult males and females this is usually taken to indicate a low probability of transportation. Using this criterion, the common species such as those listed on Fig. 1 would seem to be *in situ,* i.e. they are preserved in the environment in which they lived. The species and genera listed for the Globigerina Limestone on Fig. 3 are mostly typical of neritic environments. There is a

lack of shallow coastal species and genera, and *Oblitacythereis* is normally associated with bathyal or deep circalittoral depths. It is a member of the pyschrosphere, the benthos found in the colder and deeper waters of the oceans at the present day. However, all the other ostracods belong to the thermosphere, warmer waters shallower than 1000m where conditions are much more changeable. Thus the ostracods indicate a deep circalittoral environment some distance from the shore line. Thus if all the evidence is put together, we can picture an area towards the edge of a neritic platform, 150-200m deep. The rich planktonic fauna must have been swept onto this platform from deeper areas out to sea.

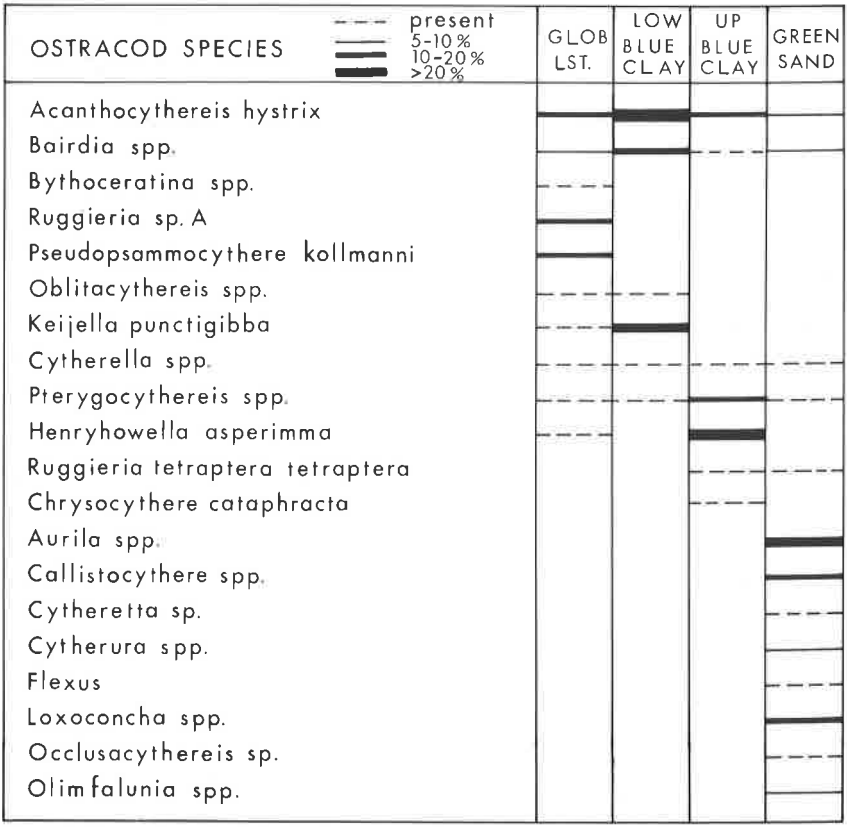

Figure 3. The stratigraphical distribution of some characteristic ostracod species.

There is a great difference between the faunas of the Globigerina Limestone and the Greensand. In the latter there are abundant larger forams typified by *Heterostegina*, and amongst the smaller forams the planktonics constitute only 40-45% of the fauna. The smaller benthonic forams contain different genera, with shallow water forms such as *Elphidium* and *Cibicides*. Once again, hyaline genera are dominant. As can be seen on Fig. 3, the ostracods differ too, with many typical

near-shore, subtidal genera such as *Aurila* and *Callistocythere*. The benthonic forams and ostracods also show a great increase in diversity and abundance in the sediment, with something approaching 100 species of ostracods. This all indicates much shallower water, certainly less than 50m depth, near-shore, but still with a totally unrestricted access to the open sea because planktonic forams are still common.

No reference has been made to the macrofossils or sediment in this short report. This is intentional because the aim has been to demonstrate the ways in which microfossils have helped our understanding of Malta's geology. However, just as "no man is an island", so no single branch of geology should be considered in isolation, and any coherent synthesis will use evidence from all relevant parts of the subject. But that is another story . . .

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BOOK REVIEW

Scotland's Environment during the Last 30,000 years. 1983. R. J. Price. Scottish Academic Press, Edinburgh. 224pp. 86 figs., 16 photographs (including a coloured frontispiece), 6 tables. Hardback: £27.50. Paperback: £15.00.

This attractively-produced book gives a clearly-presented picture of Scotland's environment during the last part of the Quaternary period. It is based on research published by numerous writers (including the author) between 1960 and 1982 and, in addition, includes a summary of earlier views expressed by such 'giants' of geological research as Archibald and James Geikie, Louis Agassiz and T. F. Jamieson.

An introductory chapter, in which the present physical environment, palaeoenvironments, dating of Quaternary environmental changes, the history of research into Scotland's environmental changes and Quaternary environmental changes within the NE Atlantic Ocean are discussed, is followed by a summary of conditions in Scotland during the period of the Quaternary that extended from about 130,000 to 30,000 years before present (bp). The third chapter comprises a brief discussion of the nature, build-up, retreat and down-wastage of the last major ice-sheet, which may have existed in Scotland between 27,000 and 14,00 bp, whilst the landforms and deposits that resulted from the ice-sheet are considered at greater length. In the fourth chapter, the Lateglacial period, extending from *c* 14,000 to 10,000 bp and the subject of the most extensive and intensive Quaternary research in Scotland during the last 20 years, is discussed in great detail. This chapter comprises more than one-third of the whole book. It includes a three-page table listing radiocarbon dates for organic matter from Scotland and consideration of the chronology of the Lateglacial Interstadial (*c*14,000-11,000 bp) and the Loch Lomond Stadial (*c* 11,000-10,000 bp), together with the landforms and sea levels, vegetation and soils, fauna and climate of those periods. Similar aspects of Scotland's environment during the early Postglacial period (*c* 10,000-5,000 bp) are considered in Chapter 5, emphasis being on landforms and sea levels, and vegetation and soils. In the penultimate chapter, the time-span discussed is from *c* 5,000 bp to the present day. The emphasis is on vegetation and soils but landforms and sea levels, fauna and climate are also considered. In the final chapter, the magnitude and frequency of environmental changes are examined in retrospect and prospect.

A major advantage of this book compared with some recent 'review' articles on the Quaternary in Scotland, is that it presents a balanced, unprejudiced statement of the results of Quaternary research in the country during the last 20 years. It is highly recommended as reading for both the specialist and the more general reader who is interested in Scotland's recent geological history.

W.G. Jardine

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