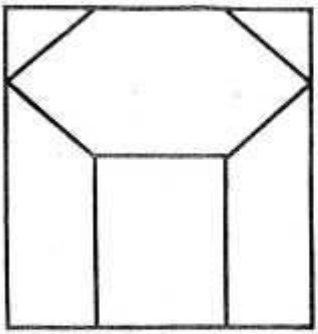

Geology

In Northern Ireland

NO 1 JUNE 1979 30P

CONTENTS

Geology in Northern Ireland

Here is the first issue of what I hope will be a varied and interesting newsletter of Northern Irish geology. There will be three issues a year, in January, May and October, and the subject matter will be anything geological. There are an increasing number of people, organisations and companies interested in geology, and an increasing number of spheres in which geology has an influence. Perhaps this newsletter may help to bring them all together.

Future issues will continue to have news about societies, lectures and field trips, and information from the Ulster Museum, Conservation Branch, etc. There will also be series on the Mourne Mountains and the teaching of geology, articles on applied geology, research being undertaken, etc., etc. Letters or articles from anyone on any geological topic will be very welcome.

My thanks go to Robert Hood for designing the cover and to Sean Watters for the photography. The authors of the present articles deserve special thanks for their prompt production of their articles, and many others, too numerous to mention, gave me encouragement and advice. Particular thanks are due to Mrs. Liz Venard for typing many of the manuscripts and to Miss Lillian Grigg, of the Ulster Museum Geology Department for typing the finished pages.

Ian S. Johnston,
Geology Department,
Queen's University,
Belfast.

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The Belfast Geologists Society

The society welcomes anyone who is interested in geology. No standard of achievement is expected. The annual subscription is £1. Enquiries to Mr. H.S. Black, M.A., Hon. Secretary, Belfast Geologists Society, 'Shanvarna', 6 Gibson Park Avenue, Belfast, 6.

The Society's summer field excursion programme includes:-

May 26-27th	Dalradian Structures of N.W. Donegal.	Dr. T.B. Anderson
June 9th	The Cushendun Area.	H.E. Wilson, M.Sc.
June 23rd	The Giant's Causeway.	Dr. J. Preston
September 8th	The Granites of Tyrone.	A.E. Griffith, B.Sc.
September 22-23rd	The Sligo Basin.	R.E.H. Reid, B.Sc.
October 6th	Clogher Head.	Dr. T.B. Anderson
October 20th	Late glacial features around Slieve Gullion.	H.S. Black, M.A.

H. Black

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GEOLOGY AND NATURE CONSERVATION IN NORTHERN IRELAND

Joseph S. Furphy

There is no standard definition of the term 'nature conservation', but one which would receive general acceptance is 'the wise (planned) use of the natural resources so that neither the resources nor man suffer as a result of their exploitation'. With regard to the floral and faunal components of the environment, such a definition is reasonable, but when considering geology it is at once apparent that a different set of parameters apply. In order to locate and describe geological features it is frequently necessary to eliminate flora and fauna, and there is also a continuing need to prevent the natural processes of plant colonisation obscuring significant exposures on cliff and quarry faces. It is also often desirable, and in some cases essential, to continually remove samples from certain sites for research and teaching purposes.

Two or three decades ago few renowned geological sites were under threat, but recently several pressures have been building up, resulting in the general realisation that practical conservation measures are called for lest some sites lose their value, or even disappear. Among the most obvious threats are dumping in quarries, reclamation of agricultural land, afforestation, quarrying of critical exposures, development of land for industrial or domestic building, and excessive sampling of fossils and minerals. These pressures are becoming more manifest at a period when there is also a marked increase in the demand for sites for study purposes as the needs of examination syllabuses are met.

But sites do not need to be conserved solely for the purposes of education. Many locations are of great value to the research worker, and still others have a great significance in the public eye - the Giant's Causeway being our prime example. Public interest in matters geological is increasing at a fairly fast rate - spurred on by the stimuli of television programmes and the series of maps and memoirs published by the Geological Survey.

Conservation measures therefore have to take account of the potential users of the sites as well as their inherent natural qualities, and the threats to them. Geological conservation would therefore seem to merit its own definition, which would be on the lines of 'geological conservation is the wise use and maintenance of those geological localities which are of importance for the purposes of research, education and enjoyment by the public'.

This leads on to consideration of the methods of conservation to be adopted, and more directly to the selection of sites to be conserved. As a first step,

it is desirable that representative samples of all the major rock types, minerals and structures be included on protected sites. Before final selections are made, there have to be literature searches as well as inspection of the possible localities on the ground. In selection, many factors have to be borne in mind, including current land ownership and the attitude of the owner, ease of access, vulnerability to threats and relation to other conserved sites.

Geological conservation has many inherent contradictions, and one of these revolves around fossil localities. Fossils are of considerable attraction to geologists and non-geologists alike, for scientific and acquisitive reasons, and consequently several localities are extensively worked over. In the case of those places with rare fossil faunas, what procedures should be followed in order to maintain them as viable sites? If details of a site are published in journals, or if a site becomes a nature reserve with attendant publicity, it is all too likely that the site will be all the more ruthlessly exploited, despite whatever regulations are invoked to control such activity. On the other hand, if details are not divulged, the site might be lost through a drainage scheme or some form of development. In practice, a list of critical fossil localities is kept by Conservation Branch of the Department of the Environment, and not divulged to any outside party. The sites on the list, which is not exhaustive, are monitored so that there can be advance warning of any potentially harmful developments. This method of conservation is non-statutory, and is basically weak; it is the lowest form of control.

Because of the increased number of planning applications relating to mineral abstraction and general quarrying, there is now a small team in the Planning Division of the DoE dealing with these applications. This team considers the nature conservation aspects of applications in the same way as they do visual factors, and this can be considered as the next lowest level of conservation.

Where the conservation value of a site can be maintained by the exercise of a measure of planning control, the site can be notified as an Area of Scientific Interest (ASI). All planning applications in ASIs are referred to Conservation Branch for observations, and in turn the Branch may consult the Nature Reserves Committee, the advisory body established under the Amenity Lands Act (1965) to provide such advice to the Department. To date, several geological type localities and structures have been notified as ASIs, and in general this form of protection is adequate.

The highest form of protection is that of nature reserve. Inside this broad heading there are several subdivisions - the National Nature Reserves (NNRs) owned or managed by Conservation Branch which are the best-known examples of habitats, localities of extremely rare plants or animals, of internationally important geological features or any combination of these aspects; Forest nature reserves which are sites of lesser significance on Forest Service land often with high educational potential and which are managed with conservation and not economic forestry as the primary objective; and nature reserves managed by voluntary bodies.

In general, it is the intrinsic scientific value of a site which has led to its becoming NNR, but in one case a secondary aspect is highly significant. This is the Portrush NNR, which includes portions of the Portrush sill and the indurated Liassic shales, but which is of international significance because of its role in the Neptunist versus Vulcanist controversy. The NNR adjoins the Portandoo Countryside Centre, where further information can be obtained from the Warden or his staff. (Phone Portrush 823600). On the NNR all sampling is forbidden; past excesses have seriously depleted the scientifically valuable ammonites.

Kebble is the westernmost townland on Rathlin Island, and was established as NNR for its seabirds and grassland habitats as well as its geology. Here the geological interest is in the cliff faces, which display several lava flows

and interbasaltic horizons, and in the caves; wave-cut platforms and seastacks. During the summer months a warden is in residence, and his advice must be sought before visits are made to the cliff-tops - certain areas are out-of-bounds during the bird nesting season in order to avoid disturbance to the vast seabird colonies; access to the cliff faces is not allowed at any time. Certain other cliffs on Rathlin are owned by the Royal Society for the Protection of Birds; the Kebble warden will advise on visiting conditions.

In the Fermanagh limestones there are three NNRs with a high geological content. Hanging Rock, near Lower Lough Macnean, is a knoll reef with a vertical cliff, up which access is not permitted, and below which there is scree and woodland on clays. Nearby the Marble Arch Forest NNR includes a riverine gorge as well as the karst feature which gives the site its name; there is also the entrance to an extensive cave system. The NNR at Crossmurrin, off the Marlbank Scenic Route, is primarily a grassland reserve, but it also includes some poor limestone pavement. A fourth NNR in Fermanagh with a geological interest is Correl Glen Forest NNR, with its sandstones as well as limestones. For information on any of these NNRs, contact should be made with the Warden at Castle Archdale Country Park, phone Irvinestown 588.

The disused quarry outside Lisburn known as Belshaw's Quarry was acquired by Conservation Branch as a NR (not strictly in the National series) primarily for educational use. Displaying several rock types and structures typical of South Antrim's geology, one chalk face was blasted in order to provide fresh material for school parties to work over and thus avoid damaging another more critical face. This is one of the very few positive steps that have been taken to facilitate geological education, partly due to the pressures to acquire the several sites of undoubted NR or NNR status in other aspects occupying much staff time; this is true of the voluntary bodies as well as the government agency.

The National Trust, in its North Antrim properties, owns internationally important geological sites such as the Giant's Causeway, Fair Head and Murlough Bay. Among other sites of very high local significance are Carrick-a-rede with its volcanic vent and the fossiliferous site of Whitepark Bay.

Conservation through nature reserves alone is not enough, because for several reasons most geology will be taught in more familiar, less dramatic and more convenient localities. There will be a need to ensure that all such sites are not destroyed either through overuse or development. It is also true that some NRs are not capable of withstanding large numbers of visitors, with or without hammers, and for this reason too conservation outside NRs is vital. Information on places which are suitable for educational use are contained in a booklet entitled 'Field Study Sites in Northern Ireland' published by the QUB Teachers' Centre. This booklet also gives general information on organising field trips, etc., and lists the relevant organisations.

As a good conservation principle, a code of conduct for geological visits to all sites should be observed. Basically this code of conduct is: observe the Country Code; ensure that permission is obtained before visits are made; desist from unnecessary hammering of outcrops; inform relevant bodies if a site is damaged or threatened, or if any new sites are discovered. It is also desirable to join an organisation dealing with conservation; the recently-formed Ulster Trust for Nature Conservation (Secretary J. Forsyth, 24 Malone Park, Belfast) is the most relevant, as one of its activities will be the establishment of reserves with education as a principal role.

Conservation Branch (Hut 1, Castle Grounds, Stormont, Belfast, BT4 3SS, phone 768716) is the government body responsible for geological conservation; further

information on all aspects can be obtained from it. All exchange of information and ideas is valuable in that the end product should be the maintenance of an environment for succeeding generations to enjoy and to use for research and education.

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THE ULSTER MUSEUM GEOLOGY DEPARTMENT

P.S. Doughty

Formed in 1970.

Keeper	Philip S. Doughty
Assistant Keeper	Rab Nawaz
Museum Assistant	Kenneth James
Scientific Officer	John Wilson
Secretary/Typist	Mary McTear

Collections.

The Department houses approximately 100,000 specimens. The earliest date from the late 18th century and all aspects of Ulster collecting throughout the 19th century, local and international, are reflected in the specimen collections. The 20th century, with the decline of the amateur collector and the dominance of the professional, has seen a gradual change of emphasis and balance.

The mineral collection, some 10,000 specimens, is international and one of the finest in the U.K. provinces. It has particular strengths in quartz minerals, carbonates, and zeolites, and one of the most important mineral garnet assemblages in the world. About 1,000 mineral species are present in the collection and current purchasing policy is constantly increasing the number.

The fossils form by far the largest part of the collection and they are predominantly Irish, with a smattering of quality display specimens or specimens of special interest from the rest of the world. There are moderate holdings of type, figured and cited specimens, including Portlock material from Tyrone, Tate material from Co. Antrim, Swanston graptolites from Co. Down and Olaloye's collection from Co. Fermanagh. With the rising concern now being expressed about specimen security and curatorially staffed repositaries, increasing quantities of published research material are also being deposited. The major collections will be treated individually in later issues of the Newsletter.

The petrology collection is essentially Irish with about 5,000 specimens but in addition there are small collections of meteorite and tektite material, larger collections of glacial erratics, as well as sedimentary phenomena in variety, including a wide range of concretions.

The gemstone collection is by far the finest in Ireland and about the fifth most important public collection in the U.K.

A collection of around 1,000 early geological photographs is centred around the Welch Collection of plate negatives.

There is an interesting collection of early books and maps. Copies of Burnett's "Sacred Theory of the Earth", 1st editions of James Hutton's "Theory of the Earth", Charles Lyell's "Principles of Geology" and Murchison's "Silurian System" are among the bibliographic treasures and William Smith's "Geological Map of England and Wales" and three editions, including the first and last, of Griffith's "Geological Map of Ireland" among the cartographic.

The Department has a working library of several hundred volumes including periodicals and over a thousand reprints but there is no lending facility.

Displays.

The galleries have expositions of geochronology, the place of the earth in the universe, the origins of life, inheritance, evolution, fossilization, the variety of life, the historical geology of Ireland and Irish landscape.

At the present time work is in progress on the mineral and gemstone exhibit which will complete the first phase of long term displays.

The Department also mounts temporary exhibitions circulated by the Institute of Geological Sciences. A major problem in science generally and geology in particular at the present time is the dearth of popular public touring exhibitions of any kind. To the scientist outside museums this may seem a relatively minor matter of small import, but government currently tends to regard the arts and culture as synonymous, and scientific culture's failure to make impact is to some extent due to its inability to mount provoking exhibitions to match those in recent years of antiquities and fine arts.

Research.

The museum serves the needs of a variety of research workers and conducts limited research programmes of its own. The specimen collection is, by far, the finest Irish collection available, and it is now likely that even if the national collection in Dublin were unpacked, (an unlikely eventuality) it would remain so. It is by no means comprehensive, but present curatorial effort, and the goodwill of research workers active throughout Ireland, is resulting in rapid expansion in a variety of fields

Every specimen in the mineral collection is now catalogued and its record computerized, and although current printout is being checked and revised, the indexes, even in their present form, are powerful research tools. One obviously fruitful line, awaiting a mineralogy of Ireland, is the geographic index showing minerals with museum voucher specimens for the counties of Ireland, both the Republic and the North, but indexes under mineral name and collector are also available and a large number of special searches possible. When all records are checked a catalogue with indexes of the mineral collections will be published but this cannot now be before 1980.

Research projects are well advanced on Northern Ireland zeolites and on the Carboniferous rocks around Armagh, Loughgall and Benburb. Some work is also in progress on the history of geology in Ireland involving major figures such as Portlock, McCoy, and Lord Cole, and a variety of lesser known but significant figures in the emergence of Irish geology.

The technical demands of most visiting research workers can be met within the museum, and x-ray diffraction and fluorescence will be possible shortly from museum resources.

Services.

The traditional identification service for geological specimens remains an important aspect of work and each year the Department copes with hundreds of enquiries. Most are handled by the Staff but where appropriate or necessary they are re-directed to colleagues in the Institute of Geological Sciences, university departments, or the major national museums. The service ranges from simple information about a handful of holiday rocks to detailed identification of school collections. Large private collections are treated differently and usually collectors are offered facilities in the Department to perform the work themselves.

Arising from the special position of museums and their appreciation of identification problems facing amateurs, work is progressing in the Department on the preparation of a guide to the fossils of the Carboniferous Limestone of the British Isles, in collaboration with the Palaeontological Association. The book, intended to resemble the Peterson Field Guides in final format, is in the early stages of preparation, but should figure around 600 species.

There is no education officer in the Department, although groups preparing for G C E "O" and "A" level practical examinations are given crash courses showing the material on their syllabuses in a diversity that a school could not offer. There is no other education service offered to schools. The only additional educational activity in the Department is a regular winter series of classes for adults undertaken in collaboration with Queen's Extra-Mural Department.

Occasional ventures include prestige lectures by well known scientists on geological subjects, field excursions open to a wider public, geological bus tours around routes of outstanding interest, programmes of geological films and some experimental presentations such as readings from general and geological literature accompanying the projection of outstanding slides of rocks, fossils, minerals and the landscape.

There are a small number of specially prepared information sheets on sale as well as postcards, and photographs from over 700 early glass plate negatives on geological subjects can be prepared to order as can photographs taken from specimens in the collection.

The possibilities offered by the collection are too numerous to list and many of the demands though initially appearing unconventional are perfectly valid in context. In other words if you think we can help, don't be afraid to ask.

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THE GEOLOGICAL SURVEY OF NORTHERN IRELAND

A.E. Griffith

Following the Department of Commerce's decision, early in 1978, to fund further deep drilling in search of minerals the planning and execution of the first phase of the exploration programme has dominated the work of the Geological Survey. Even though the drilling programme has occupied most time the other functions of the Geological Survey in advising government departments on hydrogeological and major civil engineering schemes together with the preparation of maps and memoirs for publication has continued.

The first borehole in the deep drilling programme at Killary Glebe [H 86946788], near Coalisland, was spudded in on 11 December, 1978 and drilling continued till the 5 January, 1979. Four coal seams were penetrated in the Carboniferous strata at depths below 1040 metres but as these were not thick enough to justify exploitation and the strata underlying them are known to be unproductive elsewhere in County Tyrone, the hole was abandoned at a depth of 1152.7 metres.

Following the completion of the Killary Glebe hole the drilling rig, owned by Kenting Drilling Services of Nottingham and Calgary, was ready to move to the next site at Ballymacilroy near Ahoghill on the 10 January, 1979. However, on that date one of this winter's blizzards began with the result that the large articulated vehicles, with some £600,000 worth of drilling rig on board, were unable to be moved in safety and the borehole was not, in fact, spudded in until

19 January, 1979. Work on the Ballymacilroy borehole continued until 17 March, by which time it was, at 2272m, the deepest borehole ever drilled on land in Ireland. Disappointingly no coal seams were encountered.

The borehole sites at Killary Glebe and at Ballymacilroy, were chosen on the basis of work which was carried out by the Geological Survey of Northern Ireland and commercial companies since 1947. In the late 1940's and throughout the 1950's the Geological Survey supervised an extensive drilling programme in the Coalisland and Ballycastle areas to assess whether any workable coal seams were still available for exploitation. In Tyrone this work established that although comparatively small quantities of coal remain in the Coalisland area no coal bearing strata existed immediately to the north or to the south of the main coalfield. However, attempts at finding coal bearing strata to the east of the Drumkee Fault, which limits the known coalfield on its eastern side, proved inconclusive. In one borehole, in Dernagh townland, a thin sequence of Coal Measures strata was encountered at a depth of 885 metres. Although traces of coal were recorded in this sequence no major seams were identified and the hole was abandoned at a depth of 939 metres. Even though no economic coal seams were found this hole demonstrated that, at least in places, coal measures do occur beneath the Tertiary basalt lavas and Mesozoic sedimentary rocks which blanket much of north eastern Ireland.

Following this drilling programme and drilling at localities in Antrim and north Down the Department of Commerce commissioned, in 1959-60, gravity and aero magnetic surveys of the whole of Northern Ireland to aid further mineral exploration. The main result of the gravity survey was to confirm the existence of a number of areas in which thick sequences of sedimentary rocks were likely to occur below the basalt lavas in the north-eastern part of the Province. Interestingly, the existence of these sedimentary basins had been suggested many years earlier, on purely geological grounds, by Mr. W.B. Wright of the Geological Survey of Great Britain.

Following the geophysical surveys deep boreholes were drilled at Larne in 1962-3, at Magilligan in 1963-4 and at Port More, near Ballycastle, between 1965 and 1967. Although thick salt deposits were discovered in the Larne borehole only two thin coal seams were found at depths of over 1142 metres in the Magilligan borehole. Consequently, the problem of whether Carboniferous rocks, possibly containing coal and/or natural gas, exist at depth in at least some place beneath the post-Carboniferous rocks of north-eastern Ireland, particularly in Antrim and the eastern parts of Londonderry, Tyrone and north Armagh still remains unanswered. The drilling of the Killary Glebe and Ballymacilroy boreholes was another step towards elucidating the deep geology of Northern Ireland and although no economic coal reserves have been proved the possibility still remains that coal and/or natural gas exists in deeply buried strata below the post-Carboniferous rocks of north-east Ireland.

The results of both boreholes are currently being written up and it is hoped to publish preliminary accounts within the next 6 weeks.

Before Christmas the Causeway Coast Memoir was published. This memoir, unlike other geological memoirs in the United Kingdom, is available in two volumes and describes the geology of the area covered by the one-inch geological map Sheet 7. The reason for departing from the traditional style of memoir in one volume was to try and make available, in terms intelligible to the interested layman as well as to the professional geologist, an account of the geology of the Causeway area which sold at a reasonable price. An H M S O brochure giving details of the publication is enclosed with this newsheet.

Since Christmas three geological maps have been published. These are the first of the new series of 1:50,000 geological sheets for Northern Ireland and are available

in either folded or flat editions. The flat, colour printed edition costs £1.35 and the folded map with a glossy cover costs £1.45. All are obtainable from the Ordnance Survey, Ladas Drive, Belfast, BT6 9FR. The sheets which have just become available are Omeroy Sheet 34, in solid and drift editions, and the new composite map covering the Mourne Mountains which includes parts of four of the original Geological Survey of Ireland sheets. The latter map has, in addition to a generalised geological account of the area an itinerary of suggested excursions which should provide a representative picture of the geology of the sheet.

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'O' LEVEL GEOLOGY FIELDWORK

R. McMurray

The importance of fieldwork as an inherent part of the subject should be emphasized to the students and a good basic training in observation, and interpretation of these observations in the field, should be encouraged. The following article presents one system for tackling 'O' level fieldwork and suggests possible routine procedures to be followed at the selected locations. No doubt a number of teachers have their own method of approach and are perfectly happy with it; but others may be glad of an opportunity to have some set pattern for tackling the exercise.

The N.I.G.C.E. Examinations Board for Geology make the following points in their supplementary notes on the 'O' level syllabus. (i)

1. The field notes are based on a practical application of geological knowledge and as such are considered an important part of the course. Although no specific percentage of the total marks will be allocated to it, the field note books may be used by the examiners in deciding the actual grades awarded in the examination.

2. It should be stressed that the examiners shall receive the actual notebook (hard covered note book of suggested size about 4" x 6") used in the field - not a fair copy written up subsequently.

3. Work carried out on material (e.g. identification of faunas) may also be included and is covered under the note on "ancillary practical work".

4. Attention is drawn to the fact that examiners do not wish to see evidence of laboratory work other than that supplementary to the fieldwork.

5. The fieldwork at ordinary level is not intended in any way to be independent project work. The object is that pupils should be trained to observe, and to interpret their observations by the teacher in the field.

6. It is difficult to be catagoric about the time spent on fieldwork, for clearly the more experience a pupil has in the field the better. Teachers should therefore encourage pupils to go out and discover for themselves during their own time. However, perhaps a not unreasonable minimum of fieldwork under supervision (for submission to the examining board) which the panel would expect is three half days per year, i.e. three days for the course.

7. An aspect of fieldwork that the panel feels strongly about is that with the principle of uniformitarianism in mind, pupils must receive some

demonstration on modern beaches to show features of the shoreline, recent sediments and sedimentary structures, unconformities, faunas, etc., and to think in terms of the modern environment, these should then be related to similar features seen elsewhere in the rock succession in Northern Ireland.

In the same document there is a note on field behaviour and every teacher should endeavour to ensure that all field work is carried out according to the recommendations given.(i)

The suggested programme to utilize at each field location is as follows, and is designed to tie in with the above points in a practical situation. Before particular sites are visited it would be desirable that the pupil had been taught the relevant theory relating to the field phenomenon he is going to see. For example it would be feasible to tell the class to read their notes on sedimentary structures, cross bedding, etc., before a field trip to Scrabo.

In the field notebook the pupils will be expected to record the following:

1. Draw a diagram of a selected outcrop and label fully all the relevant information that is observed. The pupils are made aware of the fact that not all of them will observe and record the same details; some naturally will be better at picking up important details while others will miss the obvious. All should be encouraged and prepared to "give it a chance" and make the effort to go about the field work in a routine and scientific manner. Normally the pupils will draw and label diagrams and note only what they see before any guidance is offered. A sketch diagram of the whole area should initially be attempted and as much detail noted as possible. From this master diagram a few specific sites can be selected to be studied in more detail. For example, when visiting Belshaw's Quarry a general sketch is made first of all, to show the chalk/basalt relationship and also to pick out any details the pupils may observe. This is then followed by a closer look at the dyke, fault and flints in the chalk, at points in the face of the quarry. Careful attention to scale should be made when drawing diagrams. Once they have observed and noted what they have seen at that outcrop a general discussion of all that is present can take place.

2. This leads to the recording of the observations in note form. The following list can be used at each location and hence the habit of noting the 'obvious' along with other observations will become second nature.

   a) rock type or types;

   b) any evidence of bedding, jointing, dip etc.;

   c) weigh up evidence;

   d) structures e.g. - current bedding
      - slump structures
      - folding, faulting and tilting;

   e) relationship between rocks i.e. intruded igneous into sedimentary, unconformities, etc.

   It is possible that some locations will present phenomena that the pupils have not yet met in classwork; in this instance the instructions and teaching takes place in the field and the pupil learns at first hand what is the cause of what he observes. In other instances and with practice he may be able to identify and recognize features quite easily, and unaided.

3. The next stage is to interpret what the observations tell and this may take the form of a geological history for the location, which notes the events in order of happening. This section may be included with the note on observations but scope may be possible for relating in more detail to any specific problems encountered at this stage.

4. The collection of some samples (fossils, rock types, etc.) may lead to ancillary practical work being carried out later in school. The specimens collected in the field provide the basis for the study, and diagrams/descriptions can be made at a later date.

5. Another section which I think beneficial to include in the note book after the field trip is a 'reference to text' note. This includes the relative age of the rocks and what 'should' be found in some locations. The pupils have access to the N.I. Regional Geology pamphlet (ii) and, although much more detailed in places than they need, it provides a good reference for them to glean further information of the geology studied. The environments of deposition for particular rock types can be described and hence a full picture of the geology of the area noted. This section must not be too long as it is only meant as a conclusion to the previous field work section.

Having used this system over the last couple of years I feel that most of the requirements noted in the introduction are met. All the observation and recording is done in the field and only the ancillary practical and reference to text are noted at a later date. The main aim is to train the pupils to observe and interpret those observations in the field. It is also important that the records they make, by diagrams and notes, should be clear and tidy so that future reference to field sketches and notes can be trusted to provide accurate data on specific locations. Not all the notebooks turn out as one might wish, but most of the pupils are guided to follow a definite pattern of enquiry for each location studied with the hope that they will develop and practice observation and recording techniques.

NOTES

Equipment:

1. At this level the notebook is the most important item to be carried.
2. One hammer in the charge of the teacher is all that is necessary; especially with regard to conservation in some of the more popular sites. (i)
3. Sample bags or some means of carrying the rocks back to school.
4. Hand lenses: a few per group.
5. O.S. map and geology map of the area can be useful in the hands of the teacher. (iii)

Some 'O' level sites in Northern Ireland

Most of these sites suit the Belfast area, and the list is by no means comprehensive but offers a good starting point. Hopefully in other parts of the province comparable sites may be found. Ref. No. (iii) is useful in this context.

Belshaw's Quarry - chalk, lava flows, dykes, fault;

Scrabo - sandstone, sedimentary structures, sills, dykes;

Coalpit Bay - fold, dyke;

Blackhead - lava flows;

Any sandy beach for structures.

References:

(i) N.I.G.C.E. Examinations Board: Geology: 'Supplementary Notes on ordinary level syllabus'. Obtainable from The N.I.G.C.E. Examinations Board, Beechill House, 42, Beechill Road, Belfast, BT2 4RS.

(ii) "Regional Geology of N.I.". The Geological Survey of Northern Ireland, H.M.S.O., Belfast.

(iii) "Field Study Sites in Northern Ireland", edited by P.M. Thomlinson. The guide was produced by a group based in the Q.U.B. Teachers' Centre.

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SAND DUNES - A SCARCE AND FRAGILE RESOURCE

R.G.W. Nairn

The study of Quaternery sediments has traditionally been the area where the interests of geologist and geomorphologist overlap while within this period, coastal sand dune systems have provided equal attraction for both the earth scientist and the ecologist. The basic fact that dune building in this country is dependent on plant growth, illustrates the point that the study of sand dunes is the study of a whole environment. In a sand dune system geology, geography and biology cannot be divorced from one another; a study of one aspect demands an understanding of the others.

This concept is all too often overlooked not only by students but also by the planners and managers of coastal dunes. There is, unfortunately, ample evidence of this in Northern Ireland where, at many coastal resorts, sea walls and promenades have been built between beach and dunes, disrupting the natural recycling of materials between them. The causes of many of our present problems of beach and dune erosion can be traced back to earlier 'coastal protection' works which effectively cut off the supply of sand on which stability depended. There is, around our coasts, a finite amount of re-worked glacial sediments and any extraction of this from beach-dune systems must be seen as detrimental to the coastline as a whole. More often than not, the dominant factor in dune erosion problems is the ever-increasing recreation pressure on these areas. Footpaths and vehicle tracks quickly break down the thin vegetation cover, exposing bare sand to the wind.

Various methods have been employed to restore badly eroded sand dunes. The best-known of these are probably sand-fences, designed to slow down the wind flow and cause it to deposit sand. In some cases, erosion has gone so far that the construction of a completely new artificial line of foredunes has become necessary, as at Newborough Warren in Anglesey (jointly managed by the Nature Conservancy Council and the Forestry Commission). Recent work on the Portrush dunes (Wilcock and Carter, 1977. Biol. Conserv. 11, 279-291) has shown that the regrading of a dune face can achieve rapid restoration of stability before such major and expensive dune reconstruction becomes necessary.

However, the restoration of dunes could never succeed without the specialized dune building plants, most important of which is marram grass. This remarkably well adapted plant has extensive root systems which bind the loose sand and it can tolerate a burial rate of up to one metre per year (Ranwell, 1972. Ecology of Salt Marshes and Sand Dunes). Attempts at planting marram grass have not always met with success. It is very dependent on a good supply of wind-blown sand, on the steepness and aspect of the dune face, on the method and timing of the planting and on the absence of disturbance once it is established. The planted marram grass is usually covered with a mulch of organic compost and/or thatched. Only two years after such treatment at the Portrush dunes, a number of other native dune plants had invaded the regraded dune giving between 60-90% ground cover (Wilcock and Carter, 1977).

Introduced plants and animals have also played an important role in the stability or instability of sand dunes. The area now occupied by Murlough National Nature Reserve, Dundrum is marked on the earliest known estate map, dated 1803, as the Great Rabbit Warren. Rabbits were, of course, introduced to this country by the Normans and several centuries later they were being intensively 'farmed' on coastal dunes, in much the same way that game birds are nowadays managed for shooting. Predators were severely controlled, other grazing animals were excluded and new strains of breeding stock were introduced into the wild population, all aimed at producing the maximum yield of rabbit fur and flesh. Records from the Dundrum estate show that in the year 1789, some 4,800 rabbit pelts were sent from there to Dublin for the fur trade.

Such densities of grazing rabbits must have produced a short grass sward on the inland dunes and massive instability on the seaward dunes. This instability would have been very much in evidence on the Murlough dunes around the end of the 19th century when the Marquis of Downshire introduced the thorny shrub, sea buckthorn here to prevent buildings near the coast being swamped by mobile sand. Apart from the original plantings, this too appears to have been controlled from further spread into the mobile dunes by the pressure of rabbit grazing, until about 1955 when myxomatosis decimated rabbit populations in Ireland. Many parts of the Murlough dunes, which were mobile sand in 1951, were already well vegetated by 1962 (as seen from aerial photographs).

W.D. Linton (1955. Unpublished B. Sc. Thesis, Queen's University of Belfast) working on the vegetation of the Murlough dunes in the early 1950's , noted the very large population of rabbits at that time and predicted the effects on the dune vegetation, of its imminent reduction. More recently, J.J. Kelly (1977, Unpublished M. Sc. Thesis, Queen's University of Belfast) has shown that the majority of the spread of the invasive sea buckthorn has taken place since myxomatosis. And it continues to advance year by year, covering new areas of open duneland with a dense, impenetrable scrub and short-circuiting the process of ecological succession from bare sand to woodland. Large areas of species-rich dune grassland have already been lost under monotonous stands of this alien plant.

The total conversion of the ecosystem by sea buckthorn is well illustrated by the breeding birds at Murlough NNR, which change from a limited number of species, dominated by ground nesters, to a dense community similar to that in deciduous woodland (Nairn and Whatmough, 1978. Irish Birds 1, 160-170). Coniferous plantations are another alternative in the stabilization of sand dunes. This has not yet happened to any extent in Northern Ireland but in the Republic of Ireland approximately 4,000 ha of the coastal zone (largely sand dunes) have been afforested (An Foras Forbartha, 1972. National Coastline Study). However, such forests are generally considered a poor commercial proposition and of course, they also radically alter the natural dune ecosystem.

Undisturbed sand dunes undoubtedly support some of the richest and most diverse natural communities of plants and animals in this country. The older the dunes, the greater the range of habitats which can develop, from calcareous foredunes to acid dune heath. Almost one-third of the Irish species of flowering plants and ferns have been recorded from Murlough NNR. Dune animals are equally diverse and specialized. Studies in Ireland are at an early stage as yet but by way of illustration, over 600 species of terrestrial invertebrates from ten different orders, have so far been listed from Murlough NNR. Protection of the very limited sand dune areas of scientific interest in Northern Ireland has recently been advanced by the declaration of two new NNR's by the Department of the Environment, Conservation Branch - at Magilligan Point and Ballymaclary (both in Co. Londonderry). Other areas are managed by the National Trust and a considerable area of sand dunes is under the control of the Ministry of Defence.

The area of sand dunes or aeolian drift in Northern Ireland, estimated by Kinahan and McHenry (quoted in Quinn, 1977. Sand dunes. Formation, Erosion and Management. An Foras Forbartha) at 1,712 ha is absolutely minimal. There is four times this area of sand dunes in Co. Donegal alone. Clearly such a scarce resource requires careful and integrated study leading to ecologically sensitive management.

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SPELEOGENESIS AND GEOLOGY IN FERMANAGH

G. Ll. Jones

The Upper Limestone of Fermanagh is of Lower Carboniferous age (Asbian Stage) and consists of the argillaceous Glencar Limestone followed by the shale-free, cherty Dartry Limestone. In the latter there is frequently developed a thick succession of mud-reef knoll limestones.

Although cave formation does occur in the Glencar Limestone, the presence of so much argillaceous material and the thin beds does not facilitate this. In the cherty facies of the Dartry, more cave formation takes place but the chert inhibits solution, causing increased collapse in the cave passages. The massive 'reef' facies however, with its mud-free lithologies, appears to encourage speleogenesis, producing Ireland's finest caves.

Massive 'reef' development occurs west and south-west of Enniskillen on Cuilcagh Mountain and Tullybrack Mountain (see fig. 1).

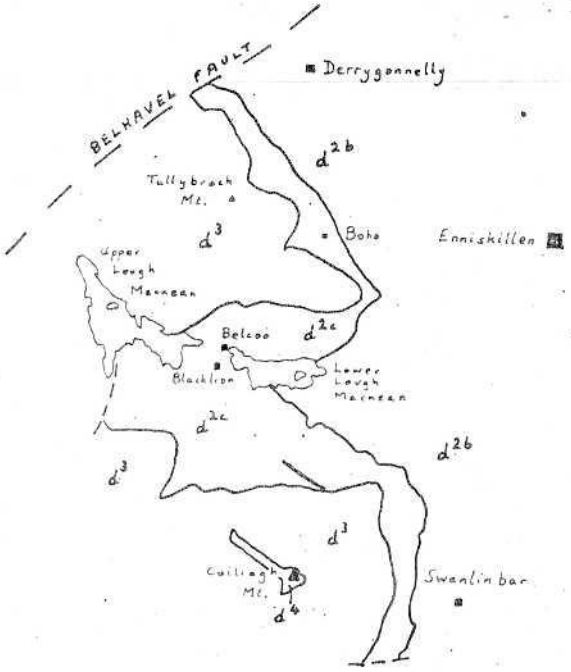


Fig. 1. Geology west of Enniskillen

The other requirements for cave development are also present here - sufficiently steep hydrological gradients and impermeable shale/sandstone caps on the mountains which concentrate the drainage into large streams. The cracks (in the otherwise impermeable rocks) through which initial seepage occurs are also present. In 'normal' cave-bearing limestones there are both horizontal bedding planes and vertical joints and faults, but the 'reef' limestone is poorly bedded. The water therefore descends immediately to a water table or other base level and the rest of the cave develops along the joints and faults, so that Fermanagh caves tend to have an L-shaped longitudinal section, as opposed to the usual step profile (see fig. 2).

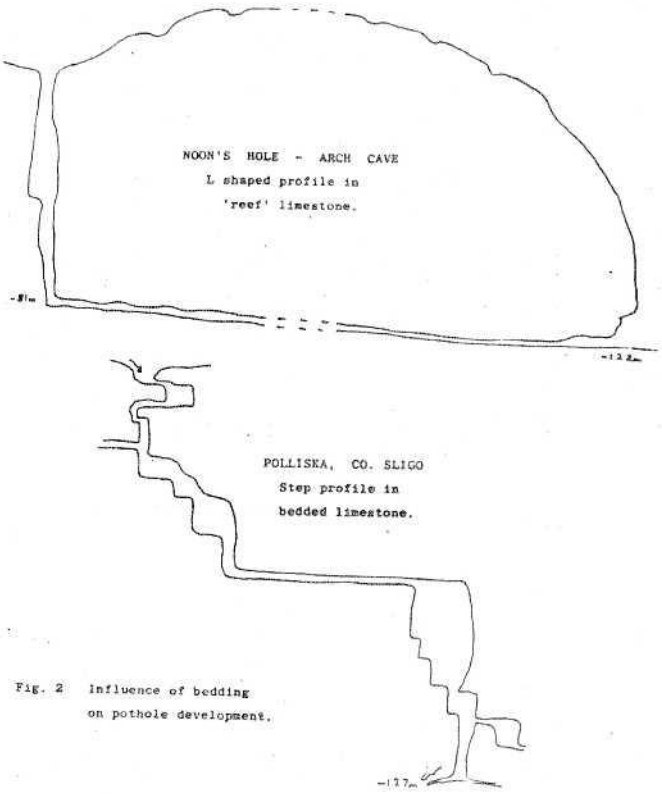


Fig. 2 Influence of bedding on pothole development.

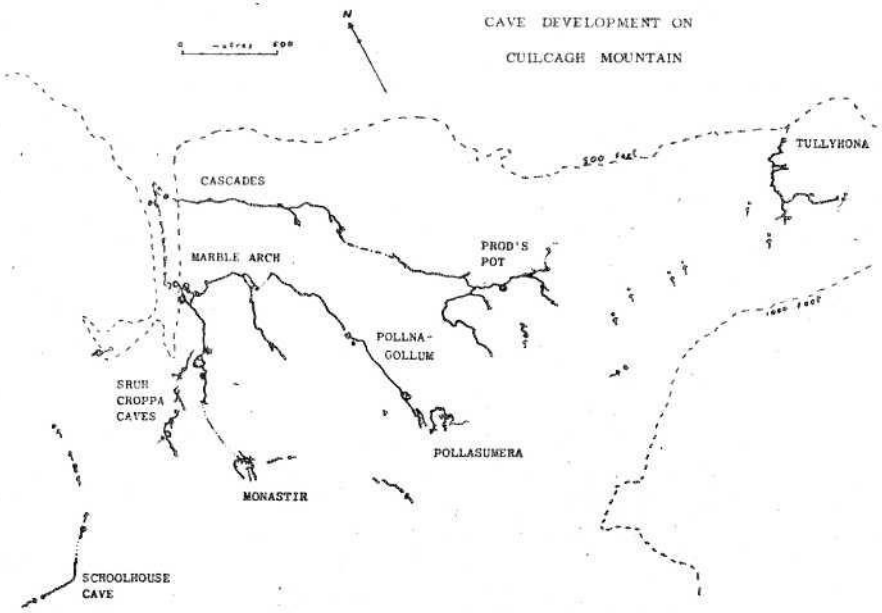
In the two 'reef' limestone areas near Enniskillen, extensive cave development has occurred and offers the best examples of the special characteristics of such caves to be found in Ireland or Britain.

The magnificent 3½ kilometre long mountain ridge of Cuilcagh (667m) bounds the remotest region in Northern Ireland. The north side of this wild upland is drained by three major rivers - the Aghinrahan, the Owenbrean and the Sruh Croppa. These disappear into spectacular swallow holes at the base of cliffs up to 35m high; they meet together underground and emerge as the Claddagh River - one of the largest springs in the British Isles. (see fig. 3.)

Fig 3

CAVE DEVELOPMENT ON

CUILCAGH MOUNTAIN



The courses of these underground rivers are accessible through Marble Arch Cave itself and also through many other cave entrances. There are over 7 kilometres of passages in this huge system, varying from small flat-out crawlways to magnificent river galleries, often 10m wide and high. The rock itself, being compact unbedded 'reef' limestone, does not form any flat roofs but gives rise to soaring archways with delicate pendants and sculptured buttresses. Frequently it presents a striking dappled appearance due to infilled cavities in the 'reef'. The turbulence of the rivers past and present has caused the rock surface to scallop with many small concavities.

Skirting around the east side of the Marble Arch system is the Prod's Pot/Cascades cave. Several tributaries converge near the base of the 60m deep pothole to form a lively river which runs west for nearly 2 kilometres. It passes through echoing chambers, beautiful streamways and silent sumps (completely flooded passages), before resurging in the side of the Claddagh Gorge at the Cascades Rising (part of the local water supply).

Further east again the Tullyhona resurgence cave is situated within a single 'reef' knoll. It is an exciting and picturesque cave guarded by a very tight squeeze at the entrance. To the west of Marble Arch there is still an area of continuing exploration where many caves wait to be discovered.

The Tullybrack Mountain caving area (see fig. 4) has a greater thickness of 'reef' limestone than the Marble Arch area. Entrances therefore tend to be deeper and the potholes often descend 80m before reaching a base level and thereafter following a gently inclined course.

The magnificent systems of Noon's Hole/Arch Cave and Reyfad/Pollnacrom are major undertakings for the potholer due to the seriousness of descending these sombre shafts. Their tinkling streams can quickly turn into thundering cataracts to trap the unwary explorer. The horizontal passages are impressive in their grandeur -

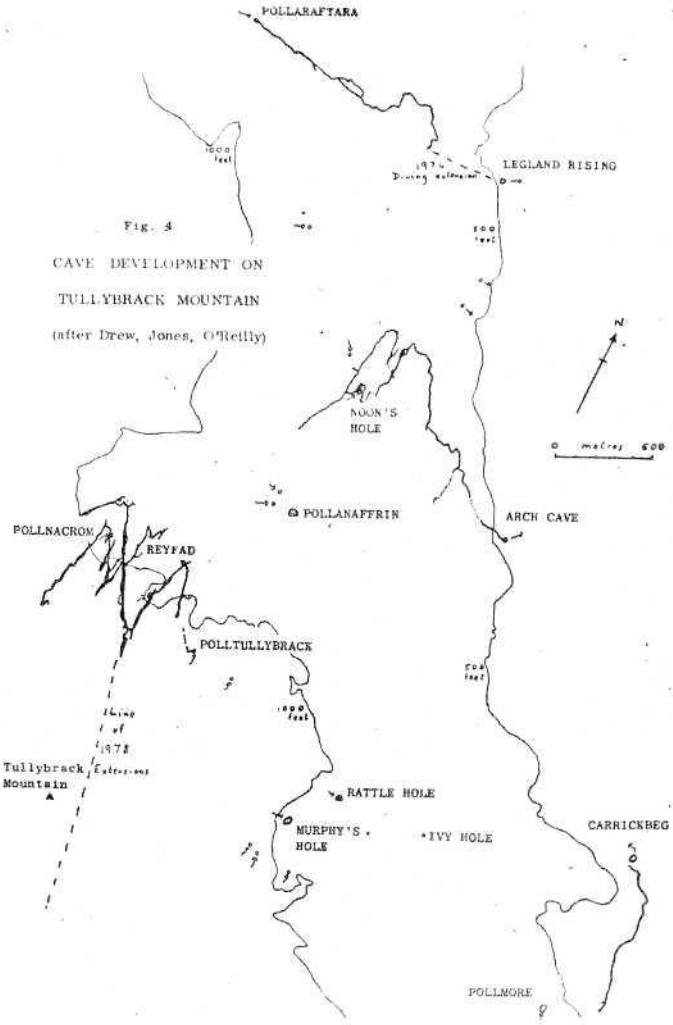


Fig. 4

CAVE DEVELOPMENT ON TULLYBRACK MOUNTAIN

(after Drew, Jones, O'Reilly)

frequently 15m wide and 20m high with vast sand dunes and boulder fields. The calcite formations (or pretties to the cynical caver) in these grottoes are very beautiful and often include the delicate branching helictites which appear to defy gravity. In 1978 local cavers found major downstream extensions to Reyfad which took them over 150m below the entrance, making it the deepest pothole in Ireland.

At the northern end of the area, the long cave of Pollaraftara has only a small pothole entrance but the long crawls just inside will sap the enthusiasm of the weaker spirits. This cave is strongly influenced by a major fault which results in an inclined cross section to the passage.

To the south, the well known Boho caves are developed in the cherty facies and have a character all their own. There are numerous black chert nodules sticking out of the walls, and in between them can be found a profusion of silicified fossils. They include the small solitary coral Amplexizaphrentis ennishilleni, named in

1851 after Lord Enniskillen who found the original fossil. It is an easy cave to wander into, but the novice can easily get lost in the 1½ kilometre maze of narrow passages.

The formation of these caves is not a recent phenomenon. Glacial deposits can be seen lying in situ in the larger surface geomorphological features, whilst within the caves large glacio-fluvial deposits include cross-bedded or laminated, sands, silts and clays. The sheer size of the main passages with their vast deposits only partly removed by the small modern streams, indicates the great age of these systems - dating back to at least the last interglacial period (Williams 1970). This compares significantly with the young, clean caves formed post-glacially in Co. Clare - Ireland's other main caving area.

Conclusions

This extensive speleogenesis in mud-reef knoll limestone, not only provides exciting and beautiful caverns for the potholer, but also a unique scientific locale for the investigation of the factors affecting cave development. A place to keep speleologists happy and busy for decades.

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VOLCANOES IN THE SKY THE VOYAGER I MISSION TO JUPITER

Ian S. Johnston

There has been considerable interest in volcanicity on other members of the solar system, particularly after the discovery of the huge cones on Mars. However, one of the larger satellites of Jupiter, Io, has suddenly been brought, literally, into focus by the successful Voyager I space probe which passed close by the giant planet recently. Io was seen to have active volcanoes and a very young surface.

The Staff of the Armagh Planetarium were quick to exploit new information made available by the Jet Propulsion Laboratory (JPL) in California, and, on 15th March, conducted a second of their live telephone links up with JPL in Los Angeles. Slides and short films, new to Europe, were flown especially from California and projected

in a lecture room at the Planetarium. Mr. T. Murtagh controlled proceedings at the Armagh end where the voice of Dr. Richard Lane speaking at JPL was remarkably well amplified to the assembled company. Dr. Lane had an identical set of slides in front of him so that his excellent 1½ hr. long talk matched perfectly the superb views of Jupiter and its satellites viewed in the Planetarium.

Io, the second innermost of the larger satellites of Jupiter, has always been observed to have a yellow colour, and this was shown by Voyager to be the result of its surface being composed largely of sulphur! It also has a ring of sulphur ions in orbit around it, and it is preceded and followed in its orbit around Jupiter by a cloud of sodium vapour!

To describe the glorious photographs of Io I refer to one of the JLP staff who said that he had seen better pizzas! The surface has a crusty, yellow-orange colour, with irregular patches of white and brown, and some rough, black spots and cracks. The dome shaped volcanoes are enormous by earth standards and some have been observed spouting thin plumes of material 100 km above the surface and then falling back in a curve to the surface. Whether or not they classify fully as volcanoes I'm not sure, but with the very high sulphur content of the surface of Io, perhaps they are more akin to hot sulphur springs on earth, albeit on a gigantic scale! Sulphur, indeed, will flow at much lower temperatures than, for example basalt, particularly if mixed with volatiles. The heat source for this activity is thought to be the immense tidal forces within Io caused by the gravitational attraction of Jupiter.

Io has many other interesting features particularly in its relationship with Jupiter. For example, its movement through the enormous magnetic field of the giant planet creates an electric current in a similar way to that in which a current is produced when a wire moves in a magnetic field in a dynamo. The current produced by Io is estimated to be about 1,000,000 amps and flows in an eliptical path to and from the magnetic poles of Jupiter.

Many other intersting facts and ideas were given by Dr. Lane particularly about Jupiter's bands of atmosphere, some of which circle in opposite directions at speeds of up to 300 mph! This atmosphere is now thought to consist of sulphur, oxygen, sulphur dioxide and carbon as well as the hydrogen and helium which, before Voyager, were thought to be the main constituents.

I certainly look forward to hearing about the next stage in the Voyager mission, a pass close by Saturn.

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BOOK NEWS ETC.

Journal of Earth Sciences, Royal Dublin Society

This is a completely new journal sponsored by the R.D.S. It is well produced, much better then the Scientific Proceeding, and costs £5 per annum for two issues. It specialises in Irish geology and should improve its image overseas. Subscriptions and papers to Dr. R. Charles Mollan, Science Officer, R.D.S., Thomas Prior House, Ballsbridge, Dublin, 4.

Field Guide to a traverse in the North West Irish Caledonides. T.B. Anderson et al, 1978. Geological Survey of Ireland. Guide Series No. 3. £1.50 from G.S.I. 14 Hume Street, Dublin, 2. This describes five field excursions:

1. Lr. Palaeozoic rocks and structures in Co. Louth.
2. Lr. Palaeozoic rocks and structures in Co. Down.
3. Stratigraphy and structure in the Dalradian of Western Inishowen, Donegal.

4. Structure and stratigraphy of the Dalradian of Creeslough, Donegal.

5. Structure and stratigraphy of the Dalradian in Rosguill, Donegal.

A Geology of Ireland. C.H. Holland, Ed. In press.

Awaited with interest! This should be an up-to-date text suitable for A level and undergraduates. Printing difficulties have held it up.

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