GEOLOGY teaching

VOLUME 2
NUMBER 3
SEPTEMBER 1977

RHOMBIC DODECAHEDRON

ODODECAHEDRON

develop alternate pairs of faces at expense of those in between

develop four low triangles on each face

CUBE

bevel edges

bevel edges

continue beveling

continue beveling

combine

combine

POSITIVE AND NEGATIVE TETRAHEDRA

SHOPFLOOR
Crystalllography
Minerals

Good practice in the use of visual aids

ARTICLES
Does degree level geology teaching need a new approach?

What qualifications best fit a student for a geology degree course?

Geology degree entrance requirements

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ATG ENQUIRY
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COMMENT
The views of the Association?
PHASE DIAGRAMS AT A LEVEL

The new Oxford A level syllabus, introduced in the 1976 examination, included work on the phase diagrams in igneous petrology. One of the specified systems for study is the forsterite-silica system. As this topic is not covered in sources easily available to the school teacher, the Geology Revision Panel of the Board requested the Awarder, Dr D. Bell, to provide guidance. This has been done in the form of a 15 page document, circulated to schools in June of this year. The document explains in detail how the phase diagram should be interpreted, showing its application in a wide range of contexts. Not intended as a pupils' text, but as a teachers' guide, this is perhaps an example of the kind of material needed when a board brings material into a syllabus with which teachers may not be familiar. It is not known if the document is available to the 'general public' circulation has been to schools entering candidates for A level Geology for the Oxford Board.

GEOLOGY TV SERIES

Brenda Horsefield, who produced the BBC's 'Before the Ark' series a few years ago, is currently planning a new geology series for the evening further education slot. The programmes will probably be transmitted next winter. They aim to introduce geology not in the conventional manner using 'traditional' sub-disciplines, but using examples of local geology. Thus volcanic process will be discussed during a visit to Arthur's Seat in Edinburgh, sedimentation on the Norfolk Coast, granites on Dartmoor, and so on. The last programme will be on the theme of 'Britain through space and time', based on a forthcoming new palaeogeography book by Dr Brian Lovell of Edinburgh University.

Report of COSTA* meeting of June 25th

In its introductory session the meeting was addressed by Miss Elizabeth McCreaeth, of Unilever Education Section on the employer's point of view on the current debate about the curriculum. Among the points made were:-

- That although oracy had improved for all grades of new employees both numeracy and literacy were generally woefully inadequate.
- Business is predominantly about communication between individuals - these abilities were also notably lacking, even in graduates.
- That profiling of students, using written reports, would, in the end, be more valuable than statements about examination results since the results tell very little about particular skills acquired by students.
- That in terms of in-service training Unilever have roughly an 8 year cycle for managers. This is seen as essential and is not very far from a recommendation in the James Report which suggested one term of retraining for teachers for each 7 years of service.

A progress report on the Schools Council N & F Proposals from the 18+ Steering Group is now available from the Schools Council, 160 Great Portland Street, London W1N 6LL for those who are interested.

In the business part of the meeting several associations indicated that they had not received invitations to the Regional Meetings organised by the DEI recently. The ATS is among these, and further representations in the DEI by COSTA on this general point are to be made.

Following the item on 'Language across the Curriculum' in the last journal it was interesting to receive a report from the COSTA Commission on this topic which met at Norwich (during the NATE Conference). There is a constant stress in the report on the care which teachers need to take with both oral and written English. Particularly under attack were the language of many textbooks and also teachers' own worksheets! Perhaps more room could be made for pupils to respond to written questions in an oral manner e.g. using tape recorders. The importance of being able to verbalise ideas (because this leads to clearer concept formation) is also stressed in the report.

It is intended that there should be continued co-operation between subject associations in the area and geology teachers have as much a part to play as anyone. COSTA is particularly interested in encouraging participation of subject associations in each others activities in this field and cross-fertilisation of ideas through their journals.

David Scott, Secretary

* Council of Subject Teacher Associations
THE SOUTH KENSINGTON LECTURES IN GEOLOGY

These lectures are intended for adult audiences with a general interest in the earth sciences. They are not designed for specialists but should have a particular appeal to amateur geologists, sixth-formers, students from colleges of education and technology, and members of university extra mural, WEA and other part time classes.

Each lecture will be followed by time for questions and discussion.

The meetings are to be held in the John Smith Flett Theatre at the Geological Museum. Admission is free but tickets must be obtained in advance by application (enclosing an SAE please) to Mr J Wilkinson, The Geological Museum, Exhibition Road, London SW7 0DE.

All lectures at 1900 hours

Friday
21.10.77 Meteorites and the Early Solar System Dr. R Hutchison

Friday
18.11.77 The Geology of Mars from Viking Dr J E Guest

Friday
21.1.78 The Geology of Dams and Reservoirs Professor J L Knill

Friday
12.2.78 Some Geological Problems of the Army Dr. L R M Cocks

Friday
17.2.78 Recent and ancient coastal salt deposits Dr. D J Shearman

Friday
21.4.78 Permian Britain - a landscape of deserts and tropical seas Dr. D B Smith

Also at the Geological Museum:

A course of 22 lectures entitled 'Minerals & Man', and a 3 day field meeting arranged jointly by the Geological Museum and the University of London Department of Extra Mural Studies with the co-operation of the British Museum (Natural History).

The lectures will be held in the John Smith Flett Lecture Theatre at the Geological Museum at 6.30pm on Thursday evenings beginning on 6 October 1977.

This wide ranging course will provide up to date information and a forum for discussion for anyone interested in the development of mineral resources.

The course fee will be £8 and for further information and enrolment please apply to:

The Deputy Director (Extension Classes)
University of London
Department of Extra Mural Studies
26 Russell Square
London WC1B 5DP

LONDON BOARD REPRESENTATIVE

The ATG has recently asked Dennis Hart to continue as its representative on London's Advisory Panel for Geology. The Secretary would be pleased to learn of any member interested in serving in such a capacity for any Board.

EDUCATION DIGEST

Education, formerly the official journal of the Association of Education Committees (the Association was wound up earlier this year) published a digest on geology teaching in its issue of 24th June 1977. The 'digest' is a regular feature of the Journal, and is specially written for the busy education committee member, administrator or headteacher. Copies may be obtained at 15p each from Councils and Education Press Ltd., 10 Queen Anne Street, London W1M 9LD. Teachers may like to put a copy in front of their head, appropriate lea adviser, or Education Committee member.

GEOL OGY FO R T OURI STS

A recent leaflet for tourists visiting the Isle of Man described the island as follows:

The principal geological features arise from the consequences of the glacial period and include Manx slate and granite, carboniferous limestone and red sandstone, together with the sand and gravel mounds and evidence of volcanic activity in basalt and ash.
CUMBRIA GROUP FORMED

A new geology teachers' group has been formed in the Cumbria area. Details of its activities are available from R.V. Davies, Warden of Kendal Teachers Centre, Stricklandgate, Kendal, Cumbria.

MANCHESTER GROUP OF GEOLOGY TEACHERS

Ann Dawbon, Manchester Museum, The University, Manchester M13 9PL

The group held two successful field meetings in June, visiting three sites and discussing their field potential. Fourteen members attended a lively meeting in July to discuss the 1977 A level exam; a document based on this discussion will be sent to the Board. A meeting is planned for September 14th when Mrs R. Preece will discuss the site recording programme. So far some 40 sites have been logged, and now it is intended to assess their teaching potential - as elsewhere, the intention is to ease the over-use of a few well known sites. Later meetings are likely to include practical and experimental sessions in the context of the new JMB C level, local fieldwork and visits to the University department and Salford Mining Museum.

WALSALL GEOLOGY TEACHERS WORKING PARTY

N.W. Dutton, Darlaston Comp. School, Herberts Park Road, Darlaston, Walsall.

The group held a meeting to discuss the 1977 West Midlands CSE papers, at which many criticisms were aired. A very interesting lecture to pupils and staff by Dr Richard Hamblin of the IGS took place in July, and the new teaching materials on 'Fossils and Geological Time' were sent to schools at the end of term. Work on a booklet on 'Field Techniques' has begun.

WEST DEVON GEOLOGY TEACHERS GROUP

Dr R.W. Mayhew, College of St. Mark and St. John, Derriford Road, Plymouth PL6 8BH

The inaugural meeting was attended by fifteen people from both schools and colleges. It was decided to operate rather informally, involving as wide a cross-section of teachers as possible. Members attended a field meeting at Cigga Head in Cornwall (by invitation of the Cornwall Group, from whom 'Regional Round-Up' would like to hear), and the Devon Group's own activities got off the ground with a meeting at Cawsand Bay.

AEROCRUISE educational visits to MAJORCA-the ideal introduction to the ecology of a Mediterranean island

Although Majorca is best known in Britain as a holiday resort, most of the island apart from the south - and its adjacent islands have been isolated from the main flow of European progress over the past two centuries and have been virtually untouched by industrialisation and the tourist boom. To students of geology, therefore, the Aerocruise Field Study Centre at Soller - some 30 kms north of Palma - offers exceptional opportunities to study the limestone features of the sierras. Accommodation is in the 2-star Hotel Esport - originally a 16th century manor house and today provided with modern amenities including swimming pool and tennis court - so that you are sure of the facilities needed to make study a pleasure.

Our prices are fully inclusive. They cover return travel by Laker Airways jet services from Gatwick Airport (including in-flight meals or refreshments); full-board hotel accommodation; airport/hotel/airport transfers; local airport taxes; and one free seat for group leaders for every 15 paid seats.

5 days, 4 nights £53.75 (departing Gatwick Monday) per person
8 days, 7 nights £67.75 (departing Gatwick Saturday) per person

Dear Sir,

It is with the greatest reluctance that I, normally a retiring unassuming character, once more request space in your correspondence columns, for three recent developments have absolutely staggered me:

- the new JMB 'O' level Geology syllabus;
- the Schools Council Working Paper No.56;
- the tone of Brian Daley's article in GEOLOGY teaching 2/2, (June '77, pages 79-81)

Can this new 'O' level exam be taken after one year? (As Geoffrey Brown states in the same issue, over 75% of schools confine geology to the 6th form; they take 'O' level after one year and 'A' level after two.) If not, then standards must be lowered or else the pass rate will fall, and then entries will plummet.

According to the Schools Council Working Paper, and Brian Daley, the writing is on the wall for the Geography teacher teaching Geology, and yet Geoffrey Brown shows, via his A-level sample, the huge percentage of geographers teaching geology. If geology is handed over to science, science alone. To attempt to do so would cause the universities to reduce the 6th form; they take 'O' level is similarly treated.

In the same issue, Richard Whittaker provides the answer to our subject's dilema. He is a man who is too modest to call himself a geologist, yet whose love and enthusiasm for the subject are unbounded - a man of deep geological knowledge who is not a teacher, yet whose field trips are enthralling.

As he points out, geology appeals to a wide spectrum of pupils, it can never be anchored to science alone. To attempt to do so would cause numbers taking the subject to plummet. He also points out that the universities have their entrance requirements for geology and these are well-publicised. The schools should concentrate on providing these qualifications for their pupils if they really do care about them.

Of course, as Brian Daley states, science is becoming less popular with the young, for it is fact-ridden, boring, dogmatic, and (above all) unparticipatory - so when the ship is sinking don't hang on to the anchor! I am afraid I remained unmoved by his Churchillian appeal for magnanimity and self-sacrifice. I have such a regard for my Head of Science that I fear for his heart condition should I suggest to him that from now onwards his physics, chemistry, biology and general science courses should revolve around geology which in future will act "as the very foundation of school science".

Finally, what do I do? As Head of Geography do I walk into the staffroom one day and say to my friend the Head of Science "from now on geology is your responsibility - its allowance for books and equipment will have to come out of your requisition, not mine"? If I do not wish to teach under his scientific care has he got the staff to take over? Do they want to? Do we have to fight our battles for recognition all over again?

The ATG, the JMB, the Schools Council may collectively and unintentionally kill off geology and reduce its size from that which we know today to a mere rump, but they won't kill off my geology, nor I suspect the geology of a lot of other teachers.

Yours faithfully,
Fred Holcroft,
54 Pemberton Road,
Winstanley,
Wigan.

Dear Sir,

As a teacher of geology possessing a Mountain Leadership Certificate, I should like to make two comments about the June News item entitled "High Altitude Fieldwork". Firstly, the certificate is not designed to equip people "to indulge in advanced climbing exercises" - it is designed to ensure that leaders of walking parties in wild country are capable of coping with the basic essentials of safety and security. I spend much of my spare time walking in mountainous areas of the UK, with and without parties of young people. Frequently, I am appalled and ashamed to see other school groups so badly equipped and badly led, despite LEA regulations.

One only has to study the statistics released by Mountain Rescue organisations to realise just how easy it is for school parties to get into difficulties - and how hard it can be to get out of them.

Secondly, the suggestion of a Field Course Leadership Certificate as an alternative to the Introductory part of the MLC is an excellent idea. I am ready and willing to help start one, with the assistance of the ATG's Council.

Yours faithfully,
P.J. Smith,
Lecturer,
North Lindsey College of Technology, Southorpe, S. Humberside.

Dear Sir,

I enclose a copy of a question that appeared in the recent CEE Biology paper set by the South-east Regional Examinations Board. You may wish to use it as the first problem in a "Spot the Mistakes" competition. On a more serious note, I think it absolutely disgraceful that such a table is allowed to be published in an official examination. It certainly will not do any good for the geological "cause", and I doubt if a geologist was consulted for checking the information.

Yours faithfully,
G.J. Sparks
Head of Humanities, Southway, Park Barn County Secondary School, Guildford.
The following is a simplified geological/evolutionary table. Study it carefully and answer the questions based upon it.

<table>
<thead>
<tr>
<th>ERA</th>
<th>EPOCH</th>
<th>TIME SCALE MILLIONS OF YEARS</th>
<th>DOMINANT PLANT TYPE</th>
<th>DOMINANT ANIMAL TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENOZOIC</td>
<td>Eocene</td>
<td>65</td>
<td>Flowering plants</td>
<td>Mammals</td>
</tr>
<tr>
<td></td>
<td>Oligocene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MESOZOIC</td>
<td>Cretaceous</td>
<td>225</td>
<td>First seed bearing plants</td>
<td>Reptiles</td>
</tr>
<tr>
<td></td>
<td>Jurassic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PALAEOZOIC</td>
<td>Carboniferous</td>
<td>570</td>
<td>Spore bearing plants</td>
<td>(A) Fish</td>
</tr>
<tr>
<td></td>
<td>Devonian</td>
<td></td>
<td></td>
<td>Invertebrates</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
<td></td>
<td>Early land plants</td>
<td></td>
</tr>
</tbody>
</table>

(i) What group of vertebrates was dominant at (A)?
(ii) From what group of plants did the early land plants evolve?
(iii) Name an important group of reptiles, now extinct, found in the Mesozoic era.
(iv) Name one animal or plant known to you that is now extinct and give two reasons why such animals become extinct.
GEOLOGY and GEOLOGY & ENVIRONMENT in the BA, BSc, BEd Degree and Honours Degree and DipHE MODULAR COURSE

The Modular Course at Oxford Polytechnic gives the individual student considerable freedom to choose his own programme of study and to change it as his knowledge increases and interests develop. He is given the opportunity of spending a proportion of the time working outside his chosen field(s) of study, for which appropriate credit is given in the final assessment of the degree. Over 500 modules are offered by the Polytechnic (21 available in the Geology field and 36 available in the Geology & Environment field, including modules in Geophysics and Engineering Geology) and the student takes three or more modules each term, though in a number of cases modules are joined together to form larger units for teaching and assessment purposes.

Modules are grouped together into fields of study. The student specialises in one double field from:

1. Environmental Biology - GEOLOGY AND ENVIRONMENT
   Human Biology - Physical Sciences
   or a combination of two single fields from:
   - Anthropology
   - Biology
   - Catering
   - Education
   - English Literature
   - Food and Nutrition
   - French Language and Contemporary Studies
   - French Literature
   - Geography

The well equipped teaching laboratories for Geology and Geology & Environment are located in the modern Science block in the Faculty of Technology on the main Headington site overlooking the city of Oxford. Students on the Geology and Geology & Environment fields attend a number of field courses during the vacations and also undertake a period of independent geological mapping during the long vacation between the second and third years of the course.

Entry requirements: 2 A levels (including one science subject) or good ONC/OND or equivalent.

Prospectus, course booklet and application form from: The Registry, Oxford Polytechnic, Headington, Oxford, OX1 0BP.

CITY OF LONDON POLYTECHNIC

SIR JOHN CASS SCHOOL OF SCIENCE AND TECHNOLOGY

GEOLOGY
BSc (HONS) BSc or Dip HE
within the MODULAR DEGREE AND DIPLOMA SCHEME

Geology is one of the seventeen subject areas contained within a degree scheme whereby students choose individual study programmes that reflect their personal interests and aspirations.

THE SPECIALIST

may choose to study any or all of the branches of Geology, thereby taking a programme equivalent to a 'special' degree. In addition they may strengthen their studies by the inclusion of relevant courses from cognate areas in Biology, Chemistry, Geography, Physics etc.

COMBINED STUDIES

students may combine one or more branches of Geology with another subject such as Physics, Chemistry, Geography, Biology, Mathematics etc.

The courses in Geology are described in a booklet entitled “The Modular Degree & Diploma Scheme” which may be obtained, together with application forms, from Dr Malcolm Elvines at:

Dept. of Geology
City of London Polytechnic
Walbrough House
Bigland Street
London E1 2NG

Telephone: 01-283 1030
Dr Elvines Ext 592
Dept. Secretary Ext 599
RESOURCES REPORTS

Reviews and notes about books, equipment, specimens and audio-visual aids, etc.

BRITISH GEOLOGY

A review of some recent books concerned with the geology of Britain.

BRITISH PALAEOGEOGRAPHY: AN INTRODUCTION


This book is intended to be an introduction to the historical geology of Britain. The cover and preface describe the book as being designed for students and others interested in geology which does not leave the prospective buyer very much the wiser. The degree of difficulty of the language would seem to rule out CSE and O level pupils, leaving sixth formers, undergraduates and adult amateurs as likely categories.

Much of the information presented depends on the use of palaeogeographic maps, each geological system being represented by a single map. As a result, the maps and accounts of each system tend to be oversimplified and yet the reading level is too high for those pupils who might benefit from such work. The cramped format of the book is also not conducive to clear illustrations.

The author begins with a description of isostasy and follows this up with an account of the mountain building process. The plate tectonics model is introduced to explain mountain building but this is the only part of the book where the plate tectonic theory is mentioned at all. The reviewer feels that the concepts of lateral crustal movement and isostasy are not clearly enough differentiated for the beginner in geology. A discussion of the break up of Pangea and subsequent drifting of the continents during the Jurassic then follows but the significance of orogenic events in terms of earlier plate boundaries is not discussed.

The rest of the book consists of a paleogeographic map, integrated in the text, and a simple account of the rock types and environments for each geological system. A brief description of Pre-Cambrian rock types is given but no effort is made to interpret the data in terms of past plate distributions as appears in other modern texts. The failings present in the author's description of the Pre-Cambrian tend to run throughout the rest of the book. A fairly good description of the Cambrian rock types and environments is given but the reader has little appreciation of the width of the Cambrian ocean from the palaeogeographic map. The description of the Ordovician and Silurian fails to emphasise the distinction between shelly and graptolitic facies and no attempt is made to explain the significance of Ordovician volcanic activity. A good description of the Devonian environment follows accompanied by a clear and informative map but no reference is made to the extent of the Old Red Sandstone continent. The author attempts to overcome the need for two palaeogeographic maps to show the Carboniferous environments adequately, by combining the structural effects of the Hercynian orogeny and Upper Carboniferous sedimentation on the same map, with little success.

Descriptions and maps of the Permo-Triassic are very good. A good description of the Jurassic system with a welcome reference to 'basin and,swell deposition' is spoilt by the total omission of the Purbeck regression. The accounts of the Cretaceous and Tertiary fail to mention the important fault break at the end of the Cretaceous and in attempting to explain the significance of Tertiary volcanicity in Scotland the author unfortunately refers to the sinking of the continent of North Atlantis. The description of the Pleistocene suffers from the use of a wealth of stage names which contributes little to the understanding of Pleistocene climatic changes.

A book of this nature which provides a rapid summary of the geological history of Britain could be used to assist candidates studying geology at O level or CSE level, or for revision purposes at Advanced level. This particular text falls between two stools. The reading level is too high for O level and CSE and the content is too superficial and outdated for A level. 'British Stratigraphy' by Middlemiss is a superior text of the O level category having better balance and equally good palaeogeographic maps, whilst the needs of the A level student would seem to be better served by the OU course unit on Historical Geology (A second level Geology Course Block 6). 'The Geological Evolution of the British Isles' by T.R. Owen (Geology Teaching Vol. 1, No.3) is an equally stimulating text and gives fuller coverage of the topic. The only market remaining for the book would seem to be the adult amateur but he should expect to be entertained by a text which includes modern concepts but this the book certainly fails to do.

Alan Seago
THE GEOLOGY OF WILTSHIRE - A FIELD GUIDE


This book is aimed at those people who have an interest in, but no specific knowledge of, geology. It does not claim to be a comprehensive account of the stratigraphy and detailed structure of the area.

The introduction is quite long and introduces and explains, in a very readable fashion, basic and not so basic geological terms which are printed in heavy, black type. Most of these are related to the rocks found in Wiltshire. The diagrams and maps are clear and well annotated.

I do not understand why the author, on his stratigraphical column, subdivides the Jurassic system into stages and does not do the same with the Cretaceous, of which the south and east of the county is largely composed. The author continues his introduction by outlining the geological history of Wiltshire from Devonian times to the present day and explains the processes of weathering, erosion and the development of soils. The introduction is concluded by reference to the work of William 'Strata' Smith.

The author then subdivides, on geological grounds, the county of Wiltshire into eight regions and works progressively from the Cotswolds in the north west to the Chalklands and Tertiary deposits in the south. The concluding chapter is devoted to the Greensands of the west of the county. The text is easily understood and the author takes great pains to assume little, if any, geological knowledge on the part of the reader. He explains all ideas and theories that are put forward. Each chapter has what I presume was once a photograph of a locality referred to in the text, but these have been apallingly reproduced. Fortunately the diagrams, sections, maps and sketches are abundant, well drawn, labelled and reproduced. Every effort has been made to print these on the page to which they are referred in the text, thus avoiding, in the main, flipping backwards and forwards from text to diagram.

The content is by no means limited to the pure geology of the area; indeed in some places this takes a secondary place. Most chapters begin with a geographical introduction to the area which is followed by a general introduction to the geology. Then follows a more detailed account of the geology which is normally stratigraphically treated. The author then explains, frequently in some detail, the geomorphology and drainage of the area and often refers to the work of other authors and even quotes verbatim from their works. The chapter is usually concluded by a section on agriculture, ecology, soils and vegetation. Throughout the book the author digresses readily into the economic and applied aspects of geology; particularly into the relationships between geology, building stones, town site and scenery. These diagrams make very interesting reading and provide the type of additional information that lives up any field trip, particularly for the less academic child. Every chapter ends with a site description and grid reference location of geological exposures within the region described. The interpretation of the rocks seen is left to the observer.

Factually, this book is very accurate; certainly there are no glaring errors although very rarely the terminology used is unusual. Perhaps less space should have been given to the fringe aspects of geology and rather more to the academic aspects as it might be claimed that the contents of the book do not fairly reflect the title. Nevertheless some of the information provides entertaining reading. Perhaps the best chapter as far as geological content is concerned is the one devoted to the Vale of Wardour, although the geological exposures listed might have included the Chalk so that one might be able to view exposures representing the whole of the Upper Jurassic and Cretaceous in one itinerary and in one relatively small area.

Two appendices are included - one suggesting a mapping exercise using strike lines, (there are better localities than the one outlined), and the other outlines a seven day tour of Wiltshire's geology. Somehow I cannot envisage many schools being able to afford to spend seven days fieldwork in the limited age range of rocks represented in Wiltshire. However, each itinerary could form a useful basis for day trips.

References are listed near the end of the book and generally make suitable reading. They are tabulated on a chapter by chapter basis and the author lists both specific and general references. They range from purely geological references to one titled "A Shepherd's Life".

I consider this book to be good value for money and as far as I am aware there are no similar books devoted to the geology of Wiltshire. As such it is a welcome addition to the increasing number of field guides available. It would be a valuable addition to the school library and could readily be used by teachers contemplating geological, geographical or biological fieldwork in or around Wiltshire for any ability and age level.

Bob White

ARDNAMURCHAN - a guide to geological excursions


The Tertiary igneous complexes of the Ardnamurchan peninsula have long attracted the attention of geologists and, whilst the popularity of this classic area continues undiminished it is only relatively recently that an attempt has been made to produce an authoritative and up-to-date field guide to the area, to replace J.E. Richey's (1948) guide.
The Ardnamurchan guide, published 1976 is undoubtedly biased towards an undergraduate and professional audience, although there is such that the enthusiastic teacher could incorporate into his courses and use in field classes with advanced students.

Just over half of the guide is concerned with an account of the geological setting of the igneous rocks and a 'meaty' resume of previous work on the 3 igneous centres of Ardnamurchan. The account makes no attempt to avoid technical terms, and whilst these should present no difficulty to a well-motivated A level pupil, the younger or less experienced geologist would feel a constant need for his geological text books and dictionaries. The text is well illustrated with several maps, tables and a diagram of Centre 3 pyroxene compositions. A supporting reference list adequately sources material and further reading. One irritating point in the general account is the continual mention of localities e.g. "Eucrite of Beinn nan Ord" without referring the reader to a convenient sketch map or providing a map reference.

The remainder of the 122 page book comprises a descriptive itinerary of 7 excursions and a 3 page appendix of Gaelic place names. The excursions are well chosen and described and include the occasional reference to local history and folklore; a 7-day excursion is necessary to visit most of the important geological localities but shorter 2-day and 3-day excursions are also recommended. Reference is made to suitable topographic and geological maps but one of the attractive features of the guide is the inclusion of a newly compiled full-colour 1:40,000 folded geological map laid out with National Grid references and stored in the rear pocket of the guide.

Itinerary descriptions are illustrated by 6 maps and a section. Some of the maps are too detailed and over-ornamented with consequent loss of clarity; also, with one exception, the excursion localities are not indicated on the maps provided, thus one's route over the ground has to be plotted from the grid references supplied and is not observed at a glance of the map.

Apart from the criticisms mentioned, the guide is undoubtedly well produced and at a retail price of £2.00 is very good value for money (the folded colour map alone is worth that!). It has compact dimensions and should readily fit most pockets, unfortunately its binding is rather flimsy and the pages soon begin to fall apart. As it has no real competitors it represents the best introduction to the geology of Ardnamurchan and a necessary "buy" for first-time visitors.

Alan Crane

GEOLOGY AND SCENERY IN SCOTLAND
J.B. Whitton. Pelican, £1.95. 362 pp., ISBN 014 021867 X, 45 plates (black and white), 54 diagrams

This book is the third part of a trilogy and was inspired by Sir Arthur Trueman's renowned "Geology and Scenery in England and Wales", which constitutes the first of the three volumes covering the structure and physique of the British Isles.

Dr Whitton, having been involved jointly with a revision of Trueman's classic, felt the need to complete what, to him, was an unfinished task. If this book does not receive the same acclaim as its more famous predecessor it may be due to the fact that there are significant differences which render such comparison invalid.

Before opening the book, two thoughts had sprung to my mind. In the first place, I wondered how anyone could hope to compete with some of the more recent publications on the subject (such as Sisson's "The Evolution of Scotland's Scenery", "The Geology of Scotland" which was edited by Professor Gordon Craig and the Excursion Guide of the Glasgow Geological Society) all of which have made significant contributions to the understanding of the Scottish scene. The other, somewhat nostalgic, thought conjured up an expectation of recapturing the satisfaction achieved from reading Trueman's work during my undergraduate days.

I was soon to find out that both thoughts were easily answered. This book has been written for the layman as well as for the professional and, as such, caters for a wide readership. It should achieve this aim insofar as the depth of treatment given to structural elements is shallower and easier to understand than in any of the works quoted above. I was not to achieve the same elation as in my younger days, but whilst it is true to say that Dr Whittow's style did not always vibrate sympathetically for me, it is still a well written and well documented work.

It begins with a summary of the geological evolution of Scotland (which could well merit the attention of every teacher of 'O' Grade geology in Scottish schools. (It is interesting to note that this chapter makes no reference to plate theory.) The remainder of the book is a stage by stage tour of Scotland starting in the Borders and finishing in the Orkneys and Shetland Islands. Each era is explained structurally and the geomorphological expression of structure accounted for. The author has given more emphasis to scenery than did Trueman and pays a good deal of attention at times to the historical and current human response to environment. He frequently refers, in anecdotal form, to famous personalities, both fictional and actual, wherever a Scottish connection exists. Whilst some readers might welcome those aside as a momentary relief from the many structural and stratigraphic explanations outlined, I found them a little irritating. There is no doubt, however, that Dr Whittow has made great efforts to compile a comprehensive and authoritative work. One cannot but be impressed by the amount of time that must have been spent in researching material for this book, let alone that required to walk and drive in every part of Scotland.

Most of the diagrams are in the form of maps or cross-sections but there are some block sketches as well as a couple of stratigraphic tables. They are all well labelled and relevant to the text but, like most paperbacks, they tend to be rather small and sometimes lack clarity and this detracts from their usefulness.
The black and white plates are bound together in the middle of the volume. They constitute a brief resume of the book's contents in that they follow a sequential order similar to that of the text. The photographs, drawn from a variety of sources, are generally adequate though I was disappointed with one or two of them. In particular, the first — of Hutton's Unconformity at Siccar Point — does now show very clearly the magnificence of this historically classic exposure.

There is a useful, though very generalised map of the solid geology of Scotland on the back cover.

When one reflects on the relatively large number of authorities quoted in the text, the bibliography is disappointingly small. Despite this, the few titles mentioned would yield an adequate starting point for further information or research for almost any reader.

One of the problems facing authors of books of this kind where a wide readership is encouraged, is the use of specialist terminology. The obvious answer is to provide a glossary of terms at the back of the book. In this case the glossary is quite adequate despite one or two omissions. Would the layman know, for example, the meaning of the term "indurated"?

The book makes its appearance at a significant time when school geology has, belatedly, become a reality and when suitable texts are being sought. I do not anticipate that this work will be used as a text in Scottish schools (nor do I expect that the author would be hoping for this) but I am sure that it will be welcomed in school and departmental libraries as a useful addition to the reference books already available on Scottish geology. In particular it will be of considerable assistance to the teachers who must initiate their pupils in compulsory fieldwork exercises. It should also be of great help to those senior pupils who are drawn towards geology as a subject of further study but the language level may be too advanced for many pupils studying at O grade or O level.

It is fair to add that most books with a regional flavour necessarily suffer from a surfeit of place names which are often unpronounceable and unfamiliar. This is particularly true of the Scottish Highlands. Hopefully, this will not detract from interest that is often stimulated in the serious reader.

I would not expect a soft-covered book such as this to stand up to a great deal of wear in the field, but, at £1.95 it must be reckoned to be good value (even if my copy of "England and Wales" cost two shillings and sixpence!). Certainly, it has already found its place on my own reference shelf.

A V Cairns

More reviews of books on British Geology will appear in the December issue.
In notifying the existence of the following books and materials the ATG does not wish to imply that it regards these books as appropriate to school geology or recommended for purchase. Where possible some details are given of the source of the books or materials, their price and their likely market according to the following scheme:

1. Infants. J= Juniors. S=Secondary (SL=Lower, SU=Upper)

Hence: book or material is particularly hard to locate.

Sources suitable for infants and junior schools and the lower parts of secondary schools are particularly hard to locate.

1. General Geology


Judson, S., Defeyes, K., Hargreaves, R.B. 1976 Physical Geology. Prentice-Hall. £10.65 SUCFTG


2. Bibliography, Biography, Curriculum Projects.


Anon. 1976 Child Education Quarterly (The summer edition is devoted to Dinosaurs: the editorial gives a number of ideas for practical classroom work). £0.25. JSL


Hodgson, A.V. & Laming, D.J.C. 1976 List of Titles of Research Theses 1960-75 on the Geology of the British Isles and Offshore Areas. Bibliographic Press Ltd. £3.50. CFT

Rockcastle, V., Salamon, F., Schmidt, V. Mc Knight, B. 1975 STEM (Space Time Energy and Matter) Elementary School Science Series. 2nd Ed. 6 books for teachers containing guidance and materials for developing concepts across the whole breadth of science including space and earth. Book 1 (ages 6-7) £1.80. 2/7-8) £2.70. 3/8-9) £3.15. 4/9-10) £3.85. 5/10-11) £4.60. 6/11-12) £4.90. London, Addison Wesley & Co. JSL

Summerson, C.H. (Ed) 1976 Sorby on sedimentology- a collection of papers from 1851-1908 by Henry Clifton Sorby 1826-1908. Miami, Univ. of Miami. 229pp. £7.5, cash with order or £8.50 invoice CFT


Anon. 1976 Offshore Europe 75 Conference Aberdeen. Kingston on Thames, Spearhead Publications. £15.00 SUCFTG

Geothermal Water Planning Unit 1976 The Wash water storage scheme feasibility study. NERC Publications Series C. 36pp. SUCFTG

Cook, E. 1976 Man Energy and Society. San Francisco Freeman & Co. 470pp Hard cover £11.30 soft cover £5.50. SUCFTG


Gozzard, J.R. 1976 The Sand and gravel resources of the country east of Newark on Trent, Nottinghamshire: description of 1:25,000 resources sheet SK85. IGS Mineral Assessment Reports 70pp. £2.75. SUCFTG

Institute of Petroleum/Aberdeen Journals 1976 Map of Scottish Oil Developments London. Institute of Petroleum £0.50. From Mrs B Harper, Inst. of Pet. 61, New Cavendish St., London W1M 3AR. SUCFTG


Knight, C.L. 1976 The Economic Geology of Australia and Papua New Guinea.1125pp £65 CFTG

McCrindle, . . 1975 The story of North Sea Oil. Hove, Wayland. 96pp. £3.60. SUCFTG

Muir, W.L.G. 1976 Coal Exploration. 644pp £30 CFTG

National Academy of Sciences - National Research Council. 1969 Resources and Man, San Francisco, Freeman & Co. £2.90. SUCFTG

Odell, P. 1976 Optimal development of the North Sea's oilfields. London, Kogan Page. 188pp £3.90 CFTG

Robinson, C. & Morgan, J. 1976 Economic consequences of Controlling the Depletion of North Sea Oil and Gas. Guest paper 3. Trade Research Centre, 6 Buckingham St., London WC2N6BX 34pp £1.00 and 15pp postage. CFTG


4. Geomorphology, Pedology

Atkinson, E. et al. (Eds) 1977 Progress in physical geography. London, Arnold £12.50 CFT
Mitchell, F. 1976 The Irish Landscape. London, Collins 240pp. £5.50. SUCFTG
Morisawa, M. 1976 Geomorphology Laboratory Manual with report forms. Chicester, Wiley paperback. £4.94. CFT
5. Geophysics
6. Historical Geology, Stratigraphy
Van Eysinga, P.W.B. 1975 Geological Timescale 3rd Edition. Amsterdam, Elsevier. 335, Jan van Nom, Galenstraat, P.O. Box 211 Amsterdam. SUCFTG
Blyth, F.G.H. 1976 Geological Maps and their Interpretation (2nd Ed.revised).London, Arnold. £2.00. SUCFTG
Maps of William Smith Facsimile colour copies. Obtainable from S.Baldwin. SUCFTG
Institute of Geological Sciences Sheet 58 Barrow in Furness 1:50,000; 85 Manchester 1:50,000; 97 Runcorn 1:50,000; 18 Brampton 1:50,000; 3 Ford 1:50,000; SK17 Millers Dale 1:25,000; SK 06 Roaches 1:25,000. Geothermal Gradients (in USA). two sheets 1:500,000 $4. Subsurface Temperatures (in USA) two sheets 1:500,000 $4. Map of World Coal Resources. (Map by Russians 1:15,000,000) 50 x 101" $40. Miller-Freeman. Map of World Mining of Copper, 34 x 49" $10.50. Miller-Freeman. 8. Mathematical Geology
Lewis, R. 1976 Computer assisted learning project. Unit 21, Drainage basin morphology. Unit 24, Radioactive decay. Chelsea College, Bridges Place, S.W.7. SUCFTG
Marriam, D.F. (Ed) 1977 Captive Management and Display of Geological Data with special emphasis on energy and mineral resources. Oxford, Pergamon. £10.00. SUCFTG
9. Igneous and Metamorphic Petrology, Vulcanism
Leonardi P., Rittman, A., Somma, E., 1977 Volcanoes and impact craters on the Moon and Mars. Amsterdam, Elsevier. £4.25. CFT
10. Marine Geology, Oceanography
11. Mineralogy, Crystallography, Geochemistry
Mason, Anita 1976 The World of Rocks and Minerals. London, Osprey. £3.25. SUCFTG
12. Palaeontology
13. Regional Geology, Field Excursion Guides
Inst. Geol. Sciences 1976 Geology of Western Shetland. London, HMSO. £10.00 CFT


Robson, D.A. 1976 A guide to the geology of the Cheshire Transactions of the Natural History Society of Northumbria. 43, 11-23. SUCFTG

Selley, R.C. 1975 Field Trip to West Scotland. London, Petroleum Exploration Society, Great Britain. 20pp. SUCFTG

Swinnerton, H.B. & (Sir) Kent, P.E. 1976 The Geology of Lincolnshire. Lincoln, Lincolnshire Naturalists’ Union from J. Rowe, c/o Page & Co. 5 Lindum Ed. Lincoln, 130pp. £3.45 + postage packing f0.35. SUCFTG


14. Sedimentology, Sedimentary Petrology

Briggs, D.J. 1976 Sources and methods in geography, sediments. London, Butterworths. £1.95. SUCFTG

Komar, P.D. 1976 Beach Processes and Sedimentation. N. Jersey, Prentice Hall. £19.65. SUCFTG


15. Structural Geology, Geotectonics

Anon. 1976 Continental Margins of Atlantic Type. Supplement to Anais de Academia Brasileira de Ciencias. $20. CFT


Carey, S.W. 1976 The Exploding Earth. Developments in Geotectonics 10. Amsterdam, Elsevier. 470pp. £23.10. CFTG


Drake, C.L. (Ed) 1976 Geodynamics: Progress and Prospects. American Geophysical Union. 238pp. £7.50. CFT


16. Catalogues


17. Films

Enquiries for purchase of following films from American Geological Institute/Encyclopaedia Britannica Earth Science programme, and other distributors cited to: Folio, Fergus Davidson Associates Ltd., 22 South Audley St., London - W1Y 6EZ (Exceptions stated). Enquiries re hire of film in first instance to a local film library or National Audio Visual Aid Library, 2 Paxton Place, Gypsum Rd., London SE27 9SS, or The Scottish Central Film Library, 16-17 Woodside Terrace, Charing Cross, Glasgow G3 7NX.


Anon. Monuments to Erosion. (The red-rock geology of Colorado Plateau). Cat. No. 3340, 16mm 11mins. £1.50 rental £0.80. SLSU

Eames, C. & Eames, R. Copernicus. 10 mins Colour. £15. SUCFTG

Eames, C. & Eames R. 1968 Powers of ten. Dimensions in time and space are explored from the nucleus of a carbon atom to the reaches of space. 8 mins Colour £150. rental £20. SUCFTG

Encyclopaedia Britannica Educational The Moon. Cat. No. 148 11 mins Black & White. SUCFTG

The Great Lakes: How they were formed. Cat. No. 544 11 mins Colour. SUCFTG

The Earth in change: the Earth’s Crust. Cat. No. 552. 10 mins Colour. SUCFTG

Mollusca: (Snails, Mussels, Octopuses). Cat. No. 783. 14 mins Colour. SLSUFTG

Crustaceans: Lobster, Barnacles, Shrimps and their relatives. Cat. 784. 14 mins Colour. SUCFTG

Energy from the sun. Cat. No. 877. 11 mins Colour. SUCFTG

Ocean tides: the Bay of Fundy. Cat. No. 1497. 14 mins Colour. SUCFTG

Minerals & Rocks: Stones of the Earth. Cat. No. 1589. 16 mins Colour. SI SUCFTG

Magnetic, electrical and gravitational fields. Cat. No. 1884. 11 mins Colour. SUCFTG

Adaptive Radiation: The Molluscs. Cat. No. 1895. 18 mins Colour. SUCFTG

Echinoderm: sea stars and their relatives. Cat. No. 1908. 10 mins Colour. SLSUFTG


Life Story of the Oyster. Cat. No. 2121. 11 mins Colour. SLSUFTG

Life Story of the Sea Star. Cat. No. 2132. 11 mins Colour. SLSUFTG

The Restless Earth. Cat. No. 220. 16 mins Colour. SUCFTG

Reflections on time (inc. Grand Canyon). Cat. No. 2221. 22 mins Colour. SUCFTG

Molecular theory of matter. Cat. No. 227. 11 mins Colour. SUCFTG

Waves on water. Cat. No. 2253. 16 mins Colour. SUCFTG

Evidence for the Ice Age. Cat. No. 2255. 19 mins Colour. SUCFTG

Plankton: Pastures of the Ocean. Cat. No. 2362. 10 mins Colour. SLSUFTG

Fish in a changing environment. Cat. No. 2454. 11 mins Colour. SUCFTG

How a Scientist Works. Cat. No. 2665. 15 mins Colour. SUCFTG

Problems of conservation: soil. Cat. No. 2842. 14 mins Colour. SUCFTG

Problems of conservation: water. Cat. No. 2794. 16 mins Colour. SUCFTG

Theories on the origin of Life. Cat. No. 2978. 14 mins Colour. SUCFTG

Origin of Life: Chemical Evolution. Cat. No. 2820. 11 mins Colour. SUCFTG

Problems of conservation: minerals. Cat. No. 2844. 16 mins Colour. SUCFTG
Problems of conservation: Our natural resources
Cat.No.2987. 11 mins. Colour. SUCFTG
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Low Reynolds Number Flows. Cat.No.21617. 33 mins Colour.
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Controversy over the moon. Cat.No.3037. 16 mm. 16 mins. Colour. $220 rental $11. SLSU
Matthews, W.H. III (Collaborator) Volcanoes; exploding the restless earth. Cat.No.3198. 16 mm 18 mins. $255 rental $11. SLSU
Moreland - Latchford Films The Position of the Moon. Cat.No.7-647 8 mins. Colour. $95. JSL
The Size of the Moon. Cat.No.7-648 8 mins. Colour. $95. JSL
Exploring the Moon. Cat.No.7-649 7 mins. Colour. $95. JSL
The Sun. Cat.No.7-636 8 mins. Colour. $95. JSL
Stars Part I. Cat.No.7-640 7 mins. Colour. $95. JSL
Stars Part II. Cat.No.7-641 7 mins. Colour. $95. JSL
Our Planet earth. 8 mins. Colour. $95. JSL
National Film Board Canada. Face of the earth (the rock cycle in action)16 mm 17 mins. Colour.
SUCFTG
Space Connection. 16 mm 18 mins. Colour. SUCFTG
Offshore (Oil Rigs at sea). 35 & 16 mins. Colour. SUCFTG
Powars, H. (Collaborator) Heartbeat of a volcano. Cat.No.2985. 16 mm 20 mins. Colour. $255 rental. $11.00. SLSUCTG
Fire Mountain (1969 eruption of Kilauea) Cat. No.2991. Colour 16 mm 9 mins. Domestic rental $7.50. SLSUCTG
Pyramid Films 1969 Crystals. 6 mins. Colour $100. rental $15. SUCFTG
Shelton, J.S. (Collaborator) How level is sea level. Cat.No.2993 (Colour).2994 (B&W)16 mm 13 mins. Colour $150, rental $9.00; 8 & W $75 rental $6.00. SLCFTG
The Beach - a river of sand. Cat.No. Colour 2369; B&W 2370. 16 mm. 20 mins. Colour $290, rental $13.50; B&W $150, rental $9.00 SLSUCTG
Earthquakes - lesson of a disaster. Cat.No. colour 3056; 16 mm 13 mins. Colour $185 rental $9.00. SLSUCTG
Rocks that form on the earth's surface. Cat.No.2198 Colour; 2199 B&W. 16 mm. 16 mins. Colour $220, rental $11.00; B&W $115, rental $7.00. SLSUCTG
Rocks that originate underground. Cat.No.2402 Colour; 2403 B&W. 16 mm 23 mins. Colour $290 rental $13.50; B&W $150, rental $9.00.SLSUCTG
Why do we still have mountains? Cat.No.2200 Colour; 2201 B&W. 16 mm 20 mins. Colour $290 rental $13.50; B&W $150, rental $9.00.SLSUCTG
Erosion - levelling the land. Cat.No.2194 Colour;2195 B&W. 16 mm 14 mins. Colour $185 rental $9.00; B&W $95, rental $6.00. SLSUCTG
Evidence for the Ice Age. Cat.No.2255 Colour, 2256 B&W 16 mm 19 mins. Colour $250 rental $33; B&W $130, rental $7.00. SLSUCTG
Reflections on Time. Cat.No.2221, Colour; 2222 B&W 16 mm Colour $290 $13.50 rental; B&W $150, rental $9.00. SLSUCTG
The ways of water (the hydrological cycle). Cat.No.Colour 3041. 16 mm 13 mins. Colour $150 rental $9.00. SLSUCTG
Shelton, J.S. Kucera, R. (Collaborators) Glacier on the Move. Cat.No.3177. Colour 16 mm 11 mins. $150, $9 rental. SLSUCTG
U.S.Dept. of Interior, Yellowstone Nat. Park Geyser Valley. Cat.No.3142. 16 mm 9 mins. $115 Rental $7.50. SLSUCTG
British Petroleum 1976 Energy in perspective. 21 mins. 16 or 35 mm Colour. BP Film Library, 15 Beaconsfield Rd., London NW10 2LE SLSUCTG
Diorama Evolution of Dinosaurs. From Peabody Museum, Yale University, Newhaven, Connecticut, U.S.A.

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The attractive colours of minerals stimulated palaeolithic man to possess pigments for decoration and for cave painting. Later many different minerals were used for ornamental purposes and the value set on precious stones in the early civilizations of the Middle East resulted in exploration for mineral deposits and in extensive trade activities which are of outstanding importance in modern societies.

A mineral is an inorganic substance which has two fundamental characteristics:

1. A mineral possesses a characteristic chemical composition which may vary between certain limits.
2. A mineral possesses an ordered arrangement of the atoms of which it is composed and this results in the development of plane surfaces known as faces which intersect to produce the distinctive crystal forms.

The industrial use of a mineral depends on one or both of these characteristics. An awareness of man's use of a particular mineral adds greatly to the interest of mineralogical studies and reduces the tendency for these to be regarded purely as irrelevant academic exercises.

There is no better way to initiate mineralogical studies than by the kind of activities devised by Emelyn Evans and described in his paper, 'Involving the student in the study of the materials and the concepts of geology,' (Geology, Vol. 3, 1971, p. 54). Starting with odd-man-out tests the student is led to study more deeply the familiar physical properties such as colour, streak, hardness, fracture and cleavage. This leads to a study of specific gravity using a simple beam balance. For a child at a suitable stage in its intellectual development, this is a splendid experiment. The fact that a substance loses weight when weighed in water is a real discovery. It needs care and patience, however, to lead the child to an appreciation of the fact that for differently sized pieces of the same mineral, if the weights in air are divided by the respective weight losses when weighed in water, the answers are always the same. This constant — the specific gravity — provides an accurate clue to the identity of a mineral. The measurement of the density of a mineral should be regarded as one of the most important routine tasks in the laboratory because apart from its use for identification it is a fundamental property which is determined by the chemical composition and the structure of the mineral. However, it is important to study first the fundamental characteristic of minerals which can be observed directly — the crystal forms.

A sequence of studies is outlined below without consideration of the level at which they might be introduced. The objectives are discussed at the end of the paper but the central theme is concerned with the measurement of interfacial angles and the construction of accurate drawings of selected crystals.

WHAT ARE THE CHARACTERISTICS OF THE ANGULAR ARRANGEMENTS OF THE FACES OF A CRYSTAL?

The interfacial angles of large crystals can be measured with a simple contact goniometer and the internal angle between the face normals is recorded. Measurements of the interfacial angles of the side faces of several quartz crystals are suitable for the discovery of the most fundamental law of crystallography first established by the Dane, Nicolaus Steno in 1669, which states that the angles between corresponding faces on crystals of a particular mineral are constant regardless of the size or shape of the crystals. The six side faces of a quartz crystal intersect to give parallel edges and this is a simple demonstration of a zone, a set of faces whose mutual intersections are all parallel. The direction of the lines of intersection of the faces of a zone is called the zone axis.

Study large crystals of gypsum. Are there any zones present? If so, what are the positions of the zone axes? Draw plans of the crystal and label the faces a, b, c, etc. Measure the interfacial angles of the faces constituting the zones. The observations will be similar to those represented in figure 1.

The faces of gypsum crystals give rise to two zones with the zone axes intersecting at 52°. Do the interfacial angles show any symmetry with regard to the plane which contains the two zone axes? In both zones the crystal faces can be said to be symmetrically arranged in that they occur in pairs, one face on each side of the plane containing the two zone axes. Each pair of faces has the same interfacial angle with respect to the two large side faces. This imaginary plane is a plane of reflection symmetry which is defined as a plane that divides the crystal so that the orientation of a face on one side is the mirror image of the corresponding face on the other side. This crystallographic symmetry depends on the constant angular orientation of similar crystal faces, the actual sizes of which are not significant.

The gypsum crystal also exhibits a centre of symmetry and a diad axis which is perpendicular to the symmetry plane. In this way it is established that the symmetry of the angular orientations of the faces of a crystal may be described in terms of elements of symmetry.
CAN CRYSTALS BE CLASSIFIED?

It is convenient to develop the study of different degrees of crystallographic symmetry by using models in which similar faces have equal sizes. The models possess geometrical symmetry as well as crystallographic symmetry. The cube must be studied with particular reference to the relationship between the axes and planes of symmetry. The three planes which are perpendicular to one tetrad axis and parallel to the other two may be described as axial planes of symmetry because the tetrad axes will be used as reference axes later.

In crystallography the term form has a special meaning. A form consists of a group of faces all of which have the same angular relationship to the elements of symmetry. The cube is a simple form composed of six crystallographically identical faces each perpendicular to a tetrad axis. In contrast the gypsum crystal is composed of three different groups of faces which are illustrated in fig. 2. Each group of faces has a particular angular relationship to the two zone axes and therefore each group of faces is a form. The gypsum crystal is composed of a combination of three different forms.

Studies of the octahedron form of magnetite and the rhombdodecahedron form of garnet crystals will introduce the concept of symmetry class since these simple forms exhibit the same degree of symmetry as the cube, and in fact they are most easily understood by direct comparisons with the cube. Gypsum provides the contrast of a different symmetry class.

It is useful to study the symmetry of the pyritohedron form of pyrite and it will then be easy to appreciate the lower degree of symmetry exhibited by pyrite cubes which often have striations on their faces. The symmetry of the tetrahedron form should be studied with particular emphasis on the relationship of the tetrahedron to the cube, fig. 3.

The cube, pyritohedron and tetrahedron belong to different symmetry classes but they all possess four triad axes. Consequently they can be grouped together and this introduces the concept of crystal system. It is not necessary at this stage to study any other particular symmetry class or to demonstrate that the 32 symmetry classes can be grouped into 7 crystal systems which are characterized by particular symmetry axes.
HOW CAN THE ORIENTATIONS OF THE DIFFERENT FACES OF A CRYSTAL BE DESCRIBED?

A most rewarding exercise at this stage is to construct drawings of the simple cubic forms. The French crystallographer, Hauy, introduced the concept of axes of reference in crystallography. The orientation of a crystal face may be described by the ratios of the intercepts the face has with crystallographic axes which are arranged parallel to axes of symmetry whenever possible. In the cubic system the three mutually perpendicular tetrad or diad axes are selected as the crystallographic axes.

Normally when we attempt to illustrate an object which contains planes and straight lines, we draw it in perspective with all parallel lines converging to a point at infinity. Since the parallelism of sets of edges on a crystal is one of the most important features it is necessary that crystal drawings should show this parallelism.

It is instructive to draw an axial cross produced by clinographic projection on which the unit intercepts are marked. The intercepts of a crystal face are determined from the interfacial angles and then the lines of intersection of the extensions of the face with the axial planes of symmetry are located. A similar procedure is followed for a second face and then the line of intersection of the two faces is located. Part of this line will represent a crystal edge which will be terminated where it meets another edge. In this way a drawing of the crystal is obtained by drawing the orientation of the faces in relation to the axial cross rather than the common practice of sketching a crystal and adding the approximate positions of the axes afterwards.

The simplified construction of the axial cross is shown in fig. 4. Note that, KO is perpendicular to zO.

PO = 3LO = 9LQ = 27PK;
ZO, LQ and PR are all parallel.
OQ = +x, OP = -y, OR = +z.
Erase the construction lines and remember that the drawing represents three axes at right angles on which the unit intercepts are all equal.

The method of construction of the drawing of the pyritohedron is illustrated below but an appropriate sequence of studies could be:

1. Study and draw the icositetrahedron to understand intercept ratios which are determined by measuring the angle between the edges and the tetrad axis.
2. Study the cube and intercepts at co. In order to avoid the mathematical differences of co, introduce Miller indices.
3. Draw the rhombdodecahedron and/or the pyritohedron to become familiar with Miller indices.

HOW CAN AN ACCURATE DRAWING OF THE PYRITOHEDRON BE PRODUCED?

The three diad axes are selected as the crystallographic axes. The front face of the pyritohedron indicated in fig. 5, intersects the x and y axes and is parallel to the z axis. A section of the crystal in the plane parallel to the x and y axes is shown in fig. 6. Measure the interfacial angle between the two front vertical faces and determine the intercept ratio of the face which cuts the positive ends of the x and y axes.

The interfacial angle between the front faces of the pyritohedron is 126°52' and therefore the angle between the x axis and the face indicated in fig. 5 is 63°26'. The ratio x/y = tan 63°26' = 2. Therefore the intercept on the y axis is at 2. What are the Miller indices of the face?

The reciprocals of the intercepts are 1, 1/2, 1/co and after clearing the fractions the Miller indices are (210). Along which lines will the (210) face intersect the two vertical planes of symmetry? Since the (210) face is parallel to the z axis the lines of intersection of the (210) face with the vertical planes of symmetry will be parallel to the z axis and will pass through the intercepts x and 2y as shown in fig. 7.
What are the intercepts of the face on the pyritohedron indicated in fig. 8?

This particular face is parallel to the y axis and has intercepts of 2x and z, so that the indices will be (102).

Along which lines does the (102) face intersect the axial planes of symmetry?

The lines of intersection of the (102) face with the planes of symmetry are shown in fig. 9. Where in the vertical planes of symmetry are the points of intersection of the (102) and (210) planes which are represented by figs. 7 and 9 respectively?

The lines of intersection of the (102) and (210) planes with the vertical plane of symmetry which is parallel to the y axis are shown in fig. 10 and the point of intersection of the two lines is marked A. The edge between the (102) and (210) faces is obtained by joining the points of intersection A and B in fig. 10.

The drawing of the pyritohedron fig. 11, is completed by determining the indices of the other faces and then locating the lines of intersection of the faces with the axial planes of symmetry and with each other.

WHY DO THE CRYSTAL FACES AND CLEAVAGE PLANES OF A PARTICULAR MINERAL ALWAYS SHOW THE SAME ANGULAR ARRANGEMENTS?

In 1781 Hally put forward the hypothesis that crystals were made up of small units bounded by cleavage planes. Halite crystals can be made from cubes which completely enclose space. Can the cleavage octahedra from fluorite be packed together to completely fill space?

As the concepts of physics and chemistry developed it became evident that the crystal units were not solid particles but were arrangements of atoms. The 3-dimensional structure of a crystal is produced by the periodic repetition of the smallest grouping of atoms which provides the characteristics of the crystal.
Two dimensional patterns such as those used for wall papers may be divided by equally spaced parallel lines in such a way that a single design is outlined and it can be seen that the repetition of this design in two directions generates the pattern. The way in which the pattern is built up can be understood in terms of a network consisting of sets of parallel lines and the points of intersection of the lines. It can be demonstrated that all 2-dimensional patterns of points fall in one of the following five types of unit pattern: rectangle, square, rhombus, centred rectangle and hexagon.

Crystal structures are complicated by the manner in which the smallest grouping of atoms is repeated in 3-dimensions to generate a crystal structure may be represented by a 3-dimensional framework of parallel equally spaced planes. Intersections of the planes are represented by lines and points, and the framework is called a space lattice. The French crystallographer, Bravais demonstrated in 1848 that only fourteen kinds of unit cell are required to describe all possible space lattices.

In addition to the primitive cubic cell which is represented by a point at each corner, there are body centred and face centred cubic cells which display the 4 triad axes of the cubic system. The primitive cell in the face centred cube is a rhombohedron as shown in fig. 12, but it is more informative to describe this space lattice in terms of the cubic crystallographic axes so that the characteristic symmetry is retained. The number of points for each unit cell in a cubic face-centred lattice may be worked out from a drawing of the unit cell and it will be seen that each face point counts as $\frac{1}{2}$ and each corner point as $\frac{1}{8}$th because they are shared with adjacent unit cells.

Consider the closest packing of layers of spheres using either models or by drawing plans of circles. When the third layer overlies the first layer, hexagonal close packing is produced. However, when the spheres of the third layer occupy the alternative positions of rest so that the fourth layer overlies the first layer, a tetrahedron is produced as in fig. 13. To which system does the tetrahedron belong? Hence the name cubic close packing. The native elements Au, Ag, Cu and Pb have cubic close packing structures and a 3-dimensional drawing of a cube produced by cubic close packing of atoms of the same kind is shown in fig. 14. Which space lattice best represents this packing arrangement?

This demonstration of the relationships between the symmetry of the cube and tetrahedron, the packing arrangement of spheres and the face centred cubic lattice is an important step in avoiding the isolation of crystallographic studies.

**Figure 12**

**Figure 13**

**Figure 14.**

**WHAT IS THE DISTANCE BETWEEN THE IONS IN A HALITE CRYSTAL?**

Minerals are compounds which have characteristic chemical compositions. If the weight %'s of the elements which compose a mineral have been determined by one of the methods of chemical analysis, the proportions of the atoms in the mineral can be calculated easily. For example, halite consists of approximately 39.4% Na and 60.6% Cl by weight. Since Na and Cl have different atomic weights, different numbers of atoms of each element would be required in order to make up the same approximate weight and therefore it is necessary to calculate the proportions of Na and Cl ions that make up the weight %'s which are characteristic of the halite crystal. The calculation of the atomic proportions is shown in the table below.

<table>
<thead>
<tr>
<th>Element</th>
<th>% Weight</th>
<th>Atomic Wt.</th>
<th>Atomic proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>39.4</td>
<td>22.99</td>
<td>$1,713 = 1$</td>
</tr>
<tr>
<td>Cl</td>
<td>60.6</td>
<td>35.457</td>
<td>$1,709 = 1$</td>
</tr>
</tbody>
</table>
This indicates that halite consists of approximately equal numbers of Na and Cl ions and it can be represented by the formula NaCl.

Estimates of the distance between the ions in halite had been made in the following manner before the discovery of X-rays.

The Molecular weight of a pure substance is a relative number taking 16 as the weight of the oxygen atom as a reference. NaCl has a molecular weight of 58.45.

The gram molecule or mole of a substance is the quantity having a mass in grams equal to its molecular weight. A mole of NaCl consists of 58.45 grams.

The number of molecules in a mole is the same for all substances. This physical constant known as Avogadro’s number is $6.023 \times 10^{23}$ molecules per mole.

Since Na and Cl occur as ions there are $2 \times 6.023 \times 10^{23} = 1.2046 \times 10^{24}$ ions in a crystal of halite which weighs 58.45 grams.

The number of ions along a halite cube edge is approximately the cube root of $1.2046 \times 10^{24} = 1.064 \times 10^{8}$.

The density of halite is 2.16 g/cc. Therefore a halite crystal weighing 58.45 grams will occupy a volume of $58.45 / 2.16 = 27.06$ cc approximately, and the side of the cube will be approximately 3 cm.

We now have an estimate of the number of ions present along a particular edge of known length and consequently an estimate of the distance occupied by an ion can be obtained.

The spacing of the ions = $3 / 1.064 \times 10^{8} = 2.819 \times 10^{-8}$ cm.

Consequently the distance between the centres of two ions on the edge of a halite cube is estimated to be $2.819 \text{A} = 2.819 \times 10^{-8} \text{cm}$.

**HOW ARE THE Na AND Cl IONS ARRANGED IN THE HALITE STRUCTURE?**

The structure of halite was the first to be determined by X-ray methods and it is usually studied in O-level chemistry often with the structure of diamond and graphite. A consideration of the main steps in the reasoning is relevant here.

A halite crystal is arranged so that a primary beam of X-rays is diffracted in turn from planes of ions which are parallel to the (100), (110) and (111) planes, and the angles of diffraction are recorded as in figure 15. The Bragg equation is $n \lambda = 2d \sin \Theta$. What are the ratios of the spacings of the planes which are parallel to (100), (110) and (111) respectively?

It can be seen that $d = n \lambda / 2 \sin \Theta$ and if $n$ and the wavelength $\lambda$ are constant, $d$ is proportional to $1/\sin \Theta$.

Consequently the ratios of the spacings of the (100), (110) and (111) planes can be calculated from the reciprocals of the sines of the observed diffraction angles shown in fig. 15 and these are $1: 0.704:1.15$.

**Figure 15**

The next step is to study the ratios of the spacings of the planes of points in the three cubic lattices. The ratios are shown in fig. 16 in terms of the edge ($a$) of the unit cell and they are derived from the relationship that the square on the hypotenuse is equal to the square on the other two sides. The calculated ratios are -

<table>
<thead>
<tr>
<th></th>
<th>$d_{(100)}$</th>
<th>$d_{(110)}$</th>
<th>$d_{(111)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple cubic</td>
<td>1</td>
<td>0.707</td>
<td>0.577</td>
</tr>
<tr>
<td>Body-centred</td>
<td>1</td>
<td>1.414</td>
<td>0.577</td>
</tr>
<tr>
<td>Face-centred</td>
<td>1</td>
<td>0.707</td>
<td>1.154</td>
</tr>
</tbody>
</table>

Which cubic lattice best represents the structure of halite?

Halite has a face-centred cubic lattice and the edge of the unit cell will be twice the spacing between the (100) planes and equal to 5.64 A.

The second major step in the determination of a crystal structure is to calculate the number of atoms per unit cell from the size of the unit cell, the density and the chemical composition.
HOW MANY MOLECULES OF NaCl ARE THERE IN A UNIT FACE-CENTRED CUBE OF HALITE?

Since there are $6.023 \times 10^{23}$ molecules in 27.06 cc of halite, the number of molecules in a face-centred cube

\[
\text{Number of molecules} = \frac{\text{Volume of unit cell} \times \text{Avogadro's number}}{\text{Volume occupied by a gram molecule}} = \frac{(5.64 \times 10^{-8})^3 \times 6.023 \times 10^{23}}{27.06} = 3.993
\]

Therefore the nearest whole number of pairs of Na and Cl ions in a unit cell of halite is 4.

The content of the unit cell is usually represented by $Z$ and for halite $Z = 4$.

The third major step in the analysis of a crystal structure is to deduce the positions of the atoms within the unit cell from the relative intensities of the diffraction beams. The procedure is essentially one of trial and error. A structure is postulated and its diffraction pattern is calculated and then compared with the observed diffraction pattern. We can tackle the main problem. How can the equivalent of 4 molecules of NaCl be accommodated in the face-centred unit cell while retaining maximum symmetry?

A drawing of the face-centred cube can be used to determine that there are 4 points for each unit cell in a face-centred lattice. If the Cl ions are placed at the face-centred cubic lattice points they contribute 4 ions to the unit cell so where can the 4 Na ions be placed?

If the Na ions are placed in between the Cl ions along the lines parallel to the cube edges it will be found that there are 4 ions per unit cell so that the requirement $Z = 4$ is satisfied. The Na ions also form a face-centred lattice which is displaced from the Cl lattice in the direction of the cube edge by a distance of $\frac{1}{2}$ the unit cell edge as shown in fig. 17. The X-ray observations are consistent with this model which also satisfies the requirement that each Na ion is surrounded by Cl ions to which it is attracted by ionic bonds.

The very important concepts of co-ordination number and ionic radius can be introduced here. How are the Na and Cl ions arranged in the close packing tetrahedra and does this arrangement have any significance with regard to the development of cleavage in halite crystals?

It can be seen from a drawing of the face-centred unit cell that the Na and Cl ions form alternate layers in the close packed tetrahedron and this is why the ionic bonds are strongest in the directions perpendicular to the (111) planes. In contrast because of the arrangement of the ions in the (100) planes the repulsive forces between the like ions are strong so that the bonding forces are relatively weak and consequently halite cleaves parallel to the (100) planes.

Sir Lawrence Bragg solved the structure of halite in this way in 1913 and demonstrated that crystals are not composed of discrete molecules but consist of continuous 3-dimensional arrays of atoms with repeated patterns.

WHY DO THE CORNERS FALL OFF FLUORITE CRYSTALS?

Fluorite is composed of approximately 51.3% Ca and 48.7% F by weight and the atomic weights are 40.08 and 19 respectively. The density of fluorite is 3.18 g/cc and the X-ray measurements show that it has a face-centred cubic lattice with an edge of 5.4626 Å. How many formula units of fluorite must be assigned to the unit cell?
Calculations similar to those used for halite reveal that there are twice as many F ions as there are Ca ions in fluorite and that the unit cell contains the equivalent of 4 CaF$_2$ molecules.

If Ca ions are assigned to the face-centred lattice positions and represent 4 ions, where can the 8 F ions be placed within the unit cell to retain maximum symmetry?

If the face-centred cell is divided into 8 smaller cubes the F ions can be placed at the centres of these as shown in fig. 18. The X-ray record is consistent with this model. Study the (100) planes and see why these strongly bonded, and study the (111) planes and see the reason for the well developed cleavages parallel to the (111) planes.

What are the co-ordination numbers of Ca and F in fluorite? Fluorite, CaF$_2$ is said to have 8:4 co-ordination.

**Figure 18**

**Figure 19**

**Figure 20**

**WHY DOES DIAMOND OCCUR AS CRYSTALS WITH THE OCTAHEDRON FORM?**

X-ray studies show that diamond has a face-centred unit cell with an edge of 3.5667 Å and the pattern is similar to that of fluorite. Since the density of diamond is 3.5 g/cc and the atomic weight of C is 12.001, how many C atoms must be assigned to the unit cell of diamond?

Similar calculations show that 8 C atoms must be assigned to the unit cell and 4 can be represented by the face-centred lattice points. Where can the other 4 C atoms be placed?

In the diamond structure only 4 C atoms are available to occupy sites at the centres of the smaller cubes but a symmetrical arrangement is produced if the 4 C atoms are placed at the centres of 4 cubes with a tetrahedral arrangement as shown in fig. 19. The C atoms within the unit cell are represented by heavy open circles and these also form a face-centred lattice which is displaced from the first lattice along the cube diagonal [111] indicated by the arrow in fig. 19.

What is the co-ordination number of C in diamond? It can be seen from a drawing of the unit cell of diamond that each C atom is surrounded by 4 C atoms to which as held by covalent bonds and this is the reason for the exceptional hardness of diamond. Fig. 20 is a view along one of the (111) planes to show the stacking of the covalently bonded tetrahedra. It can be seen that the C atoms at the centres of the tetrahedra are approximately 3/4 the repeat distance from the apices of the tetrahedra and it is the relative weakness of these bonds that gives rise to the perfect (111) cleavage in diamond.

Since in diamond the atoms are all of the same kind, the stacking arrangement of the tetrahedra is similar in both directions on all four triad axes and therefore diamond exhibits the octahedron form, although the symmetry of the unit cell is not the same as the cube.

**WHY DO CRYSTALS OF SPHALERITE OCCUR WITH THE TETRAHEDRON FORM AS IN FIGURE 21?**

Pure sphalerite is composed of approximately 67% Zn and 33% S by weight with the atomic weights 65.38 and 32.066 respectively. The density of sphalerite is 4.096 g/cc and the X-ray pattern is similar to the pattern of diamond indicating a face-centred unit cell with a side of 5.406 Å. How many molecules are associated with each unit cell of sphalerite?

There are four molecules of ZnS associated with the unit cell and if the Zn atoms occur at the lattice points the four S atoms occur at the centres of 4 small cubes within the unit cell as shown in fig. 22. The S lattice in fig. 23 is displaced in the [111] direction.

What are the co-ordination numbers of Zn and S? and how are the co-ordination groups stacked?

The Zn atoms are surrounded by 4 S atoms to give (ZnS$_4$) tetrahedra and the S atoms are surrounded by 4 Zn atoms to give (SZn$_4$) tetrahedra. In fig. 23 the stacking of the tetrahedra in the (111) and (111) directions is illustrated.
Turn the diagram and look at the $(S_{2n})_4$ tetrahedra first because the view downwards onto the bases which are indicated by heavy stippling. The apices of the $(S_{2n})_4$ point in the $(111)$ direction and in fig. 23 it is inclined towards the observer.

Now look at the stacking of the $(ZnS)_4$ tetrahedra which are viewed from below with the direction of the apices $(111)$ inclined away from the observer. Since the $(ZnS)_4$ and $(S_{2n})_4$ tetrahedra point in the opposite directions, the surfaces on opposite sides of the crystal have different characteristics so that in extreme conditions only one face develops and the crystal grows with the tetrahedron form.

**HOW CAN WE DESCRIBE THE ORIENTATION OF FACES WHICH HAVE IRRATIONAL INTERCEPT RATIOS?**

Study crystals of barytes. Are there any zones present and what are the interfacial angles between the faces which compose the zones?

Plans of a barytes crystal with labelled faces are shown in fig. 24. Usually barytes crystals have a pair of well developed faces $(a, d)$ and two forms $(b, c, e, f, g, h, m, n)$ each consisting of four faces which are inclined to the larger faces. The edges reveal the presence of two zones at right angles to each other and parallel to the large faces. There are also two prominent sets of cleavage planes which are parallel to crystal faces labelled $p, q, r, s$ in fig. 24, and perpendicular to the two large faces so that the zone axis is perpendicular to the other two zone axes. These three zone axes can be used as the crystallographic axes. There are six possible ways of labelling the axes but the conventional orientation is used in fig. 24. Study of the interfacial angles will reveal their symmetrical arrangement with respect to planes of reflection symmetry which are perpendicular to each of the zone axes.

What are the intercept ratios of the face $b$ if the intercept on the $y$ axis is unity?

The angle between the face $b$ and the $y$ axis is $52^\circ 42'$ and the tangent gives the ratio $z/y = 1.3127$. Therefore, the intercept ratios of face $b$ are $\infty:1:1.3127$. It would be very inconvenient to use the irrational ratio $1.3127$ as the unit of measurement on the $z$ axis so it is the convention to have different units of measurement on the $y$ and $z$ axes. The unit intercept on the $z$ axis is $1.3127$ times the unit intercept on the $y$ axis. When this convention is accepted, what will be the Miller indices of the face $b$?

The general orientation of the face $b$ with respect to the crystallographic axes can be described by the indices $(011)$ and this avoids the use of irrational numbers in the intercept ratios or indices. The exact angular orientation of the face can be calculated if the ratio of the unit intercepts $z/y$, the axial ratio, is known just as the axial ratio may be obtained if the interfacial angle is known.

If the face $g$ is regarded as the $(101)$ face, what are the ratios of the intercepts of this face on the $x$ and $z$ axes with regard to the unit intercept on the $y$ axis?
The angle between the face $g$ and the $x$ axis is $38^\circ 51'$ therefore the ratio $z/x = \tan 38^\circ 51' = 0.8054$. But the ratio of the intercept on the $z$ axis is $1.3127$ relative to unit intercept on the $y$ axis, therefore the ratio of the intercept on the $x$ axis is $1.3127/0.8054 = 1.629$. Consequently the ratios of the unit intercepts on the crystallographic axes may be defined as $1.629 : 1 : 1.3127$. These are known as the axial ratios and the definition of these ratios allows the faces to be indexed with simple rational numbers.

What are the indices of the face $p$ which is parallel to one of the sets of cleavage planes?

The angle between the face $p$ and the $y$ axis is $78^\circ 20'/2$, and therefore the ratio $x/y = 0.8147$. The intercept ratio of face $p$ on the $x$ axis is obtained by dividing the measured intercept by the axial ratio: $0.8142/1.629 = \frac{1}{2}$ so that the Miller index is 2. Consequently the complete indices of the face $p$ may be obtained by dividing the ratios of the unit intercepts by the intercept ratios of face $p$ as follows:

<table>
<thead>
<tr>
<th>Axial ratios</th>
<th>1.629</th>
<th>1</th>
<th>1.3127</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed ratios</td>
<td>0.8147</td>
<td>1</td>
<td>$\infty$</td>
</tr>
</tbody>
</table>

A plane which has intercept ratios of $1.629 : 1 : 1.3127$ so that the indices can be designated $(111)$ is called the parametral plane. Ideally the procedure would be to select a crystal face which intersects all three crystallographic axes and designate this the parametral plane so that the ratios of the intercepts of this plane would define the ratios of the unit intercepts on the three crystallographic axes, the axial ratios. However, the $(111)$ plane is rarely present on barytes crystals and so it has been necessary to develop the concept of axial ratios from a study of the dome faces.

If a number of faces intersect a particular crystallographic axis, are the intercept ratios irrational numbers?

Some crystals of barytes have a series of dome faces parallel to the $y$ axis as shown in fig. 25. Fig. 26 is a section showing the interfacial angles of the three dome faces $v$, $g$, $w$ and also the angles between these faces and the $x$ axis. If the intercept that the face $w$ makes with the $z$ axis is regarded as unity, what are the intercept ratios of the faces $w$, $g$ and $v$ on the $z$ axis?

The tangents of the angles between the $w$, $g$, $v$ faces and the $x$ axis are $0.4027$, $0.8054$ and $1.609$, and therefore the ratios of the intercepts of the faces $w$, $g$, $v$ on the $z$ axis are $1, 2, 4$. This is a demonstration of the Law of Rational Ratios of Intercepts and it establishes the concept of different units of intercept on the three crystallographic axes. These different units of intercept are the ratios of the lattice repeat distances along the axes as shown in the inset lattice in fig. 26. What are the Miller indices of faces $v$, $g$ and $w$?

Since the Miller indices of face $g$ are $(101)$ the intercept ratios of faces $v$ and $w$ on the $z$ axis are $2$ and $\frac{1}{2}$, so that the indices are $(201)$ and $(102)$ respectively?

It could be argued that a true discovery approach would allow the student to adopt any of the six ways of labelling the axes and to select alternative faces from which to work out the axial ratios. Each individual effort could be checked for correctness and then the student could study the accepted orient-
The drawing of the orthorhombic crystal of barytes, fig. 25, was constructed on an axial cross on which the unit intercepts have been modified to the appropriate axial ratios. This exercise ensures that the intersection of the faces are accurately drawn and it reinforces the understanding of the concept of axial ratios, particularly because when drawing combinations of forms it is necessary to adjust the actual lengths of the intercepts in order to get the desired effect. However, there is little to be gained by modifying the axial cross in order to draw crystals of the other systems.

**Figure 25**

**Figure 26**

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**WHAT CAN BE DONE IF THE SYMMETRICAL RELATIONSHIPS OF THE FACES OF A PARTICULAR MINERAL ARE OBSCURED BY THE VARIATION IN THE SIZES AND SHAPES OF THE FACES?**

The angular position of a face may be recorded by projecting the normal to the face from the centre to the surface of a sphere. The point on the sphere which represents the direction of the face-normal is called the pole. The position of the poles on the upper hemisphere of a sphere can be represented on a stereographic projection. The preparation of a stereogram representing the directions of the face normals is made easy by the use of a stereographic net such as fig. 27 on which great and small circles are marked at 10° intervals. The zone axes of barytes are placed in the cardinal positions and the directions of the normals to the (001), (011), (101) and (210) faces can be located as shown in fig. 27, and the other faces complete the stereogram fig. 28. The open circles represent poles to faces which occur on the lower hemisphere. The angular relations and symmetry of the common faces of a barytes crystal are clearly shown by the stereogram fig. 28.

**Figure 27**

**Figure 28**

---

The crystallographic axes are diad axes and these are perpendicular to planes of reflection symmetry. The operation of these symmetry elements on the poles of the four faces shown in fig. 27 gives rise to the poles of all the faces that may be present on a barytes crystal of the kind shown in fig. 24.
The concept of the symmetry elements operating on a pole to reproduce the forms is the basis on which the 32 symmetry classes is built up. This is the type of approach to crystallography adopted by the mathematicians. It emphasizes the abstract concepts and its goal is the specification of the possible arrangements of planes, axes and points in space.

WHAT ARE THE OBJECTIVES OF THE SEQUENCE OF CRYSTALLOGRAPHIC STUDIES FOR GEOLOGISTS DISCUSSED HERE?

In contrast to the abstract mathematical approach the principal objective of the structure suggested here has been to introduce and establish the main concepts of crystallography and crystal chemistry by posing questions concerning observations of particular features of selected common minerals.

The construction of drawings of the cubic crystals emphasizes the significance of crystal edges, zones, zone axes and symmetry planes and gives a thorough understanding of intercept ratios and Miller indices without involving the difficult abstract concept of axial ratios. The student has the reward of good drawings of the simple forms of crystals. An additional advantage of these construction exercises is that the student is encouraged to think in 3-dimensions and to represent the 3-dimensional solids in 2-dimensional diagrams. Consequently the skills learned in constructing drawings of exact geometric models are of value in the study of all geological structures.

The main concepts of the chemical nature of minerals and the reasoning used in the determination of the crystal structures are introduced in order to understand the characteristic physical properties of certain cubic minerals. These are particularly interesting and rewarding studies because they involve the application of the concepts of crystallography, the space lattice, the packing arrangements of atoms, chemical composition and atomic ratios, bonding, coordination number and electrical neutrality of crystal structures. The studies provide a sound understanding of many of the main concepts of mineralogy, and the realization of the simplicity of the reasoning involved and the use of numerical calculations to solve relevant problems could give the student of geology considerable confidence.

Then the study of the barytes crystals introduces the concepts of axial ratios and the Law of Rational Ratios of Intercepts which can be understood in terms of the different repeat distances on the axes of a space lattice. However, as a result of the studies of the structures of some cubic minerals the student should be able to appreciate the nature of the more complex and less symmetrical structures of the common rock forming minerals without necessarily getting involved in the details.

The suggested structure is flexible in that it offers many branches but there is no end. There will always be questions concerning the form, utility or beauty of crystals which will stimulate the inquiring mind to search for understanding.

SHOPFLOOR

CRYSTALLOGRAPHY

For pupils who find the crystal forms of the Cubic System a little bewildering, this issue's cover picture might prove of some assistance.

Closed forms are the distinguishing feature of this system, and from a few basic forms others can be derived by partially developing or "squeezing out" alternate faces. The diagram shows how, by starting with the cube, processes like truncating (replacing an edge between two faces by a face equally inclined to both) or bevelling (where the inclination is unequal) can produce the more complex versions of the simpler forms.

When using the diagrams a few points are worth noting:

- the arrows indicate only one possible "line of approach", eg. the trapezohedron can be derived from an octahedron of the form (211) by bevelling instead of as shown;
- further forms can be developed from those illustrated, eg. replacing each face of the octahedron by six scalene triangles results in a hexoctahedron; developing alternate faces of this leads to a diploid;
- in general forms on the left hand side of the diagram have a higher symmetry than those on the right;
- the use of shading or colouring might help - simple forms in one colour (or shading), combinations in two colours, carrying the one colour through the stages until that form is finally squeezed out.

G Cooke, Crossmceiliog School, Cwmbran, Gwent
MINCARDS

Minicards is an interesting and effective way of learning mineral properties.

Description of the cards

On one side: the name of the mineral
on the reverse: the properties of the mineral; composition, crystal system, density, hardness

Using the cards

The general principle of use is that they should be used name-side up, the player remembering the properties listed on the reverse, though it will be necessary at certain times to turn the cards over to check.

A large number of "games" can be devised, either for individual or group use. One example is given in detail:

Ordering by hardness

Students work in pairs; one lays out the cards (name side up) so that the minerals are arranged from left to right in order of increasing hardness. The second student examines the order, and states any corrections he would wish to make. Together they then check the order by turning the cards over. Any out of place cards are put in the correct place and once more turned name-up for the correct order to be read through. When the hardnesses are well memorised, a modification of the game is for the first student to intentionally make one mistake in the order. The second player must then locate this deliberate mistake. It is a simple matter to devise some system for scoring, if desired.

Other 'games'

Ordering by relative density, sorting into silicate and non-silicate, finding pairs (where any one property is more or less the same), even snap could be played on this basis: Ordering silicates in increasing polymerisation of silicate ions, subdividing non-silicates according to composition (sulphides, oxides, etc.). Card games such as rummy, where sets and runs are laid could, with some modification, be played.

Need

If we are going to learn something, practice is essential. But in a school course the pupils do not spend much time looking at minerals, and only occasionally need to identify them later on. The cards therefore lend interest and variety in learning the mineral properties, an otherwise tedious and difficult operation. They also are more likely to draw out relative differences than just studying the mineral themselves.

They have been found to be effective with my A level students when they made the cards themselves. Although this in itself is a useful learning experience, the time spent is too long and it is better if cards can be obtained ready made.

Danger

Care must be taken by the teacher that "playing the game", doesn't entirely detract from the prime purpose, as some properties, such as habit, might be rarely touched on in 'the game'.

Acknowledgement

Thanks to Peter Whitehead for encouragement, and to my students for helping compile the cards.

B.L. Welters
Walsall Blue Coat Comprehensive

GOOD PRACTICE IN THE USE OF VISUAL AIDS


Although many academics are aware of the educational benefits that follow from the use of visual aids, they are often subjected to the most unintelligent use of such aids at schools, colleges or the lectures organised by learned societies. Geology as a subject lends itself to visual expression, and it is a pity that all too often visual data is presented in a complex and indigestible manner. In the hope that expert advice would help improve presentation and preparation of such material, the ESEMG* and GIG* asked Tim Long of the National Centre for Audio Visual Aids, and Dr Nita Spektorov from Surrey University to act as the keynote speakers at the meeting. Sir Peter Kent, who is known to have a keen interest in the correct use of visual aids was in the chair.

- ESEMG - Earth Science Education Methods Group
- GIG - Geological Information Group
Both speakers believed that their essential role was to persuade teachers to use visual aids and to encourage them in their attempts to improve and perfect both technique and presentation. Tim Long stressed that teachers should be aware of the various points that made the use of the overhead projector or video tape academically important. He listed the break up of verbal flow, the focussing of attention, the graphical presentation of numerical data and greater personal contact with the group as essential criteria. He stated that the level of perception depended on audience motivation and intelligence, and that the various members of a group respond differently to different modes of learning. Teachers should be aware of this and plan their lectures so that verbal and visual components met the needs of all or most of their audience. He stressed the view that visual aids make a major contribution in the attraction and holding of attention, and developed the theme that visual aids should be used to challenge the audience to see and study relationships, ensuring recall and acting as a guide to learning.

Both speakers reminded the meeting of the value of diagrams and slides prepared ahead of lectures, and emphasised the value of early preparation to those of us not endowed with artistic ability or licence: They also expressed the hope that apart from those lacking artistic talents, academics who suffered from anti-projector or other mechanical phobia would finally realise the full value of visual aids.

In the second of the two lectures Dr Spektorov noted that good visual aids take time to prepare and demand advance planning; slides and diagrams from learned papers, although easily prepared, often make the poorest contributions to lecture illustration. Bad visual aids can be a real drawback and Dr Spektorov encouraged the audience to consider a number of criteria in the preparation of lecture programmes. These should be related to student needs and perhaps the amount of essential notes one would expect to be taken during a given period. The criteria noted by the speaker can be linked with type of aid one would use.

Dr. Spektorov's own lecture was organised around the comparison of good and bad material with a considerable amount of time being devoted to the ways in which academics could improve their use of visual aids. She emphasised that with 35 mm slides the full use of the frame was important and that like Mr Long, she too believed that colour slides often improved the effect. Full frame usage were shown to eliminate unimportant data, the small typed descriptions often seen to the side of figured specimens or diagrams being excluded to the benefit of the object itself. The redrawing of a figure before slide preparation was also seen to improve the value of the subject as a source of educational information; complex diagrams being broken down into relative sections and numerical data being expressed in the form of histograms etc.

Both Dr Spektorov and Mr Long noted that vision dominates sound during lectures and that few students can devote their full attention to someone speaking, while they themselves try to interpret information displayed in a visual form. Slides and other aids were shown to be of value when one chose to introduce a new point and that the design and legibility of the aid in question were important factors in the retention of audience interest. The use of the right type face in the preparation of visual aids was emphasised by both speakers, a bold 9-point type being regarded as the minimum acceptable. Lower case was preferred to block capitals, research showing that the latter was more difficult to read. The value of the correct print size and careful design was expressed clearly through the quality illustrations used during both lectures.

Whilst dealing with the use and preparation of diagrams for the overhead projector, Mr Long and Dr Spektorov commented on the value of colour and presented a number of examples where standard illustrations could be improved upon. Many teachers already experiment during the preparation of visual aids and I am sure that black negative-clear line transparencies are in widespread use. It is, however, still fascinating to see the bones of animals, stratigraphic units or other lines on a negative background 'come alive' through the use of coloured pens. It is also an experience to be taken step by step through the geological history of an area, when the lecturer concerned has given the matter a lot of thought and uses composite transparencies to build up the events that affected the regions; successive side flaps containing information relevant to each new point or story-line.

The value of all these aids were stressed by both speakers and the audience were left in no doubt that Mr Long and Dr Spektorov were experts in their vocational field.

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Dick Moody

<table>
<thead>
<tr>
<th>Lighting</th>
<th>Preparation</th>
<th>Point to/at</th>
<th>Note taking</th>
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<td>Complete blackout</td>
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<td>Yes but with some difficulty</td>
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Modified from handout supplied by Dr Spektorov
DOES DEGREE LEVEL GEOLOGY TEACHING NEED A NEW APPROACH?

Mike Boulter outlines an alternative type of degree programme that is not centered on the conventional lecture-practical approach.

THE PRESENT SYSTEM

The debate on the purpose of higher education for geologists is inevitably influenced by the educational and geological developments of the last few years. The belief that its purpose is solely to pursue knowledge for its own sake and, or, that its role is to apply the specialism to human and political requirements is now being questioned. There is a growing body of opinion favouring the view that it is for the student to play some role in determining the particular purpose and emphasis that the individual educational experience should offer.

The past ten years have seen a period of unprecedented growth of geology in higher education in Great Britain. The number of students studying the subject at degree level has more than doubled; greater numbers of students stay on to do research; the Council for National Academic Awards and many new universities and polytechnics have established their identity; the Open University has started and more than 30 polytechnics have been formed. Many more academic staff are employed as a result of this expansion and they are supported by an even greater increase in administrative and technical staff. In addition, the bureaucratic growth through this same developmental stage has created more committees and 'office jobs' for all concerned professionally with aspects of earth science education.

At the same time, revolutionary developments took place in the subject itself. The growth of earth science manpower and the use of more sophisticated equipment, and investigations of new geological problems inevitably lead to more journals being started and more societies and specialist groups being launched. By comparison with today, degree level geology of the early sixties looks small and simple.

Over the same period of time there have also been changes in external attitudes and circumstances affecting the work of geologists in establishments of higher education. Higher education is less of a privilege. Lower economic growth is reducing the need for more geologists (University Grants Committee, 1974; Caswell, 1976). Cutbacks in public expenditure affect the practice and role of academic geology. Employers are increasingly frustrated by an irrelevance of the new graduate's training to the work situation. Students are regarding their futures with some trepidation, and so are more critical about the nature and relevance of their courses.

It is interesting to examine the philosophy and structure of the science courses that are offered in universities and polytechnics against this background of change and uncertainty. Despite this background, in terms of what the students spend their time doing on courses very little has changed since the sciences were first taught at the university. The transmission of knowledge from scientific paper, text book, to teacher and finally to student takes place using a rigid paradigm (Kuhn, 1970). All available forms of knowledge within the geological sciences are transmitted by members of the geological establishment, who are themselves trained by their specialist predecessors. Such a system is the respected norm, but a growing body of opinion (Lakatos and Musgrave, 1970) is of the view that this one-way transmission of inherited knowledge not only inhibits originality but also prevents new ideas being conceived and explored. Thus thought and its development are suppressed. Obviously, communication from specialists to students, whether by lecture, seminar or textbook is a necessary part of the learning process; but teaching science in this way has important consequences. Such a class-room situation is a manifestation of a larger problem which inhibits scientific progress and which only allows development within rigidly defined boundaries (Feyerabend 1975). It does not allow sufficient flexibility of thought to give fully challenging tests to a particular view. A maximum breadth of knowledge is required to apply the more varied tests that are possible, whereas by normal practice the only hypotheses that are accepted into the scientific world are those that can be empirically tested. This limits science to a very narrow style of experiment, relevant to a limited area of knowledge. This line of argument challenges the notion that scientific knowledge has a primary role within the education of geologists. The skill of learning how to cope with the new times of change in both subject and society may be as important as the knowledge itself. Surely the educational system should be flexible enough to incorporate experiments on such ideas?

Most undergraduate geology courses are mainly concerned with the transmission of information to students. Thus most students anxious to succeed devote their time to rote learning. I believe that this is at variance both with the interests of the student and of society at large. Since the subject and the society are changing so quickly, rote learning is inhibiting the development of intellectual skills. Colleges are ceasing to help students learn how to think. The present methods may have been suitable just after the war, but their continued - and thoughtless - perpetuation should not continue without some debate and without considering alternative teaching strategies. For students of geology, some of this change can be obtained through learning within the discipline.
But education should adopt other pursuits and methods in order for students to develop creatively and to take responsibility for their own work. Teaching method has to adapt to benefit not only the student but also science and its methodology. Organisational ability, working with people, efficiency at problem formulation and analysis are the kinds of general skills that most graduates are called upon to practice on entering employment. Such skills are just as important to the geologist as they are to others and should be learnt as part of an academic course.

THE PURPOSE OF HIGHER EDUCATION FOR GEOLOGISTS

Below I outline six types of experience that a geology course can provide. There are doubtless other ways of objectifying geological education, but these serve as an example of one particular approach.

The practice of scientific techniques

Though science courses have traditionally a substantial practical and (if relevant) field experience, they are usually associated with a direct theoretical counterpart. In this model the main objective is to provide a direct opportunity to work with a whole variety of equipment. For example students would be given a short course on microscopy, would be shown how to use the instruments and be lectured on their applications and significance. In the field, techniques of mapping are already taught in this way. Time would not be spent on the same technique for more than a necessary minimum period, in contrast to a conventional paleontology course, during which students may spend every practical session throughout the year looking at fossils with a hand lens and making drawings.

Surely it is sufficient to learn the techniques of observation and drawing, and then pass on to something else? Other kinds of task occurring regularly in geological work would be included as essential parts of this course (e.g. the use of geological literature, mapping, the use of computers, microscope, techniques of scientific description, photography etc.).

General abilities

General skills such as the ability to work with people, writing, personal organisation, institutional operation etc. can be learnt by experience rather than by the more conventional teaching methods. The project is an ideal vehicle to bring this kind of experience into the course, either for the individual or for a group. For example, a group of students may work for one day a week for a term on fossils from a new locality in Kent. It would be for the students themselves to arrange appointments with the quarry owners, travel, collecting specimens, communicating with other interested workers etc. A whole host of business administration tasks can be involved with such work, whether it is directly geological or not. Such work would become a substantial and important part of the course itself.

Transferability of experience

An important assumption that is made in proposing these skill-based components within a course of higher education is that if a skill can be undertaken in one context then it can also be done in another. If an individual finds out for himself how to operate a particular piece of equipment the chances are that he will have learnt a methodology that can be applied to many others. He need not be concerned with the intimacy of the machine, but with the procedure of finding out about the method and to have the competence of working it. This concept of transferability involves processes such as obtaining, absorbing, comparing and critically evaluating the material, whatever the problem.

The methodology and philosophy of science

Geologists are concerned with testing ideas about the Earth. Hopefully, they are concerned with applying some kind of scientific method. Therefore it is essential for the philosophy of such processes to be explained to students involved with its practice. Intensive programmes of reading and discussion of the literature of scientific philosophy will help students learn the value, limitations and significance of scientific method, and the consequence for the development of science. These discussions would be especially useful if there were an opportunity to apply such ideas to other course components (e.g. project work).

Basic facts of geological knowledge

GCE A level syllabuses and the content of many first year undergraduate university courses contain a general review of the breadth of geological knowledge. This is a useful base for those committed to that particular discipline. Associated subjects are also relevant and are often presented as 'geological chemistry' 'geological biology' etc. The difficulty for those concerned with designing such courses is to know where to stop. But if a student is experienced with the methodology of independent investigation he is able to work in depth on geological problems without the support of a course of lectures and practical classes. Once an undergraduate has completed a course on basic geological knowledge at an elementary level, conventional cognitive teaching can give way to learning by experience. The time saved thereafter can be used for projects and other activities that are more suited to the practice of independent academic study and its associated skills that the student needs to learn. Through practising methodology, referring to the primary, secondary and tertiary literature, consulting relevant specialists and individuals, advanced and detailed work can be undertaken more fruitfully. Such an approach will make courses more relevant both to students, and for future geological needs than is possible in a formal course devised by others.
Placing less emphasis on the academic subject content side of curriculum design means that the student's particular requirements become paramount to define course content. This switch is extremely important, and a comparative example might help to explain its significance. In a cognitive based course, third year undergraduates may (or may not) have a detailed course on Quaternary pollen analysis. There are about four textbooks on the topic and usually these would cover the syllabus. Lectures, practical classes, field trips and examinations would form the basis of the course, which usually would be taught by a specialist in the field. The consequences of this procedure are familiar to all who teach in higher education. Some students would find the experience of continuing usefulness throughout their lives either in their future work or in other ways. Some might gain important understanding of the subject through such studies but others would do the work solely to pass the examination, and would then forget all the influences that it had had. Conversely, students on an activity based course would work on projects, some of which might be concerned with a peat deposit containing pollen. The problems presented by the project would provide opportunities to consult the same four textbooks and specialist staff. But the primary emphasis would be on the student's experience of the combination of theoretical knowledge, methodology and scientific practice. The student's experience of this combination would form the basis of the study.

Detailed research projects

The key to this particular alternative structure of higher education can be based on the research project, so that many of the objectives of postgraduate education are brought into the undergraduate sphere. Research projects can give opportunities to practice the skills and methods that are associated with the combination of knowledge, methodology and practice. The project can serve as a vehicle through which this can be experienced. If a number of projects can be taken by students during their three year degree course and a number of internal and external agencies are used to aid their completion, then a large range of areas of geology can be covered.

CONCLUSION

There are many ways in which these and other kinds of experience can be included within an educational programme. It may be argued that most existing courses in geology already have many of them, and that that concerned with general skills is covered elsewhere - in the students' union for instance! But if the criticism of present higher education methods that are expressed here are at all acceptable, and if these six 'experiences' are at all relevant, then clearly existing course structures are not satisfactory. One implication is that syllabuses are no longer necessary for most of the three year course (with the exception of the short courses associated with the experiences of foundation knowledge, technique and philosophy. Instead the student must decide which interests he is to experience, select the research projects accordingly and take full responsibility for its value as a learning process.

This kind of approach has important consequences for the process of study and learning. Instead of learning by stimulus-reward (Borger and Seaborne, 1966) as some believe takes place on courses with syllabuses, lectures and examinations, it involves learning by experience - by performing a set of activities relevant to each of the six points mentioned above. Instead of structuring a course around a set of lectures and practical classes that are fixed, an alternative approach is to structure the course around a combination of the cognitive and the practical, relevant to the six experiences described.

In this article I have tried to set out a number of principles which might serve as an alternative to the existing model of higher education for geologists. They are offered here in the hope of stimulating a debate on the fundamental purposes of teaching in geology, and challenge some of the fundamental assumptions lying behind the planning of the existing courses for prospective geologists in universities and polytechnics. They are not intended as a blueprint for immediate application or rejection, but rather should be seen as a stimulus for the introduction of new ideas into course design. One of the things that the polytechnics have already shown the universities is that course planning can take a very great deal of time and energy. If this article serves to make some people pause and reconsider some of their basic responsibilities as educators, then perhaps it will have served some purpose.

REFERENCES

WHAT QUALIFICATIONS BEST FIT A STUDENT FOR A GEOLOGY DEGREE COURSE?

John Weaver, G. Andrew Tomson and Paul J. Hill

The sixth form student who has expressed an interest in Geology may want to know how well his particular aptitudes fit him for courses in Geology. There are a wide range of such courses ranging from Engineering Geology, Geophysics and Geochemistry to Earth Science degrees, where Geology may be linked with Humanities or Social Science. The purpose of this article is to give some indication of the qualifications and qualities sought in students applying for courses with a strong geology component either as a single subject or part of a dual subject degree. The following remarks are based on experience gained in interviewing and monitoring the progress of students taking the London External BSc degree and in planning a CNAA BSc degree in Earth and Life Studies at Derby (now Derby Lonsdale College of Higher Education).

A sample of 222 students, taking Year 1 Geology over the 5 year period 1969-1973, whose degree results are known, has been studied. Of these 222 students 96 went on to take Geology as part of a dual degree or for a single degree.

Minimum entrance qualifications for B.Sc degrees tend to be fairly uniform, with O level Mathematics and two science A levels usually required. The list of suitable A levels for such degrees is often fairly long, and may include subjects that geologists would not regard as useful. How much science other than Mathematics is essential? At O level we are certainly looking for an ability to cope with scientific disciplines. Thus the subjects failed or not attempted often asked as much light on the applicant's aptitudes as do the passes. Table 1 shows that a high proportion of the students taking Year 1 Geology at Derby had an O level in Chemistry, Physics or Biology. 93% of them had passes in at least two of these subjects. Those with no pass in any of these subjects had an O or A level pass in Geology. The numbers of students with O level passes in Geography and Geology, have remained fairly stable at 95% and 30% respectively. Table 2 illustrates that in the Derby sample some 80% of the students had an A level pass in Geography and 45% an A level pass in Geology. The majority of students also had at least one A level pass in Biology, Chemistry, Physics or Mathematics. Of the students who went on to take Geology in Year II and/or Year III nearly 50% had A level passes in Geography and Geology only, 76% had an A level pass in Geography and 65% had an A level pass in Geology (Table 3).

Table 1: 'O' Level Qualifications

<table>
<thead>
<tr>
<th>Year</th>
<th>No of students taking Year 1 Geology</th>
<th>% number of students with 'O' level</th>
<th>% number of students with 'O' level sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maths</td>
<td>Chem</td>
</tr>
<tr>
<td>1969</td>
<td>13</td>
<td>100</td>
<td>69.2</td>
</tr>
<tr>
<td>1970</td>
<td>43</td>
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</tr>
<tr>
<td>1971</td>
<td>82</td>
<td>100</td>
<td>48.8</td>
</tr>
<tr>
<td>1972</td>
<td>40</td>
<td>100</td>
<td>60.0</td>
</tr>
<tr>
<td>1973</td>
<td>44</td>
<td>100</td>
<td>52.3</td>
</tr>
<tr>
<td>TOTALS</td>
<td>222</td>
<td>97.3</td>
<td>52.7</td>
</tr>
</tbody>
</table>

Table 2: 'A' Level Qualifications

<table>
<thead>
<tr>
<th>Year</th>
<th>No of students taking Year 1 Geology</th>
<th>'A' Level Subjects</th>
<th>Students with single or dual degree in Geology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Geog</td>
<td>Geol</td>
</tr>
<tr>
<td>1969</td>
<td>13</td>
<td>7</td>
<td>53.9</td>
</tr>
<tr>
<td>1970</td>
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<tr>
<td></td>
<td></td>
<td>96</td>
<td>43.2</td>
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</table>
Many students although interested in Geology, have stated that they were unable to take Geology in school because of timetable clashes or no qualified teacher at their school. Others have stated that they were advised against A level Geology as an adequate preparation for a degree in Geology, while some stated that they had developed an interest in Geology through A level Geography. The high proportion of students with O and A level Geography compared with the small proportion with O and A level Geology illustrates this point (Tables 1 and 2). However, the varied A level background of the students obtaining degrees in Geology appears to have had little effect on the standard of their degrees (Table 3). The apparent deficiency in Science A levels does not appear to have been a major obstacle. Table 3 illustrates that students with only Geography and Geology at A level competed on equal terms with those who possessed a "pure" science A level background.

From experience we consider that suitability for a degree course in Geology is not simply a matter of having taken useful A levels. Only by reviewing an applicant's total educational experience can we begin to assess whether he is likely to be successful. For this reason the interviewing of each applicant is extremely important. We must consider the motivation of each student in wishing to study Geology, and his aptitude and willingness to take part in large amounts of fieldwork. This is especially the case with those who have no school experience of either Geology or another field based subject.

In the light of experience with the External London BSc degree (now discontinued), the entry requirements for the CNAA Geology degrees at Derby are designed to allow a reasonable degree of flexibility of subjects studied. We feel that while the application form tells the admissions officer the qualifications, only the interview will give an idea of the aptitude of each student. Where choice of degree course is delayed until the end of Year 1 (as in the case at Derby) the interviewer has to bear in mind the avenues open to the student.

The debate of how best to equip sixth formers for Higher Education courses in Geology will certainly continue. Undoubtedly Geology requires the support of other sciences, but whether those subjects are as important as A level as Geology is itself questionable. It is clear that different A level backgrounds are equally suitable and the decision to admit students to the course will always rely heavily on interview.

GEOLOGY DEGREE ENTRANCE REQUIREMENTS

Background

In recent issues of GEOLOGY teaching, there has been considerable debate about the fact that degree entrance requirements for geology do not require an A level pass in the discipline, unlike the situation in the other sciences. Many teachers see this situation as a "stab in the back;" undermining their efforts to establish more geology courses in schools.

In order to augment the information provided in the CRAC Guide to Earth Sciences Degrees, GEOLOGY teaching wrote to 61 universities, polytechnics and colleges of higher education to seek their opinions on this issue. 27 returns were received (21 from university departments, 3 from polytechnics, one from a Higher Education College, and two that were not attributable, due to the option of the responders of remaining anonymous). It appears that the sample covered 560 first year entries (excluding the Scottish Universities) and so probably represents around two thirds of the annual entry into geology degree courses. The information and comments given below are not meant to provide an exhaustive survey of higher education's attitude to school geology, but hopefully will add something to the current debate about the place of geology in all curricula.

GCSE Passes in Geology

Excluding the Scottish Universities, 37% of students in departments supplying relevant data had O level passes in geology, and 41% had A level passes. Moreover, many departments pointed out that often
individual students did not have passes in the subject at both levels; therefore the proportion of students entering degree courses with some prior knowledge must be higher than these two figures.

Does your department run separate first year courses tailored to those who have, and have not, taken geology at A level?

The responses indicate that the London Colleges (except Imperial College) are the only ones able to offer alternative courses of this kind, largely because their flexible course-credit system allows them to do so. One other department responded as follows:

"We have done so up to and including the present year, but have decided reluctantly to abandon it since the A level background of the student proved so varied and in most cases so inadequate."

Do you prefer applicants NOT to have taken A level Geology

Excluding Scottish Departments, seven departments gave replies which clearly showed their dislike of A level geology, but none went as far as saying they 'disqualified' candidates with such a qualification. Two departments expressed a preference for students with passes in A level Geology. Some of the comments on this question are reproduced below:

"In general, those few students who came here with 'A' level geology tend to be 'a pain in the neck' because they 'know it all' and are learning 'nothing new' and are therefore bored. It is odd that such students commonly score below average in the examinations. Whether a year of boredom or inherited misconceptions (or different conceptions?) or other factors yield this result is not clear, but our better students have generally spent their school years on subjects other than geology."

"We prefer pupils to have taken and passed well in Geology. This gives a good indication of their motivation in the subject and we believe it better to attract such students than those with mediocre Maths, Physics or Chemistry who may well also be mediocre geologists!"

"On balance, yes, we prefer applicants not to have taken A level geology since we prefer to take students with the basic physical sciences or a biological science A levels. However, students with A level geology +2 basic science subjects are treated equally favourably at present as long as they have good O level grades in all their sciences. Geology at A level is welcome as a motivating influence and as useful in itself for students who are clear that they are going in for either observational geology or general environmental careers. For those who seek to treat geology as a physical science subject (which we prefer), pure science experience is more vital."

"We make no distinction in vetting applicants. What we try to look for are people who have done, and will do well, whatever their background. Ideally, we would like people to have three out of Maths, Physics, Chemistry, Biology (or Zoology or Botany) and Geology, but we are happy to consider any reasonable combination. The problems we find with people who do not have a numerate background is their fear of even attempting anything with numbers. We wouldn't dream of ever saying you must have or must not have A level geology. Perhaps the weakest combination offered is the Geology plus Geography & another (or is it that the weaker candidates do this option?). On balance, I personally would advise a would-be professional geologist to do 'O' level geology, but to concentrate on the basic sciences for A level. For others, A level geology would be an excellent subject."

"We prefer our students to have A levels chosen from Chemistry, Maths, Physics, Geology and Biology with particular emphasis on the first. Opinions differ as to the value of Geology A level. A good grade from certain Boards can be a definite advantage to a student in our First Year Course which assumes no previous knowledge of geology, thereafter the advantage of having extra factual information fades but the advantage in the training to think as a Geologist that these people usually have acquired remains valuable. However, we should stress that our system of entry tends to preclude rigid qualifications requirements organised on a Department basis."

"There is a curious paradox here. I regard Geology as an excellent subject for schools. It has an intrinsic interest and is a good subject for introducing scientific thinking and reasoning. The practical aspects have appeal and value BUT we prefer our Honours students to have a good grounding in Chemistry, Physics and Mathematics. Hence, if only three subjects can be attempted at A level, then these should not include Geology."

Please outline your views on the 'quality' of school geology courses as influenced by exam board practices.

"Exam board practices and ideas are often ahead of schools: they ought to be
a continual 'prod' for teachers to keep up to date .... the pressure to do fieldwork must come from the exam. boards. If they did not do so, I suspect no fieldwork would be done in many schools."

"A level courses are conservative and at the moment still tend to be traditionally based upon descriptive learning by rote. There is a need for more application of the basic sciences to geology teaching in the laboratory, and an ever present need for as much local fieldwork and observational training as possible."

"The fact that different exam boards have differing styles of examination and assessment is to be welcomed and, in reality, does not significantly affect the progress of undergraduates. There should be as much experimentation as is considered reasonable at school level, both in examinations and in teaching. When all is said and done, what University Depts. require are students who have a zest for the subject and know something about it. We can then correct deficiencies in their school's training. School teachers, in general, are overburdened by the vast 'balanced' curricula laid down by Exam Boards. Their teaching would probably be much more effective if they could teach in greater depth what they themselves really know well. Instead, the more assiduous try to plough through acres of the syllabus which, basically, they are hardly competent to teach. Bad teaching of this kind is more difficult to dispose of at University level than no teaching."

"I think there is little doubt that the JMB at least (I am not so familiar with the others) has influenced what is taught considerably. From listening to school-teachers talking I am not so sure that some of them are able to touch some of the newer requirements very effectively."

Please outline your views on the 'quality' of school geology courses as influenced by school teachers:

"School teachers, of course, vary enormously. The worst are probably those who have had no training in Geology and who approach the subject from an understanding of Geography. The practice of linking Geology and Geography, possibly because both are field subjects, is most unfortunate."

"Good teachers almost always equate with good students; some good students are produced inspite of bad teaching. The worst fault of schools is in getting the balance wrong between sections of the subject (eg. geographers always overemphasize geomorphology; crystallography and metamorphic petrology are rarely taught well)."

"Judging by the school training received in Geology by the students in this department the quality of the courses and the dedication of the geology teachers in schools is very high indeed. We have no complaints at all on this score."

"Much geology teaching is done by geography teachers of the pre-quantitative school. As such it is too descriptive and is based on an insufficient application of physics and chemistry to the subject. However, observational powers of many students entering this department are obviously good and this seems a satisfactory area."

"Having examined for the JMB I am absolutely certain that individual school-teachers leave their stamp on their pupils - some v.good and some v.bad! However, most seem to impart an enthusiasm which I suspect is rare amongst some other scientific disciplines. Long may that continue."

The Last word

In answer to a final request at the end of the questionnaire for comments that ought to be passed on to teachers, one respondent made the following points:

". There are now roughly 1400 annual applicants for Geology under UCCA and about 700 are admitted. This national 2:1 ratio conceals vastly different ratios in particular Departments (ours is 9:1)."

. Over 900 Geology students will graduate in 1977 (c.700 from Universities, 200 from Polytechnics); there is most certainly not a corresponding number of jobs. Many Geology students will have to diversify into other fields. How many universities warn students about this?

. We feel strongly that Geology teachers should have detailed knowledge of which Departments offer training in the various fields of applied geology which are so critical at the present time, but hardly mentioned in schools."
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<tbody>
<tr>
<td>1/2/3</td>
<td>E</td>
<td>Exhibition at Entrance Hall, Central Library, Northgate Street, Ipswich. (Ipswich Geol. Group).</td>
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<tr>
<td>2</td>
<td>E</td>
<td>Oil is where you find it. North Sea Strike. 2.30, Geol. Museum</td>
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<tr>
<td>2</td>
<td>E</td>
<td>Marbles in Westminster Cathedral. 3.00 pm, Main entrance, 42 Francis St., London SW1. Details: Only 25 adm. Book via M. Pugh, Dept. of Geology, Imperial College, Prince Consort Road, London SW7 2BP (50p deposit) (Geol. Association).</td>
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<tr>
<td>3</td>
<td>E</td>
<td>Lomond Hills. Details from: S.I. Hogarth, 9 Blinkbonny Road, Edinburgh EH4 3HY (Edinburgh Geol. Soc.)</td>
</tr>
<tr>
<td>4</td>
<td>E</td>
<td>Field work. To excavate a section in Icenian Crag. 11.00 am, Wroxham, 7 miles NE of Norwich. Details from: R.A.D. Markham, C/o Museum, High Street, Ipswich (Ipswich Geol. Group).</td>
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<td>4</td>
<td>E</td>
<td>Birch Coppice Open cast Site. Details from D.J. Wraight, 569 Parkfield Road, Wolverhampton, WV4 6EL (Black Country Geol. Soc.)</td>
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<td>8</td>
<td>E</td>
<td>Workshop Visit. Over Kellet &amp; Balderstone. Details from: Joan Rycroft, 29 Oak Tree Road, Kendal, Cumbria (Westmorland Geol. Soc.)</td>
</tr>
<tr>
<td>9-11</td>
<td>E</td>
<td>Upper Jurassic, Vale of Wardour, Wilts. Details from: M. Pugh, Department of Geology, Imperial College, Prince Consort Road, London SW7 2BP (Geol. Assn.)</td>
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<tr>
<td>11 or 18</td>
<td>E</td>
<td>Manifold Valley. Details from: D.M. Morrow, 54 Cyprus Road, Mapperley Park, Nottingham NG3 5EH (E. Midlands Geol. Soc.)</td>
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<tr>
<td>17</td>
<td>E</td>
<td>The Arnboth Dyke (BS). 10.30 at Fisher Gill, Thirlmere GR 305171 (Cumberland Geol. Soc.)</td>
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<td>17</td>
<td>E</td>
<td>Ordovician Rocks in Longsleddale. Details from: Joan Rycroft, 29 Oak Tree Road, Kendal, Cumbria. (Westmorland Geol. Soc.)</td>
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<td>17-19</td>
<td>E</td>
<td>The Cheviot Hills. Details from: S.I. Hogarth, 9 Blinkbonny Road, Edinburgh EH4 3HY (Edinburgh Geol. Soc.)</td>
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<tr>
<td>18</td>
<td>E</td>
<td>Coralline Crag Pits. 11.00 am at Woodbridge Railway Station. Details from: R.A.D. Markham, C/o Museum, High Street, Ipswich (Ipswich Geol. Group)</td>
</tr>
<tr>
<td>22</td>
<td>L</td>
<td>An expedition to South Georgia with the British Antarctic Survey - T. Pettigrew. 7.45 at Dudley Library (Black Country Geol. Soc.)</td>
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**October**

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<tr>
<td>1</td>
<td>E</td>
<td>St. Monans &amp; Bishop Hill. Details from: S.I. Hogarth, 9 Blinkbonny Road, Edinburgh, EH4 3HY (Edinburgh Geol. Soc.)</td>
</tr>
<tr>
<td>1</td>
<td>E</td>
<td>The Skiddaw Borrowdales Junction. 10.00 am at Grange in Borrowdale GR 253175 (Cumberland Geol. Soc.)</td>
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<td>5</td>
<td>L</td>
<td>The Outlook for world energy - Sir Kingsley Dunham. 7.30 pm, Derwent Centre Cockermouth (Cumberland Geol. Soc.)</td>
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<td>6</td>
<td>L</td>
<td>Informal meeting. 7.45 pm at Dudley Library (Black Country Geol. Soc.)</td>
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<td>14-16</td>
<td>E</td>
<td>Meerbrook Staffs. Details from: Chris Darmon, 25 Hornbeam Close, Chapeltown, Sheffield S30 4H3 (Nationwide Geol. Club)</td>
</tr>
<tr>
<td>15</td>
<td>E</td>
<td>Demonstration. Stuart Baldwin Palaeontological Reproductions. Details from: M. Pugh, Dept. of Geology, Imperial College, Prince Consort Road, London SW7 2BP (Geol. Assocn.)</td>
</tr>
<tr>
<td>15</td>
<td>E</td>
<td>Exposures in Motorway Excavations. Details from: D.M. Morrow, 54 Cyprus Road, Mapperley Park, Nottingham NG3 5EH (E. Midlands Geol. Soc.)</td>
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<tr>
<td>22</td>
<td>E</td>
<td>Great Colne Oxfordshire. Details from: M. Pugh, Dept. of Geology, Imperial College, Prince Consort Road, London SW7 2BP (Geol. Assocn.)</td>
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INTRODUCTION

Anyone who has worked with teachers generally will know how weightily they receive the pronouncements of examination boards. The arrangements made by boards with respect to syllabuses and examinations greatly influence teachers' professional work and often their private lives. For example teachers' commonly expressed wishes not to teach the amount of stratigraphy which a board decrees illustrate their professional dilemma, whilst multiple pressures to mount CSE O and A level fieldwork only in the holidays or at weekends typify their private difficulties.

In the absence of geology in the curriculum and timetable of the 11-14 year old and the lack of local or national curriculum development projects in geology for 14-18 year olds, the influence of the examination boards on the curriculum at CSE O and A level is very great. It follows, therefore, that the potential leader role of boards in initiating changes in such a curriculum is equally great. Whether changes are positive and desirable will depend upon the degree of consensus achieved between legitimately interested parties about what adjustments to a board's syllabus or examination are necessary. The parties which might have a legitimate interest include the pupils, the parents, the teachers, the representative appointed by unions or subject association, the councils of subject associations like ATG, the examiners, the users of assessment grades (such as employers, universities and colleges), and the board officers and committees which look after the welfare and development of a subject. It might be considered by our members that it is the overall task of the boards to reconcile the pressures emanating from any conflicting viewpoints presented by such bodies and to serve the best interests of all these groups and the nation as a whole.

Discussions amongst members of the ATG editorial group revealed that there was much about the organisational and administrative procedures of the boards with respect to CSE O and A level geology which was unclear or unknown. The position seemed to be that few had a grasp of the overall national picture. Indeed some ordinary members who wrote to the Editor of the ATG do not fully comprehend their local situation. The procedures for the construction of syllabuses in geology appeared to members of the editorial group to vary widely. Concern was expressed over the frequency with which updating or wholesale revision took place. Interest also centred upon the nature of the committees asked to carry out the work, the composition of the membership of those committees, and whether or not representation on the committees appeared to relate to the recognition of the views of legitimately interested parties in proportion to their claim to present an important viewpoint. (Compare the current debate about the nature and the status of Schools Council). The organisation of the preparation, writing and making of examinations based upon board syllabuses appeared to be equally varied.

All boards employed chief examiners and examiners, but some came mainly from universities and other sectors of tertiary education, others mainly from schools. Some boards organised preparatory committees composed of teachers and others to discuss and suggest amendments to examination papers submitted by examiners. The term of reference and composition of such committees was of great interest. Other boards appeared to leave the task of setting and vetting examinations to the examiners.

Responsibility for subject interests amongst board officials was occasionally noticed. Sometimes there appeared to be a secretary deputed to look after the welfare and progress of a subject, and this was often accompanied by a personal commitment and interest beyond the call of duty. In other cases it appeared that the policy was to derive wider benefits from employing secretaries to staff subject committees randomly. In such situations the secretaries found that it was easier to make comparisons between subjects, and views on the strengths and weaknesses of certain procedures were taken in the light of this wider experience, to the benefit of geology in particular.

In view of these general possibly inaccurate impressions, it was resolved by the editorial committee that an exercise should be mounted to try to seek information about what arrangements actually existed in some of these areas of concern in the hope that a national picture would emerge concerning (a) the general nature of the procedures which are employed by the boards and (b) the personnel whom they invite to employ to carry out those procedures. Armed with this information it was anticipated that it might be possible to see more clearly how boards interpret their role, to discern where power and influence over curricula and examinations lie, and subsequently to debate more rationally whether these arrangements are appropriate. The outcome of these discussions was the preparation of the letter mentioned in the next section.

THE ENQUIRY AND THE RESPONSE

The following letter was sent to every CSE and GCE Board in England and Wales: i.e. 14 CSE Boards and 8 GCE Boards. In addition boards in Northern Ireland and Scotland of comparable standing were approached.

Dear Secretary,

30th March 1977

On behalf of the Association of Teachers of Geology the editor of Geology Teaching asks whether you would be willing to supply the following basic information for publication in the Association's journal:

1. The names of the people who sit on the committees listed below, and the type of institution in which they work:
   - Subject/Syllabus committees to do with updating and revision of syllabuses.
   - Preparatory committees to do with the preparation or vetting of examination papers.
   - Other committees to do with geology curricula and examinations (please state).

2. The names of moderators or revisers responsible for ensuring the maintenance of standards etc. and the type of institution in which they work.

3. The names of chief examiners at each level and the institutions in which they work.

4. The names of any officers on your staff who have special responsibility for dealing with geological matters.
We ask for this information because members of ATG often enquire which teachers or other persons, from which kind of institution, form the body of people responsible for influencing the growth of the geology curriculum and the examining of the subject.

With many thanks for the information which you may be able to offer.

Yours faithfully,

D E Thompson
(Deputy Editor).

The most significant parts of the replies which were received are given below, together with sufficient context for the information to be appreciated. The names included in any lists which are followed by an asterisk denote persons who are members of ATG. Editorial additions to replies are presented in squared brackets.

Certificate of Secondary Education Boards

1. From R Kempster, Professional Assistant, Associated Lancashire Schools Examining Board, 77 Whitworth St., Manchester.Ml 6HA (Tel: 061-236 6020 & 6521).

"This Board does not offer a Mode I examination in Geology, but several Mode III schemes in the subject are moderated by the Board.

The Board's procedures with regard to Mode III examinations may be summarised as follows. A school submits its syllabus proposals which are then considered by the Board's moderator. Subject to agreement being reached on syllabus content and the form of the examination, a scheme is then presented for approval to the Examinations Committee. Schools submit draft question papers in the Autumn term preceding the examination and may be invited to revise their drafts in the light of reports which they will receive on them from the moderators. After the examination, the moderators submit final grades based on the evidence of the work which they have seen and the recommended grades submitted by the schools. A sub-committee of the Examinations Committee is responsible for the general oversight of Mode III examinations, and seeks to equate standards in Mode III examinations with those imposed under Mode I.

The Board's moderators are all practising teachers with substantial experience of CSE examining. I am afraid that it is not the Board's policy to divulge the names of either individual schools offering Mode III examinations or of Chief Moderators and their assistants.

2. From Mr A Johnson, Secretary, East Anglian Examinations Board, The Lindens, Lexden Rd., Colchester CO3 3RL (Tel: 0206 71244).

25 April 1977. "I hope to let you have fairly soon a list of the names of these people but I am asking each of them if they have any objection to their name being published before I pass the names to you.

As it is the Board's practice to encourage teachers to submit both queries and complaints (or congratulations!) to the Committees responsible via the Board, I would prefer that the names of the Chief Examiner and Chief Moderator are not included in your Journal." [Mr Johnson revealed to the Deputy Editor the officers who deal with geology but asked for this information not to be published because]

Neither of these people are Geology specialists and the work of both is purely administrative not requiring any particular knowledge of the subject.

It is the Board's practice to ask that correspondence is addressed to me rather than to individual members of my staff.

Teachers who telephone the Board are asked to state the subject of their enquiry and they do not, therefore, need to ask for a particular person."

3. From D H Board, Secretary, Metropolitan Regional Examinations Board, Lyon House, 104 Wandsworth High Street, London SW18 4LF (Tel: 01 870 2144).

"The Geology syllabuses are in fact considered by the Geography Panel and at the present time there is no Mode I Geology examination, only Mode 3.

I would, however, be grateful if any enquiries regarding standards of work are made direct to the Board and not to servants of the Board such as moderators. I will willingly give you what information you require regarding the examining of Geology at CSE level."

Geography Panel North west area (ILEA): Mr A C Hardern (Paddington School), Mrs T J Chitty (Hampstead School). North east area (ILEA): Mrs H M Dance (Archway School), Mr F T Seaden-Jones (Chairman) (Highbury Hill High School). South west area (ILEA): Mr R B Pope (Ernest Bevin School), Miss A M Lassiere (Vice Chairman) (Vauxhall Manor School), South east area (ILEA): Mr J L Cannon (Kingsley School), Mr J Ellis (Abbe Wood School). Croydon: Mrs J H Fairclough (Purley High School for Girls), Mr T J Evans (John Newham High School). Newham: Mr A J Marshall (St Bonaventure's School), Miss H A Olds (Sarah Bonnell School). Examinations Committee Representatives: Mr J C N Ballie (Hammersmith and West London College). Co-opted Members: Miss M G Goss (District Inspector, Inner London Education Authority), Mrs A Gang-Davi (Clissold Park School), Mrs B Hammett (J F S Comprehensive School), Miss M S Lewis (Overbury High School). Chief Examiner: Mr F W Sharples (Deane Grammar School). Moderators: Geography - Mr N A L Colley (Spencer Park School), Mr J A Laing (Nicholas Hawksworth School). Geology - Mr J Dunk (College of St John, Plymouth), Mr G R J Browning (Portsmouth Polytechnic).

4. From D H Board, Secretary, Middlesex Regional Examining Board, 53-63, Wembley Hill Road, Wembley, Middlesex HA9 8BH (Tel: 01-903-3961).

"I am not willing to provide you with the names of our committee members without consulting the committee; its next meeting will not be until the autumn, and I shall write to you further then.

We do not offer a Mode I in Geology, and therefore have no Chief Examiner. Our Moderator for geology is G R J Browning, M.Sc., D.I.C., M.I.M.M., who works at Portsmouth Polytechnic. Any enquiries to the Board should be addressed to the Secretary of the Board."

5. From J E Tipping, Secretary, North West Regional Examinations Board, Orbit House, Albert Street, Eccles, Manchester, M30 0WL (Tel: 061-788-9521).

"I am enclosing a copy of the Geology Panel list which I hope will be helpful to you. The name of the member of the secretariat responsible for Geology is Mr J E Greenhalgh (Ext. 35)."

Subject Panel. Chairman: Mr F Holcroft* Ashton-in-Makerfield CS School, Ashton-in-Makerfield, Wigan, Lancs. Moderating Sub-Committee: Mr Chapman, Mr
McNeal, Norden Cnty. Sec. Maghull, Liverpool, Dr T Sloan, Blackpool College.

Members (6): Mr M J Collins North Manchester High School, Tuson College, Rishton, Lancs. Mr P R2 Brooklands Avenue, Macclesfield, SK11 8LB. Mr J Mate High School, Sixth Form Centre, Blackpool.

Liverpool: Mr J A Law Anfield Comp School, Breckside. Wirral: Mrs M E Williams Rock Ferry High School, Rock Ferry, Birkenhead.

Liverpool: Mr J A Law Anfield Comp School, Breckside Park, Liverpool L6 4DN Mr J Moore, Gateacre Comp. School, Grange Lane, Woolton, Liverpool L25 4SD. Wigan: Mr A Seago St John Rigby RC 6th Form College, Gathurst Road, Orrell, Wigan. Bury: Mr S Marshall, East Ward Sec. School, Deal Street, Bury, Lancs. Trafford: Mr D Chapman, Stretford Grammar School, Gorebridge Road, Stretford, Manchester.

Stockport: Mr R E Tapp, Reddish Vale School, Reddish Vale Road, Reddish, Stockport, SK5 7HD. Tameside: Mr R Brown, Partington Secondary School, Lees Road, Ashton-under-Lyne, Lancs. Chief Examiner: Mr W C Boast Pensby Sec. Sch. for Boys, Irby Road, Heswall, Wirral, Cheshire. Chief Moderator: Mr G A Metcalfe, Lauder Technical College, Priory Lane, Dunfermline, Fife.

6. From D M Bonser, Assistant Secretary, Southern Regional Examinations Board, 53 London Rd., Southampton, SO9 4YL (Tel: 0703-32312).

27th April 1977. I am in the process of contacting the Chairman of our Geology Subject Panel to check whether he has any objections to the publication of the information that you have requested in the Journal. It will contact you again as soon as I have his reply. I do not, however, anticipate that there will be any difficulties.

16th May 1977. I have now heard from the Chairman of the Geology Panel and am in the process of providing you with the information that you requested. You may also like to note the following information about the main functions of the various committees:

Steering Committee: Vetting of examination papers. Preliminary work on syllabus revision, changes in procedures, etc. for consideration by the Panel.

Moderation Sub-Committee: Awarding of the grades after marking and first moderation of the examination through the consortia. Consortium Secretariats: Arranging initial moderation and organising meetings in order to act as a forum for Geology teachers to make their views known to the Panel. If you require any further information, please do not hesitate to contact me as the officer of the Board's staff responsible for Geology or Mr Perkins, the Chairman of the Panel.


7. From P N Anderson, Secretary, The South-East Regional Examinations Board, Beloe House, 2 & 4 Mount Ephraim Road, Tunbridge Wells, Kent, TNI 1EU (Tel: 0892-35311).

"Since this Board does not operate a Mode I examination in geography, a Regional Subject Panel for it does not exist and a Chief Examiner is not required. A small number of moderators are responsible for reviewing new Mode 3 submissions in geography and for covering the maintenance of standards in the resulting examinations. We would not wish their names to be released for publication. However, Mr J H Morris is an Assistant Examinations Officer with this responsibility. The Assistant Secretary has special responsibility among others for Mode 3 examinations in geography, would be willing to deal with any enquiries relating to these examinations."

8. From H L M Housefield, Secretary, South Western Examinations Board, 23-29 Marsh Street, Bristol BS1 4BP (Tel: 0272-23434).

"I am afraid that it is not our practice to circulate these names, for members of the committees in the various subjects offered by the Board change to such an extent that no list of members could ever be reliable. As far as examiners and moderators are concerned, it is a matter of principle that we do not divulge their names during their period of service.

I would point out that the CSE Boards are organised on a regional basis and that within the area of the Board there are well established lines of communication. Furthermore, you do not have a list of members of the Association of Teachers of Geology including those serving in the South-West. Although we do not undertake to circulate the names in the manner requested by you, I shall be very willing to help you if you care to write to me from time to time for information which you may require about this Board's activities."

9. From B Hudson, Deputy Secretary, The West Yorkshire and Lindsey Regional Examinations Board, Scarsdale House, 136 Derbyshire Lane, Sheffield S8 8SE.

"I would inform you that, in the first instance, all communications in respect of examinations conducted by this Board should be addressed to the Secretary/Treasurer to the Board and not to any individual officer, either serving on the permanent staff or serving as a panel member/Moderator/Examiner, individually. It is quite probable that, after contact with the Secretary/Treasurer officially, however, that subsequent correspondence/discussion will be dealt with by the most appropriate officer. The Board finds this the most effective way of dealing with enquiries to the satisfaction of the enquirer.

As you may know, this Board does not offer a Mode I syllabus in Geography and schools requiring CSE Examinations in this subject are encouraged to de-
vise their own Mode 3 schemes. Help in this con-
nection can be made available by the Board's Trai-
ing Officer (now a full-time member of staff and
the person concerned has very many year's
Teaching experience); the actual process of moder-
ation, however, is the responsibility of a specia-
\lly appointed Moderator in Geology, a practising
teacher of the subject in a comprehensive school.

10. From G Kendall, Assistant Secretary, Yorkshire
Regional Examinations Board, 31-33 Springfield
Avenue, Harrogate, North Yorkshire, HE1 2HW.
(Tel: Harrogate 66991).

"The members of the Regional Subject Panel are
all teachers in secondary schools within the Board's
region. Geology is not a Mode 1 CSE subject
within this region and consequently the Panel has
no responsibility for the revision of Mode I syll-
aves or the vetting of Mode I papers. A Mod-
erator is appointed by the Panel to ensure the
maintenance of standards in Mode 3 examinations.
This Moderator is responsible to the Panel. The
present Moderator also teaches at a secondary
school within the Board's region, although this
is not a requirement of the post.

Annual elections are held to the Board's region. Geology is not a Mode
10.

"Teacher of the subject in a comprehensive school."

"Annual elections are held to the
moderator also teaches at a secondary
school within the Board's region, although this
is not a requirement of the post.

Consequently it would probably not be helpful to
any of your members wish to address an
enquiry to the Panel or Moderator I would suggest
that they write to the Board and we will ensure
that it is directed to the appropriate person(s)."

General Certificate of Education Boards

1. From J A Day, Deputy Secretary General, Assoc-
iated Examinations Board, Wellington House, Aldershot,
Hants. GU11 1BQ. (Tel: Aldershot 25551).

"While the Board does not normally publish the
names, addresses and occupations of its Standing
Advisory Committee members or Chief Examiners, I
can tell you that the present Geology Standing
Advisory Committee consists of six members from
the further education sector, one member from a
high school and one member from a university. The
Board aims to keep the membership of each commit-
mee or less in line with the distribution of en-
tries for the particular subject.

The current Chief Examiner for Geology at both
Ordinary and Advanced levels is a member of staff
of a Polytechnic and the Moderator is a member of
staff of a College of Art and Technology. All
queries relating to the Board's Geology syllabus-
es and examinations should be initially addressed
to the Secretary General to the Board at the abo-
ove address."

2. From R B Howarth, Assistant Secretary, Univ-
ersity of Cambridge Local Examinations Syn-
dicate, Syndicate Buildings, 17 Harvey Road,
Cambridge. CB1 2EU (Tel: 0223 61111).

"We do not have a Standing Subject/Syllabus
Committee for Geology but when any revision of the
syllabus is required we form a Committee
which comprises the Chief Examiners and about
six teachers to ensure that practising teachers
form the majority. The names of our examiners
and moderators are as follows:

Advanced Level: Paper 1; Dr A T S Ramsay, Dept.
of Geology, University College of Swansea,
Singleton Park, Swansea, West Glamorgan. Paper 2;
Dr E A Kenyon, Department of Geology, The Univer-
sity, Manchester M13 9PL. Paper 3; Dr C R C Paul
Dept. of Geology, University of Liverpool, Brown-
low Hill, Liverpool. L69 3BX.

AO Level: Paper 1; Dr A C Higgins, Dept. of Geol-
ogy, The University, St. George's Squre, Sheff-
field, S1 3TA. Paper 2; Dr J G Cobbett Solihull
Sixth Form College, Solihull, West Midlands.

Moderator: The moderator for both Advanced level
and AO level papers is Mr B C Belson, Cambridge-
shire College of Arts and Technology, Collier Road,
Cambridge. Mr R B Howarth is the officer respon-
sible for Geology examinations at the Syndicate."

3. From C Vickerman, Deputy Secretary, Joint Mat-
ticulation Board, Manchester M15 6EU. (Tel: 061
273 2565).

"There is no difficulty in providing you with
the composition of the JMB committees concerned
with examinations in Geology, i.e. the Geology
Subject Committee and the two Preparatory Sub-Com-
mittees." "The Geology group of committees is in
the process of being reappointed for its next three
year term of office."

"It is the JMB practice to include the Reviser in
the published lists of committee membership".

"It has been JMB policy not to publish the names
of examiners, partly because such appointments are
made on an annual basis and the information could
therefore be quickly out of date, but also because
it is JMB policy not to encourage the view that
examiners have some independent authority whereas
in fact they are required to act under the direc-
tion of the appropriate committee.

As far as members of staff are concerned, as you
know the JMB does not organise its administrative
staff using a subject officer system and, although
individuals have responsibility for different asp-
icts of the work associated with a particular sub-
ject, we would not regard it as appropriate for the
names of the individuals with the relevant respons-
ibilities at some particular time to be published
if they had some permanent specific responsibil-
ity for the individual subject. As far as the
JMB is concerned, any enquiry should be addressed
to the Secretary and the appropriate member of
staff will deal with it."

Subject Committee: Chairman: D B Thompson, Keele
University. School teachers: W Cross, Todmorden
Grammar School; D J Evans Ormskirk Grammar School;
J P Evans The Crestwood School, Brierley Hill;* W Groves High Arcal School, Dudley; E M Hughes *
Tupton Hall School, Derbyshire; Mrs E E Humphries
Sheffield High School; ½ J Marsden, St Albans
School, Oldham; T Shipp Workington Grammar School; J A G Thomas The Verdin Comprehensive School,
Winsford. University College teachers: Mr J D
Crossley C F Mggt College of Education, Prescot;
Professsr R Moore Sheffield University; Dr F
Moseley Birmingham University. Additional member:
Mrs A L Dawson Manchester Museum. Reviser: Mr F
G Goodwin Saltwell Senior High School, Gateshead.
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sive School, Winsford. School teachers: J A J
Collins Ngth Manchester High School for Boys; * S
H Davies Old Hall High School, Maghull; W Groves
High Arcal School, Dudley; ½ Kennedy High Storr
School, Sheffield; D E Rees Gatway School, Leic.
University teacher: D B Thompson Keele University.
Reviser: F G Goodwin Saltwell Senior High School,
Gateshead. Geology (Advanced) Committee:
Chairman: D B Thompson Keele University. School
teachers: S H Davies Old Hall High School, Maghull; N W Dutton
Darlaston Comprehensive School; D J Evans Orms-
kirk Grammar School; E M Hughes Tupton Hall School,
Derbyshire; ½ Shipp Workington Grammar School;
J A G Thomas The Verdin Comprehensive School,
Winsford. University teacher: Dr F Moseley Birm-
ingham University. Reviser: F G Goodwin Saltwell
Senior High School, Gateshead.
Ordinary Level:

- M H Ferguson, 1.8.76—31.7.81, Eaton Hall College of Education, Retford, Notts. (Tel: 01 636 8000).

- D F French, 1967/77, Headmaster, (Chairman).
- A Dunk (College of St. Mark and St. John).
- Member(s) of the Examinations Committee: P L Buest, (Charters School, Sunningdale), R A Summers, (Education Department, Kent County Council) T W E Veal, (Borden School, Sittingbourne).

4. From C B T Gibbons, Geography Subject Officer, University of London, School Examinations Department, 66-72 Gower Street, WC1 E 6EE (Tel: 01 636 8000).

5. From M H Ferguson, 1.8.76—31.7.81, Eaton Hall College of Education, Retford, Notts. (Tel: 01 636 8000).

6. From H F King, Secretary, Oxford and Cambridge Schools Examination Board, 10 Trumpington St., Cambridge CB2 1QB. (Tel: 0223-64326).

7. From B W Fiddes, Senior Administrative Officer, Scottish Certificate of Education Examination Board, Ironmill Road, Dalkeith, Midlothian. SH 22 1B (Tel: 031 663 6601).

8. From C F H Clare, Assistant Secretary, Oxford Delegacy of Local Examinations, Exeter Place, Swindon, Oxford OX2 7BE (Tel: Oxford 54291).
The Oxford Standing Joint Committee, which provides a link between all practising teachers and the Delegacy through their professional associations, is always consulted prior to any major syllabus revision, and it acts as a channel for comments on our examination papers. On any committee (containing both teachers and examiners) which meets to consider a new syllabus in Geology, we ensure that teachers from our centres are in the majority; it has always been the Delegacy's policy to provide examinations which are appropriate to and dictated by the needs of our centres.

Requests for information regarding our geology examinations should be sent to the subject Secretary (Mr P H Clare) at the Delegacy in Oxford; where appropriate, these results will be forwarded to the person best qualified to deal with the enquiry.

A SUMMARY AND SOME QUESTIONS

As in previous investigations made by the Editor in this field, the information which is available is incomplete. Replies were not received from all boards by 1st August 1977 and some administrators restricted the information they wished to give. In the respects therefore there are undetected influences upon the growth of geology in schools and these remain part of the 'secret garden of the curriculum'.

Although differences of procedure were suspected in the first place, one cannot be but surprised by the variety of organisation of the geology curriculum and its assessment. Presumably the boards are dedicated to achieving more or less the same degree of service to pupils, parents, schools and the nation, but obviously they interpret their role in very different ways. The biggest difference lies in the traditions of the GCE and CSE boards. This would not be such a disadvantage if free choice of syllabuses and examinations were available, but clearly the regional pattern of CSE, and often in practice GCE, militates against this. A common system of examination at 16+ might pose considerable problems for the harmonisation of the geology curriculum and there have been no feasibility studies in this field. Procedures for syllabus construction and revision differ greatly. As reported here two CSE boards have a mode 1 in geology, one CSE, and one GCE. The nature and origin of the mode 3 syllabuses and the identity of their moderators and assessors are virtually unknown, and they form a large plot in the secret garden.

Is the secrecy appropriate? Who determines the need for a board to develop a mode 1 syllabus? Should ATG have a say? Does the existence of mode 1 promote the status of a subject in the eyes of the schools and the public? Should ATG actively seek mode 1 syllabuses in geology? Should ATG provide a model or two? Five CSE boards have geology subject panels, but the procedures of election to these panels differ. Some boards publish the names of the members of their panels, others conceal them as a matter of policy. If in some cases elections to membership are annual, then one questions what degree of continuity of membership is best for the purposes of syllabus revision. Is a geography panel the appropriate one to deal with mode 3 matters in geography? Are all members geologically competent? Is the composition of these panels too heavily weighted in terms of secondary school membership; ought more influence from teachers in tertiary education and from industry and commerce be brought to bear? GCE boards operate wholly different processes of syllabus construction and revision, and "mode 1" is the norm, and "mode 3" a theoretical possibility which was never mentioned in the present correspondence. Some boards do not have O level syllabuses, but all O and A syllabuses that exist are all revised episodically. Some boards have standing committees to do the job, others rely upon ad hoc arrangements. Committees often have a majority of teachers but representatives of tertiary education are more common at O level, and particularly at A level. It is important in CSE that there is a best balance of representation. Should representatives of the 'real' geological world outside education be present? The background of the membership of some of these committees was sometimes made apparent and it is likely that, as in CSE, types of schools and regional areas are represented in proportion to their entry. Representation through professional associations (teacher unions and the ATC) is sometimes a factor but one board stresses the importance of the contribution of individuals. What is the best basis for selection of members? Are all members geologically competent?

Consideration of the matter of the vetting of examination papers prior to the finalised version being taken by pupils reveals equally varied procedures. The composition of CSE mode 1 papers is often influenced by committees drawn from subject panels, whereas mode 3 papers are vetted mostly by moderators. The membership of some panels and the names of some assessors are available: others are withheld. Some assessors are secondary teachers and some are from tertiary education. Which procedures are most appropriate? Some GCE boards wish teachers or teacher-dominated preparatory committees to influence the examination paper, others leave this to the examiners who are helped by moderators or revisers, often drawn from tertiary education. Should preparatory committees exist? The composition of some of these committees and the names of some of the moderators and their places of work are published, but in other instances they are not revealed. Which policy is more commendable? Who are the chief examiners and examiners? Of all the personnel mention in the enquiry the CSE and GCE boards are generally least willing, for differing reasons, to name the examiners, but they are more willing sometimes to reveal the types of institution in which the examiners work. At CSE and GCE O level secondary teachers are sometimes employed, but college lecturers and university staff are used at all levels, and sometimes at A level.

Is this right when many university departments deny the value of A level geology and some even its right to exist? In view of the variations of procedure and worries about comparability of standards, is there any virtue in Michael Bradshaw's suggestion that the examining of geology be carried out centrally? Two, possibly three, CSE boards and one, possibly two GCE boards, have subject officers direct and at least two others positively encourage teachers to submit queries, complaints and congratulations to committees (via the board). Finally one realises that the persons named and unnamed who make up the committees, moderators, the examiners and subject officers, have a great deal of influence on the geological curriculum. It is interesting, therefore, to see how often this involvement is reflected in participation in the affairs of ATG. In one board the personnel are nearly 100% ATG members, in others membership is almost non-existent.
THE VIEWS OF THE ASSOCIATION

'Opinions and comments in this issue are the personal views of the authors and do not necessarily represent the views of the Association'. Every number of this Journal carries this disclaimer, but it seems to raise an interesting issue. Just what are the views of the Association? There are certain stated aims - given for example in the Publicity Handout/Application form - but in the light of our present discussions about the future of the subject in schools, should the Association now set about drawing up a clear policy - not just in terms of aims, but of how such aims can be realised? GEOLOGY teaching has provided a forum for a range of 'personal views', but if anything is actually to happen, should there not now be an attempt to make a consensus view clear, and then follow it up?

For a start, the ATG could discuss and decide its policy towards the following issues:

1. What approach should be made to Schools Council in response to Working Paper 58?
2. How can we get out of the 'minority subject' trap?
3. What kind of in-service training should we encourage, how should it be funded and how can teachers of other sciences be encouraged to take such training when there is little career incentive to do so?
4. What approaches should be made to industry for support?

In many ways, the second issue holds the key to everything. Do we feel that our subject should form part of a 'core curriculum' in one way or another? The Walsall Policy (written and published before the 'core curriculum' debate began, see GEOLOGY teaching 1/3, p95-6 stated as its central point that 'geology should form part of the basic education of every member of the community'. This implies that our subject should be available in every school. Will this happen if we provide material for integrated science courses? I hope that sciences teachers will go on the appropriate in-service courses. Or must we find a way to make every head set up a Geology department in the upper part of Secondary schools, from which the lower school courses would draw support as they do from other science departments? The only way this would be likely would be if A level Geology was essential for something - such as University entrance! The only subjects that are offered by every school are those that have such unavoidable necessity! Perhaps we must accept the fact that Universities have the biggest influence on the curriculum, whether this is educationally correct or not, and that an ATG objective might be to bring about in the long-term a change in University Departments' entrance requirements.

Some kind of ACTION is now needed - the case has been argued, now the time has come to actually DO something! It will do us no good to claim 'equal rights' with other subjects - they are already well established - and we can only claim a larger share of the timetable if we can prove that Geology is BETTER than anything already available!

Pete Whitehead

SUBSCRIPTIONS

Members are reminded that subscriptions for 1977/78 are due on October 1st 1977. Payment should be made by cheque or postal order (crossed) payable to "The Association of Teachers of Geology".

Subscriptions should be sent to the Assistant Treasurer, Mr P W Williams, 2 Kingsway, Northwich, Cheshire. For your convenience, we enclose an addressed envelope together with a Bankers Order. Current subscription rates are: full members £3, student members £1.5, institutional members £6.

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Contributions for the next issue of GEOLOGY teaching will be welcome, and should be sent to the Editor, from whom notes for contributors are available.

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