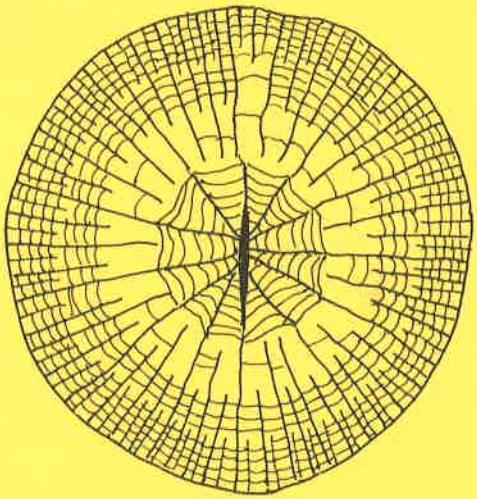
# PROCEEDINGS
## OF THE
# GEOLOGICAL SOCIETY
## OF
# GLASGOW



Session 119 1977

## PUBLICATIONS

During the session overall sales figures rose slightly, despite the rather gloomy prognostications of the previous report, with the total income from all sources standing at £1,161.77. Once again the major part of the income was provided by the Arran Guide, with sales of 533, supported by the Glasgow Guide with 208 copies sold. Both figures show a decrease on last session. However, this decrease was more than offset by a very considerable increase in the sales of the other guides stocked, with 72 for the Assynt and Lothian volumes together with 100 copies of the newly published Ardnamurchan Guide and Map.

One aspect of sales in this session, as in previous sessions, has been the purchase of popular geological publications as a service to members. This year the I.G.S. volume "Man, Mars and Meteorites" was obtained and is selling well both to members and students. For bulk orders of this kind it is often possible to obtain a considerable discount, even on government publications, which contributes to the Society's funds as well as ensuring a readily available supply of the latest geological literature. This custom will certainly continue and any suggestions from members for future purchases will be most welcome; so let us know your requirements.

At the end of this session Dr Burton relinquished the post of Publications Sales Officer to Dr C. M. Farrow in the knowledge that the office rests in capable hands.

## THE SOCIETY LIBRARY

Dr J. Hall, the Society's librarian, is in the United States for a year and there is therefore no report for the session 119.

## MEMBERSHIP

The membership of the society for session 119 was as follows:

| | |
|---|---|
| Honorary Life members | 5 |
| Life members | 4 |
| Ordinary members | 330 |
| Associate members | 17 |
| Junior members | 17 |

The membership benefited by the addition of 37 new members but, despite this figure, shows a reduction in number from session 117. This is due to a high number of resignations (or deletions) over the period 1975/76 (93 members deleted) and 1976/77 (15 members deleted). It has taken until now to ascertain the resignation figure accurately due to members' reluctance to communicate their resignation to the society in writing. This involves the membership secretary in sending many letters of enquiry to members — letters which are frequently ignored. During the current session (120) a total of 120 members have been sent letters of enquiry as to membership status and arrears to date. Of these 54 have replied, leaving a question mark over 66 who have not replied. This is to be regretted and would perhaps indicate a further reduction in membership of the society.

## OBITUARY NOTICE

### Frank A. B. Preston, C.Eng., F.R.S.E.

The death of Frank Preston on 13th January 1978 at the age of 87 terminated perhaps the longest single period of membership of the society; he joined in 1910. Born in Barrhead and educated at Shawlands Academy and at the (then) Royal Technical College, he chose municipal engineering as his profession. To it he was to render the greatest service, gaining a wide reputation in town planning.

Mr Preston was a member of many professional bodies, most of which he served as an office-bearer. Perhaps the highlights of his career were his appointment as first General Manager to Glenrothes Development Corporation and his being elected President of the Institution of Municipal Engineers (1952-1953). During the First World War he served in the Royal Navy. Between the wars and during the Second he was Burgh Surveyor of Milngavie and lecturer in municipal engineering subjects at the 'Tech'. After retirement from Glenrothes he did duty as a member of the Scottish Council (Development and Industry) and as reporter and arbiter to the Scottish Office on town and country planning matters.

Although the writer has failed to obtain evidence that Mr Preston ever took an active part in the affairs of the society, it is known that he was proud to have been a recipient of the Cowie Prize Fund. His attendance at the Centenary Celebrations in 1958 showed his continuing interest. A widower, he is survived by his two sons.

Alec Herriot

# THE QUALITY AND PRODUCTION OF AGGREGATE IN SCOTLAND AND THE UNITED KINGDOM

by **C. D. Gribble**

## The past and present

A wide variety of rock types is quarried as aggregate in Scotland. Initially mineral development was limited to centres of population in the Midland Valley, and the development of coal and steel in the Lothians and Lanarkshire accelerated transportation links along this axis. Canal links and rail systems were followed by development of roads in this century. Development in the rest of the U.K. followed a similar pattern. At first, the quarrying industry was small and diffuse, with small outputs being sold locally. Quality of the quarried material was of limited importance; availability and cost of production being the significant factors.

Sand and gravel deposits were widely exploited throughout Scotland, because of their widespread occurrence. Other important rocks such as sandstone and limestone were also quarried, the sandstone mainly for use as building stone, and the limestone for use as agricultural lime, or fluxes in the iron and steel industry. Two igneous types, dolerite and basalt, were quarried in Central Scotland, and granites and gabbros were exploited elsewhere, particularly north-east Scotland and south-west Scotland.

As time passed, aggregates became increasingly important in all constructional work and it was realised that their quality was a factor which had to be considered. Eventually a series of tests were outlined and proposed by Government departments which defined aggregate quality. Some of the tests were straightforward such as SG, Porosity and Water Absorption and Void Ratio, but other tests attempted to investigate the strength of the rock material and the effects of traffic on it. In particular, Abrasion Value, Impact Value, Crushing Strength, and Polished Stone Value were of real importance in assessing the quality of roadstone aggregate. The Abrasion Value (AAV) measures the resistance of the aggregate to wear and the Impact Value (AIV) measures its resistance to sudden impact; in both tests low values indicate good results. Crushing strength (ACV) on the other hand, measures the resistance of aggregate to a gradually applied load, again low values indicating good resistance. Polished Stone Value (PSV) measures the resistance of a wearing course (i.e. aggregate + binding materials) to wear by rubber tyres; and the skid resistance of the road surface has high values indicating good skid resistance.

A large number of results from various rock aggregates are shown in Figures 1 and 2. From these a number of points can be made:

1. Basic igneous rocks have the best AIV, ACV and PSV values.
2. Acid igneous rocks have the best AAV.
3. Fine grain size invariably improves the aggregate quality.

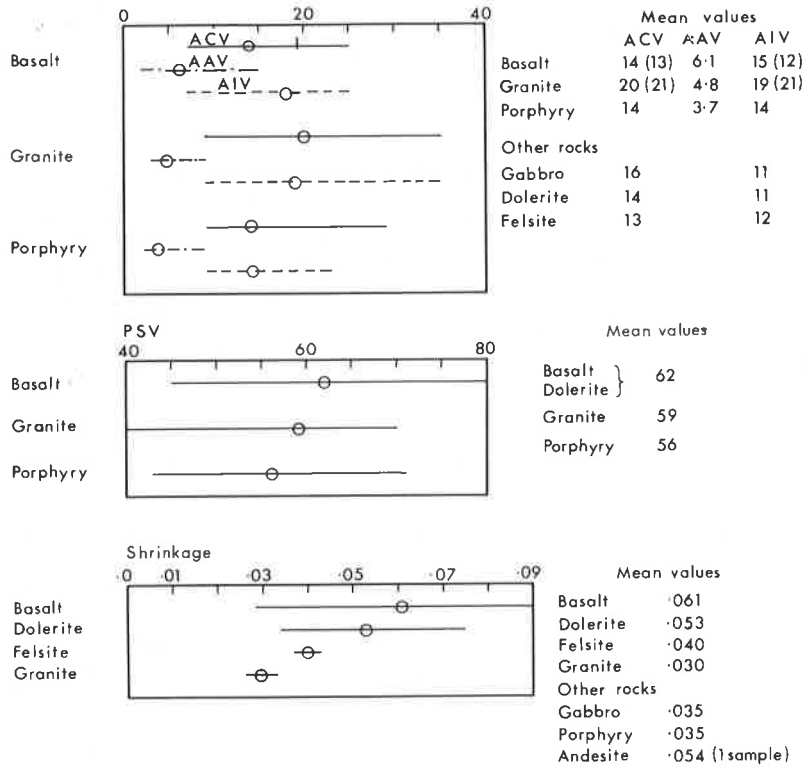



**Fig. 1. Igneous rock aggregate test data.**

4. Weathering vesicular/amygdaloidal or porphyritic texture reduces these qualities.
5. Any discontinuities present (bedding planes, schistosity) reduce these qualities.

Thus the best rocks for roadstone use are fine grained basic varieties, especially basalts and dolerites, which is fortuitous since these were already the most widely used in Scotland (particularly the Midland Valley). Sand and gravels show a wide range of results depending on their constituent particles (Fig. 3).

Aggregate for use in concrete requires a different set of qualities, although many of the tests already described are important. The drying shrinkage of the concrete particularly is of great importance, especially in structures requiring high strength. The results (Figs. 2 and 3) show that igneous rock aggregates are suitable for most concretes, but that acid varieties are best if low shrinkages are required. Sand and gravels particularly show a huge range of

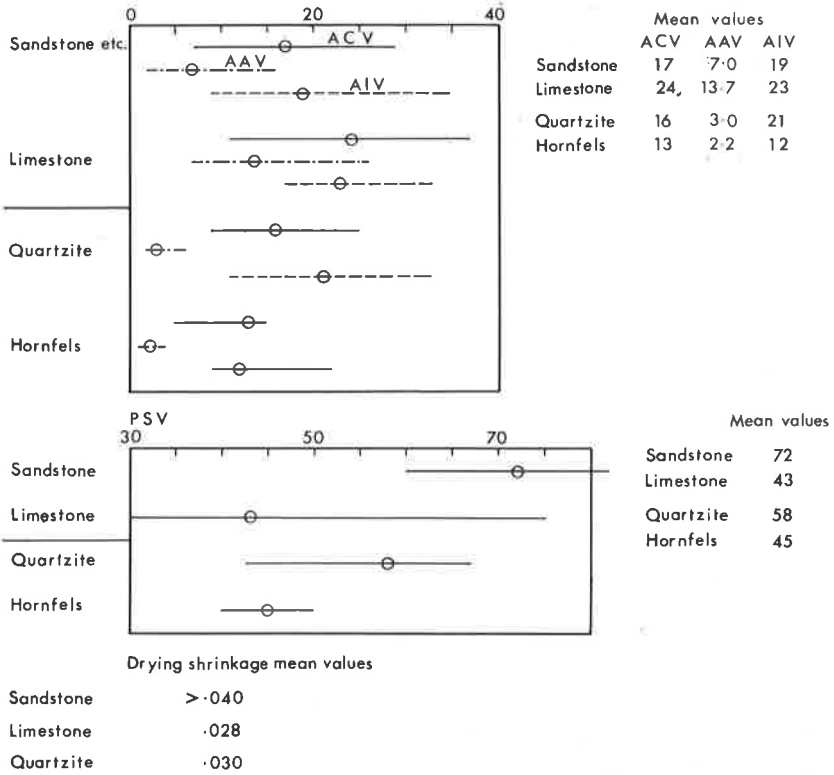



**Fig. 2. Sedimentary and metamorphic rock aggregate test data.**

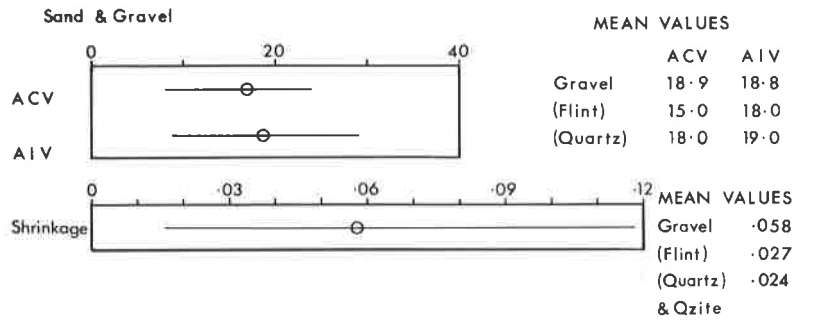



**Fig. 3. Sand and gravel test data.**

shrinkage values, and, although for many jobs any gravel would do, as long as the grain size distribution is suitable, only 2 gravel types are suitable for high strength, low shrinkage work. These are:

a) Pure quartz aggregate (such as the Lower Carboniferous grits in the Midland Valley at the top of the Calciferous Sandstones).
b) Flint gravels such as those which are worked in SE England.

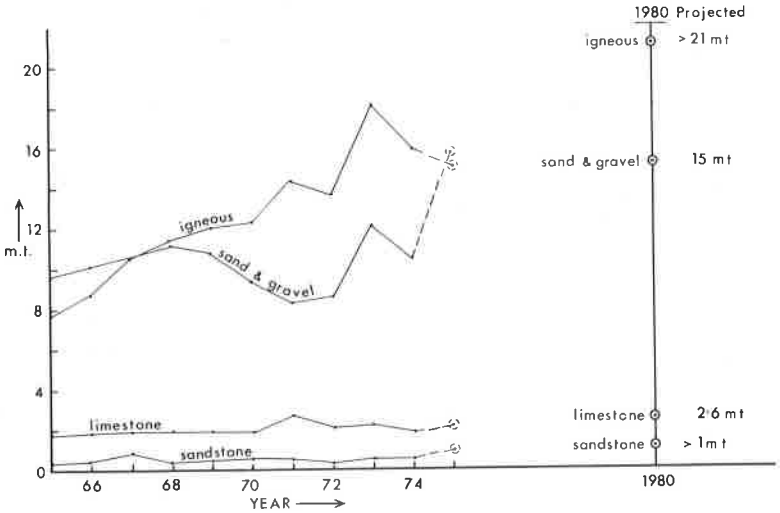



**Fig. 4. Scotland: production of natural aggregates.**

In Scotland the graph shows that sand and gravel and igneous rock are produced in about equal amounts but the production trends strongly suggest that crushed igneous rock will soon be the source of most aggregate.

Even in England, with much less igneous rock, there is a strong suggestion from the graphs that sand and gravel production is falling off, and that crushed rock aggregate will increase in importance.

Much of the crushed rock aggregate shown on Figure 5 is limestone. Figures for UK show that limestone is the most important natural rock to be quarried, after sand and gravel. Probably the reason for widespread use of limestone in the construction industry in England is because of the paucity of igneous rock for commercial exploitation. Limestone makes good concrete aggregate but it is not too good in road construction having a high AAV, low PSV and often being friable and porous.

In Scotland, where an abundance of igneous rock (as well as limestone) is available, limestone production in 1975 showed that of 2.255 million tonnes produced, 1.862 million tonnes were used for agriculture, cement manufacture, and in iron and steel and other non-construction uses (i.e. 82.6%).

Contrast this with England where, out of 72,215 mt total production, only 17,128 mt were used for non-constructional uses i.e. 23.7%.

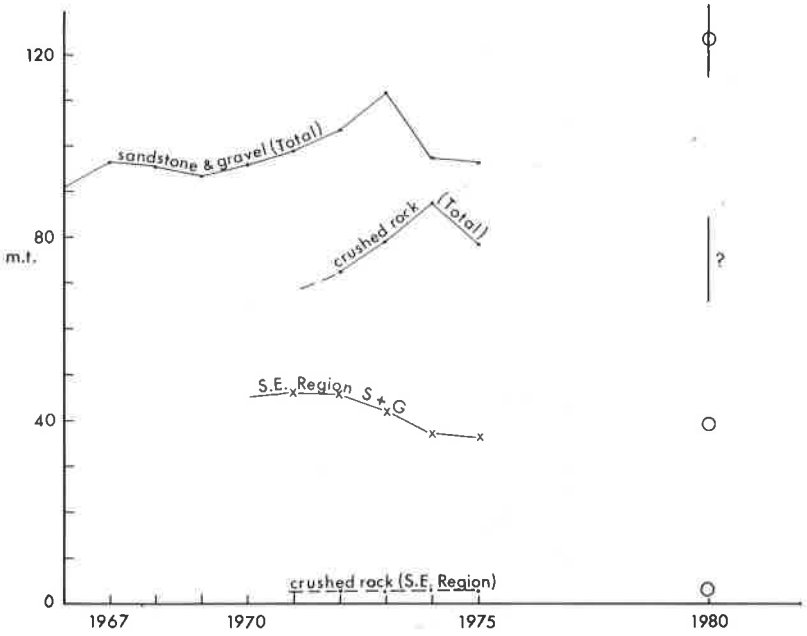



**Fig. 5. England: production of natural aggregates.**

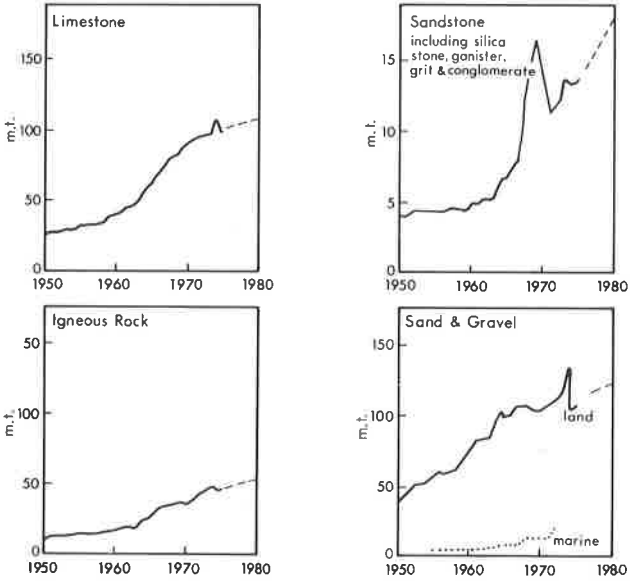



**Fig. 6. Aggregate production in the UK for limestone, igneous rock, sandstone and sand and gravel.**

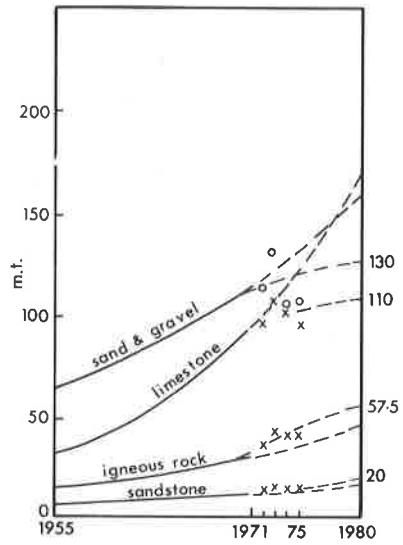



**Fig. 7. Combined graph of aggregate production in the UK for selected rock types.**

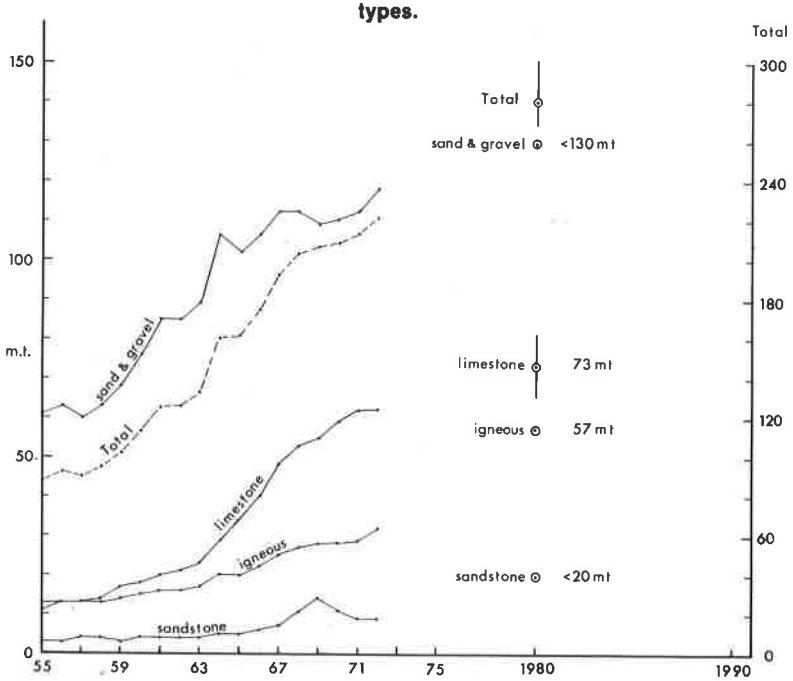



**Fig. 8. Aggregate consumption in the UK.**

The graphs for individual rocks (Fig. 6) show the trends in aggregate production over a long period, and their combined graph (Fig. 7) attempts to predict production in 1980 and beyond, in the UK.

## The future

What of the future? The aggregate consumption graph (Fig. 8) predicts a 280 mt usage of aggregate in the UK in 1980, and government estimates suggest that this will at least *double* by the year 2000. If this is so, where will all this natural aggregate come from?

There is no doubt that sand and gravel production will rise, even although synthetic materials may well be used as concrete aggregate (steel needles, expanded low density slate, furnace slags and so on). However, gravel deposits have some inherent difficulties concerning their quality and exploitation. In particular:

a) Most deposits have limited reserves and very few (if any) large well-situated deposits exist which have still to be exploited.
b) The quality of the gravels in most deposits is unknown and furthermore is unpredictable, since deposits are often heterogeneous in the type of rocks constituting the gravel.
c) Exploitation of gravel deposits is very wasteful of land. If the average thickness of a deposit is taken as between 5 and 10 m, then 1 mt of aggregate is produced from between (approx.) 15 and 30 acres of land. This compares very unfavourably with igneous rock where 1 mt of aggregate would be produced from 6 acres of land (dolerite) or less than half that (< 3) for granite or basalt.
d) Gravel deposits frequently underlie good, arable (well-drained) land. There is certainly no doubt that sand and gravel deposits will continue to be exploited, since their wide availability and low costs of production make them attractive to developers, but it is unlikely that the huge increase in aggregates anticipated by the end of this century, can be met from sand and gravel production alone.

The scale of the problem must be appreciated. At the moment in Scotland about 16 mt of igneous rock aggregate is being produced each year, and about half of this total comes from about a dozen quarries. Some of the quarries in England have still larger annual productions with the largest being 2 mt + per year from a limestone quarry. The increase in demand for aggregate in the UK (see Fig. 7) suggests that more than 50 new quarries of at least this size need to be opened by the year 2000 (as well as substantially increasing production at existing large quarries, which, of course, would reduce the amount of their available rock reserves — a "swings and roundabouts" situation).

The factors that would influence sites for these new very large quarries would be:

a) Huge reserves of rock.

b) Rock quality as good as possible and homogeneous rock types.
c) Situation well away from population centres, and outcropping beneath poor quality farming land.
d) Good access to transportation.

It is clear that very few rock types are suitable. Factors a) and b) strongly suggest that igneous rocks are the most suitable and c) and d) imply the utilisation of rock reserves in remote areas with aggregate transportation by sea. Road transport is not feasible because of environmental problems and cost (6.5p (minimum) per tonne per mile now, and likely to increase). Rail is also unlikely because of the cost of building new rail links to the rock deposit. Furthermore the movement of aggregates does not depend on rail at the present time ($< 15\%$ of total aggregates being transported in this way). Thus it seems likely that large igneous intrusions on the coast become the only rocks that meet all the requirements set out and Scotland is the most probable source of these with its prolific coastal granite.

**Acknowledgements**

I wish to thank Mrs M. Leeper for draughting the figures, and Edinburgh University who persuaded me to write this paper and deliver it as the 1978 Swiney lecture.

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Although no specific references are given the following texts were consulted in the preparation of this paper.

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## SOCIETY MEETINGS (Session 119)

Meetings were held in the lecture theatre in the New Geology Building by kind permission of Professor Leake.

### 14th October, 1976

**Professor Percival Allen, F.R.S.** (University of Reading) gave a lecture on **"Ice Ages in the Central Sahara".**

The igneous and metamorphic basement of the Hoggar massif is followed unconformably by virtually undeformed Lower Palaeozoic sediments. The oldest of these may overlie lateritized basement, with implications of tropical conditions. These are followed disconformably by complex sequences culminating in undoubted glacial and proglacial sediments. The latter include tillites, dropstones, stone polygons, striated pavements, ?pingoes, ?kettles and eskers. They record at least three advances and retreats of the ice. The glaciated area appears to have extended into South America and South Africa, and was in every sense Ordovician 'Antarctica'.

### 11th November, 1976

The following new members were enrolled: Mr Michael Bailey, B.A., F.R.Met.S.; Mr Alexander Downie, B.Sc.; Mr M. William Henley, B.Sc.; Mr Duncan B. Macbrayne, B.Sc.; Miss Marion W. McNair; Mr George R. Offord; Mrs G. R. Offord; Mr Thomas Sharpe; Mr H. Arthur Turnbull.

**Dr M. K. Chadwick** (University of Strathclyde) lectured on **"Geological Psychology — Its relevance to observation in the earth sciences".**

Experimental investigations into the psychology of observation in geology reveal that what a geologist thinks he sees, and what is actually there, can be very different indeed. It also appears that the same perceptual biases can be shared by the majority of geologists. This leads to reports of observations being reliable from one observer to the next, but despite this reliability the reports can still be erroneous. The relevance of psychology to the understanding of geological thinking, especially the problem of training people to "think in three dimensions" was discussed.

### 9th December, 1976 (Annual General Meeting)

The following new members were enrolled:

Dr Abd-El Mohsen, M.Sc., Ph.D.; Dr Roger Anderton, B.Sc., Ph.D., F.G.S.; Mr David Atkins, B.Sc.; Miss Stella Crampton; Mrs Alison Lawson; Mrs Judith Lawson, B.Sc., Ph.D.; Mr Hugh MacDonald; Mrs Beatrice McLean; Mr Lewis M. Murdoch; M/s Mavis Wilson, B.Sc.; Mr Lawrence M. Winfield.

The following office-bearers were elected:

**Council members:** Professor B. E. Leake; Dr P. R. Thomas; Mr B. J. Brown; Dr B. Cooksey; Mrs B. Black; Mr T. Naismith and Mr J. R. Mirtle.

**President:** Mr A. Herriot.

**Vice-Presidents:** Dr W. D. I. Rolfe and Dr C. D. Gribble.

**Secretary:** Dr J. G. MacDonald.

**Treasurer:** Dr D. W. Powell.

**Membership Secretary:** Mr C. Gillen.
**Publication Sales Officer:** Dr C. J. Burton.
**Editor** (to replace Dr Gribble): Dr A. M. Hopgood.
**Editor of Society's Proceedings:** Mrs J. A. Lawson.

Written reports of Council for Session 118 were approved by the Society.

Following the business of the Annual General Meeting there was a lecture given by the retiring President, **Dr W. D. I. Rolfe** on **"Some fossil arthropod larvae".**

By neoteny, or 'Peter Pan evolution', some animals may become sexually mature whilst their bodies remain in their larval state, giving rise to wholly new groups — thus the insects are thought to have arisen as neotenous millipedes. Although the first recognition of neotony in fossils was in the arthropods (agnostid trilobites), it seems likely that some fossil larvae have been overlooked or misidentified in the geological record. Some of these will be illustrated and compared with modern counterparts. Their importance lies in the fact that some extant arthropod groups were probably derived by neotony from the larvae of extinct forms, which thus may be truly 'prophetic fossils'.

## 13th January, 1977 (Members' Night)

The following talks were given by members:

DR E. M. PATTERSON — Excavations in Hunterston post-glacial raised beach.
HONOURS STUDENTS — Student palaeontology projects, 1976.

Exhibits were displayed by the following members:
MR JOE DAVIES — (i) *Nature imitating art.* Clay ironstone concretions resembling human artifacts (from Carb. shales, Yorks).
(ii) *Dreikanters.* Wind-faceted pebbles from the top of the glacial drift, Cheshire.
DR E. M. PATTERSON, DR J. H. DICKSON, MR S. MUNRO, DR J. D. PEACOCK and DR W. D. I. ROLFE — Fauna and flora of the Hunterston post-glacial raised beach and its peat.
HONOURS STUDENTS — Selected student palaeontology projects, 1976.
DR C. J. BURTON — Fossils from the Barrandian (Bohemia) and other areas of marine Devonian.

Recent accessions to the Hunterian Museum were also shown.
MR R. P. TRIPP — Ordovician trilobites from Minuntion.
DR A. C. SCOTT — London Clay and Recent otoliths.
DR R. W. BARSTOW and MR G. FIORAVANTI — Rare minerals from various localities.

## 10th February, 1977

The following new members were enrolled:
Mr David J. A. Madill; Dr Ian MacDonald, B.Sc., Ph.D.; Dr Peter Stromberg, B.Sc., M.B., Ch.B.; Mrs Barton.

**Professor W. W. Bishop** gave a lecture entitled **"The Gregory Rift Valley, East Africa — a good place to die".**

It was with great sadness that we learnt of the sudden death of Professor Bishop so soon after this lecture. An obituary notice appeared in last year's Proceedings.

## 10th March, 1977

The following new members were enrolled:

Mr James Barton; Mr Alexander Barton; Miss Sheena M. Barton; Mr Ronald K. Duff; Mr Alan Gardiner.

The society was addressed by **Dr M. K. Russell** (University of Strathclyde) on **"Irish metalliferous ore deposits: Their discovery and genesis".**

Since 1961 several important lead-zinc-copper-silver deposits have been discovered in the Carboniferous Limestone of Ireland. One of these, Navan, is potentially one of the largest zinc ore-bodies in the world. Geological thinking and geochemical prospecting played the major part in the discoveries, aided by Providence in one case. The tracing of a glacial train of copper-stained Old Red Sandstone erratics back to source led to the first major deposit to be uncovered, at Tynagh. Silvermines was discovered as a result of a change in geological concepts, Gortdrum by doggedness in following up minor chemical anomalies in stream sediments and soils, and Navan with the aid of a lightning strike! It can be shown that a number of the ore deposits were either precipitated directly on to the Carboniferous Sea floor from solutions exhaled from hot springs or that they replaced Carboniferous Limestone shortly after sedimentation. The Carboniferous Limestones contain unusually high concentrations of manganese near some of the ore-bodies. For example at Tynagh a manganese enrichment can be traced up to seven kilometres from the metalliferous deposit. This enrichment resulted from precipitation of manganese derived from the hot springs associated with the ore deposits. The identification of manganese anomalies may be useful in the search for further deposits both in Ireland and in other metallogenic provinces.

## 5th April, 1977 (Celebrity Lecture)

The following new members were enrolled:

Mrs Elly M. Bedier de Prairie Pradeau, Cert. Geol.; Mrs Kitty M. Fleming; Ms Rosemary Griffin; Mr Anthony Hanlon; Mr Ronald G. McAulay; Miss Barbara E. Moston, LCST; Dr E. Pearpoint.

The Celebrity Lecture, a joint meeting with the Edinburgh Geological Society, was given during the Symposium on Crustal Processes and Evolution in N.W. Europe to mark the opening of the new Geology Building in the University of Glasgow as the Society's contribution to the celebrations.

**Sir Peter Kent** (N.E.R.C.) addressed the meeting on **"Vertical Movements on the Continental Shelf of N.W. Britain".**

Vertical movements constitute an aspect of global tectonics which has been overshadowed in recent years by the spectacular evidence of lateral displacement of the continents. Nevertheless it is of critical importance in relation to sedimentation and hence the distribution of economic minerals, as well as to concepts of global structure.

On land in Britain the investigation of contemporaneous movements has a long history, and for the Jurassic period in particular our terrain is classic ground. Concepts were later extended and modified as deep borings in the basins supplemented data from outcrops; they have been further augmented by the large amount of data from offshore areas, particularly from the North Sea. With a much wider spread of data it is possible to review the growth and history of basins and of positive structures, and to make an initial attempt to disentangle epeirogenic and eustatic elements in sedimentary control.

## SOCIETY EXCURSIONS (Summer 1977)

| | |
|---|---|
| 23rd April | **Central Ayrshire — Leader, Mr W. G. Holden.** The effects of the Ice Age in the Strathaven, Muirkirk and Cumnock areas with evidence of glacial deposition, fluvioglacial erosion and meltwater channels was seen. |
| 7th May | **Ballagan Beds in the Campsie area. Leader, Dr G. E. Bowes.** Lithology and sedimentary structures in this unusual sequence of sediments was examined in several stream sections. |
| 21st May | **Perth District — Leader, Dr M. Armstrong.** The Lower O.R.S. of the Perth district and relationship with the Arbuthnott Group was examined. Sedimentary intercalations within the lavas are well exposed in new road cuttings and the higher strata of the Garvoch and Strathmore Groups were visited on the north side of the Tay as was the dolerite dyke at Campsie Linn. |
| 4th June | **Rosneath Peninsula — Leader, Dr J. G. MacDonald.** A traverse was made of selected localities on the shore section between Rosneath and Cove including examples of Upper O.R.S. sandstone and conglomerates and the main divisions of the Dalradian succession containing a variety of structures and lithologies. |
| 18th June | **Bathgate Hills — Leader, Dr W. Mykura.** Several quarries, mines and natural outcrops in the Upper and Lower Limestone Groups were examined including the old Hildestone Silver Mine and the Bronze Age burial site at Cairnpapple Hill. Parts of the Hillhouse Mine which can be safely explored were visited. |
| 2nd July | **Joint excursion with the Edinburgh Geological Society to the Ballantrae Ophiolite suite — Leader, Dr B. J. Bluck.** Examination was made of the sedimentary, igneous and metamorphic rocks of probable oceanic origin now exposed in the Ballantrae area. |
| 3rd Sept. | **St Monans and Bishop Hill, Fife. Leader — Dr A. R. MacGregor.** The objectives were to examine the topmost part of the Upper O.R.S. and the Lower Carboniferous sediments and to see the spectacular variation in thickness of the Lower Limestone Group between the two sides of the St Monans Syncline. |
| 19-26 Sept. | **Islay — Leader, Dr R. Anderton.** A wide range of Pre-Cambrian, Dalradian and Lewisian structure were demonstrated. |

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