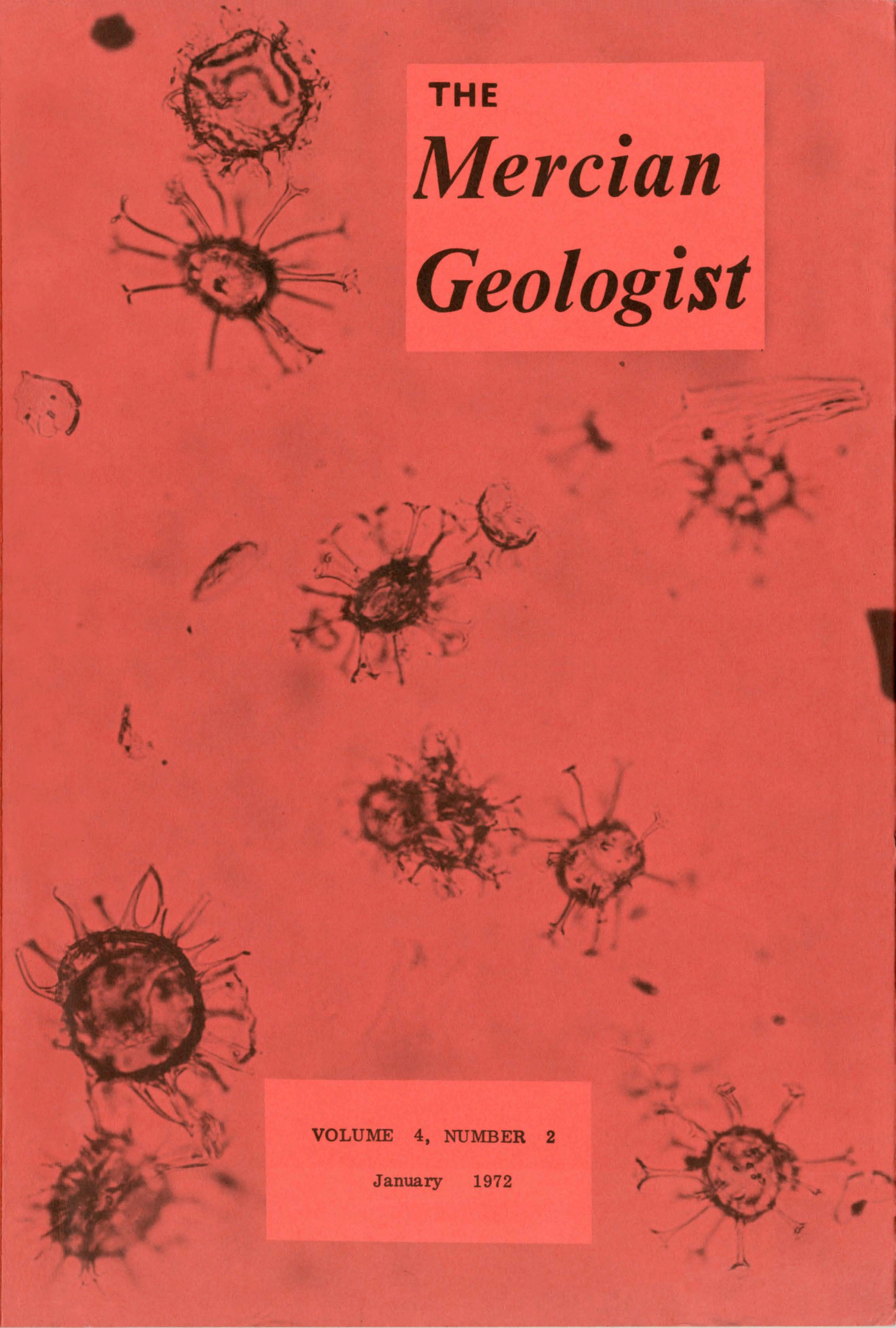
THE
# *Mercian Geologist*



VOLUME 4, NUMBER 2

January 1972

# THE MERCIAN GEOLOGIST

JOURNAL

OF THE

EAST MIDLANDS GEOLOGICAL SOCIETY

VOLUME 4 NUMBER 2

FEBRUARY 1972

EDITOR: W. A. CUMMINS

## Correction

Volume 4, Number 1, Plate 1, facing page 10.

The explanation of this plate should read as follows:-

"Specimen of fibrous gypsum, showing sedimentary structures;

A, upper surface; B, lower surface."

The photographs were of the actual specimen and not of the models.

# CONTENTS


| | | Page |
|---|---|---|
| F.M. TAYLOR | The Lower Carboniferous coral environments of Derbyshire and adjacent areas. | 81 |
| F. MOSELEY | Stereoscopic ground photographs in field geology | 97 |
| M.J. FISHER | Rhaeto-Liassic palynomorphs from the Barnstone railway cutting, Nottinghamshire. | 101 |
| R.J. HEATH | Recent discovery of a mammoth molar in the Middle Trent Valley Gravels near Egginton, Derbyshire. | 107 |
| T.D. FORD | Supplement to the bibliography of the geology of the Peak District of Derbyshire. | 109 |
| G.J. WILSON | A method for the recovery of mounted palynological residues. | 139 |
| F.W. COPE | Some stratigraphical breaks in the Dinantian massif facies in North Derbyshire. | 143 |
| W.A. CUMMINS<br>H.R. POTTER | Rates of erosion in the catchment area of Cropston Reservoir, Charnwood Forest, Leicestershire. | 149 |
| Excursion Report:- | | |
| P.A. PITTHAM | The Middle Jurassic of Northamptonshire. | 159 |
| Reviews | | 161 |

THE EAST MIDLANDS GEOLOGICAL SOCIETY

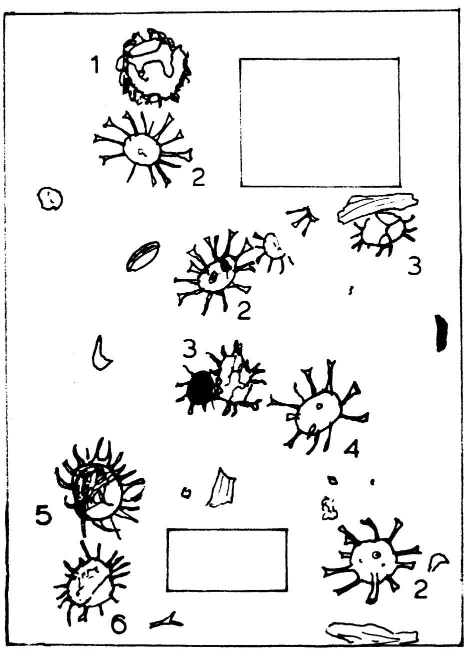
Council 1971/72




Address for correspondence: The Secretary,
East Midlands Geological Society,
54 Cyprus Road,
Mapperley Park,
Nottingham, NG3 5EB.



Price of this issue: £1.75
Subscription rates and other information may be obtained from the Secretary.


The front cover:

A palynological strew mount prepared from Upper Cretaceous Chalk by Mr. G.J. Wilson, showing an ideal concentration of dinoflagellate cysts, together with a few plant tissue fragments. The dinoflagellates represented are (1) *Spiniferites cingulatus*, (2) *Hystrichosphaeridium tubiferum*, (3) *Spiniferites ramosus*, (4) *Oligosophaeridium* sp., (5) *Cleistosphaeridium pseudhystrichodinium*, and (6) *Cleistosphaeridium multifurcatum*.
Photo and notes: W.A.S. Sarjeant.

# THE LOWER CARBONIFEROUS CORAL ENVIRONMENTS OF DERBYSHIRE AND ADJACENT AREAS.

Sixth Presidential Address to the East Midlands
Geological Society, 6th February 1971

by

F.M. Taylor

## Summary

A comparison is made between recent and Lower Carboniferous coral faunas from morphological and stratigraphical aspects. The environment of recent corals is summarised and comparisons and contrasts made of this environment with that of the Lower Carboniferous, deduced from a study of Derbyshire rocks and fossils. It is considered that the Lower Carboniferous corals lived in an equatorial warm water marine environment developing mainly as patch reefs, just below sea level, with an associated fauna. Outer barrier reefs, knoll limestone, possibly controlled by abundant crinoid growth, with or without algae and generally devoid of coral, separated the coral patch reefs from the surrounding deeper water. Land areas would be restricted to small, low islands lying to the south, the remnants of an earlier more extensive St. Georges Land. The possibility that the main Derbyshire limestone area subsided as a result of an ancient volcanic platform, floundering, allowing the accumulation of over 2,500 feet of limestones, is investigated.

## Introduction

Much has been written about coral ecology since the voyage of the Beagle and Darwin's (1837, 1842) essays on coral reefs. There is a similar volume of literature on British Lower Carboniferous (Avonian) palaeogeography, summarised in the papers of George (1958, 1962, 1963). Recent and Carboniferous corals and reefs are usually mentioned by writers on these subjects. The corals and associated faunas with their sediments have not been used to any great extent to deduce detailed Lower Carboniferous environments. Using Sir Charles Lyell's 'Principle of Uniformitarianism' - 'the present is the key to the past' - as a working hypothesis, comparisons are here made between modern and Carboniferous coral occurrences to add details to the palaeogeography of Derbyshire so far illustrated by other authors.

For the description of the ecology of modern corals I am indebted to the work of J.W. Wells, (1956, 1957), D.R. Stoddart (1966) and contributors to a coral symposium held in London in September 1970, to be published shortly. The ideas on the Lower Carboniferous palaeogeography of Derbyshire are based on the summaries of Professor T.N. George and other Carboniferous workers acknowledged in the text, and also on my own studies of Derbyshire corals and rocks since 1953.

There has been little published on the palaeoecology of the Carboniferous coral beds. Rayner (1946) has described an occurrence near Settle, Yorkshire, and Hill (1948, 1956) has written on the palaeoecology of Palaeozoic corals, considering them to form the framework of reefs in conditions similar to those of the present day. The small solitary corals are thought to have lived in deeper water and the large solitary corals in an intermediate depth position.

There is no clear indication of the depth of water involved and little can be learned from the literature about the environment in which these corals and their associated fauna lived.

If the principle of 'Uniformitarianism' is accepted, the first step to be taken in attempting to deduce Lower Carboniferous coral environments would seem to be a study of those of recent corals. Before this is done, however, I would like briefly to review morpholigical, ontogenetic and stratigraphical evidence which might suggest that there are sufficient character differences to render the hypothesis that recent and Lower Carboniferous coral environments are the same, invalid.

## Coral Morphology

It is not intended to describe in detail the skeletal structure of the various groups of corals, the modern Scleractinia, and the Palaeozoic Rugosa and Tabulata, but to draw attention to the clear differences of skeletal structure that do exist which may be the result of different environmental conditions. Three examples, concerning the form of the coral, the septal plan and the original mineral composition of the skeletal material, are discussed below.

A first assessment might suggest that there are many growth habits or forms of coral common to all three groups. This statement applies particularly to the common fasciculate and massive colonial corals. Certain forms are restricted to only one or two of the groups. There are no acknowledged solitary Tabulate corals and the slipper shaped *Calceola* and rectangular *Goniophyllum* of the Rugosa have no counterparts in the Scleractinia. Many modern solitary corals, such as the fungids, have no outer protective wall (epitheca), a feature unknown in the Lower Carboniferous. The meandroid colonies, as developed by *Meandrina* or *Mancinia* of the Scleractinia are restricted to that group, the nearest equivalent being the cateniform or chain corals exhibited by *Halysites* of the Tabulata. These distinctions are due to different methods of colony formation, the result of polyp increase producing a large number of individuals grouped together as a colony. The different methods, may well be a fundamental distinction.

The septal plan, seen in transverse sections of the coral skeleton, is determined by the mode of septal development. Modern corals possess a septal plan which is characterised by six long septa reaching to the centre of the coral, dividing the circle of septa into equal $60^o$ sectors. These six sectors are bisected by six shorter septa and the resulting twelve sectors are themselves bisected by twelve shorter septa. Depending on the size of the coral there may be a further set of septa, twenty-four if fully developed, again shorter than the pre-existing septa. A distinctive radial septal plan is thus a common feature of scleractinid corals. The rugose corals developed their septa in a different manner, resulting in the alternating long and short septa characteristic of their septal plan. Tabulate corals are often without septal structures and when they do occur they are seen as small spines, usually twelve in number, (Hill, 1956; Wells, 1956). These differences are once again fundamental.

Micro-structures in the septa of corals are known from both modern and Carboniferous corals. The aragonite skeleton of the Scleractinia often changes to calcite, the more stable form of calcium carbonate, with the resulting loss of the microstructure. Further recrystalisation may result in the complete destruction of the coral, leaving only a mass of large calcite crystals. The fact that microstructures can still be found in the calcite skeletons of Carboniferous corals, or Silurian corals for that matter, suggests that calcite, rather than aragonite, was the original mineral deposited. Aragonite is more commonly formed in a warm marine environment and calcite in cooler areas at the present time. (See also Sorauf 1971)

Other examples could be given but these three illustrations alone are sufficient to show that there are fundamental, skeletal differences between the three groups of corals and it would not be surprising to learn that these reflect differences in the respective environments.

## Evolution and Geological History

Historically, there is no continuity between Palaeozoic and Mesozoic coral faunas. Rugose corals are known from Upper Permian strata, represented by the small solitary coral populations of Timor and Armenia. No tabulate or scleractinid corals of this age are known. The first small colonial corals of the Middle Trias are all thought to be scleractinids and claims of rugose corals from the Lower Triassic rocks have still to be substantiated. There are no clear morphological similarities between the last rugose corals and the first scleractinids and Hill (1960) claims that there is no certain evolution of the modern corals from the rugose corals.

The scleractinid corals have had a long existence commencing at the beginning the Middle Triassic, on present estimates (Harland, 1964) over 215 million years ago. During this time environmental changes could occur accompanied by, or independant from, any adjustments of scleractinid physiology. The group is extremely successful at present, as successful as the Rugosa were at the close of the Lower Carboniferous.

Skeletal differences have purposely been emphasised but corals of all ages are placed within the same phylum, the Coelenterata, indicating the essential similarities that are also common to all groups. It is generally accepted that the composition of sea water has changed little over the last 600 million years, a constant environmental factor. It still seems worth while to consider modern coral environments as a key to those of the Lower Carboniferous.

## Modern coral environments

All modern corals are marine organisms living in saline water with an optimum of 33 to 36 parts of dissolved salts per thousand. They are intolerant of any degree of dilution or concentration outside the range 27 to 40 parts per thousand. Breaks in continuous coral growth occur beyond these limits.

The corals are sessile organisms and require that all materials necessary for life be brought to them, and that all toxic waste products be removed. They live, therefore, in regions of moderate to strong current activity.

Other ecological conditions are less stringent and allow modern coral faunas to be divided into two main groups, the warm water, so-called reef corals, and cold water, non-reef, solitary coral faunas.

The colonial corals flourish in a warm water environment with optimum temperatures between $25^{o}$ and $29^{o}$C. Another factor said to facilitate skeletal secretion is strong sunlight. The reason for this is a little obscure as the polyps are most active with reduced illumination, feeding especially at night. The environmental restriction may be imposed by the zoanthellae (algae), which are considered to be an important symbiant in the coral tissue and would require sunlight for photosynthesis. It follows, that coral growth is most active between the low-tide mark and a depth of about 20 metres.

Solitary corals also thrive in the conditions outlined above but are more tolerant of variations in temperature and light. They can live in much cooler situations with temperatures down to $4{\cdot}5^{o}$C and in depths down to 500 metres or more. Strong sunlight is not an essential condition and these corals are without zoanthellae. Deposition of calcium carbonate in the skeleton is much slower and no large masses of coral are formed.

Geographically, warm-water reef corals are restricted to a zone approximately $30^{o}$ north and south of the equator with variations where warm water currents will allow growth at higher latitudes and cold currents will restrict growth even in equatorial regions (Wells, 1957, Pl.9). The main areas of modern reef development are the central Pacific islands, the Gulf of Arabia, the Red Sea, Indonesia and the Caribbean (West Indies), covering in all an area of over 68 million square miles.

Solitary corals live in the same areas and extend beyond them into higher latitudes, including the North Sea and the Western Isles of Scotland, but coral populations in these higher latitudes are insignificant.

The distribution of corals in the warm-water areas takes one of the following forms:

(a) Fringing reefs, immediately off-shore, below low-water mark.

(b) Barrier reefs, usually separated from the fringing reefs and the shore-line by a lagoon.

(c) Atoll reefs, developing on the flanks or crater of a subsiding volcanic caldera.

(d) Patch reefs, found in any shallow water region, but covered at low-tides.

(e) Isolated coral development, frequently made up of single large colonies or solitary corals, sited in the path of a favourable current.

Atoll reefs frequently attain great thickness, with growth of the coral keeping pace with subsidence. Exploration at Eniwetok Atoll (Ladd, 1953) has proved corals down to depths of over 4,000 feet, the corals remaining unaltered at that depth and the lowest ones being of Eocene and Miocene age. There are basaltic foundations to the atoll and the sediments show shallow water characteristics throughout. Darwin's (1837) subsidence hypothesis seems now to be proved.

Other reefs are usually much less thick. With the surface of the sea restricting growth upwards, development of the reef is outwards and horizontally, with steep faces towards areas of maximum water movement.

The corals are just one factor of the reef populations. Of equal importance are the calcareous algea, which bind the various consistuent parts of the reef together. Other organisms, including foraminfera, echinoderms, molluscs and fish, live in sheltered crevasses or cavities in the developing reef. All these organisms provide a wealth of small food particles for the coral polyps, particularly eggs, larvae, spat and other small fragments. It is now doubted whether plankton is the only food source as it is relatively scarce in areas where currents and waves are strong.

Debris derived from the break-up of the reef during storms, or when the reef building organisms are killed, contribute in a large way to the amount of limestone in and around the reef area.

Despite the attacks of predators, including the much publicised star-fish (*Acanthaster planci*), the Scleractinia are remarkably successful and since the Miocene at least, have contributed much to the life of the warm water oceans. Their remains are to be found, either fragmented or complete, in many thousands of feet of limestone sequences.

Next to be considered, are the Lower Carboniferous coral environments, as they might have developed in the North Midlands (Derbyshire) area.

## The Derbyshire Lower Carboniferous coral environments

### General conditions and situation

The present location of the British Isles, despite the favours bestowed upon the country by the warm Gulf Stream oceanic current, precludes the growth of reef corals around its shores. The occurrence of large colonial corals now preserved in limestones of Wenlock, Middle Devonian, Lower Carboniferous and Jurassic ages has always created a problem concerning their environment. Before the idea of continental drift became acceptable, it was necessary to consider changing the positions of the poles and equator, ameliorating climatic conditions generally over the globe or assume that Palaeozoic corals were more tolerant to adverse conditions than those of the present day. The occurrence of fossil corals has been used as circumstantial evidence in favour of continental drift. Recent ideas on continental drift and polar wandering, derived from palaeomagnetic data, independantly allow the British Isles to be placed within the $0^{o}$ - $30^{o}$N position during the Permian Period, as accepted by Holmes (1965, p.1231) and the same author (p.1232) does not think that the position would be greatly changed during the Lower Carboniferous. With the possible existence of a warm-water current and with the restricted volume of a much reduced 'Atlantic Ocean' the geographical position of the 'British Isles' could be a little further to the north to achieve substantially the same climatic conditions. Warm-water marine conditions are thus envisaged right across the present British Isles, during Lower Carboniferous times, extending into Europe on the one side and North America on the other.

The lack of coarse terrigenous detritus (siltstones and sandstones) in the Lower Carboniferous sediments of the Derbyshire area, suggests the absence of large deltas originating from land surfaces (St. George's Land) with high relief. Small islands are acceptable, possibly less than 100 feet high, separated by channels in which limestone could be deposited. Eunson (1884) has described Carboniferous limestone from bore-holes near Northampton, south of the postulated islands. They form part of St. George's Land, a land area extending from East Anglia to Wales, and can be positioned in the open channel depicted on the Visean palaeogeographical maps of Wills (1951) or Rayner (1967). The deposition of mud, either with or without calcium carbonate was often extensive and requires a source area, the nearby St. George's Land or further afield.

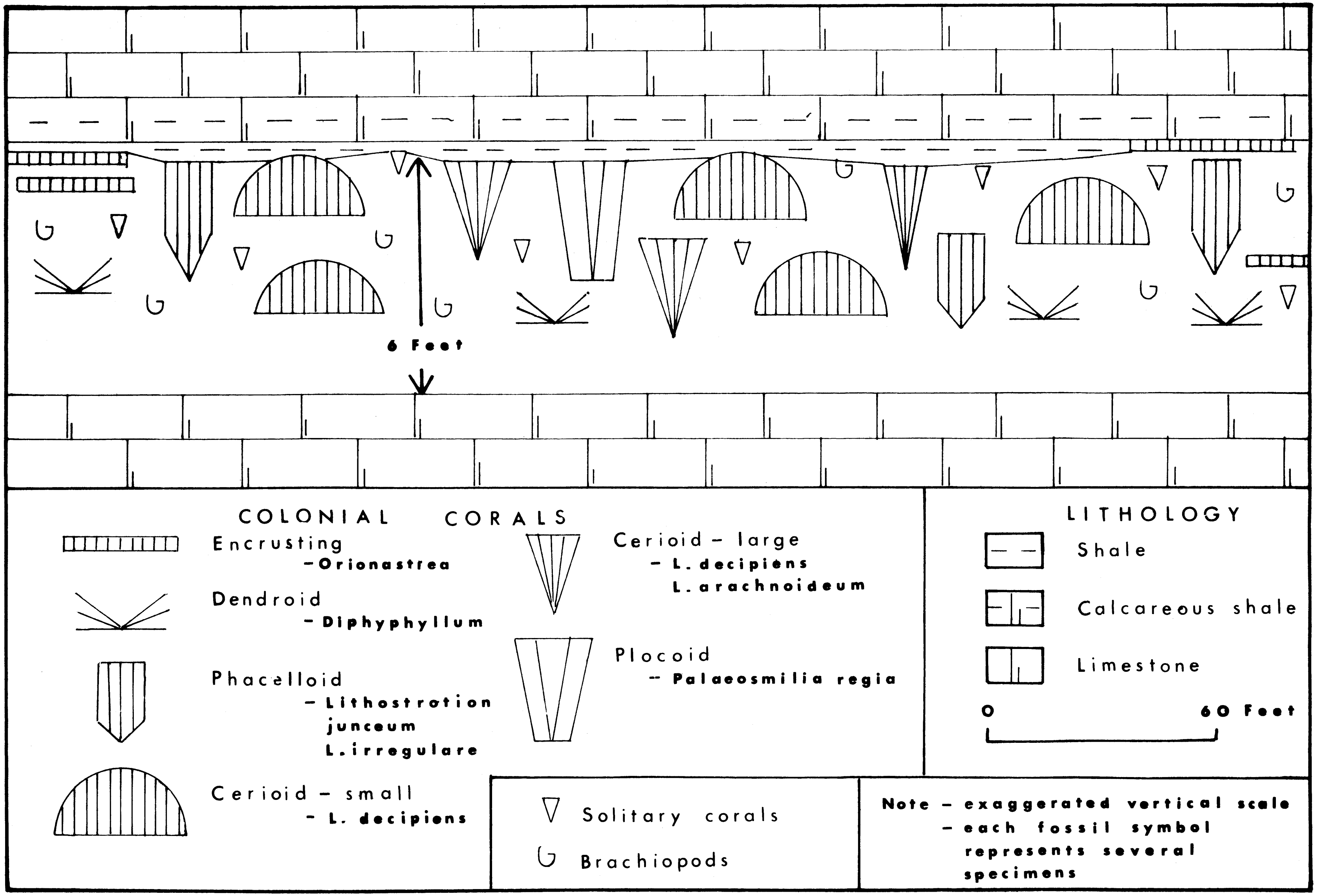
High temperatures are envisaged not only from the tropical position of the islands but also from the development of minerals in some areas. These minerals include any chemically precipitated calcite and dolomite in the limestones. The less porous, more compact dolomitic limestones of south Derbyshire and north Leicestershire suggest almost immediate dolomitisation. Dolomitisation of Carboniferous limestone in this area is complicated by the later cover of Permian and Triassic beds and the consequent addition of magnesium ions to the Carboniferous limestone from the Permo-Triassic sediments resulting in the highly porous rocks now seen near Brassington at the Harboro' Rocks and Rainstor Tor. Finally, the discovery of anhydrite in a bore-hole near Hathern, Leicestershire (Llewellyn and Stabbins, 1970) indicates intense evaporation in part of the area at least during the late Tournasian, early Visean times.

The details of the marine environments of the Derbyshire area can be studied commencing with the coral beds, which appear to be situated centrally, and then bordering environments can be briefly examined, as these appear to have an effect on the distribution of the coral populations.

## The coral patch reefs

The evidence for the details of this environment is obtained from a study of the Derbyshire Lower Carboniferous coral beds and associated rocks. For structural and erosional reasons, it is not possible to trace a single coral bed over the entire Derbyshire limestone area, but some of the coral and other fossil beds do have considerable lateral extent. The *Davidsonia septosa* brachiopod and coral bed can be traced discontinuously over many square miles, (Cope 1936, Sadler 1964) and the *Orionastraea* coral-brachiopod bed likewise has been mapped over much of the northern and eastern part of the Derbyshire limestone outcrops (Shirley and Horsfield, 1940, 1945; Shirley, 1959). This horizon is of great interest as in many places the corals can be found in their original growth positions. Other coral beds, including most of those containing only solitary corals appear to have been disturbed before preservation, though the lack of attrition of the corals suggests that they have been moved only a short distance.

A well developed example of a Carboniferous coral reef can be seen at Coomsdale (SK 222743) (text-fig.1). On the flanks of the reef, encrusting colonies of *Orionastraea* sp. only a few mms. thick can be seen. They are generally associated with fasciculate colonies of *Diphyphllum* sp. with branches arranged almost horizontally. Adjacent to these colonies, on the sheltered side towards the centre of the reef, more upright fasciculate colonies are to be found including *Lithostrotion irregulare*, *L. junceum*, *Syringopora* sp. and *Lonsdaleia duplicata*. Moving further towards the centre of the reef, are the small massive colonies of *Lithostrotion decipiens* and *Lonsdaleia floriformis*. In the centre of the reef, mud is rarely seen and the limestone matrix is light coloured. The largest colonies seen are examples of *Palaeosmilia*




Text-fig.1. - Diagrammatic section across a Lower Carboniferous coral patch reef, based on the exposures of such a reef in Coombsdale, Derbyshire, zone $D_2$.

*regia* over one metre high but, in the centre of the reef, colonies of *Lithosotrotion decipiens* and *Thysanophyllum* sp. also approach this size. A section through the coral bed is illustrated in text-fig. 1.

Elsewhere, comparable sections of coral reef can be seen near Bakewell, Monsal Head and Crich. Despite the absence of *Orionastraea* in some of these localities, the occurrence of other corals and their stratigraphical position near the top of the Carboniferous limestone suggests that the corals beds at these localities are of the same age.

Associated with the colonial corals are solitary ones both large and small. They are subordinate to the colonial corals and include members of the Clisiophyllidae and the Zaphrentacae. There are abundant brachiopods, mainly gigantoproductids and spiriferids. Foraminifera are frequently found in the darker coloured limestones at the margins of the patch reefs and there are usually abundant crinoid columnals.

Occasionally it is possible to see the development of a new colony on the remains of another but the development of hundreds of feet of continuous coral growth, as in modern coral atolls is unknown in the Carboniferous.

It is concluded that the corals grew mainly in patches, subcircular in outline and separated by channels. Broken and uprooted corals show that the reefs were frequently eroded, thus contributing to the accumulation of limestone beds and accounting for the incomplete preservation of the patches.

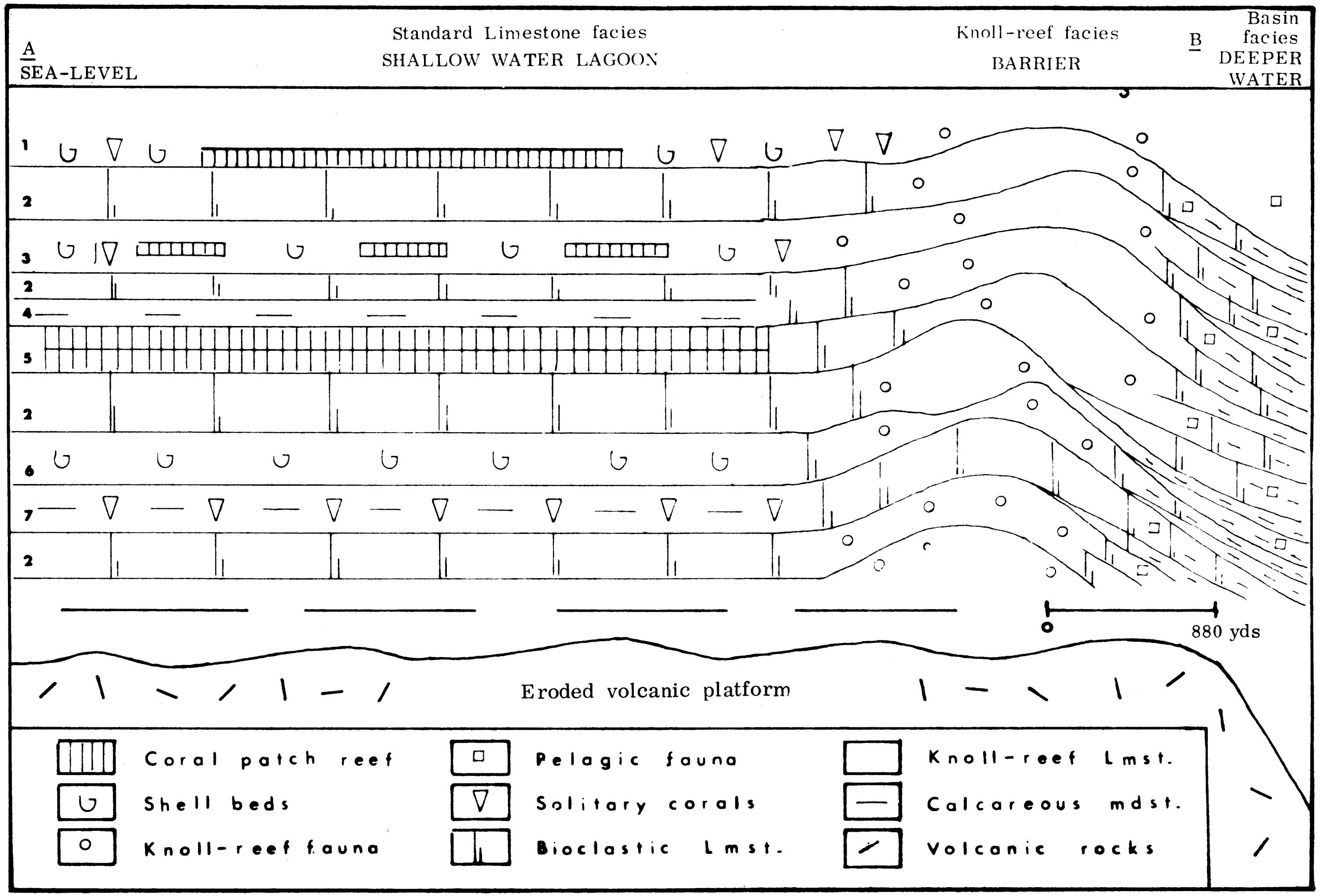
Away from the coral patch reefs, the sea floor was in places crowded with brachiopods. It is thought that these shells, mainly productids, originally lived in the areas bordering the channels and that they frequently became detached and collected in shell banks.

Elsewhere, deposition of mud results in the formation of shaley limestones. The calcareous mud seems to have been an ideal habitat for small solitary corals, *Zaphrentites* and *Cythaxonia* and for brachiopods, including the smaller productids and *Martinia*. Inarticulate brachiopods and trilobites may be an important part of the fauna. The introduction of increasing quantities of mud frequently killed off the corals and they are now located in the lowest layers of the shale horizons. The source of this mud is uncertain but it occurs repeatedly throughout the Lower Carboniferous. The fauna associated with the small solitary corals suggests that the depth of water has not increased very much, rather it is the sediment which controlled the character of the fauna. The distribution of these three environments (coral patch reefs, brachiopod lenses, solitary coral patches) is shown diagrammatically in plan view on text-fig. 3, and in section at the top of text-fig. 2, together with the various rock types (numbers 1 to 7) which may be found (See also p. 91). Isolated coral occurrences may be found between the patches mentioned above (text-fig.3).

Undoubtedly, the optimum time for patch coral reef development in the Derbyshire limestone area was in the D. zone. There is preserved at this time a much greater variety of colonial corals than at any other. Before the D. zone, the patch reefs are smaller with the centres of the coral reefs made up of the larger massive *Lithostrotion* colonies and the large clisiophyllid corals. The smaller solitary corals continue to be found in the areas of mud deposition.

## The Carboniferous barrier reefs

The patch reefs described above eventually give way laterally to mound shaped masses of limestone (text-fig.2) which have been described as knoll-reefs by Black (1954) and Parkinson (1957) or knoll limestone by Whiteman (1961). Their occurrence in Derbyshire has been described by many authors, including Wolfenden (1958) from the north and west, Parkinson (1950), Prentice (1951) and Ludford (1951) from the west; Shirley and Horsfield (1940, 1945), Shirley (1959) and Smith and others (1967) from the east, and in the south there is the work of Mitchell and Stubblefield (1941) from the Breedon area. The distribution of the knoll-reef limestone has recently been reviewed by Ford (1968) and illustrated by maps for different




Text-fig.2. Section along the line A - B, text-fig.3, showing the range of variation of the Standard Limestone facies, nos. 1-7, and its relationship with other facies and with the basement, at depth. Not drawn to scale.

1. Developing coral patch reef and associated fauna at the surface.
2. Bioclastic limestones, the result of erosion of 1.
3. Incomplete preservation due to partial erosion.
4. Mud or fine volcanic ash covering 5.
5. A well preserved coral patch reef.
6. is a well preserved shell bed, with only occasional corals.
7. Small solitary corals preserved in dark muddy limestones or calcareous shales.

times during the Lower Carboniferous. Combining all the known Derbyshire knoll reef occurrences on a single plan emphasises the marginal characteristics of these knoll limestones in relation to the coral patch reefs (standard limestone facies) and is the starting point for text-fig.3. The separate maps (Ford 1968) show that the distribution is at present dependant on the subsequent erosion of the limestone, which now outcrops in the areas indicated. The correlation of the knoll - reefs with adjacent coral patches is also subject to the availability of the necessary faunal evidence, often scarce.

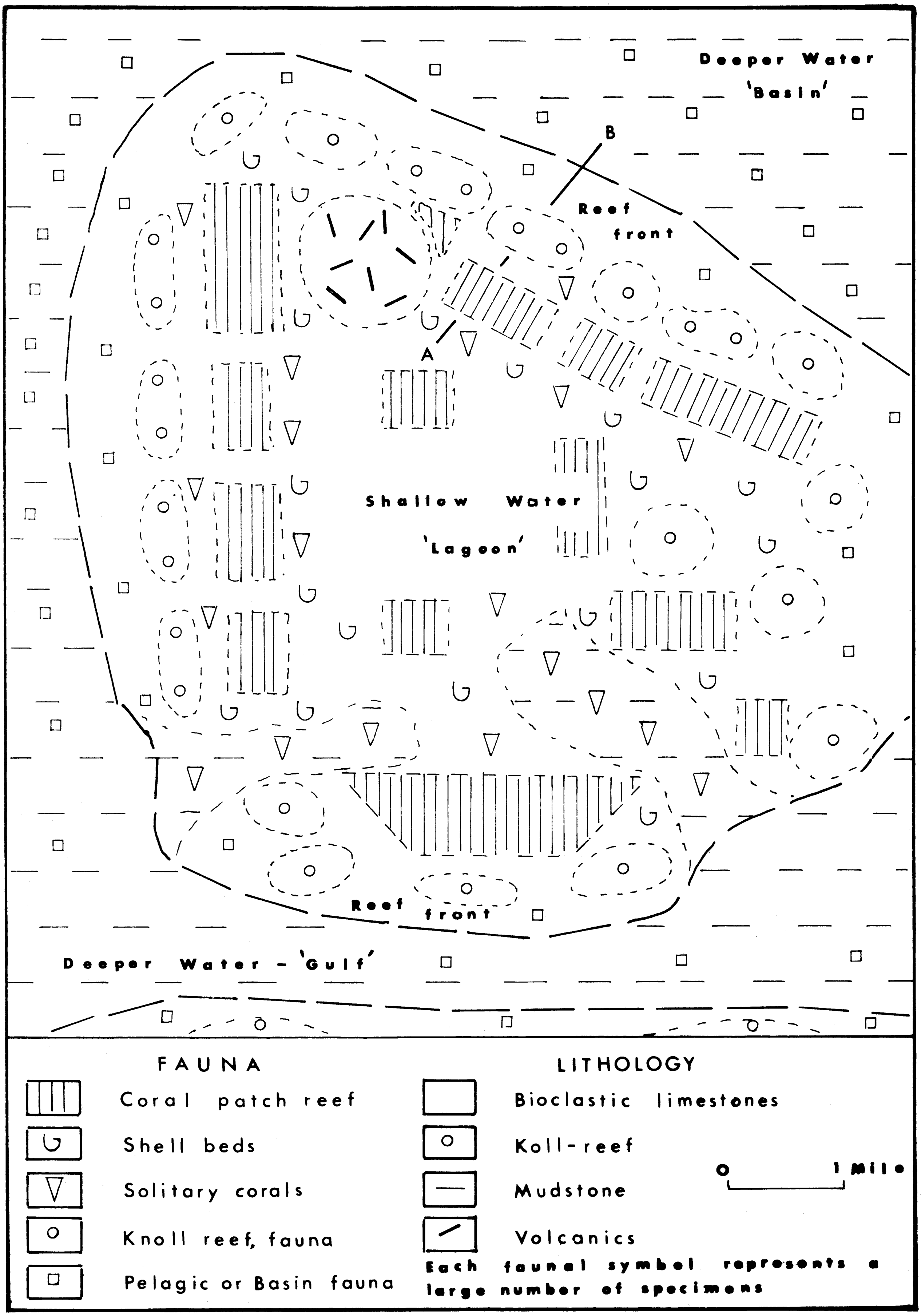
The Derbyshire knoll-reefs appear to vary in character, although the published details make comparisons difficult. In the north-west, Wolfenden describes the knoll-reefs as long, narrow ridges, the result of algal growth and accretion. Elsewhere, many knoll reefs are subcircular or elliptical in shape. Both can rise to over 100 feet from their bases, gradually being built up and at any one time a little above the adjacent coral patch sea floor (text-fig.2). In origin these mounds have been compared with those at Clitheroe, where Black and Parkinson consider them to have been developed by organic means, either algal or some other unknown bonding organism. Whiteman (1961) on the other hand, with his experience of the Guadelupe reefs of Texas and New Mexico, is convinced that the Clitheroe knoll-reefs are lime banks accumulated by currents. These views have recently been reiterated (Parkinson, 1969; Whiteman, 1968). Whatever their origin, the knolls are considered to be marginal, on the one side to the 'shelf' or 'lagoon' conditions and, on the other to the deeper water of the 'basin' or 'gulf'.

Many animals found these knoll-reefs suitable for colonisation. Many species of foraminifera, brachiopods, mollusca, trilobites, goniatites, bryozoans, crinoids and fish have been recorded from them. The brachiopod faunas are far more varied here than amongst the coral-patch reefs. The most notable absentees are the corals. Occasional ones, both solitary and colonial are found, such as the large specimens of *Lithostrotion* from Treak Cliff, Castleton, but information regarding the orientation of such corals is lacking. *Amplexus coralloides* is often recorded from the Clitheroe knoll-reefs but seems to be rare in Derbyshire. The tabulate coral, *Michelinia* is a much more frequent find. The presence of algae in the knoll-reefs is still a debatable point, with most of the evidence in Derbyshire being composed of trace fossils, structures said to be of algal origin. These structures consist of laminated patches of limestone, '*Collenia*', or nodules made up of concentric layers of laminated limestone, '*Girvenella*'. Fragments of shells and other fossils may be coated with concentric layers of the same limestone.

It is here envisaged that these mounds and ridges were marginal to the coral patch reefs and that there were channels through the reefs, possibly of considerable depth (Sadler, 1964a). The mounds and ridges could well have broken the surface of the sea at low-tide and, in any case, separated the coral patch reefs from somewhat deeper water beyond. They would therefore perform the function of present day barrier reefs, even if their organic origin is debatable. The flanks of these reefs are always associated with prolific crinoid debris. The crinoids must have lived in close proximity to, if not on the reef itself, in miriads. Perhaps the occurrence of these organisms as reef builders was responsible in some way for the knoll-reef development. The main mechanism would be to provide an area free from current activity which would allow calcite mud banks to accumulate.

## Deeper water basin or gulf environment

Becoming more remote from the coral environment, but added here to complete the immediate picture of Derbyshire Lower Carboniferous environments, are the slopes leading away from the knoll-reefs to somewhat deeper water. Beyond the bioclastic limestone comprising the 'reef-front' or 'reef apron', on the deeper side of the reef, the limestones become more shaley and are comparable in lithology to the solitary coral facies described earlier. These shaley limestones lack corals or other fossils which would indicate shallow water littoral type conditions, but possess the free swimming pelagic faunas, the goniatites, free swimming bivalves and fish. In Derbyshire, limestones of this facies have yet to be described satisfactorily. Many limestones said to be of basinal facies contain solitary corals, articulate and inarticulate brachiopods, trilobites and crinoid debris, suggesting that they were developed in a shallow water environment. Ford (1968) has commented on the lack of evidence for depth of water in basin type limestones. The existence of the outer reef slopes, however, cannot be doubted in




Text-fig.3. - Map illustrating possible distribution of marine environments, in an area to the north of St. Georges Land, based on evidence available from D. zone coral beds of Derbyshire.

some areas, particularly around Castleton. It is considered that, however the reef-knolls are developed, deeper water with free oceanic circulation may be found comparable with the areas found beyond modern barrier reefs. The occurrence of the barrier-reefs facing in all directions at various times during the Lower Carboniferous suggests that deeper water not only occurs to the north and south, the Lancashire Trough and the Widmerpool Gulf (Falcon and Kent 1960) respectively, but at certain times may well have been present to the east and west.

### Fringing coral reefs

In the Derbyshire area there is no direct evidence of the St. George's Land coast line situated in the south Midlands. Small islands may well have been present and, if this is the case, fringing reefs might have developed adjacent to the coast.

## Preservation of the coral beds

Coral beds occur at infrequent intervals in limestone sequences. Much of the Carboniferous limestone is made up of fragments of fossils, broken and eroded or even fragmented to single crystals. Current bedding testifies to the existence of currents. Unconformities separate all Shirley's (1959) major groups of limestones indicating major erosion surfaces. Minor ones, channels, variations in bed thickness, all point to movement of sediment. Only occasionally were conditions suitable for the preservation of the fauna living at the time, on any large scale. The conditions were usually catastrophic, including the sudden influx of mud into the area (text-fig.1) which killed off the living fauna and preserved the skeletons as fossils in the top beds of the limestones. Volcanic debris was also shot into the area from a number of vents, located in the Derbyshire area through the work of Bemrose (1907) and Smith (1967). A vent is shown diagrammatically in text-fig.3. The result of the volcanic activity was the outflow of lava, ash and fine dust, covering and preserving the fauna in some cases, for example the *Davidsonina septosa* bed in the Via Gellia, near Cromford.

Text-fig.2 is a diagrammatic section through about 20 metres of limestone showing (1) the development of coral reef at the surface; (2) limestone formed by erosion of the reefs; (3) eroded, incomplete, coral-brachiopod bed; (4) mud or fine volcanic ash covering (5) a well preserved coral bed; (6) is a well preserved shell bed with occasional corals, preserved by excessive limestone sedimentation and (7) solitary corals preserved in dark coloured limestones beneath calcareous muds. All these limestones are adjacent to the developing barrier reef with its abundant crinoid and other reef faunas.

## A Derbyshire atoll or atolls

Using the modern coral environments, so far, coral patch reefs, isolated coral occurrences, fringing reefs, and barrier reefs have all been discussed. There remains the possibility of a Derbyshire atoll. The information available is meagre and obscured by subsequent erosion of the limestones and earthmovements altering their disposition. The possibility of caldera subsidence is suggested only by the encircling knoll-reefs as shown in text-fig.3, the result of combining barrier reefs of all ages on one plan, with shallow water in the centre and deeper water around. However attractive this idea might be it must be stated that the marginal reefs which occurred throughout the Lower Carboniferous in Derbyshire may well have existed only in the positions fortuitously preserved at the present day. The one bore hole which has pierced the base of the limestone (Cope, 1949) records volcanic rocks said to be comparable with those of Charnwood Forest and thus of Pre-Cambrian age but they could be younger than this.

It is concluded that there was gradual, but irregular subsidence of a much eroded volcanic platform, which has allowed the accumulation of over 1000 metres of limestones during the Visean, with some renewal of volcanic activity during the time.

## Lower Carboniferous cherts

High accumulations of silica, forming nodular, and tabular masses, both concordant and discordant with the bedding, are commonly seen in the highest limestones, particularly in close proximity to the mineral veins. The mineralisation and silicification of the limestones, for the purpose of this address, are considered to be subsequent to original deposition and have not been taken into account in this study.

## Conclusions

Certain comparisons can be made between modern and Lower Carboniferous coral reefs. The geographical position of the reefs may have been similar with corresponding climatic and depth characteristics. Although there are morphological differences, the corals would be subject to the same hazards of life. The corals are associated with other forms of life. There are coral patch reefs and isolated coral occurrences at both times.

In contrast the Carboniferous corals never took advantage of the knoll-reefs (barrier-reefs) as do the modern corals, their place being taken by brachiopods and other organisms including possibly crinoids. The Carboniferous massive corals tend to occur as patch reefs, protected from the extremes of their environment by fasciculate coral populations and by the incomplete outer knoll reefs.

The possibility that the Derbyshire shallow water limestones were deposited within the lagoonal area of a large atoll is discarded in favour of the hypothesis that the shallow water was the result of slow irregular subsidence of a 'stable' area, possibly a much eroded volcanic platform.

There are always associated faunas, although vastly different at the two times. Modern brachiopod populations are relatively insignificant compared with those of the Carboniferous. The reverse is true of the mollusca.

What would keep the corals off the knoll-reefs during the Carboniferous? One can only speculate - a privilege of a Presidential Address. Perhaps trilobites and goniatites were able to feed on the coral polyps, as the 'crown of thorns' starfish does at the present time. The crinoids, in close proximity to the knoll-reefs, may well have prevented the settling of the coral larvae, or the accumulation of lime mud may have been too great for the developing corals.

It is clear that the evolution of corals and adaptation to their environment since the Carboniferous has resulted in the greater success of modern corals, but the morphological changes prevent an exact environmental comparison.

## Acknowledgements

I would like to take this opportunity to thank Professor L.R. Moore, of the University of Sheffield, for encouragement and advice during early years at the commencement of my studies of Lower Carboniferous corals, whilst at that University. Since that time, I have been able to discuss freely problems of Lower Carboniferous geology with many experts, particularly Dr. T.D. Ford, Professor F.W. Cope, Dr. F. Broadhurst and Dr. H. Boynton. I would like to thank them all for their forbearance and help, however small it may seem to have been.

F.M. Taylor, Ph.D., F.G.S., M.I.M.M.,
Department of Geology,
The University,
Nottingham, NG7 2RD.

## References


BEMROSE, H.H. Arnold — 1907. The toadstones of Derbyshire; their field relations and petrography. Quart. J. Geol. Soc. Lond., Vol. 63, pp. 241-281.

BLACK, W.W. — 1954. Diagnostic characters of the Lower Carboniferous knoll-reefs in the N. of England. Trans. Leeds Geol. Assoc. Vol. 6, pt. 5, pp. 262-297.

COPE, F.W. — 1936. The *Cyrtina septosa* band in the Lower Carboniferous succession of North Derbyshire. Sum. Prog. Geol. Surv. for 1935, pt. 2, pp. 529-537.

1949. The Woodale bore-hole, near Buxton. Abs. Proc. Geol. Soc. Lond. Vol.105, p. iv.

DARWIN, C. — 1837. On certain areas of elevation and subsidence in the Pacific and Indian Oceans as deduced from the study of coral formations. Proc. Geol. Soc. London Vol. 2, pp. 552-554.

1842. The structure and distribution of coral reefs. London.

EMERY, K.O., TRACEY, J.L., and LADD, H.S. — Geology of Bikini and nearby atolls. U.S. Geol. Surv. Prof. Paper 260A, 265 pp., 73 Pls., 84 figs.

EUNSON, H.J. — 1884. The range of Palaeozoic rocks beneath Northampton. Quart. J. Geol. Soc. Lond. Vol.40, pp. 482-489.

FALCON, N.L. & KENT, P.E. — 1960. Geological results of petroleum exploration in Britain 1945-1957. Mem. Geol. Soc. Lond. No.2., 56 pp., V. Tables.

FORD, T.D. — 1968. The Carboniferous Limestone in Sylvester-Bradley P.C. and Ford T.D., (Eds.) The Geology of the East Midlands pp. 59-82 Plate V. Leicester.

GEORGE, T.N. — 1958. The Lower Carboniferous palaeogeography of the British Isles. Proc. Yorks. Geol. Soc., Vol. 31, pp.227-318.

1962. Tectonics and palaeogeography of southern England. Sci. Progress Lond. Vol.50, pp. 192-217.

1963. Tectonics and palaeogeography of northern England. Sci. Progress Lond. Vol.51, pp. 32-59.

HARLAND, W.B., SMITH, A.G., and WILCOCK, B. — 1964. The Phanerozoic time-scale. pp. 260-262. Quart. J. Geol. Soc. Lond., Vol. 120S.

HILL, D. — 1948. Distribution and sequence of Carboniferous coral faunas. Geol. Mag. Vol.85, pp. 121-148.

1956. Rugosa in Moore, R.C., (Ed.) Treatise on Invertebrate Palaeontology, Pt. F., pp.F233-F327, Lawrence, Kansas.

HILL, D. (Continued).

1960. Possible Intermediates between Alcyonaria and Tabulata, Tabulata and Rugosa, and Rugosa and Hexacoralla. Int. Geol. Congress. 23, Norden, Part 22, pp.51-58.

HOLMES, A. 1965. Principles of Physical Geology. 2nd. Ed. Nelson, London.

LADD, H.S., et al. 1953. Drilling on Eniwetok Atoll, Marshall Islands. Am. Assoc. Petrol. Geol. Vol.37, pp. 2257-2280, 2 pl. 5 figs.

LLEWELLYN, P.G. & STABBINS, R. 1970. The Hathern Anhydrite Series, Lower Carboniferous Leicestershire, England. Trans. Inst. Min. & Met., B. Vol.79, pp. B1-B15, Figs. 1-7, and discussion 1971, Vol.80, pp. B47-49.

LUDFORD, A. 1951. The stratigraphy of the Carboniferous rocks of the Weaver Hills district, North Staffordshire. Quart. J. Geol. Soc., Lond. Vol.106, pp.211-230.

MITCHELL, G.H. & STUBBLEFIELD, C.J. 1941. The Carboniferous Limestone of Breedon Hill and associated inliers. Geol. Mag., Vol.78, pp.71-76.

PARKINSON, D. 1950. The stratigraphy of the Dovedale area, Derbyshire and Staffordshire. Quart. J. Geol. Soc., Lond. Vol.105, pp. 265-294.

1957. The Lower Carboniferous reefs of Northern England. Bull. Am. Assoc. Petrol. Geol., Vol.41, pp.512-537.

1967. The Lower Carboniferous Limestone knolls of Clitheroe, Lancs. Geol. Mag., Vol.104, pp.371-389.

1968. -ditto- Geol. Mag., Vol.105, pp.299-301.

PRENTICE, J.E. 1051. The Carboniferous Limestone of the Manifold Valley region. Quart. J. Geol. Soc., Lond. Vol.106, pp.171-209 and discussion Vol.107, p.335.

RAYNER, D.H. 1946. A $D_2$ coral bed near Settle. Trans. Leeds Geol. Assoc. Vol.6, pp.14-25.

1967. The stratigraphy of the British Isles. 453 pp. Cambridge.

SADLER, H.E. 1964. The origin of the 'Beach Beds' in the Lower Carboniferous of Derbyshire. Geol. Mag., Vol.101, pp. 360-372.

1964a. Conditions of sedimentation of the *Cyrtina septosa* band in the Lower Carboniferous of Derbyshire. Mercian Geol. Vol.1, pp.3-10.

SHIRLEY, J. & HORSFIELD, E.L. 1940. The Carboniferous Limestone of the Castleton - Bradwell area, north Derbyshire. Quart. J. Geol. Soc. Lond., Vo..96, pp.271-299 and discussion Vol.97, pp.180-181.

1945. The structure and ore deposits of the Carboniferous Limestone of the Eyan District, Derbyshire. Quart J. Geol. Soc. Lond. Vol.100, pp.289-310.

SHIRLEY, J. 1959. The Carboniferous Limestone of the Monyash - Wirksworth area, Derbyshire. Quart. J. Geol. Soc., Lond., Vol. 114, pp. 411-429.

SMITH, E.G., RHYS, G.H., & EDEN, R.A. 1967. The Geology of the country around Chesterfield Matlock and Mansfield. Mem. Geol. Surv. G.B., 430 pp., London.

SORAUF, J.E. 1971. Microstructure in the exoskeleton of some Rugosa (Coelenterata). Journ. Paleo., vol. 45, pp.23-32, 2 Pls.

STODDART, D.R. 1966. Reef studies at Addu Atoll, Maldive Islands. Atoll Research, B. No.116. 122 pp.

WELLS, J.W. 1956. Scleractinia, in Moore, R.C. (Ed.) Treatise on Invertebrate Palaeontology Pt. F., pp.F328-F444.

1957. Coral Reefs, in Hedgpeth, J.W. (Ed.) Treatise on marine ecology and palaeoecology, Vol.1, Ecology. pp.609-632, pl.9, and Vol.2, Palaeoecology, pp.773-782. Baltimore.

WHITEMAN, A.J. 1961 In, The Geology of the country around Clitheroe and Nelson. Earp et al.., Mem. Geol. Surv. G.B., London.

1968. Lower Carboniferous limestone knolls, Clitheroe, District Lancashire and Yorkshire. Geol. Mag., Vol. 105, pp. 298-299.

WILLS, L.J. 1951. A Palaeogeographical Atlas of the British Isles and adjacent parts of Europe. London.

WOLFENDEN, E.B. 1958. Palaeoecology of the Carboniferous reef complex and shelf limestone in N.W. Derbyshire, England. Bull. Geol. Soc. Am., Vol.69, pp.871-898.

Manuscript received 11th August 1971

# STEREOSCOPIC GROUND PHOTOGRAPHS IN FIELD GEOLOGY

by

F. Moseley

## Summary

Stereoscopy with ground photographs taken in the field is an obvious but apparently little used technique. Using the methods of normal aerial photography, stereo-pairs and line overlaps can be taken. The resulting three dimensional stereomodel greatly assists in the interpretation of geology and, should there be the requirement, photographs can be planned for use with the stereometer, thus making quantative determination a possibility.

## Introduction

The value of aerial photographs to field geology is well established, and there can be few field geologists who do not make use of stereoscopy, both in the field and the laboratory. It has always seemed to follow that field geology would make equal use of stereoscopic ground photographs, and it is an invariable surprise to find this aspect largely ignored. The advantages of stereoscopy with ground photographs are just as significant as with aerial photographs and do not depend on special equipment. Indeed the rather expensive stereocamera is completely unnecessary and, using a single camera, distance exaggeration can be any desired amount, giving stereomodels which reveal more detail than can actually be seen when standing at the same viewpoint. Furthermore if a record is kept of such items as baseline measurement between photograph stations, positions of prominent landmarks and camera focal length, information retrieval can be quantitative. Close up stereomodels permit more accurate appraisal of many features ranging from orientation of bedding, joints etc., to details of shell beds or of individual "non collectable" fossils. The minimum value of these stereomodels therefore is to provide a permanent three dimensional check on observations, and the maximum is to add unrealised facts to the observations and to permit some quantative evaluation. Moreover the method is so simple that any individual can achieve impressive results without prior training, and the additional expense is minimal. For convenience, comments below are placed under headings of distant and near outcrops, although in essence there is no major difference in principle.

## Distant Landscapes

The advantages and disadvantages of ground stereoscopy of distant landscapes are comparable to those of high oblique aerial photographs. Such ground stereoscopy is of particular value in situations where vertical aerial photographs do not permit reasonable interpretation. The most obvious examples are the vertical cliffs which are so common along the coasts and in mountainous areas, or it may be that the scale of the aerial photography is too small to show required details or that it was not taken at the most suitable time of year (for example north facing slopes on many British air photographs are in deep shadow, and ground photographs can fill in the missing information). Even where the vertical photographs allow a first order interpretation ground stereoscopy can still make a most important contribution, far exceeding that to be derived from single flat photographs. Reference to plate 6 will immediately reveal the additional information available when the stereoscope is used. The methods to be employed in taking the photographs will vary considerably, depending upon the nature of the ground to be photographed and the sort of information retrieval which is required.

*Stereopairs* are most commonly used. Frequently it is single crags on mountainsides for which the photography is required, or on other occasions it may not be possible to move a sufficient distance parallel to the exposure to take more than two or three stereo-photographs.

*Line overlaps* will occasionally be appropriate, especially in the case of sea cliffs, when it will be possible to sail at any required distance parallel to the cliffs. Some inland escarpments also lend themselves to this kind of treatment.

In all cases whether steropairs or overlaps are being taken there are a number of general points which are applicable, and these are as follows:-

1. The camera focal length should be recorded.

2. Exact positions of several landmarks in the field of view should be noted on the vertical aerial photographs and maps, and on field sketches.

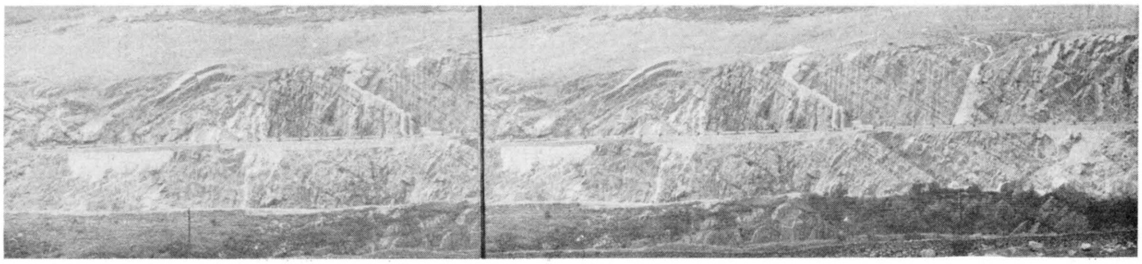
3. The compass orientation of the camera should be recorded and should be the same for each camera position, and the camera elevation or depression should also be the same for each position. In the case of line overlaps it may be necessary to photograph along doglegs, in which case camera orientation would periodically be altered.

4. If quantitative measurements are to be made, for example with the stereometer, base line measurements between stations should be taken and the positions of these stations accurately recorded on the aerial photograph. It will be appreciated that camera spacing between individual photographs depends on a number of factors and the following are relevant.

a) Normally, largely for reasons of economy, aerial photographs are taken with a 60% overlap, resulting in considerable vertical exaggeration. This is generally necessary since the eye cannot resolve stereoscopically at distances much greater than 400 metres and the effective eye base must therefore be appreciably increased.

b) Ground photographs will vary between two extremes. On the one hand cliff faces may present similar "relief" (in relation to a vertical plane) to that presented by topography in the aerial photographs and a similar 60% overlap may be used with advantage. This is especially so in the case of line overlaps, since the greater the overlap the greater the number of photographs which will be required. The new M6 section 1 mile south of Tebay, Westmorland (Plate 6A) required 18 photographs for a line overlap 500 metres long, and 5km. of the coastal cliffs of Akrotiri, Cyprus required 70 photographs. At the other extreme mountainous terrains may present a considerable depth of view and in these cases more than 60% overlap is needed if the whole view is to be readily accommodated stereoscopically. If sequences resembling line overlaps are required for such areas, the effect is best achieved by a series of overlapping stereopairs each with 80% or more overlap. The anticlinal hill and the gorge from the Betic Cordilleras of southern Spain (plate 6 A & B) are examples of this situation, and it will be noted that for these cases the parallax difference between foreground and background does not exceed 0.75cm, a suitable value for the pocket stereoscope. The percentage overlap is of course determined by the distance between camera stations, and increase or decrease of this distance will increase and decrease the distance exaggeration. It is a fact that on stereopairs such as those of plate 6 much more can be ascertained from the stereoscopic view, than from ground observation from the same viewpoint, since the main areas in the fields of view are beyond the range of the stereoscopic vision of the eyes.

If the points discussed above are adhered to during survey then it clearly becomes possible to make the same type of calculation that can be achieved with aerial photographs. For example use of the stereometer will permit distance calculation of any desired locality. However for most occasions this sort of information will not be essential and, in these circumstances, a quickly taken stereopair may be all that is required, and will still have the tremendous advantages over the single photograph which have been discussed above.



A

B

C

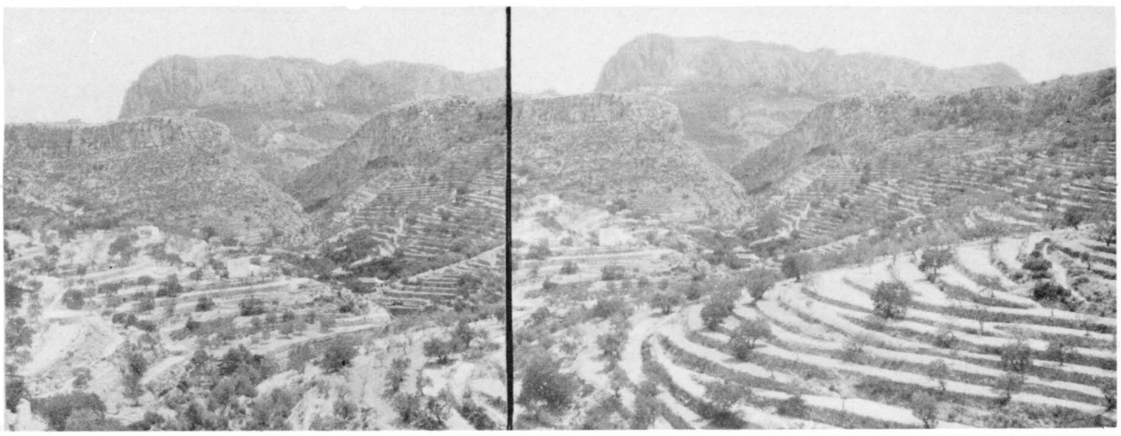
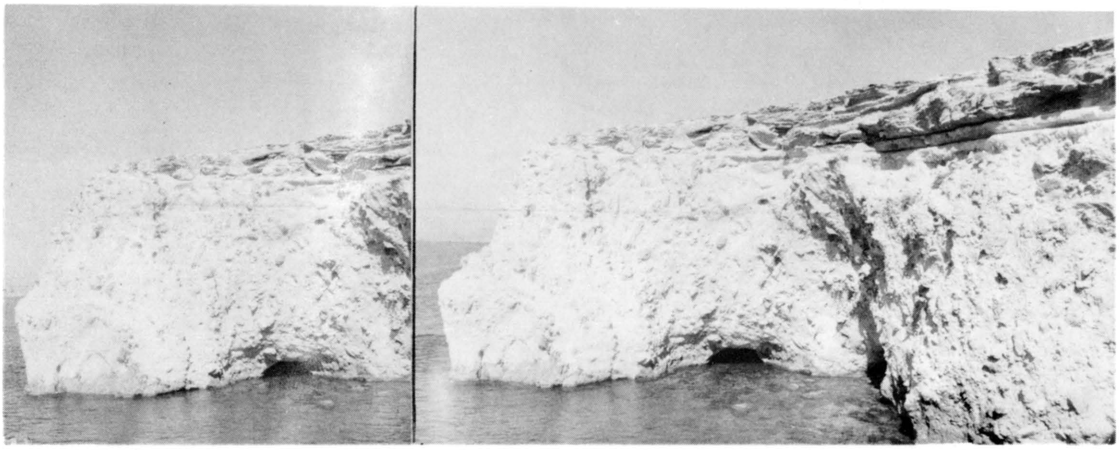


PLATE 6

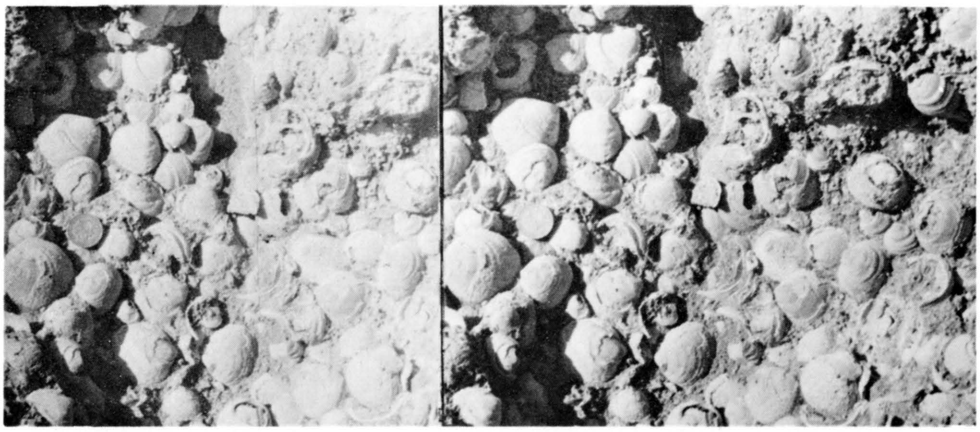
A. M6 (below) and A685 one mile south of Tebay, Westmorland. The section shows folded Silurian strata, with a small thrust cutting the syncline, and a high angle fault cutting the anticline, joints and drill holes show up clearly to the right of the photograph.

B. Sierra Bernia, Pre-Betic Cordilleras of S.E. Spain. The skyline is of Oligocene limestone and the middle distance is an anticline in Cretaceous limestone. In the foreground Cretaceous marls have a low angle fault contact with the limestone.

C. Pre-Betic Cordilleras, S.E. Spain. The foreground shows an escarpment of Oligocene limestone transected by the antecedent Gorge del Estret. The background is formed by a klippe of Eocene limestone which has been thrust over soft Miocene rocks.



A



B

C

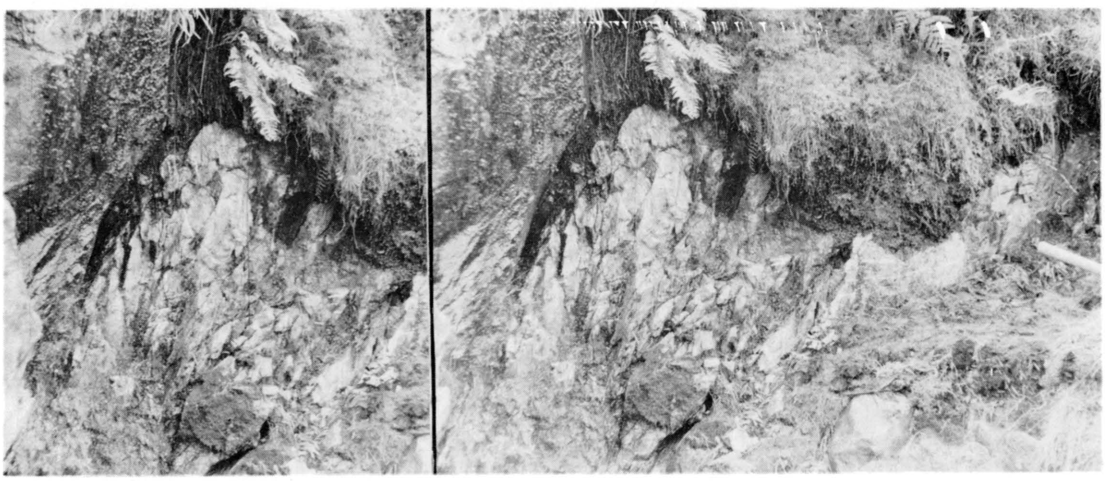


PLATE 7

A. Akrotiri, Cyprus. Miocene boulder beds with crystalline limestone boulders in a chalk matrix, overlain by Pliocene shell sands. The cliff is 60 feet high.

B. Akrotiri, Cyprus. A Pliocene shell bed showing the bedding plane surface, mostly with *Glycimeris* sp.

C. Warnscale Bottom, Cumberland. Tectonic junction between folded Skiddaw Slates and Borrowdale Volcanic rocks. It will be noticed that use of the stereoscope immediately resolves the complex orientations of joints and cleavage in the slates. The white lines are along bedding traces.

## Close up stereoscopy

There is no need to repeat those observations above which clearly apply whatever the object distance. Stereo-photographs of quarry faces and natural rock outcrops, whilst they should never be regarded as an alternative to thorough field investigation, are nevertheless useful for recording details of bedding, joints, lithologies and other small scale rock features. It is a common experience that intersecting planar surfaces (particularly joints) can be difficult to visualise and interpret on single photographs. This is especially so where those surfaces make oblique angles to sections of quarry and cliff faces, in which case a confusing picture is generally the result. It is remarkable how readily these features are resolved by steroscopy (plate 7C). The imagination can rapidly multiply other situations where stereo-photographs will be of value, for example where weathered surfaces reveal igneous, sedimentary and metamorphic structures and textures (the scale of the structures may be too large to permit collection of specimens), or likewise important fossils may stand out from a weathered surface, but it may not be possible to collect them without risk of destruction. Stereo-photographs are clearly important in these cases and steromodels of fossils will give greater chance of subsequent identification.

It has been the intention of this paper to draw attention to a little used but perfectly obvious method of field geology. Many possible refinements and extensions will be apparent, especially to photogrammetrists, and there is no reason why any three dimensional surface from a macro to a microscopic scale should not be recorded in this way.

## References

ALLUM, J.A.E. 1966. Photogeology and regional mapping. Pergamon, i - xii, 107 pp.

LATTMAN, L.H. and RAY, R.G. 1965. Aerial photographs in field geology. Holt, Rinehart & Winston, i - x, 221 pp.

# RHAETO-LIASSIC PALYNOMORPHS FROM THE BARNSTONE RAILWAY CUTTING, NOTTINGHAMSHIRE

by

M.J. Fisher

## Summary

Samples from the Barnstone Railway Cutting have been examined palynologically and the microfloral assemblages recovered compared with those recorded from selected Rhaetian sections in the Bristol Channel area. Typically Rhaetian assemblages are found to persist into the Pre-Planorbis Beds (*sensu* Sykes et al. 1970) and the evidence for presuming the presence of "White Lias" is discussed.

## Introduction

The Rhaetian succession exposed in the Barnstone Railway Cutting has recently been redescribed by Sykes, Cargill and Fryer (1970). They conclude that in the cutting the Upper Rhaetian comprises some 6' of Cotham Marls overlain by an impersistent Nodular Limestone 3" - 6" thick, which is in turn overlain by $5\frac{1}{2}$' of Liassic Pre-Planorbis Beds.

Jukes-Browne (1885) had previously recorded the presence of "White Lias" in this section and Kent (1970, p. 367) suggests that there may be a "partial representative" of the "White Lias" above the Cotham Beds in South Nottinghamshire. Although the palaeontological evidence cited by Sykes et al. would appear to support their conclusions, the palynology of the interval above the Nodular Limestone would suggest a correlation with the Upper Rhaetian of the Bristol Channel area.

Twelve samples from Barnstone were examined using standard palynological techniques and the results, based on counts of 200 specimens, are summarised in table 1. In the list below, the sample locations refer to those given by Sykes et al. (text fig.3).

Sample 12 - Limestone No. 3.

Sample 11 - Between Limestones Nos. 3 & 2.

Sample 10 - Shale immediately above Limestone No. 2.

Sample 9 - Limestone No. 2.

Sample 8 - Between Limestones Nos. 2 & 1.

Sample 7 - Below Limestone No. 1.

Sample 6 - "Thin Limestone"

Sample 5 - Between "Thin Limestone" & Nodular Limestone.

Sample 4 - Nodular Limestone.

Sample 3 - Immediately below Nodular Limestone.

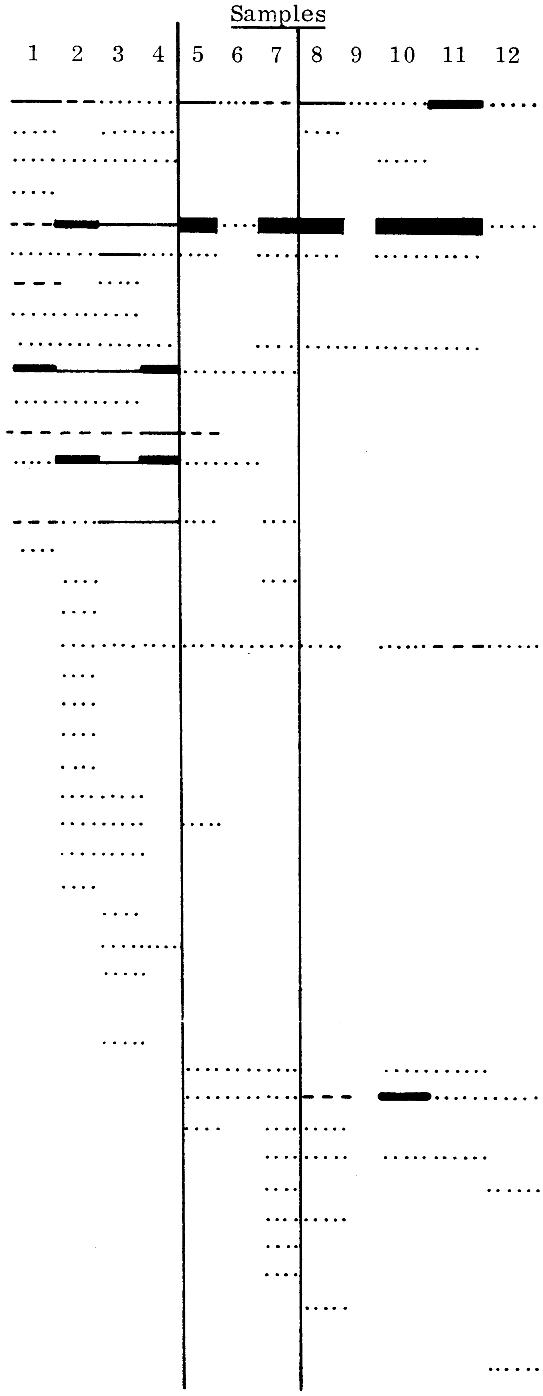
Sample 2 - 6" (15 cm.) below Nodular Limestone.

Sample 1 - 12"(30 cm.) below Nodular Limestone.

## TABLE 1

## PALYNOLOGY OF THE RHAETIAN AND "LIASSIC" BEDS OF BARNSTONE

Palynomorphs (*Acritarchs; †Dinoflagellates)




"Bisaccates" indet.
*Brachysaccus microsaccus* (COUPER) MÄDLER
*Calamospora* sp.
*Cingulizonates rhaeticus* (REINHARDT) SCHULZ
*Circulina* spp.
*Classopollis torosus* (REISSINGER) BALME
*Convolutispora microrugulata* SCHULZ
*Cymatiosphaera* sp. *
*Gleicheniidites* spp.
*Ovalipollis ovalis* KRUTZSCH
*Protohaploxypinus* sp. nov.
*Rhaetipollis germanicus* SCHULZ
*Rhaetogonyaulax rhaetica* (SARJEANT) LOEBLICH & LOEBLICH †
*Ricciisporites tuberculatus* LUNDBLAD
*Tigrisporites microrugulatus* SCHULZ
*Anemiidites spinosus* MADLER
*Baculatisporites* sp.
*Cyathidites minor* COUPER
*Gnetaceaepollenites tortuosus* (MÄDLER) comb. nov.
*Kyrtomisporis speciosus* MÄDLER
*Limbosporites lundbladii* NILSSON
*Punctatosporites* sp.
*Stereisporites psilatus* (ROSS) comb. nov.
*Taeniaesporites rhaeticus* SCHULZ
*Tsugaepollenites* sp. nov.
*Zebrasporites fimbriatus* KLAUS
*Converrucosisporites luebbenensis* SCHULZ
*Cyclogranisporites* sp.
*Duplexisporites scanicus* (NILSSON) PLAYFORD & DETTMAN
*Tetraporina* sp.
*Granulatisporites subgranulosus* (COUPER) comb. nov.
*Heliosporites reissingeri* (HARRIS) CHALONER
*Vitreisporites pallidus* (REISSINGER) NILSSON
*Camarozonosporites golzowensis* SCHULZ
*Classopollis* sp. nov.
*Lycopodiumsporites* sp.
*Polycingulatisporites liassicus* SCHULZ
Spores of ?*Naiadita lanceolata* BUCKMAN
*Duplexisporites problematicus* (COUPER) PLAYFORD & DETTMAN
*Camarozonosporites laevigatus* SCHULZ

KEY: <5%   5-9%   10-24%   25-50%   >50%

## Stratigraphical Palynology

In the North Sea Basin, the transition from the Rhaetian to the Hettangian is accompanied by an abrupt microfloral change which, as Geiger and Hopping (1968) suggest, probably occurs within the Rhaetian rather than at the Triassic Jurassic boundary. This is certainly true of the classic Rhaetian sections in the Bristol Channel region where the major microfloral boundary is found near the base of the Cotham Beds. Here the Sully Beds (Grey Marls), Westbury Beds and Lower Cotham Beds contain a distinctive microflora which correlates with the "typical" Rhaetian assemblages of the North Sea Basin and includes *Cingulizonates rhaeticus* (Reinhardt) Schulz, *Limbosporites lundbladii* Nilsson, *Ovalipollis ovalis* Krutzsch, *Perinosporites thuringiacus* Schulz, *Rhaetipollis germanicus* Schulz, *Ricciisporites tuberculatus* Lundblad, *Tsugaepollenites* sp. nov., *Zebrasporites interscriptus* (Thiergart) Klaus, and *Z. laevigatus* (Schulz) Schulz. These forms range to the base of the "Estheria Limestone" at Garden Cliff, Westbury-on-Severn, Gloucestershire, to Richardson's "Cotham Bed 4" (1910, p. 29) at Lilstock, Somerset and to the base of the Cotham Beds at Lavernock, Glamorgan. At Westbury-on-Severn and Lavernock however, some elements of the Lower Rhaetian microflora, including *Ovalipollis ovalis*, *Rhaetipollis germanicus*, *Ricciisporites tuberculatus* and *Tsugaepollenites* sp. nov., persist in low frequences in the younger Cotham Beds where they are found in association with spores of the bryophyte *Naiadita lanceolata* Buckman. These higher Cotham Beds are also characterised by the appearance of *Camarozonosporites golzowensis* Schulz, *Classopollis* sp. nov., *Lycopodiumsporites* spp. and *Polycingulatisporites liassicus* Schulz together with *Brachysaccus microsaccus* (Couper) Mädler, *Circulina* spp., *Classopollis torosus* (Reissinger) Balme and the dinoflagellate *Rhaetogonyaulax rhaetica* (Sarjeant) Loeblich which persist from the Lower Rhaetian. The absence of *Naiadita* spores and the relative abundance of *Heliosporites reissingeri* (Harris) Chaloner serve to distinguish the Langport Beds from the Cotham Beds but, as yet, there is little positive palynological evidence to differentiate between the Langport Beds, Watchet Beds and Pre-Planorbis Beds. *Classopollis* sp. nov. has not been recorded from the Hettangian however, and *Polycingulatisporites circulus* Simoncsics and Kedves and *Tsugaepollenites mesozoicus* Couper, which are common in the Lower Liassic, appear to be absent from the Rhaetian.

Orbell (1971) has recently published a summary of a palynological investigation of Rhaetian sections from the South of England and his results, in general, corroborate those outlined above.

The four lowest samples (1-4) from Barnstone contain a varied microflora which correlates with the basal Cotham Beds of the Bristol Channel. Samples 5 and 7 (sample 6 was very poorly palyniferous), are completely lacking in species restricted to the lower Rhaetian but, as in the higher Cotham Beds at Westbury and Lavernock, rare specimens of *Ovalipollis ovalis*, *Rhaetipollis germanicus* and *Ricciisporites tuberculatus* are encountered. Sample 7 however also contains *Naiadita* spores, *Camarozonosporites golzowensis*, *Classopollis* sp. nov., *Lycopodiumsporites* sp. and *Polycingulatisporites liassicus* which would appear to confirm the correlation with the higher Cotham Beds. The overlying samples (8-12) have yielded a Rhaeto-Liassic microflora, including *Classopollis* sp. nov. and abundant *Heliosporites reissingeri*, which is comparable with those recorded from the Langport and Watchet Beds.

The inference from these results is that the interval assigned to the Cotham Beds of Sykes et. al. at Barnstone is equivalent to the basal Cotham Beds in Somerset and that the immediately overlying section, to the base ( ? ) of Limestone No. 1, is correlative with the upper Cotham Beds. Although the palynological evidence recorded cannot conclusively prove the presence of Langport Beds at Barnstone, the occurrence in Sample 12 of *Classopollis* sp. nov., which appears to have a restricted stratigraphical range, is of some note. What is apparent is that there was a major marine transgression during the deposition of the Upper Cotham Beds equivalents, with the introduction of a fauna of Liassic aspect. Unless the Rhaetian microfloras resulted from reworking, of which there is no evidence, it must be assumed that either the ranges of the nominally Liassic faunas recorded by Sykes et al. should be extended into the Upper Rhaetian, or that the ranges of the Rhaetian microfloras be extended into the basal Liassic. The Rhaetian microfloral succession in the Bristol Channel area indicates that the higher Cotham Beds are palynologically well defined and there is no evidence to suggest that such forms as, for example, *Rhaetipollis germanicus* and *Naiadita* spores could range into the basal Liassic. As no evidence of a non-

## EXPLANATION OF PLATE 8

Fig. 1. *Ricciisporites tuberculatus* Lundblad. Sample 2.

Fig. 2. *Granulatisporites subgranulosus* (Couper) comb. nov. Sample 5.

Fig. 3. *Platysaccus* sp. Sample 1.

Fig. 4. *Taeniasporites rhaeticus* Schulz. Sample 2.

Fig. 5. *Classopollis* sp. nov. Sample 7.

Fig. 6. *Brachysaccus microsaccus* (Couper) Mädler. Sample 1.

Fig. 7. *Gnetaceaepollenites tortuosus* (Mädler) comb. nov. Sample 2.

Fig. 8. *Convolutispora microrugulata* Schulz. Sample 1.

Fig. 9. *Heliosporites reissingeri* (Harris) Chaloner. Sample 10.

Fig. 10. *Tsugaepollenites* sp. nov. Sample 2.

Fig. 11. *Tetraporina* sp. Sample 3.

Fig. 12. *Vitreisporites pallidus* (Reissinger) Nilsson. Sample 5.

Fig. 13. *Duplexisporites scanicus* (Nilsson) Playford & Dettman. Sample 3.

Fig. 14. *Zebrasporites fimbriatus* Klaus. Sample 2.

Fig. 15 & 16 *Classopollis torosus* (Reissinger) Balme. Sample 2.

Fig. 17. *Ovalipollis ovalis* Krutzsh. Sample 1.

Fig. 18. *Rhaetipollis germanicus* Schulz. Sample 1.

Fig. 19. *Camarozonosporites golzowensis* Schulz. Sample 7.

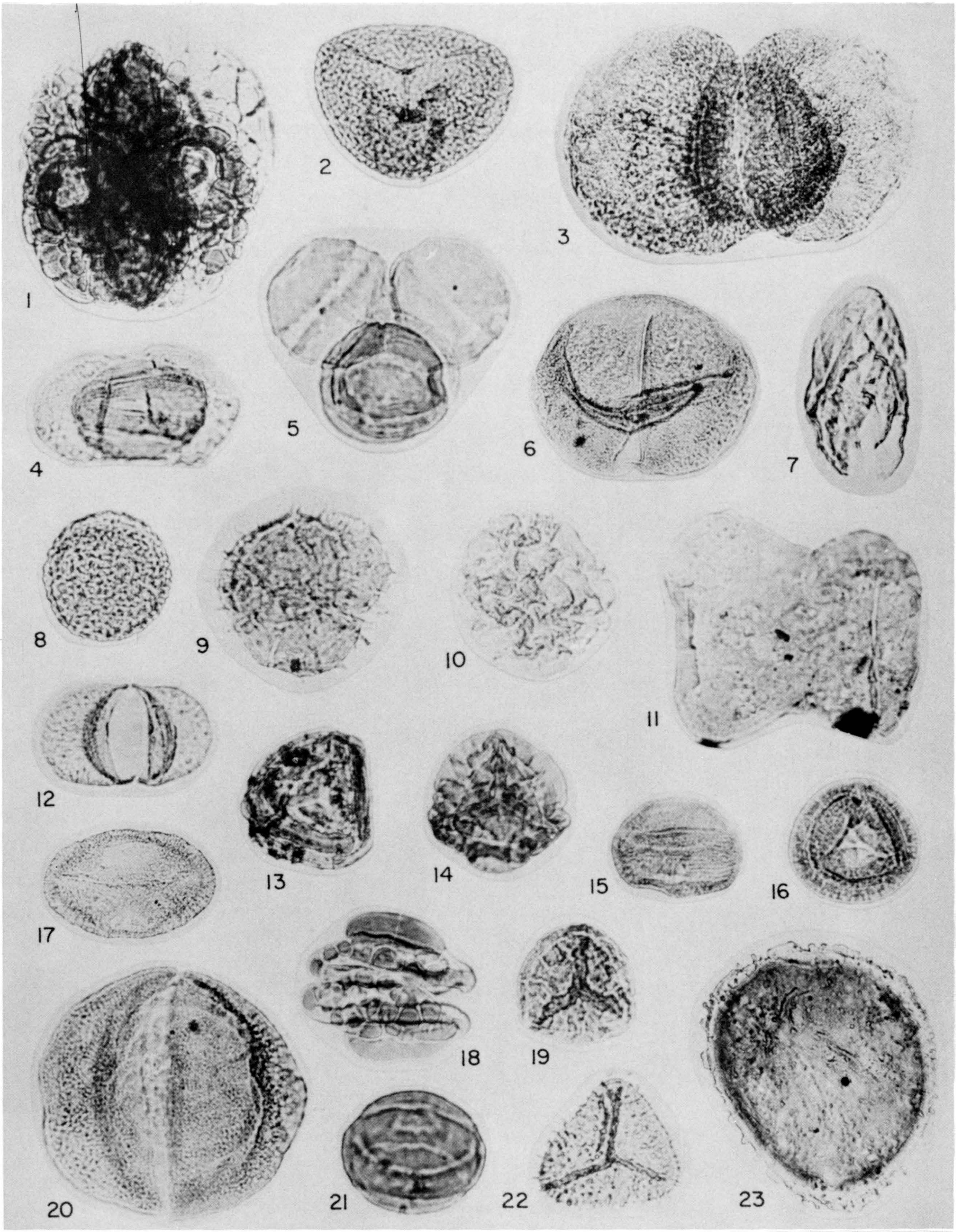
Fig. 20. *Protohaploxypinus* sp. nov. Sample 1.

Fig. 21. *Circulina* sp. nov. Sample 1.

Fig. 22. *Anemiidites spinosus* Mädler. Sample 2.

Fig. 23. *Naiadita* spore. Sample 7.

All x 500 except figs. 12 and 21, x 1000.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

sequence above Limestone No. 1 has been recorded by Sykes et al. and as the faunas above and below this unit are comparable, it is thought possible that the Cotham Beds at Barnstone are overlain conformably by Upper Rhaetian Langport Beds.

## Conclusions

Correlation with the Rhaeto-Liassic sections in the Bristol Channel area indicates that a relatively complete Rhaetian succession is developed in the Barnstone Cutting. The microfloral assemblages suggest that the lower Cotham Beds are represented by the Cotham Marls and Nodular Limestone of Sykes et. al. and that the upper Cotham Beds are represented by the lower part of the interbedded limestones and shales assigned to the Pre-Planorbis Beds by Sykes et. al. The upper part of the "Pre-Planorbis Beds" *sensu* Sykes et al., to limestone 3 at least, is considered to be equivalent to the Upper Rhaetian Langport Beds ("White Lias").

The marine transgression which terminated the deposition of the Cotham Marls is consequently considered to be of Upper Rhaetian age rather than of Liassic age and, in the section examined, no evidence of undoubted Jurassic microfloras was found.

## Taxonomic Notes (see Table 1)

*Circulina* spp. includes forms referable to *C. meyeriana* Klaus and to *Circulina* sp. nov. (pl. 8, fig. 21).

*Protohaploxypinus* sp. nov. (pl. 8, fig. 20) has been recorded by Schulz (1967, p. 598) as *Striatites* cf. *microcorpus* Schaarschmidt from the Middle Rhaetian of the Central German Basin.

*Ephedripites tortuosus* Mädler (1964, p. 194) has been assigned to the genus *Gnetaceaepollenites* (Thiergart) Jansonius because it possesses spiral ribs. *G. tortuosus* has been recorded from the Lower Liassic of England but at Barnstone is found in association with a typically Rhaetian assemblage.

*Trilites psilatus* Ross, assigned to the genus *Sphagnumsporites* by Couper (1958, p. 131) is here reassigned to the genus *Stereisporites* Pflug which has taxonomic priority.

*Tsugaepollenites* sp. nov. (pl. 8, fig. 10) has been recorded from the Westbury Beds and basal Cotham Beds in the Bristol Channel region and rarely from the Upper Cotham Beds of Lavernock.

*Concavisporites subgranulosus* Couper (1958, p. 143), because of the absence of a kyrtome and possession of a granulate exine, has been assigned to the genus *Granulatisporites* (Ibrahim) Potonie and Kremp.

*Classopollis* sp. nov. (pl. 8, fig. 5) has been recorded from the Upper Cotham Beds of Westbury-on-Severn and the Langport Beds of Lilstock and Lavernock.

The new species noted above will be fully described in Fisher (in prep.).

## Acknowledgements

The author would like to thank Mr. J.H. Sykes who made the Barnstone samples available and Dr. A. Whittaker (I.G.S. Exeter) who assisted in the collection of the Lilstock samples.

## References


COUPER, R.A. 1958. British Mesozoic miospores and pollen grains. Palaeontographica, vol. 103, sec. B., pp. 75-179.

FISHER, M.J. (in prep.) New Palynomorphs from the British Upper Triassic.

GEIGER, M.E. & HOPPING, C.A. 1968. Triassic Stratigraphy of the Southern North Sea Basin. Phil. Trans. Roy. Soc. London. Ser.B., vol.254, pp. 1-36.

JUKES-BROWN, A.J. 1885. The Geology of the South West part of Lincolnshire. Mem. Geol. Surv. U.K., pp. 19-21.

KENT, P.E. 1970. Problems of the Rhaetic in the East Midlands. Mercian Geologist, vol. 3, pp. 361-373.

MÄDLER, K. 1964. Bemerkenswerte Sporenformen aus dem Keuper und unteren Lias. Fortschr. Geol. Rheinld. u. Westf., vol. 12, pp. 169-200.

ORBELL, G. 1971. Spores and pollen grains from three sections in the South of England and their relationship to the Swedish Rhaeto-Liassic macroflora. J. Geol. Soc., vol. 127, pp. 299-300.

RICHARDSON, L. 1903. The Rhaetic Rocks of North-West Gloucestershire. Proc. Cottes. Nat. Field Club, vol. 14, pp. 127-174, and supplement, pp. 251-257.

1905. The Rhaetic and contiguous deposits of Glamorgan. Quart. J. Geol. Soc., London., vol. 61, pp. 385-424.

1911. The Rhaetic and contiguous deposits of West. Mid., and part of East Somerset. Quart. J. Geol. Soc., Lond., vol. 67, pp. 1-74.

SARJEANT, W.A.S. 1963. Fossil dinoflagellates from Upper Triassic sediments. Nature, vol. 199, no. 4891, pp. 353-354.

SCHULZ, E. 1967. Sporenpaläontologische Untersuchungen Rätoliassischer Schichten in Zentralteil des Germanischen Beckens. Päläont. Abh., sec. B, vol. 2, pp. 541-633.

SYKES, J.H., CARGILL, J.S., & FRYER, H.G. 1970. The Stratigraphy and Palaeontology of the Rhaetic (Triassic) Beds of Barnstone, Nottinghamshire. Mercian Geologist, vol. 3, pp. 233-264.

# RECENT DISCOVERY OF A MAMMOTH MOLAR IN THE MIDDLE TRENT VALLEY GRAVELS NEAR EGGINTON, DERBYSHIRE

by Robin J. Heath

## Summary

The discovery of a mammoth molar in the river gravels of the Middle Trent Valley is recorded. The tendency of the tooth to split and crumble has been checked by treatment with plastics.

## Introduction

Late in 1968 a visit to the gravel pits at Egginton led to the disclosure by workmen that a tooth had recently been found. The tooth was subsequently acquired for study, treated with preservatives, and returned to its owner.

## The Nature of the Gravels

At a locality near Eggington Station (SK 255293) extensive, well-stratified sheets of mixed sand and pebbles occur, varying considerably in texture and colour. The deposits are approximately thirteen feet (four metres) thick with the upper surface virtually level at about 150 feet O.D. Beneath the gravels purple to chocolate coloured clays were found. The overburden had been removed prior to exploitation. The workings were kept dry by pumping, through the abandoned pits are now filled with water. The gravels probably belong to the Floodplain Terrace.

## Description of the Tooth

The tooth is built up of 25 narrow close-packed plates and is identified as a molar of the mammoth, *Elephas primigenius* Blumenbach (see Leith Adams 1877-81). The grinding surface is characteristically flat and the pattern of ridges on it is shown in Plate 9.

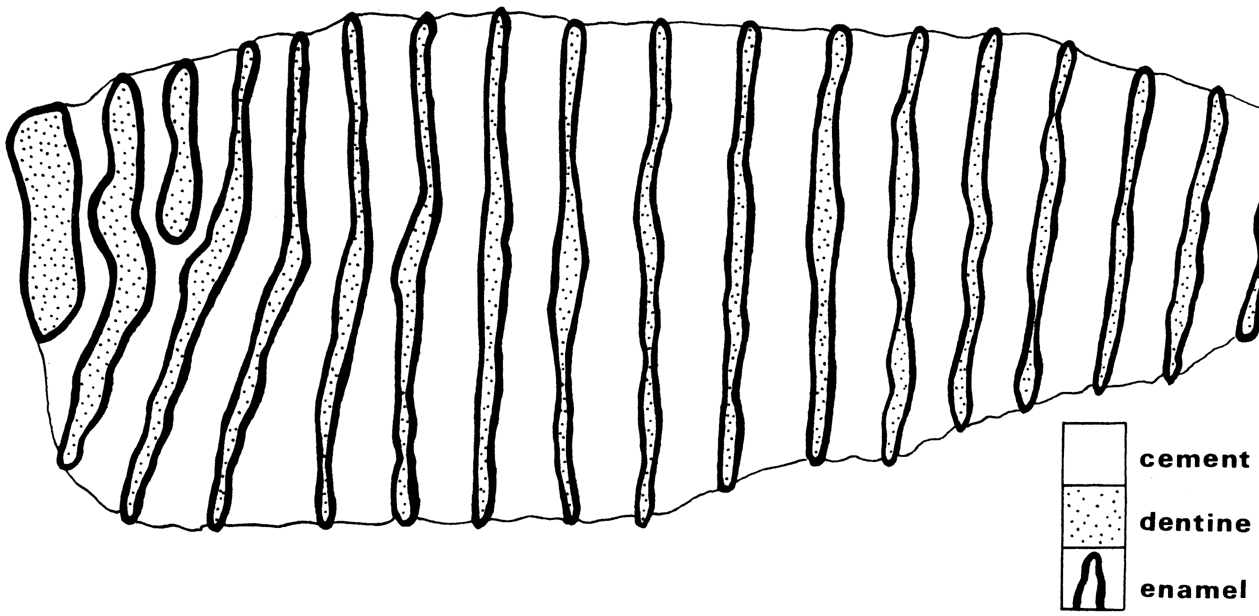
## Preservation

Owing to the lamellar construction of elephant molars there is a tendency for them to split open on drying (see Plate 9.) A comprehensive treatment became urgent in order to preserve it, modifying the method of Rixon (1961). The process consists essentially of impregnating the tooth with plastic materials, first by repeatedly soaking with polyvinyl butyral dissolved in 95% alcohol and then by coating in polyvinyl acetate emulsion. On completion the tooth remained stable under varying climatic conditions and should be in a suitable condition for permanent display.

## Acknowledgements

The co-operation of Hilton Gravel Ltd., Hilton, Derbyshire, in granting access to their gravel pit, and to Mr. Burford of Etwall who made the tooth available for study, are gladly acknowledged. The author is deeply indebted to Mr. B.D. Adams, a former colleague, for his invaluable help in the field and in the laboratory. Thanks are also due to the School of Photography, Derby College of Art, for Plate 9. and to Revertex Ltd., The Strand, London, for the generous gift of two bottles of polyvinyl acetate emulsion.

Robin J. Heath, M.Sc., F.G.S.,
Department of Biological Sciences,
Derby and District College of Technology,
Kedleston Road,
Derby.




Text-figure 1. The pattern of ridges on the grinding surface of a third molar of *Elephas primigenius* (length 20 cm).

References

ADAMS, A.L. 1877-81. Monograph of British Fossil Elephants. Palaeontological Society.

POSNANSKY, M. 1960. The Pleistocene Succession in the Middle Trent Basin. Proc. Geol. Assoc., vol. 71, pp.285-311.

RIXON, A.E. 1961. The Conservation of Fossilized Material. Museum Journal No.61, pp.205-207.

Manuscript received 28 June 1971.


PLATE 9

Lateral view of a third molar of *Elephas primigenius* from the Trent Valley Flood Plain Gravels near Egginton, Derbyshire.

# SUPPLEMENT TO THE BIBLIOGRAPHY OF THE GEOLOGY OF THE PEAK DISTRICT OF DERBYSHIRE

by

Trevor D. Ford

The following is a supplement to the bibliography published in the Mercian Geologist (Ford and Mason, 1967), which covered items up to and including 1965. This supplement uses the same criteria of definition of the Peak District and of what constitutes "geology", but the subject index includes some new categories such as geophysics, hydrology and economic geology, for which there were too few entries prior to 1965 to justify separate listing. The supplement begins with items published in or before 1965, which were missed in the original compilation, and continues with a list of items published between 1966 and 1970 inclusive.

It is hoped to issue further supplements at roughly five year intervals and the compiler sincerely hopes that all users will keep him informed both of any items missed up to date and of items published in the future. Please give full bibliographic details in all cases, including Ph.D. and M.Sc. theses.

Trevor D. Ford, B.Sc., Ph.D., F.G.S.,
Geology Department,
University of Leicester,
Leicester, LE1 7RH.

## Bibliography


1726

HOOKE, R. — Philosophical Experiments and Observations. Derham, London, 391.p. Reprinted Cass. 1967. pp.37-40. Letter by John Carte on "The Belland" caused by fumes of lead and other curious observations.

1794

PITT, W.A. — General View of the Agriculture in the County of Stafford. (2nd edition in 1813).

1818

WALFORD, T. — The scientific tourist through England, Wales and Scotland. 2 vols. (Vol.2. includes Derbyshire). Booth, London. c.300 un-numbered pages.

1831

D T. — On the Lead Mines and Mineral Laws of Derbyshire. Quart. Mining Rev.Vol.2. pp.64-69.

1832

Von BUCH, L. — Über Ammoniten. 2$^{n}$ Konig. Akad. Wiss. Abh. Berlin. 56pp. 5 pls. (discusses Martin's "Ammonites", 1809).

1844

GARNER, R. — The Natural History of Staffordshire. Voorst. London. (with supplements up to 1860).

1862

WARDLE, T. — On the geology of the neighbourhood of Leek, in John Sleigh's "Ancient History of Leek" (privately reprinted in 1863).

1870

PERCY, J. — The Metallurgy of Lead. Murray, London.

1883

BROUGH, B.H. — (On Ecton Mines - in german) Berg. und Huettennmaenische Zeiting. Vol. XLII, p. 613.

1885

WHITAKER, W. — List of works on the geology, mineralogy and palaeontology of of Staffordshire, Worcestershire and Warwickshire. Rep. Brit. Assoc. for 1885. pp. 780-813.

1897

MARTEL, E.A. — Irlande et Cavernes Anglaises. Paris. (translated by F.A. Winder, 1914 q.v.)

1898

CLARKE, E. — The Board of Agriculture, 1793-1822. Jour.Roy.Agric.Soc. Vol.9. (3rd Series) p.1. (review of County Reports including Farey, 1811).

MONK, H.G.N. — Report on the appearance of Goitre in the Ashop and Derwent Valleys, in : Leicester Water Supply.

WARDLE, T. — Prospectus of the Leek and Manifold Valley Light Railway. With a report on minerals.

1900

MARTEL, E.A. — La Blue John Mine (Angleterre). Mem.Soc.Speleologie. Vol.IV. No.23. (translation of part of Barnes & Holroyd 1896)

1903

LINTON, W.R. — Flora of Derbyshire (with coloured geol.map) Bemrose, London, 455.p.

MOORE, S. — Note on an unmapped toadstone in Derbyshire. Geol.Mag.Dec.4. Vol.10, pp.84-86.

1904

CRICK, G.C. — Note on *Pericyclus fasciculatus* M'Coy (from Beeston Tor). Geol. Mag.Dec.5. Vol.1. p.27.

1906

SHELDON, J.P. — In the valleys of the Hamps and Manifold. Moorlands Press, Leek.

1914

WINDER, F.A. & S.C. PHILLIPS — The Caverns of Derbyshire. (translation of Martel, 1897). 46.p. Hartley Seed, Sheffield.

1919

SINGTON, T. — The Search for Petroleum in Derbyshire now in progress. Trans. Inst.Min.Eng. Vol.57. p.25.

1920

THOMAS, H.H., HALLIMOND, A.F., & E.G. RADLEY. — Refractory materials; ganister and silica rock, sand for open hearth furnace; dolomite: Petrography and Chemistry. Mem.Geol. Surv.Rep.Min. Res.Vol.16.

1924

TONKS, L.H. & WRIGHT, W.B. — The South-westerly thickening of the Millstone Grit in Lancashire. Summ. Prog.Geol.Surv. for 1923. Appendix II. pp.150-7.

1926

WARNES, A.R. — Building Stones: Their properties, decay and preservation. London.

1928

TOMKEIEFF, S.I. — On the Volcanic Complex of Calton Hill, Derbyshire. Q.Jl. Geol.Soc. London. Vol.85, pp.703-718.

JESSOP, P. — The Igneous Rocks of North Derbyshire, D.I.C. Thesis, Imp. Coll. London. 40 pp.

1929

LOVEGROVE, E.J. — Attrition tests of British Roadstones. Mem.Geol. Surv. G.B.

SARGENT, H.C. — Further studies in Chert.I. Geol.Mag.Vol.66. pp.399-413.

1935

SEARLE, A.B. — Limestone and its products, their nature, production and uses. Ernest Benn, London. 709 pp.

TURNER, J. SELWYN. — A review of Dinantian and Namurian Vulcanicity in north-west and central Europe. Geol.Mag.Vol.72. pp.458-470.

1943

FRANKS, F. — The Mining of Fluorspar. British Steelmaker, October, 1943. pp.445-7.

1945

DAVIS, A.G. — The Lower Carboniferous in a boring at Alport: Appendix I. Micro-organisms in the Carboniferous Limestone. Proc. Yorks Geol. Soc. Vol.25. pp.312-317.

1946

LOVELY, H.R. — Geological occurrence of oil in the United Kingdom with reference to the present exploratory operations. Bull.Am.Ass.Petrol.Geol. Vol.30. pp.1444-1516.

STUBBLEFIELD, C.J. — The genotype of *Cummingella* Reed. Geol.Mag.Vol.83. pp.186-191.

1947

ANON. — Hopton Wood Stone. Private publn. Hoptonwood Stone Firms Ltd. London. 19p. & plates.

1949

WHITE, P.H.N. — Gravity data obtained in Great Britain by the Anglo-American Oil Co.Ltd. Quart. Jour. Geol. Soc. London. Vol.104. pp.339-364.

1950

ANON — The Names in W. Martin's "*Petrificata Derbiensa*". Bull. Zoo. Nomen. Vol.IV. pp.16-18, 114, 450-2.

1952

BLUME, H. — Die Landschaft des Peak. Geog. Gesell. Wien. Mitteilungen. Bd.97. pp.151-179.

1952

WRIGHT, J.A. — Brachiopod communities in Avonian Reef Limestone of the Pennines Ph.D. thesis no. 1134. Univ. Glasgow. 79 pp.

1953

SCURFIELD, G. — Ecological observations in Southern Pennine Woodlands. J.Ecol. Vol.41, pp. 1-12.

1954

CHALLINOR, J. — The early progress of British Geology.
I Leland to Woodward, 1538 to 1728. Ann.Sci.Vol.9, pp. 124-153.
II Strachey to Michell, 1719 to 1788. Ann.Sci.Vol.10, pp. 1-19.
III Hutton to Playfair, 1788 to 1802. Ann.Sci.Vol.10, pp. 107-148.

1955

JOHNSON, R.H. — An investigation of the landforms and morphological evolution of part of the limestone area of Derbyshire. M.A. Thesis. University of Sheffield.

SCHNELLMANN, G.A. — Concealed lead-zinc fields in England. Trans. Inst. Min.Met.Vol.64. pp.477-485 & 617-636.

1956

TILLOTSON, E. — The Derbyshire Earth Tremor of Jan. 10th. Nature, London. Vol.177. p.165.

1957

NASH, D. — Jug Holes and the Nature of the Matlock Mines. Trans.Cave Res. Gp. G.B. Vol.5. No.1. pp.13-22.

SHAHIN, A.A.W. — A geomorphological study of the area drained by the Rother in Derbyshire and Yorkshire. Ph.D. thesis. University of Sheffield.

1958

ANON. — Bowne & Shaw Quarries. Min.& Qy.Eng.Vol.24. Nos.10 & 11, pp.428-437 & 490-9.

ANON. — Cauldon Low Quarry. Mine & Quarry Eng. Vol.24, No.5, pp.204-209. & No.6.

ANON. — Tunstead Quarry. Mine & Quarry Eng. Vol.23, No.11, pp.462-471, & No.12, pp.506-515.

BARNES, F.A. & H.R. POTTER. — A flash flood in western Derbyshire. East Midld. Geog. Vol.2. No.10. pp.3-15.

BRIDGES, E.M. — An investigation of the profile of soils, and on the age and morphological relations of the surface facets on which they are developed, (mainly Wye Valley). M.Sc. thesis. University, Sheffield.

BUCHAN, S. — Variations in mineral content of some groundwaters. Proc.Soc.Water Treatment & Examination. Vol.7. (1) pp.11-29.

FORD, T.D. — Ashford Black Marble. Monumental Jour.Vol.25. pp.279-288.

1958

NEVES, R. — Upper Carboniferous Spore Assemblages from the *Gastrioceras subcrenatum* horizon, North Staffs. Geol. Mag. Vol. 95. pp.1-19.

YOUNG, A. — Some considerations of slope form and development, regolith and denudational processes. (including the southern Pennines). Ph.D. thesis University of Sheffield.

1959

BOWER, M.M. — A summary of the available evidence and a further investigation of the causes, methods and results of erosion of blanket peat. M.Sc. thesis. Univ. London.

SCURFIELD, G. — The Ashwoods of the Derbyshire Carboniferous Limestone, Monks. Dale. J.Ecol. Vol.47. pp.357-369.

1960

BUNTING, B.T. — Bedrock corrosion and drainage initiation by seepage water on a gritstone escarpment in Derbyshire Nature. Vol.185. (No.4711) p.447.

EVERITT, C.W.F. & J.C. BELSHÉ. — Palaeomagnetism of the British Carboniferous System. Phil.Mag. Vol.5. pp.675-685.

MUELLER, G. — The distribution of Uranium in naturally fractionated organic phases. XXI Int. Geol. Cong. (Copenhagen) part XV. pp. 123-32. (includes discussion of Windy Knoll bitumens).

PIGOTT, C.D. — Natural History, in Peak District - National Park Guide. No.3. ed. P. MONKHOUSE. pp.13-20. H.M.S.O.

1961

BOWER, M.M. — The distribution of erosion in the blanket peat bogs in the Pennines. Trans. Inst. Brit. Geog. No.29. pp.17-30.

HIGGINS, A.C. — Some Namurian conodonts from North Staffordshire. Geol.Mag.Vol.98. pp.210-224.

NEVES, R. — Namurian plant spores from the Southern Pennines. Palaeontology. Vol.4. pp.247-279.

1962

ABOU-EL-ENIN, H.S. — The geomorphology of the Moss valley with some consideration of its wider regional significance. M.A. thesis University of Sheffield.

DOORNKAMP, J.C. — Observations on the development of cuestas with special reference to selected examples near Sheffield. M.Sc. thesis. University of Sheffield.

DOUGLAS, I. — An evaluation of some techniques used in the study of landforms with special reference to limestone areas. B.Litt. thesis. Univ. Oxford.

1962

HAWKES, H.E. & J.S. WEBB.
Geochemistry in Mineral Exploration. Harper's Geoscience. New York (pp.60-61 on Gregory Mine, Ashover).

1963

RAMSBOTTOM, W.H.C. The Carboniferous Limestone brachiopod *Streptorhynchus anomalus* (J. De C. Sowerby). Trans. Leeds Geol. Assoc. Vol.7. pp.175-179, Pl.3.

1964

ABOU-EL-ENIN, H.S. An examination of the evolution of surface forms in the area drained by the Sheaf, upper and middle Don, with a particular reference to the Quaternary Era. Ph.D. thesis. University of Sheffield.

DOUGLAS, I. Intensity and periodicity in denudation processes with special reference to the removal of material in solution by rivers. Zeit. Geomorph. Vol.8. pp.453-473.

HOUSTON, W.J. Fluorspar production in Derbyshire and Yorkshire. Quarry Manager's Jour. Vol.48. pp.148-154.

TALLIS, J.H. Studies of Southern Pennine Peats. Part I. The general pollen record. J. Ecol. Vol.52. 323-331. Part II. The pattern of erosion. J.Ecol. Vol.52, 333-334. Part III. The behaviour of *Sphagnum*. J.Ecol. 52, 345-353.

TYLECOTE, R.F. Roman Lead working in Britain. Brit.Jour.Hist.Sci. Vol.2. Pt.1, pp. 25-43.

WILLIAMS, R.B.G. Fossil patterned ground in Eastern England. Buletyn Peryglacjalny. Vol.14. pp.337-349.

WRIGHT, M.D. Petrology and Sedimentation history of the *Reticuloceras* stages of the Millstone Grit between Longdendale and Marsden in the Central Pennines. M.Sc. thesis. Univ. London.

1965

ANON. Fluorspar flotation at Glebe Mines. Mining Mag. Vol.113 pp.276-283.

ANON. The Cavendish Mill (fluorspar). Mining & Minerals Eng. Vol.1. No.15. pp. 579-596.

ANON. A new fluorspar processing plant. Quarry Manager's Jour. Vol.49. pp.415-420.

ANON. Topley Pike Limestone Quarry, Quarry Manager's Jour. Vol.49, (February).

MUMBY, K. Automation in Derbyshire Quarries. (Waterswallows Basalt). Quarry Manager's Jour. Vol.49. pp.501-504.

ROEDDER, E. Liquid $CO_2$ inclusions in olivine-bearing nodules and phenocrysts from basalts. Amer.Miner. Vol.50, pp.1746-1782 (includes some from Calton Hill, Derbyshire).

TALLIS, J.H. Studies of Southern Pennine Peats. Part IV. Evidence of recent erosion. J. Ecol. 53, 509-520.

USPENSKII, V.A. & A.L. GORSKAYA.
Elaterite as a mineralogical group. Trudy Vnigri. New Series. No.5. Moscow 1951. English Translation: Israel Program Sci.Transl. pp.203-218. Jerusalem.

ANON. Fluorspar - New plant in Derbyshire. Mining Jour. Vol. 265, p.65, and 1967. Mining Annual Review (1966), p. 299.

BATTEN, R.L. The Lower Carboniferous Gastropod Fauna from the Hotwells Limestone, Compton Martin, Somerset. Monogr. Palaeontogr. Soc., Part 1, pp. 1-52, Pls. 1-5. Part 2, pp. 53-109, Pls. 6-10 (discusses various Derbyshire spp.)

BRIDGES, E.M. Soils, Chapter 4 in "Nottingham and its region". Brit. Assoc., pp. 103-109.

BRIDGES, E.M. The Soils and land use of the district north of Derby. Mem. Soil Surv. G.B., Sheet 125, 112 pp.

COLLINSON, J.D. Antidune bedding in the Namurian of Derbyshire. Geol. en Mijn., Vol. 45, pp. 262-264.

DAVENPORT, T.G. The nature of mineralisation in Derbyshire with special reference to Middleton Mine, Wirksworth. M.Sc. dissertation, Univ. Leicester.

EDWARDS, K.C. (editor) Nottingham and its Region. Brit.Assoc.Nottingham, 538 pp.

ELKINGTON, T. Padley Gorge Nature Trail. Peak Park Guide, Bakewell, 10 pp.

ESCH, H. Comparative diagenetic studies of Upper Carboniferous Sandstone and shale in N.W. Germany and in the East Midlands of England. Fortschr. Geol. Rheinld. u. Westfal. Vol. 13 (2), pp. 1013-1084.

FREEMAN, T.W., RODGERS, H.B., and KINVIG, R.H.
Lancashire, Cheshire and the Isle of Man. Nelson, London, 308 pp.

FITCH, F.J., MILLER, J.A., & THOMPSON, D.B.
The palaeogeographic significance of isotopic age determinations on detrital micas from the Triassic of the Stockport-Macclesfield District, Cheshire (and on Millstone Grit micas from Hayfield) Palaeogeogr., Palaeoclim., Palaeoecol. Vol. 2. pp.281-312.

FORD, T.D. The limestones of Derbyshire. Part 1, Deposition pp. 15-17, Part 2, Lithification, pp. 5-6, Part 3, Folding and Faulting, pp. 3-5. Derbyshire Caving Ass. Newsletter, Vol.1, Nos. 3, 4 and 5.

FORD, T.D. Biographical Notes on authors on Derbyshire: Johann Jacob Ferber, 1743-1790. Bull. Peak Dist. Mines Hist. Soc., Vol.3, No.1, pp.68-70.

FORD, T.D. and KING, R.J.
The Golconda caverns, Brassington, Derbyshire. Trans. Cave Res. Group G.B., Vol. 7, No.2, pp. 91-114.

GEOLOGICAL SURVEY MAPS.
6" :1 mile SK 07NW (Combs), SK 08 SW (Whaley Bridge), SK 08 NW (New Mills).

HASLAM, D.R. A faunal study of the Haslingden Flag Marine Band at two localities near Disley, Cheshire. M.Sc. thesis Univ. Manchester.

HOLDSWORTH, B.K. Radiolaria and sponges in Namurian "bullion" limestones. Proc. Geol. Soc. Lond., No. 1630, pp. 34-35.

HOLDSWORTH, B.K. A preliminary study of the palaeontology and palaeoenvironment of some Namurian Limestone Bullions. Mercian Geol., Vol.1, No.4, pp. 315-337.

HOLDSWORTH, B.K. Radiolaria from the Namurian of Derbyshire. Palaeontology, Vol.9, pp. 319-329.

HUDSON, R.G.S., CLARKE, M.J., and BRENNAND, T.P. The Lower Carboniferous (Dinantian) stratigraphy of Castle Island, Co. Kerry. Sci. Proc. Roy. Dublin Soc., Ser. A, Vol.2, pp.297-317. (with comparisons to Pindale, Derbyshire.)

JACKSON, J.S. R.G.S. Hudson, An appreciation, including a list of Hudson's publications. Sci. Proc. Roy. Dublin Soc., Ser. A. Vol.2, pp. i-ix.

KING, C.A.M. Geomorphology, Chapter 2 in "Nottingham and its region". Brit. Assoc., pp. 41-59.

KING, R.J. Epi-syngenetic mineralisation in the English Midlands. Mercian Geol., Vol.1, pp.291-301.

KIRKHAM, N. Eyam Edge Mines and Soughs. Part IV. Bull. Peak Dist. Mines Hist. Soc., Vol.3, Pt.2, pp.103-118.

KIRKHAM, N. Eyam Edge Mines and Soughs. Part III. Bull.Peak Dist.Mines Hist. Soc., Vol.3, Pt.1, pp.43-57.

LAKIN, A.E. Limestone extraction and processing (Cauldon Low). Quarry Managers Journal. Vol.50, pp.277-280.

MALKI, N. A re-examination of some of the basaltic horizons of the Lower Carboniferous Limestone of Derbyshire. M.Sc. thesis, Univ. Sheffield, 66 pp.

MITCHELL, M. and WHITE, D.E. Catalogue of figured, described and cited Carboniferous corals in the collections of the Geological Survey and Museum, London. Bull. Geol. Surv. G.B., No.24, pp. 19-56.

MORRIS, P.G. The use of the terms Shale Grit, Farey's Grit and Yoredale Grit in the Namurian of the Central and South Pennines. Mercian Geol., Vol.1, pp. 303-313.

MORRIS, P.G. The stratigraphy of the Upper Dinantian and Namurian rocks east and south-east of Leek, North Staffs. Ph.D. thesis University of London.

MOSELEY, F. The volcanic vents and pocket deposits of Derbyshire. Mercian Geol., Vol.1, No.3, pp.283-285.

NEVES, R & OWENS, B. Some Namurian Camerate Miospores from the English Pennines. Pollen et Spores. Vol.8. pp.377-380.

OWEN, D.E. New Carboniferous polyzoa from Derbyshire. (L'pool. and Manchr.) Geol. J., Vol.5, pp.135-148.

PEACOCK, J.D. AND TAYLOR, K. Uraniferous collophane in the Carboniferous Limestone of Derbyshire and Yorkshire Bull. Geol. Surv. G.B., No.25, pp. 19-32.

PITTY, A.F. An approach to the study of Karst Water, illustrated by results from Poole's Cavern, Buxton. Univ. Hull Occ. papers in Geog., No.5, 70 pp.

PITTY, A.F. Landform studies in the Peak District of Derbyshire. D.Phil. thesis Univ. Oxford.

PITTY, A.F. The estimation of discharge from a Karst Rising by natural salt dilution. J. Hydrol., Vol.4, pp.63-69.

RADLEY, J. Peak Millstones and Hallamshire Grindstones. Trans. Newcomen Soc., Vol.36, (for 1963-1964), pp.165-174.

RAMSBOTTOM, W.H.C. A pictorial diagram of the Namurian Rocks of the Pennines. Trans. Leeds Geol. Ass., Vol.7, Pt.4, pp.181-184.

RIEUWERTS, J.H. A list of the soughs of the Derbyshire Lead Mines. Bull. Peak Dist. Mines Hist. Soc., Vol.3, Pt.1, pp.1-42.

ROBEY, J. Field Grove Mine, Sheldon, Derbyshire. Bull.Peak Dist.Mines Hist. Soc., Vol.3, Pt.2, pp.93-101.

SADLER, H.E. A detailed study of microfacies in the Mid-Viséan ($S_2$-$D_1$) Limestones near Hartington, Derbyshire. J. Sediment. Petrol., Vol.36, pp.864-879.

SADLER, H.E. and WYATT, R.J. A Lower Carboniferous $S_2$ inlier near Hartington, Derbyshire. Proc. Geol. Ass. Lond., Vol.77, pp.55-64.

SALMON, L.B. Some aspects of the geology of Giants Hole, Castleton. Cave Sci., Vol.5, Pt. 38, pp.287-297.

SPALDING, D.A.E. Biographical notes of authors on Derbyshire: Gideon Algernon Mantell (1790-1852). Bull. Peak Dist. Mines Hist. Soc., Vol.3, Pt.2, pp.85-92.

SPALDING, D.A.E. Notes on naturalists in the Sheffield area. Sorby Record, Vol.2, pp.28-36.

SPALDING, D.A.E. Natural history societies in the Sheffield area, I. Derbyshire. Sorby Record, Vol.2, pp.73-76.

TAYLOR, B.J. and WILSON, A.A. Field meeting report: Congleton district. Proc. Yorks. Geol.Soc., Vol.35, pp.433-435.

TAYLOR, F.M. Geological tour of the Southern Peak District (excursion report). Mercian Geol., Vol.1, No.3, pp.267-274.

TAYLOR, F.M. Geology, Chapter 1, in "Nottingham and its region", edited by K.C. Edwards. Brit. Assoc., pp.11-40.

TAYLOR, F.M. A Landslide at Matlock, Derbyshire, 1966. Mercian Geol., Vol.1, pp.351-355.

WALKER, R.G. Shale Grit and Grindslow shales: transition from turbidite to shallow water sediments in the Upper Carboniferous of Northern England. J. Sediment. Petrol., Vol.36, pp.90-114.

WARWICK, G.T. and SHIMWELL, D.W.
Lathkilldale nature trail. Peak Park Guide, Bakewell, 18 pp.

WEBB, J.S., THORNTON, I, and FLETCHER, K.
Seleniferous soils in parts of England and Wales. Nature, Vol.211 (5046), p. 327.

WILCOCKSON, W.H. and ANDERSON, D.
Edale Nature trail. Peak Park Guide, Bakewell, 8 pp.

1967

AHMED, MOHAMMAD R. The petrology and diagenesis of some Upper Carboniferous Sandstones (Upper Millstone Grit and Lower Coal Measures) of the Sheffield Area. Ph.D. thesis, University of Sheffield.

ANON. Diversification of products at a major limestone quarry. (Middle Peel Quarry, Wirksworth). Quarry Man. Jour. Vol.51, No.12, pp.473-479.

ANON. New outlets for Derbyshire Limestone - Hoveringham's Dene Quarry. Quarry Man.Jour. Vol.51(9), 325-330.

ANON. British Fluorspar Mine. Mining Magazine. Vol.117. No.2. pp.121-2.

ANON. Middle Peak Quarry. Mining and Minerals Eng., Vol.3, No.10, pp.370-377.

BROADHURST, F.M. and SIMPSON, I.M.
Sedimentary infillings of fossils and cavities in limestone at Treak Cliff, Derbyshire. Geol.Mag., Vol.104, pp.443-448.

BROWN, I.J., and FORD, T.D.
The Magpie Mine, Sheldon, Derbyshire. Peak Dist. Mines Hist. Soc., Spec. Publ. No.3, 16 pp.

BROWN, J.S. (Econ.Geol.Monograph No.3), see 1969 entry.

BRYAN, R. Climosequences of soil development in the Peak District of Derbyshire. East Midl. Geog., Vol.4, No.4, pp.251-261.

BRYAN, R. The relative erodibility of some Peak District soils. Ph.D. Thesis, Univ. Sheffield. 340 p.

CALVER, M.A. Faunal succession in the Coal Measures of Britain. Proc. Meeting Subcom. Carb. Strat. Sheffield.

CLEMMOW, R.J. Middleton Mine: suppressing drilling dust. Mining and Minerals Eng., Vol.3, No. 9, pp.330-340.

COLLINSON, J.D. Sedimentation of the southern part of the Grindslow Shales and the Kinderscout grit. D.Phil. Thesis. Univ. Oxford, 192 p.

COLLINSON, J.D. and WALKER, R.G.
Namurian sedimentation in the High Peak, pp. 80-88 in Neves and Downie (qv).

COPE, F.W. The Wye Valley, pp.1-8 in Neves and Downie (qv)

CURTIS, C.D. — Diagenetic iron minerals in some British Carboniferous Sediments. Geochim. et Cosmochim. Acta. Vol.31. pp.2109-2123.

DOWNING, R.A. — The geochemistry of groundwaters in the Carboniferous limestone of Derbyshire and the East Midlands. Bull. Geol. Surv. G.B., No.27, pp. 289-307.

DUNHAM, K.C. — Mineralisation in relation to the Pre-Carboniferous basement rocks, Northern England. Proc. Yorks. Geol. Soc., Vol.36, pp. 195-201.

FORD, T.D. — The caves of Derbyshire, 2nd edn. Dalesman Publishing Co., Clapham, 135 pp., maps.

FORD, T.D. — The underground drainage systems of the Castleton area and their evolution. Cave Sci., Vol.5, No.39, pp.369-396.

FORD, T.D. and BROWN, I.J. — The Magpie Mine, Sheldon, Derbyshire. Peak Dist. Mines Hist. Soc., Spec. Publ., No.3, 16 pp.

FORD, T.D. — The first detailed geological sections across England, by John Farey, 1806-1808. Mercian Geol., Vol.2, pp. 41-49.

FORD, T.D. — A quartz-rock-filled sink-hole on the Carboniferous Limestone near Castleton, Derbyshire. Mercian Geol., Vol.2, pp. 57-62.

FORD, T.D. and MASON, M.H. — Bibliography of the geology of the Peak District of Derbyshire (to 1965). Mercian Geol., Vol.2, No.2, pp. 133-244.

FORD, T.D. — Some mineral deposits in the Carboniferous Limestone of Derbyshire, pp. 53-75 in Neves and Downie (q.v.).

FRANCIS, E.A. — The Namurian and lowermost Westphalian in the southern part of the Goyt Syncline, pp. 109-115 in Neves and Downie (q.v.).

GEOLOGICAL SURVEY. — 1":1 mile map: sheet 99 Chapel-en-le-Frith. Solid and Drift Editions.

GREENOUGH, G.B. — The Riber Mine 1950-59. Derbyshire Stone Ltd., Matlock. (also issued as supplement to Bull. Peak Dist. Mines Hist. Soc.

HIGGINS, A.C. — The Bradfield-Ewden Area, pp. 89-94 in Neves and Downie (q.v.).

HIGGINS, A.C. — The significance of Conodonts in the Carboniferous of Europe. Proc. Meeting Subcom. Carb. Strat. Sheffield. (1965), pp. 77-91.

INESON, P.R. — Trace element geochemistry of wallrock alteration in the Pennine ore-fields and Cumberland ironfield. Ph.D. thesis Univ. Durham, 286 pp.

JOHNSON, R.H. — Some glacial, periglacial and karstic landforms in the Sparrowpit-Dove Holes area of North Derbyshire. East Midl. Geog., Vol.4, No.4, pp. 224-238.

KENT, P.E. — A contour map of the sub-Carboniferous surface in the north-east Midlands. Proc. Yorks. Geol. Soc., Vol.36, pp.127-133.

KIRKHAM, N. and FORD, T.D. — The Ecton Copper Mines, Staffs. (2nd enlarged edition). Peak Dist. Mines Hist. Soc., Spec. Publ. No.1, 27 pp. 9 plans, photos.

MAYHEW, R.W. The Ashover and Chatsworth grits in north-east Derbyshire, pp.94-103 in Neves and Downie (q.v.)

MAYHEW, R.W. A sedimentological investigation of the Marsdenian Grits and associated measures in N.E. Derbyshire. Ph.D. thesis. University of Sheffield.

MOORE, L.R. The regional geological setting, pp. ix-xiv in Neves and Downie (q.v.)

MORRIS, P.G. The Namurian succession in the area around the Coombes Brook, near Leek, Staffordshire. Mercian Geol., Vol.2, pp. 15-30.

MORRIS, P.G. The Namurian ($E_1$-$E_2$) strata between Waterhouses and Cauldon, near Leek, Staffordshire. Proc. Geol. Assoc. Lond., Vol.78, pp.335-345.

MOSELEY, F.M. and AHMED, S.M.
Carboniferous joints in the north of England and their relation to earlier and later structures. Proc. Yorks. Geol. Soc., Vol.36, pp.61-90, Pls. 3-4.

NEVES, R and DOWNIE, C. (editors).
Geological excursions in the Sheffield region and the Peak District National Park. Univ. Sheffield, 163 pp.

NEVES, R. The Crich Inlier, pp. 42-47 in Neves and Downie (q.v.)

NEVES, R. Stratigraphic distribution of Carboniferous miospores - a progress report on the results of C.I.M.P. Stratigraphy Working Group (1965). Proc. Meeting Subcom. Carb. Strat. Sheffield (1965). pp. 77-91.

NICHOL, I and WEBB, J.S.
The application of computerised mathematical and statistical procedures to the interpretation of geochemical data. Proc. Geol. Soc. Lond., No. 1642, pp.186-199.

SHIRLEY, J. The Visean rocks of the Matlock-Wirksworth-Monyash area, pp.32-36 in Neves and Downie (q.v.).

SMALLEY, I.J. The subsidence of the North Sea basin and the geomorphology of Britain. Mercian Geol., Vol.2, No.3, pp.267-278.

SMITH, E.G., RHYS, G.H., and EDEN, R.A.
Geology of the country around Chesterfield, Matlock and Mansfield. Mem. Geol. Surv. G.B., 430 pp.

SMITH, E.G. The Namurian and Basal Westphalian rocks of the Beeley-Holymoorside area, pp. 103-108 in Neves and Downie (q.v.)

SMITH, A.H.V., and BUTTERWORTH, M.A.
Miospores in the coal seams of the Carboniferous of Great Britain. Pal. Ass. Spec. Paper, No.1.

STEVENSON, I.P. The Castleton reef belt and adjoining areas, pp. 14-22 in Neves and Downie (q.v.)

STEVENSON, I.P. and MITCHELL, M.
North Derbyshire: field meeting report. Proc. Yorks. Geol. Soc. Vol.36, pp.23-25.

TAYLOR, D., NICHOL, I., and WEBB, J.S.
Enrichment of base metals in the Triassic sandstones of South Derbyshire. Trans. Inst. Min. Met., Vol.76, pp.B214-215.

THOMPSON, D.B., and WORSLEY, P.
Periods of ventifact formation in the Permo-Triassic of the north-east Cheshire basin. Mercian Geol., Vol.2, No.3, pp.279-298.

WILCOCKSON, W.H. The geology of Edale: excursion report. Mercian Geol., Vol.2, pp. 109-110.

WILKINSON, P. Volcanic rocks in the Peak District, pp. 47-52 in Neves and Downie, (q.v.).

WOLFENDEN, E.B. Earl Sterndale area, pp. 9-13 in Neves and Downie (q.v.)

WRIGHT, M.D. Comparison of Namurian sediments of the central Pennines, England and recent deltaic deposits. Sediment. Geol., Vol.1, No.1, pp. 83-116.

1968

ANON. Duffield and Wardlow Boreholes. Ann. Rep. Inst. Geol. Sci. for 1967, pp. 81-83.

ANON. Water Resources - A Preliminary Survey. Trent River Authority. Nottingham. 77 p.

ANON. Mining at Sallet Hole. Mining & Minerals Eng. Vol.4. (3) pp. 105-106.

ANON. Roadstone - a new market. (Tunstead Quarry). I.C.I. Mag.Vol.46. pp. 4-9.

BRYAN, R. Climosequences of soil development in the Peak District of Derbyshire. East Midland Geog. Vol.4. No.28. (for 1967) pp. 251-261. Discussion in No.30. pp. 371-4.

CLAYTON, K.M. Structure-surface relationships in the middle part of the Derwent basin. East Midland Geog. Vol.4. pt. 6. pp.321-328.

COLLINSON, J.D. Deltaic sedimentation units in the Upper Carboniferous of Northern England. Sedimentology. Vol.10. pp. 233-254.

EVANS, W.B., WILSON, A.A., TAYLOR, B.J., & PRICE, D.
Geology of the country around Macclesfield, Congleton, Crewe and Middlewich. Mem.Geol.Surv. G.B. 2nd edn. x and 328 pp. 8 pls.

FLETCHER, W.K. Geochemical Reconnaissance in relation to copper deficiency in live-stock in the Southern Pennines and Devon. Ph.D. thesis. Univ. London.

FORD, T.D., & KING, R.J.
Mineralisation of the Triassic Rocks of South Derbyshire. Trans. Inst.Min.Met. Vol.77. pp. B.42-3.

HADDOCK, N. The Heights of Abraham, Matlock Bath. Guide Book 24 pp. (private publication) (with a section on Roman lead mining by R.W.P. Cockerton.)

HANCOCK, W.G. Fluorspar. Mining Annual Review, p. 101.

HOLDSWORTH, B.K. & TREWIN, N.H.
Excursion to the Namurian outcrops in South West Derbyshire and North East Staffordshire. Mercian Geol.Vol.2. No.4. pp.435-8.

JENSEN, D.E. Blue John Fluorite. Earth Science. Vol.21. pp.199-202.

JOHNSON, R.H. Four temporary exposures of solifluction deposits on Pennine Hill-slopes in North-East Cheshire. Mercian Geol. Vol.2. No.4. pp.379-387.

KAY, R. Dolomitisation and the Lower Carboniferous Dolomite of the Matlock Area, Derbyshire. Proc. Cumberland Geol. Soc. Vol.2. No.2. pp.84-88 (dated Dec.1967 but issued 1968).

KIRKHAM, N. Derbyshire Lead Mining through the Centuries. Bradford Barton, Truro, 132 p.

LLEWELLYN, P.G. & STABBINS, R. Lower Carboniferous evaporites and mineralisation in the eastern and central Midlands of Britain. Trans. Inst. Min. Met. Vol.77. pp.170-173.

LLEWELLYN, P.G. & STABBINS, R. Core material from the Anhydrite Series, Carboniferous Limestone, Hathern Borehole, Leicestershire. Proc. Geol. Soc. Lond. No.1650, pp.171-180.

LLOYD, P.S. The ecological significance of fire in limestone grassland communities in the Derbyshire Dales. Jour. Ecol. Vol.56. pp. 811-826.

PITTY, A.F. The scale and significance of solutional loss from the limestone tract of the Southern Pennines. Proc. Geol. Assoc. Lond. Vol.79. pp.153-178.

POCOCK, Y.P. Carboniferous Schizophoriid Brachiopods from Western Europe. Palaeontology. Vol.11. pp.64-93. Pl.18.

SANDS, T.S. The Natural History of the Sheffield District. Sorby Nat. Hist. Soc. Sheffield. 73p.

SHIRLEY, J. (in discussion of J.A. Hill & K.C. Dunham "The Barytes Deposit at Closehouse, Lunedale, Yorkshire") Proc. Yorkshire Geol.Soc. Vol.36. (part 3). p.371.

SMART, J.G.O., & FROST, D.V. The Coal Measures and Millstone Grit of the District North-West of Nottingham. (Excursion Report). Mercian Geol. Vol.2. pp.439-442.

STRAW, A.A. Pleistocene diversion of drainage in North Derbyshire. East Midld. Geog. Vol.4. Part 5. pp.275-280.

TAYLOR, D. The interpretation of lead and zinc stream anomalies related to contamination and mineralisation in U.K. Ph.D. thesis. Univ. London.

TAYLOR, F.M. The Geology of the Castleton area. (Excursion report). Mercian Geol. Vol.2. No.4. pp.429-434.

TREWIN, N. Potassium bentonites in the Namurian of Staffordshire and Derbyshire. Proc. Yorks. Geol. Soc. Vol.37. pp.73-91.

WEBB, J.S., THORNTON I., & FLETCHER, K. Geochemical reconnaissance and hypocuprosis. Nature, London. Vol.217. pp. 1010 - 1012.

WILCOCKSON, W.H.. Geology, pp. 9-18 in T.S. Sands (editor) The Natural History of the Sheffield District. Sorby Natural History Society. Sheffield. 73 p.

YOUNG, B.R., HARRISON, R.K., SERGEANT, G.A., & STEVENSON, I.P. An unusual glauconite associated with hydrocarbon in reef limestones near Castleton, Derbyshire. Proc. York. Geol. Soc. Vol.36. Part 4. pp. 417-434.

1969

AL-KUFAISHI, F.A.M. A mineralogical and geochemical study of part of Long Rake vein in the Derbyshire orefield. M.Sc. thesis. Univ. Sheffield. 80 p.

ANON. Limestone working and transport. East Midld. Geog. Vol.4. pp.432-433.

ANON. Tunstead Limestone Quarry, Buxton. Quarry Manager's Jour. Vol.53. pp. 397-408.

BIGGINS, D. The structure, sedimentology and palaeoecology of a Carboniferous Reef Knoll at High Tor, Derbyshire. Ph.D. Thesis. Univ. London. (Chelsea).

BROWN, J.S. (Ed). Genesis of stratiform lead-zinc-barite-fluorite deposits. Econ. Geol. Monograph No.3. 443 p. (dated 1967).

BROADHURST, F.M., DUNHAM, A.C., THOMPSON, D.B., & SIMPSON, I.M. Alderley Edge and Treak Cliff. Field Meeting report. Proc. Yorks. Geol. Soc. Vol.37. pp.178-181.

BRYAN, R.B. Aggregation characteristics and maturity of Peak District Soils. Earth Sci. Jour. Vol.3. No.1. pp. 1-12.

BRYAN, R.B. The relative erodability of soils developed in the Peak District of Derbyshire. Geografiska Annal er. Vol.51, Ser.A (3) pp.145-159.

BURT, R. Lead production in England and Wales 1700-1770. Econ.Hist.Rev. Vol. 22. pp.249-268.

CAZALET, P.C.D. Correlation of Cheshire Plain and Derbyshire Dome glacial deposits. Mercian Geol. Vol.3. No.1. pp.71-84.

CLAPHAM, A.R. Flora of Derbyshire. Chap. 1. Geology by W.H. Wilcockson. Chap.2. Geomorphology by R.S. Waters. Derby Museum 382 p.

COFFEY, James R. The Geology of the Mixon and Warslow Areas, North Staffordshire. Ph.D. thesis. University of Sheffield.

COLLINSON, J.D. The sedimentology of the Grindslow Shales and Kinderscout Grit; a deltaic complex in the Namurian of Northern England. J. Sediment. Petrol. Vol.39, pp.194-221.

DUNHAM, K.C. Veins, flats and pipes in the Carboniferous limestone of the English Pennines. pp.201-207 in: BROWN, J.S. Econ. Geol. Monograph No.3.

EDMUNDS, W.M., TAYLOR, B.J., & DOWNING, R.A. Mineral and thermal waters of the United Kingdom. XXIII Inter.Geol. Cong. Prague. Vol.18. pp.139-158.

FORD, T.D. Sand-filled sink-holes and dolomite tors in the Carboniferous Limestone of Derbyshire. pp. 387-397, in: "The Periglacial Environment" ed. Troy L. Péwé. McGill Univ.Press. Proc. VII INQUA (1965).

FORD, T.D. — The Blue John flourspar deposits of Treak Cliff in relation to the boulder bed. Proc. Yorks. Geol. Soc. Vol.37. Part 2. pp.153-8.

FORD, T.D. — The stratiform ore deposits of Derbyshire. pp.73-96 in : C.H. JAMES (ed.) Sedimentary Ores, Ancient and Modern Revised. Proc. Inter-Univ. Geol. Congress, Leicester, (1967).

FORD, T.D. & KING, R.J. — The origin of the silica sand pockets in the Derbyshire limestone. Mercian Geol. Vol.3. No.1. pp.51-69.

FORD, T.D. & RIEUWERTS. — (Eds.) Lead Mining in the Peak District. Peak Park Planning Board. Bakewell. 124 pp. (for 1968).

GRAYSON, P.J. — Derbyshire Minerals and Rocks. private publication. Edensor, Derbyshire. 36p.

HEIDBERG, J. & KREJCI-GRAF. K. — Elaterite - a fossil polyethylene. Die Naturwissenschaften. Jhrg.56, Heft. 10, p.513.

HOLDSWORTH, B.K. — Namurian radiolaria of the genus *Ceratoikiscum* from Staffordshire and Derbyshire. Micropalaeontology. Vol.15. pp.221-229.

HOLDSWORTH, B.K. — The relationship between the genus *Albaillella* and the ceratoikiscid Radiolaria. Micropalaeontology. Vol.15. pp.230-236.

INESON, P.R. — Trace element aureoles in limestone wallrocks adjacent to lead-zinc-barite-fluorite mineralisation in the Northern Pennines and Derbyshire orefields. Trans. Inst. Min. Met. Vol.B.78, pp.B.29-40.

JOHNSON, R.H. — The Derwent-Wye confluence re-examined. East Midld. Geog. Vol.4. pp.421-426.

JOHNSON, R.H. — The glacial geomorphology of the area around Hyde, Cheshire. Proc. Yorks. Geol. Soc. Vol.37. pp.189-230.

KING, R.J. & FORD, T.D. — Mineral localities at the base of the Trias in Leicestershire and Derbyshire. Excursion Report. Mercian Geol. Vol.3. No.1. pp.85-88.

KIRKHAM, N. — Lead mining at Crich, Derbyshire. Manchester Assoc. of Eng. Proc. 113th Session. No.5. 17.p.

MELLORS, P.T. — Towards a new cave concept in Derbyshire. The Speleologist. Vol.2. No.16. p.15. (Dec.1968). The Speleologist. Vol.3. No.17. p.15. (Spring, 1969).

MORRIS, P.G. — Dinantian and Namurian stratigraphy east and south-east of Leek, Staffs. Proc. Geol. Assoc. London. Vol.80. pp.145-176.

MORRIS, P.G. — An occurrence of the productid brachiopod *Striatifera striata* (Fischer) in the Carboniferous Limestone of North Staffordshire. Mercian Geol. Vol.3. pp.147-150. Pl.11.

NIXON, F. — The industrial archeology of Derbyshire. David & Charles. Newton Abbot. 307p.

PARKINSON, D. — Relative growth, variation and evolutionary trends in a Carboniferous rhynchonellid brachiopod. J. Palaeo. Vol.43. pp.95-110, Plts. 19-20.

PERING, K., & PONNAMPERUMA, C.
Alicyclic hydrocarbons from an unusual deposit in Derbyshire, England - a study in possible diagenesis. Geochim. Cosmochim. Acta. Vol.33. pp. 528-532.

RAMSBOTTOM, W.H.C. Reef distribution in the British Lower Carboniferous. Nature, London. Vol.222. pp.765-766.

ROEDDER, E. Environment of deposition of stratiform (Mississippi valley type) ore deposits from studies of fluid inclusions. pp.349-362 in : BROWN, J.S. Econ. Geol. Monograph No.3.

SADLER, H.E. Conditions of deposition of two brachiopod beds in the Carboniferous Limestone at Bolt Edge near Sparrowpit, Derbyshire. Mercian Geol. Vol.3. No.1. pp.31-34.

SAID, M. The Pleistocene geography of the Burbage Basin. Ph.D. thesis. University of Sheffield.

SCHNELLMANN, G.A. & SCOTT, B.
The Lead-zinc mining areas of Great Britain. 9th Commonwealth Mining and Metallurgical Congress. (1969). Mining & Petroleum Geology Section. Paper 2. pp.1-33.

SIMPSON, I.M. & BROADHURST, F.M.
A boulder bed at Treak Cliff, North Derbyshire. Proc. Yorks. Geol. Soc. Vol.37. part 2, pp. 141-152.

SPEARS, D.A. A laminated marine shale of Carboniferous age from Yorkshire. J. Sediment. Petrol. Vol.39. pp.106-112.

STEPHENSON, T. The Pennine Way. H.M.S.O. 122p.

WATERS, R.S. Geomorphology. Chapter 3, pp.15-28 in Clapham "Flora of Derbyshire". Derby.

WILCOCKSON, W.H. Geology. Chapter 2, pp.4-14 in Clapham "Flora of Derbyshire". Derby.

1970

ANON. Tideswell Dale National Park Trail. Peak Park Board. Bakewell 8p.

ANON. The Peak: Story of a National Park. Peak Park Board, Bakewell. 45p.

BARRATT, M.S., COURTIER, D.B., HUGHES, D.O., & ROBERTSON, J.M.
Land use planning and mineral resources with special reference to aggregates for the construction industries. pp.48-66 (Peak Dist. pp. 60-62). in "Geological Aspects of Development and planning in Northern England" Yorks. Geol. Soc. (ed. P.T. Warren). Leeds. 167p.

BIRD, R.H. Notes on the Western Elton Mining Field. Bull. Peak Dist. Mines Hist. Soc. Vol.4. No.4. pp.306-311.

BOULTER, M.C. An Upper Tertiary Flora from Derbyshire. Ph.D. thesis, London University. 138 pp., 20 pls., 3 text-figs.

BOULTER, M.C. *Cryptomeria* - a significant component of the European Tertiary. Paleont. Abh., vol.3, pp.279-288, 1 pl., 4 text-figs.

BOULTER, M.C., & CHALONER, W.G.
Neogene fossil plants from Derbyshire, Rev. Palaeobot. Palynol. Vol.10. pp.61-78.

BROADHURST, F.M., EAGAR, R.M.C., JACKSON, J.W., SIMPSON, I.M., & THOMPSON, D.B.
The area around Manchester. Geol. Assoc. London. Guide No.7. Revised edition 51 p.

BROADHURST, F.M. & LORING, D.H.
Rates of sedimentation in the Upper Carboniferous of Britain. Lethaia, Vol.3. No.1. pp.1-9.

BRYAN, R.B. Parent materials and texture of Peak District Soils. Zeitschrift für Geomorphologie. Vol.14. pt.3. p.262-274.

CELENK, O. Geochemical study of mineralisation along the eastern part of Long Rake, Derbyshire. Dissertation abstract. Trans. Inst. Min. Met. Vol. B.79. p.B51.

CHALLINOR, J. The progress of British Geology during the early part of the Nineteenth Century. Ann. Sci. Vol.26. pp.177-234.

COLLINSON, J.D. Deep channels, massive beds and turbidity current genesis in the Central Pennine Basin. Proc. Yorks. Geol. Soc. Vol.37. No.4. pp.495-519. Pl.23-25.

DUNHAM, K.C. Mineralisation by deep formation waters: a review. Trans. Inst. Min. Met. Vol.B.79, pp.B127-136.

DURRANCE, E.M. Release of strain energy as a mechanism for the weathering of granular rock materials. (with ref. to Millstone Grit tors, etc.) Geol.Mag. Vol.106, pp.496-497.

FORD, T.D., & RIEUWERTS. J.H.
Lead mining in the Peak District. Revised Edition. Bakewell. 127 p.

FRANCIS, E.A. Geology of the southern part of the Goyt Syncline, N. Staffs. (Excursion, report). Mercian Geol. Vol.3. pp.353-359.

FULLER, G.J. Early Lead Smelting in the Peak District: another look at the evidence. East Midld. Geog. Vol.5. pp.1-8.

GOWER, C.F. Fracturing and mineralisation in the Matlock District. Dissertation abstract. Trans. Inst. Min. Met. Vol. B 79, p.B52.

HADDON, R. The district around Eyam. A Field Study Guide. Youth Hostels Assoc. London. 41p.

HEIDBERG, J. & KREJCI-GRAF, K.
Über die struktur von Elaterit aus der Odin Mine, Derbyshire. Erdöl u. Kohle. Jhr. 23. Heft 5. pp.269-275.

HODGE, B.L. Flourspar. Mining Annual Review pp.104-108.

HOLDSWORTH, B.K., EDWARDS, C.A., & TREWIN, N.H.
Discussion of P. Morris's paper of Proc. Geol. Assoc. London. Vol.80 pp. 145-175, 1969. with reply by Morris. On North Staffs. Millstone Grit.

INESON, P.R. & AL-KUFAISHI, F.A.M.
The mineralogy and paragenetic sequence of Long Rake Vein at Raper Mine, Derbyshire. Mercian Geol. Vol.3. pp.337-351.

INESON, P.R. Trace element aureoles in limestone wallrocks adjacent to fissure veins in the Eyam area of Derbyshire orefield. Trans. Inst. Min. Met. B. Vol.B79. pp. B238-245.

LLEWELLYN, P.G. & STABBINS, R.
The Hathern Anhydrite Series, Leicestershire. Trans. Inst. Min. Met. Vol. B79, pp.B1-15, discussion in Vol. B80 (1971) pp.B47-50.

LUDFORD, A. The stratigraphy and palaeontology of the Lower Carboniferous Rocks of Northeast Staffordshire and adjacent parts of Derbyshire. Ph.D. thesis. Univ. London. (Chelsea).

MACKENZIE, K.J.D. Thermal decomposition of Derbyshire allophane. Clay Minerals. Vol.8. pp.349-351.

McARTHUR, J.L. A geomorphological study of the Upper Derwent basin. Ph.D. thesis. University of Sheffield.

MORRIS, P.G. Carboniferous conodonts in the Southwestern Pennines. Geol. Mag. Vol.106, pp.497-499.

MORRIS, P.G. Holothurian spicules from the Lower Carboniferous near Waterhouses, North Staffordshire. Mercian Geol. Vol.3. pp.353-359.

MUELLER, G. Indications of High Temperature Processes in Organic Geochemistry (bitumens in Derbyshire) pp. 443-468 in G.D. HOBSON & G.C. SPEERS "Advances in Organic Geochemistry". 577p. Pergamon. Oxford.

NEWELL, P. Limestone Heath in the Peak. Peakland Archeo. Newsletter. No.25. pp.33-38.

NEWMAN, D. The district around Hartington: Field Study Guide. Youth Hostels Assoc. London 49p.

NICHOL, I., THORNTON, I., WEBB, J.S., FLETCHER, W.K., HORSNAIL, R.F., KHALEELEE, J., & TAYLOR, D.
Regional geochemical reconnaissance of the Derbyshire area. Rept. 70/2. Inst. Geol. Sci. 37p. 16 maps.

OBIAL, R.C. Cluster analysis as an aid in the interpetation of multi-element geochemical data. (with examples from Derbyshire). Trans. Inst. Min. Met. Vol.B.79, pp.175-180.

OBIAL, R.C. Multi-element geochemical studies in the Southern Pennine Orefield and North Leicestershire. Ph.D. Thesis. Univ. Leicester. c200p.

ORME, G.R. The $D_2$-$P_1$ reefs and associated limestones of the Pindale - Bradwell Moor area of Derbyshire. C.R. 6me Internat. Cong. Strat. Geol. Carb. Sheffield. Vol.3, pp.1249-1262, Pls. 1-3.

ORME, G.R. An unusual shallow water facies in the Visean Limestones of Derbyshire. C.R. 6me Internat. Cong. Strat. Geol. Carb. Sheffield. Vol.3. pp.1263-1274, Pls. 1-3.

ORME, G.R. & FORD, T.D.
Polyphase mineralisation in Chert from the Ashford Black Marble Mine, Derbyshire. Proc. Yorks. Geol. Soc. Vol.38, pp.163-173, Pls. 9-10.

ROBEY, J.A. & PORTER, L. The copper and lead mines of the Mixon area, Staffordshire. Bull. Peak. Dist. Mines Hist. Soc. Vol.4. No.4. pp.256-280.

SADLER, H.E. Boring algae in brachiopod shells from Lower Carboniferous ($D_1$) limestones in North Derbyshire, with special reference to the conditions of deposition. Mercian Geol. Vol.3. pp.283-290.

SHAW, K. *Pseudamusium ellipticum* limestone: a new lithostratigraphic unit in the Lower Carboniferous at Castleton, Derbyshire. Mercian Geol. Vol.3. pp.223-231.

STEVENSON, I.P., HARRISON, R.K. & SNELLING, N.J. Potassium-argon age determinations of the Waterswallows Sill, Buxton, Derbyshire. Proc. Yorks Geol. Soc. Vol.37. pp.445-448.

TREWIN, N.H. A dimorphic goniatite from the Namurian of Cheshire. Palaeontology. Vol.13. No.1. pp.40-46. Pl.12.

WALKDEN, G.M. Environmental studies in the Carboniferous Limestone of the Derbyshire Dome. Ph.D. thesis. Univ. Manchester.

WHITE, G.H. Mineralisation and structural setting at Ashover, Dissertation abstract. Trans. Inst. Min. Met. Vol. B.79. p.B.52.

## AUTHOR INDEX


A

Abou-el-Enim, H.S. 1962, 1964
Ahmed, M.R. 1967
Al-Kufaishi, F.A.M. 1969, 1970
Anderson, D. 1966
Anon. 1947, 1950, 1958, 1958, 1965, 1965, 1965, 1965, 1966, 1967, 1967, 1967, 1967, 1968, 1968, 1968, 1969, 1969, 1970.

B

Barnes, F.A. 1958
Barratt, M.S. 1970
Batten, R.L. 1966
Belshé, J.C. 1960
Biggins, D. 1969
Bird, R.H. 1970
Blume, H. 1952
Boulter, M.C. 1970
Bower, M.M. 1959, 1961
Brennand, T.P. 1966
Bridges, E.M. 1958, 1966
Broadhurst, F.M. 1967, 1969, 1970
Brough, B.H. 1883
Brown, I.J. 1967
Brown, J.S. 1967, 1969
Bryan, R.B. 1967, 1968, 1969, 1970
Buchan, S. 1958
Bunting, B.T. 1960
Burt, R. 1969
Butterworth, M.A. 1967

C

Calver, M.A. 1967
Cazalet, P.C.D. 1969
Celenk, O. 1970
Challinor, J. 1954, 1970
Chaloner, W.G. 1970
Clapham, A.R. 1969
Clarke, M.J. 1966
Clarke, E. 1898
Clayton, K.M. 1968
Clemmow, R.J. 1967
Coffey, J.R. 1969
Collinson, J.D. 1966, 1967, 1968, 1969, 1970
Cope, F.W. 1967
Crick, G.C. 1904
Curtis, C.D. 1967

D

D................., T. 1831
Davenport, T.G. 1966
Davis, A.G. 1945
Doornkamp, J.C. 1962
Douglas, I. 1962, 1964
Downie, C. 1967
Downing, R.A. 1967, 1969
Dunham, A.C. 1969
Dunham, K.C. 1967, 1969, 1970
Durrance, E.M. 1970

E

Eagar, R.M.C. 1970
Edmunds, W.M. 1969
Eden, R.A. 1967
Edwards, C.A. 1970
Edwards, K.C. 1966
Elkington, T. 1966
Esch, H. 1966
Evans, W.B. 1968
Everitt, C.W.F. 1960

F

Fitch, F.J. 1966
Fletcher, K. 1966, 1968
Fletcher, W.K. 1968, 1970
Ford, T.D. 1958, 1966, 1967, 1968, 1969, 1970
Francis, E.A. 1967, 1970
Franks, F. 1943
Freeman, T.W. 1966
Frost, D.V. 1968
Fuller, G.J. 1970

G

Garner, R. 1844
Geological Survey Maps. 1966, 1967
Gorskaya, A.L. 1965
Gower, C.P. 1970
Grayson, P.J. 1969
Greenough, G.B. 1967

H

Haddock, N. 1968
Haddon, R. 1970
Hallimond, A.F. 1920
Hancock, W.G. 1968
Harrison, R.K. 1968, 1970
Haslam, D.R. 1966
Hawkes, H.E. 1962
Heidberg, J. 1969, 1970
Higgins, A.C. 1958, 1961, 1967
Hodge, B.L. 1970
Holdsworth, B.K. 1966, 1968, 1969, 1970
Hooke, R. 1726
Horsnall, R.F. 1970
Houston, W.J. 1964
Hudson, R.G.S. 1966

I

Ineson, P.R. 1967, 1969, 1970

J

Jackson, J.S. 1966
Jackson, J.W. 1970
Jensen, D.E. 1968
Jessop, P. 1928
Johnson, R.H. 1955, 1967, 1968, 1969

K

Kay, R. 1968
Kent, P.E. 1967
Khaleelee, J. 1970
King, C.A.M. 1966
King, R.J. 1966, 1968, 1969
Kinvig, R.H. 1966
Kirkham, N. 1966, 1967, 1968, 1969
Krejci-Graf, K. 1969, 1970

L

Lakin, A.E. 1966
Linton, W.R. 1903
Llewellyn, P.G. 1968, 1970
Lloyd, P.S. 1968
Loring, D.H. 1970
Lovegrove, E.J. 1929
Lovely, H.R. 1946
Ludford, A. 1970

M

McArthur, J.L. 1970
Mackenzie, K.J.D. 1970
Malki, N. 1966
Martel, E.A. 1897, 1900
Mason, M.H. 1967
Mayhew, R.W. 1967
Mellors, P.T. 1969
Miller, J.A. 1966
Mitchell, M. 1966, 1967
Monk, H.G.N. 1898
Moore, L.R. 1967
Moore, S. 1903
Morris, P.G. 1966, 1967, 1969, 1970
Moseley, F. 1966, 1967
Mueller, G. 1960, 1970
Mumby, K. 1965

N

Nash, D. 1957
Neves, R. 1958, 1961, 1966, 1967
Newman, D. 1970
Newell, P. 1970
Nichol, I. 1967, 1970
Nixon, F. 1969

O

Obial, R.C. 1970
Orme, G.R. 1970
Owen, D.E. 1966
Owens, B. 1966

P

Parkinson, D. 1969
Peacock, J.D. 1966
Percy, J. 1870
Pering, K. 1969
Phillips, S.C. 1914
Pigott, C.D. 1960
Pitt, W. 1794
Pitty, A.F. 1966, 1968
Pocock, Y.P. 1968
Ponnamperuma, C. 1969
Porter, L. 1970
Potter, H.R. 1958
Price, D. 1968

R

Radley, E.G. 1920
Radley, J. 1966
Ramsbottom, W.H.C. 1963, 1966, 1969
Rhys, G.H. 1967
Rieuwerts, J.H. 1966, 1969, 1970
Robey, J. 1966, 1970
Rodgers, H.B. 1966
Roedder, E. 1965, 1969

S

Sadler, H.E. 1966, 1969, 1970
Said, M. 1969
Salmon, L.B. 1966
Sands, T.S. 1968
Sargent, H.C. 1929
Schnellmann, G.A. 1955, 1969
Scott, B. 1969
Scurfield, G. 1953, 1959
Searle, A.B. 1935
Sergeant, G.A. 1968
Shahin, A. 1957
Shaw, K. 1970
Shimwell, D.W. 1966
Shirley, J. 1967, 1968
Simpson, I.M. 1967, 1969, 1970
Sington, T. 1919
Smalley, I.J. 1967
Smart, J.G.O. 1968
Smith, A.H.V. 1967
Smith, E.G. 1967
Snelling, N.J. 1970
Spalding, D.A.E. 1966
Spears, D.A. 1969
Stabbins, R. 1968, 1970
Stephenson, T. 1969
Stevenson, I.P. 1967, 1968, 1970
Straw, A.A. 1968
Stubblefield, C.J. 1946

## T


Tallis, J.H. 1964, 1965
Taylor, B.J. 1966, 1968, 1969
Taylor, D. 1967, 1968, 1970
Taylor, F.M. 1966, 1968
Taylor, K. 1966
Thomas, H.H. 1920
Thompson, D.B. 1966, 1967, 1969, 1970
Thornton, I. 1966, 1968, 1970
Tillotson, E. 1956
Tomkeieff, S.I. 1928
Tonks, L.H. 1924
Trewin, N.H. 1968, 1970
Turner, J. Selwyn 1935
Tylecote, R.F. 1964


## U


Uspenskii, V.A. 1965


## V


Von Buch, L. 1832


## W


Walford, T. 1818
Walkden, G.M. 1970
Walker, R.G. 1966, 1967
Wardle, T. 1862, 1898
Warnes, A.R. 1926
Warwick, G.T. 1966
Waters, R.S. 1969
Webb, J.S. 1962, 1966, 1967, 1968, 1970
Whitaker, W. 1885
White, D.E. 1966
White, G.H. 1970
White, P.H.N. 1949
Wilcockson, W.H. 1966, 1967, 1968, 1969
Wilkinson, P. 1967
Williams, R.B.G. 1964
Wilson, A.A. 1966, 1968
Winder, F.A. 1914
Wolfenden, E.B. 1967
Worsley, P. 1967
Wright, J.A. 1952
Wright, M.D. 1964, 1967
Wright, W.B. 1924
Wyatt, R.J. 1966


## Y


Young, A. 1958
Young, B.R. 1968

# SUBJECT INDEX

## GENERAL


Anon. 1970
Broadhurst, F.M. et al 1970
Clapham, A.R. 1969
Edwards, K.C. 1966
Evans, W.B. et al 1968
Ford, T.D. & Mason, M.H. 1967
Freeman, T.W. et al 1966
Garner, R. 1944
Hooke, R. 1726
Linton, W.K. 1903
Moore, L.R. 1967
Neves, R. & Downie, C. 1967
Pigott, C.D. 1960
Pitt, W. 1794
Sheldon, J.P. 1906
Smith, E.G. et al 1967
Stephenson, T. 1969
Taylor, F.M. 1966
Walford, T. 1818
Wardle, T. 1862
Warwick, G.T. & Shinwell, D.W. 1966
Whitaker, W. 1885
Wilcockson, W.H. 1966, 1968, 1969


## MINERALOGY


Al-Kufaishi, F.A.M. 1969
Anon. 1965, 1966, 1967, 1968
Bird, R.H. 1970
Broadhurst, F.M. et al 1969
Brough, B.H. 1883
Brown, I.J. & Ford T.D. 1967
Brown, J.S. 1969
Celenk, O. 1970
Curtis, C.D. 1967
Davenport, T. 1966
D.T. 1831
Downing, R.A. 1967
Dunham, K.C. 1967, 1969, 1970
Ford, T.D. 1967, 1969
Ford, T.D. & King, R.J. 1966, 1968
Ford, T.D. & Rieuwerts, J.H. 1970
Franks, F. 1943
Fuller, J.H. 1970
Gower, C.F. 1970
Grayson, P.J. 1969
Greenough, G.B. 1967
Hancock, W.G. 1968
Hawkes, H.E. & Webb, J.S. 1962
Heidberg, J. 1969, 1970
Hodge, B. 1970
Hooke, R. 1726
Ineson, P.R. 1967, 1969, 1970
Jensen, D.E. 1968
King, R.J. 1966, 1969
Kirkham, N. 1966, 1967, 1968, 1969
Llewellyn, P.G. & Stabbins, R. 1968
Mackenzie, K.J.D. 1970
Mueller, G. 1960, 1970
Nash, D. 1957
Nichol, I. & Webb, J.S. 1967
Nixon, F. 1969
Obial, R.C. 1970
Orme, G.R. 1970
Peacock, J.D. & Taylor, K. 1966
Percy, J. 1870
Pering, K. 1969
Pitt, W. 1794
Rieuwerts, J.H. 1966
Robey, J.A. 1966, 1970
Roedder, E. 1965, 1969
Schellmann, G.A. 1955, 1969
Shirley, J. 1968
Smith, E.B. et al 1967
Taylor, D. et al 1967, 1968
Tylecote, R.F. 1964
Uspenkii, W.A. 1965
Wardle, T. 1898
Webb, J.S. et al 1966, 1968
White, G.H. 1970
Young, B.R. et al 1968

## PALAEONTOLOGY

| | | | |
|---|---|---|---|
| Anon. | 1950 | Neves, R. | 1966, 1967 |
| Batten, R.L. | 1966 | Orme, G.R. | 1970 |
| Biggins, D.A. | 1969 | Parkinson, D. | 1969 |
| Boulter, M.C. | 1970 | Pocock, Y.P. | 1968 |
| Crick, G.C. | 1904 | Ramsbottom, W.H.C. | 1963 |
| Davis, A.G. | 1945 | Sadler, H.E. | 1970 |
| Haslam, D.R. | 1966 | Shaw, K. | 1970 |
| Higgins, A.C. | 1961, 1967 | Smith, A.H.V. | 1967 |
| Holdsworth, B.K. | 1966, 1969 | Stubblefield, C.J. | 1946 |
| Ludford, A. | 1970 | Trewin, N.H. | 1970 |
| Mitchell, M. & White, D.E. | 1966 | Von Buch, L. | 1832 |
| Morris, P.G. | 1969, 1970 | Wright, J.A. | 1952 |

## IGNEOUS PETROLOGY

| | | | |
|---|---|---|---|
| Jessop, P. | 1928 | Roedder, E. | 1965 |
| Malki, N. | 1966 | Stevenson, I.P. et al | 1970 |
| Moore, S. | 1903 | Tomkeieff, S.I. | 1928 |
| Moseley, F. | 1966 | Trewin, N. | 1968 |
| Mumby, K. | 1965 | Walkden, G.M. | 1920 |
| | | Wilkinson, P. | 1967 |

## SEDIMENTOLOGY

| | | | |
|---|---|---|---|
| Ahmed, M.R. | 1967 | Orme, G.R. | 1970 |
| Anon. | 1947 | Ramsbottom, W.H.C. | 1969 |
| Biggins, D.A. | 1969 | Sadler, H.E. | 1966, 1969, 1970 |
| Broadhurst, F.M. | 1967 | Sargent, H.C. | 1929 |
| Collinson, J.D. | 1966, 1967, 1968, | Searle, A.B. | 1935 |
| | 1969, 1970 | Thomas, H.H. et al | 1920 |
| Esch, H. | 1966 | Trewin, N. | 1968 |
| Kay, R. | 1968 | Walkden, G.M. | 1920 |
| Llewellyn, P.G. & Stabbins, R. | 1968, 1970 | Walker, R.G. | 1966 |
| Lovegrove, E.J. | 1929 | Warnes, A.R. | 1926 |
| Mayhew, R. | 1967 | Wright, M.D. | 1964, 1967 |

## MAPS

| | |
|---|---|
| Geol. Survey. | 1966, 1967 |

## HYDROLOGY

| | | | |
|---|---|---|---|
| Anon. | 1968 | Edmunds, W.M. | 1969 |
| Barnes, F.A. & Potter, H.R. | 1958 | Ford, T.D. | 1967 |
| Buchan, S. | 1958 | Monk, H.G.N. | 1898 |
| Downing, R.A. | 1967 | Pitty, A.F. | 1966, 1968 |

## HISTORY & BIBLIOGRAPHY

| | |
|---|---|
| Bird, R.H. | 1970 |
| Brown, I.J. & Ford, T.D. | 1967 |
| Challinor, J. | 1954, 1970 |
| Clarke, E. | 1898 |
| Ford, T.D. | 1958, 1966, 1967 |
| Ford, T.D. & Rieuwerts, J.H. | 1969, 1970 |
| Fuller, J.M. | 1970 |
| Haddock, N. | 1968 |
| Jackson, J.S. | 1966 |
| Kirkham, N. | 1966, 1967, 1968, 1969 |
| Morris, P.G. | 1966 |
| Radley, J. | 1966 |
| Rieuwerts, J.H. | 1966 |
| Robey, J.A. | 1966 |
| Spalding, D.A.E. | 1966 |
| Tylecote, R.F. | 1964 |

## STRUCTURE

| | |
|---|---|
| Durrance, E.M. | 1970 |
| Gower, C.F. | 1970 |
| Kent, P.E. | 1967 |
| Llewellyn, P.G. & R. Stabbins. | 1970 |
| Moseley, F.M. & Ahmed, S.M. | 1967 |
| Smalley, I.J. | 1967 |
| Tillotson, E. | 1956 |
| White, G.H. | 1970 |

## ECONOMIC

| | |
|---|---|
| Anon. | 1947, 1958, 1965, 1966, 1967, 1968, 1969 |
| Barratt, M.S. et al. | 1970 |
| Burt, R. | 1969 |
| Clemmow, R.J. | 1967 |
| Ford, T.D. | 1969 |
| Franks, F. | 1943 |
| Greenough, G.B. | 1967 |
| Hancock, W.G. | 1968 |
| Hodge, B.L. | 1970 |
| Houston, W.J. | 1964 |
| Lakin, A.F. | 1966 |
| Lovegrove, E.J. | 1929 |
| Loveley, H.R. | 1946 |
| Mumby, K. | 1965 |
| Schnellmann, G.A. | 1955, 1969 |
| Searle, A.B. | 1935 |
| Sington, T. | 1919 |
| Smith, E.B. | 1967 |
| Thomas, H.H. et al | 1920 |
| Wardle, T. | 1862 |
| Warnes, A.R. | 1926 |
| White, P.H.N. | 1949 |

## GEOMORPHOLOGY, PLEISTOCENE & SOILS

| | |
|---|---|
| Abou-el-Enin, H.S. | 1962, 1964 |
| Blume, H. | 1952 |
| Bower, M.M. | 1959, 1962 |
| Bridges, E.M. | 1958, 1966 |
| Bryan, R. | 1967, 1968, 1969, 1970 |
| Bunting, B.T. | 1960 |
| Cazalet, P.C.D. | 1969 |
| Clayton, K.M. | 1968 |
| Doornkamp, J. | 1962 |
| Douglas, I. | 1962, 1964 |
| Durrance, E.M. | 1970 |
| Ford, T.D. | 1967, 1969 |
| Ford, T.D. & King, R.J. | 1966, 1969 |
| Johnson, R.H. | 1955, 1967, 1968, 1969 |
| King, C.A.M. | 1966 |
| Lloyd, P.S. | 1968 |
| Martel, E.A. | 1897, 1900 |
| McArthur, J.L. | 1970 |
| Mellors, P.T. | 1969 |
| Moseley, F. | 1966 |
| Nash, D.A. | 1957 |
| Newell, P. | 1970 |
| Pitty, A.F. | 1966, 1968 |
| Said, M. | 1969 |
| Salmon, L.B. | 1966 |
| Scurfield, G. | 1953, 1957 |
| Shahin, A. | 1957 |
| Smalley, I.J. | 1962 |
| Straw, A. | 1968 |
| Tallis, J.H. | 1964, 1965 |
| Taylor, F.M. | 1966 |
| Waters, R.S. | 1969 |
| Williams, R.B.G. | 1964 |
| Winder, F.A. | 1914 |
| Young, A. | 1958 |

## GEOPHYSICS

Everitt, C.W.F. & Belshé, J.C. 1960
Stevenson, I.P. et al 1970
Tillotson, E. 1956
White, P.H.N. 1949

## CARBONIFEROUS LIMESTONE

Anon. 1958, 1965, 1967, 1968, 1969, 1970
Biggins, D.A. 1969
Broadhurst, F.M. & Simpson, I.M. 1967, 1969
Clemmow, R.J. 1967
Coffey, J.R. 1969
Cope, F.W. 1967
Ford, T.D. 1958, 1966, 1969
Haddon, R. 1970
Holdsworth, B.K. 1966, 1969
Hudson, R.G.S. et al 1966
Kay, R. 1968
Lakin, A.E. 1966
Llewellyn P.G. & Stabbins, R. 1968, 1970
Ludford, A. 1970
Morris, P.G. 1966, 1969
Newman, D. 1970
Orme, G.R. 1970
Ramsbottom, W.H.C. 1969
Sadler, H.E. 1966, 1969
Shaw, K. 1970
Simpson, I.M. 1969
Smith, E.B. et al 1967
Stevenson, I.P. 1967
Taylor, F.M. 1968
Walkden, G.M. 1970
Warwick, G.T. 1966
Wolfenden, E.B. 1967
Young, B.R. et al 1968

## MILLSTONE GRIT

Ahmed, M.R. 1967
Anon. 1968
Broadhurst, F.M. 1970
Collinson, J.D. 1966, 1967, 1968, 1969, 1970
Elkington, T. 1966
Esch, H. 1966
Evans, W.B. et al. 1968
Francis, F.A. 1967, 1970
Haslam, D.R. 1966
Higgins, A.C. 1967
Holdsworth, B.K. 1966, 1968, 1969, 1970
Lovely, H.R. 1946
Mayhew, R.W. 1967
Morris, P.G. 1966, 1967, 1969
Neves, R & B. Owens 1966
Radley, J. 1966
Ramsbottom, W.H.C. 1966
Smart, J.G.O. 1968
Smith, A.H.V. 1967
Smith, E.B. 1967
Spears, D.A. 1969
Taylor, B.J. & Wilson, A.A. 1966
Tonks, L.H. & Wright, W.B. 1924
Trewin, N. 1968
Walker, R.G. 1966
Wardle, T. 1862
Wilcockson, W.H. 1966, 1967
Wright, M.D. 1964, 1967

## COAL MEASURES

Calver, M.A. 1967
Francis, E.A. 1967
Higgins, A.C. 1967
Smart, J.G.B. & Frost, D.V. 1968
Smith, F.B. 1967
Smith, A.H.V. & Butterworth, M.A. 1967

## PERMO-TRIAS

Broadhurst, F.M. et al 1969
Evans, W.B. et al 1968
Fitch, F.J. et al 1966
Ford, T.D. & King, R.J. 1968
King, R.J. 1966
King, R.J. & Ford, T.D. 1969
Thompson, D.B. & Worsley, P. 1967

## TERTIARY

Boulter, M.C. 1970
Ford, T.D. & King, R.J. 1969
Boulter, M.C. & Chaloner, W. 1970

# A METHOD FOR THE RECOVERY OF MOUNTED PALYNOLOGICAL RESIDUES

by

Graeme J. Wilson

## Summary

A simple method is given for the extraction and remounting of palynomorphs contained in glycerine jelly slide mounts.

## Introduction

There are many occasions when the palynologist requires remounts of mounted material, particularly when little or no additional residue is available. This is often the case with valuable core samples and rocks containing very low concentrations of palynomorphs, such as the purer limestones. Some of the reasons that the writer has recovered the residues from slides are:

1. Salvaging the material from broken or damaged slides (mainly as a result of the serious Nottingham University Geology Building fire of March 1970).
2. Altering the palynomorph concentration.
3. Changing the degree of staining.
4. Altering the size of coverslip used (the original coverslips used by the writer were too large for the mounts to be fully traversed with a mechanical stage).
5. Additional chemical and mechanical processing.

The method described below would also be suitable for the rejuvenation of slides in which the glycerine jelly had deteriorated. On occasions when the strew mounts are required for single-grain picking, the writer uses a slightly different method, involving the treatment of one slide at a time (Wilson, 1971, p. 32).

It is important to stress that remounts of residues can be prepared only when glycerine jelly and certain other non-permanent substances are used as mounting media. This means that it is not possible (by readily available methods) to remount residues contained in Canada balsam mounts. Furthermore there is little point in attempting to remount over-macerated residues in the hope of improving them, since nothing can be done to repair palynomorphs once they have been split, expanded or broken due to excessive oxidation, acetylation or ultrasonic irradiation. The writer tends to slightly under-macerate his samples, since the mounted residues can always be given additional treatment, if necessary, by use of the method which follows.

## Method

Slides for remounting are cleaned with cotton wool moistened with alcohol, avoiding any areas containing obvious residue (particularly in the case of damaged or broken slides). If the coverslips have been sealed with nail lacquer, this must be carefully removed with cotton wool soaked in acetone. The coverslip margin should then be washed thoroughly in acetone and wiped clean with a tissue.

The cleaned slides, all from the same sample, are placed vertically with the labels uppermost in a 100 ml. beaker. The beaker is filled with distilled water to a level just covering the coverslips. No more than ten slides should be placed in any one beaker. The beaker is then placed on a hotplate kept at about 100°C. Eventually the coverslips and residues will sink to the bottom of the beaker as the glycerine jelly melts.

The slides must then be removed individually and washed carefully, with a small amount of hot distilled water, into the beaker to ensure that all traces of residue are removed. They should preferably be handled only with a pair of tweezers during this process. Damaged or broken slides are then discarded, while those in sound condition may be cleaned with alcohol and conserved ready for reuse. The old coverslips, together with any labels which may have soaked off, are discarded; care must be exercised to ensure that no important information, given on the old labels, is lost.

The residue should then be transferred to one 15 ml. centrifuge tube and washed thoroughly with hot distilled water. If the original slides were sealed with nail lacquer, then the residue must be washed thoroughly with acetone in order to remove all traces of the sealant. The residue is then ready for either remounting or additional processing.

## Treatment of residues

The investigator, after having examined the original slide preparations, should have an idea of the amount and nature of any subsequent treatment required by the residue.

Very small residues should be treated with a heavy liquid solution (Wilson, 1971) and washed several times with water.

Larger residues should either be filtered through a sintered glass plate (Wilson, 1971) or screened through one or more sieves if these are available (Kidson & Williams, 1969). Acetylation may be used for residues containing an abundance of cellulosic matter. The residues should then be treated with a heavy liquid solution, short-centrifuged (Lennie, 1968) and washed several times with water.

### Increase in Stain

Residues requiring a deep stain should be mixed thoroughly with a few drops of alcoholic safranin solution, then centrifuged and washed several times with water. This process should be repeated at least once. The residue must then be mounted in stained glycerine jelly.

### Decrease in Stain

Safranin-stained residues requiring partial or complete removal of stain should be washed with 20% $HCl$ until the blue colour disappears from the supernatant liquid. The destained residue should be mounted in unstained glycerine jelly if unstained palynomorphs are required or in lightly stained glycerine jelly if a mild stain is required.

## Mounting

A semi-micro pipette is used to transfer 1-3 drops (depending on the required palynomorph concentration) of carefully mixed aqueous residue to the slide (Lennie, 1968). The slide is warmed on a 100°C hotplate until the water has nearly evaporated. A drop of melted glycerine jelly is added and mixed thoroughly with the residue, using a flat-tipped plastic toothpick, and is spread out with the toothpick into a square of approximately 18 x 18 mm.

The slide is then removed from the hotplate and allowed to cool. Before the jelly has completely cooled, a clean 22 x 22 mm. "O" gauge coverslip is placed on the surface and the slide returned briefly to the hotplate, enabling the jelly to migrate to the edges of the coverslip. Sufficient glycerine jelly must be under the coverslip to ensure that the larger palynomorphs, especially certain hystrichospheres, are not crushed by the weight of the coverslip; on the other hand, if too much mountant is used the mount will be too thick, the palynomorphs in different planes, and the slide difficult to examine microscopically.

The slide is left for three hours on a cool horizontal surface, to facilitate hardening of the mountant and to achieve an even spread of the residue. After this period, any residue which may have exuded around the margin of the coverslip is carefully removed with the tip of a clean scalpel and transferred to another slide. The writer has found that, by removing the excess jelly in this manner from 7-10 slides, sufficient residue can be obtained to make another rich slide mount; this is very useful when relatively little residue is available. Finally the margin of the coverslip is cleaned with ethanol, then with acetone, sealed with two coats of nail lacquer, and labelled.

Further details on palynological slide mounting are given by Andersen (1965) and Brown (1960). Methods for the preparation of single-specimen mounts are described by Wilson (1971).

## Acknowledgements

The writer completed this work under the tenure of a New Zealand Public Service Overseas Study Award. Dr. William A.S. Sarjeant kindly read and criticized the manuscript.

## References

ANDERSEN, S.T. 1965. Techniques in Palynology: Mounting Media and Mounting Techniques. In KUMMEL, B. & RAUP, D. (eds.) "Handbook of Paleontological Techniques." San Francisco, Freeman (pp. 587-98).

BROWN, C.A. 1960. Palynological Techniques. Baton Rouge, La.; privately published, 188 pp.

KIDSON, E.J. & WILLIAMS, G.L. 1969. Concentration of palynomorphs by use of sieves. Okla. Geol. Notes, vol. 29, no.5, pp. 117-9.

LENNIE, C.R. 1968. Palynological techniques used in New Zealand. N.Z. Jl. Geol. Geophys., vol. 11, no.5, pp. 1211-21.

WILSON, G.J. 1971. A chemical method for the palynological processing of chalk. Mercian Geologist, vol.4, pp. 29-36.

Graeme J. Wilson, M.Sc., F.G.S.,
Department of Geology,
The University, Nottingham.

Manuscript received 15th September 1971.

# SOME STRATIGRAPHICAL BREAKS IN THE DINANTIAN MASSIF FACIES IN NORTH DERBYSHIRE

by

F. Wolverson Cope

This short article describes some of the stratigraphical breaks in the Dinantian limestones of the Wye Valley area of North Derbyshire, which were demonstrated to members of the East Midlands Geological Society in the course of a field excursion on June 6th, 1970, led by the author. Particular attention is paid to those exposures which have not previously been described in any detail.

Apart from two major lava flows and several tuff bands within the Dibunophyllum zone, and lenses and layers of chert in the higher part of that zone, and some argillaceous shales at the top, the Dinantian sequence is an entirely calcareous one. The exposed sequence, from the lowest beds at Woo Dale, 5 km. (3 miles) to the east of Buxton, to the highest beds in the Headstone railway cutting at Little Longstone, shows a total thickness of about 500 m. (1,600 ft.) (Cope, 1933, p.128). To this can be added almost 300 m. (900 ft.) of limestones, often extensively dolomitized, which were encountered in the Woodale boring (Cope, 1948), and which lie beneath the lowest beds exposed at Woo Dale.

The limestones display a wide range of textural and gross lithological characters from biosparites to calcilutites, as well as of colour. The latter seems to depend very largely upon the amount of carbon present, and insoluble residues show little evidence of the influx of terrigenous material, though fragments of land plants have been found at several horizons. Beds vary in thickness from a few inches, typical of the higher part of the succession to scores of feet especially in the Chee Tor Beds which make up the basal part of the Lower Dibunophyllum zone. Some of these massive beds are of considerable areal extent with little change in thickness. A large part of the massively-bedded limestones consists of small detrital fragments of crinoids and brachiopods denoting widespread but possibly quite gentle current action. Sadler (1964, p.20) has given evidence for the action of more powerful currents in certain areas, at the horizon of the *Davidsonina septosa* band, near the top of the Chee Tor Beds. The thick beds of calcilutite which characterize the upper part of the Woo Dale Beds ($S_2$ zone) appear to be largely chemical precipitates with little or no evidence of current action, though within these beds there are some horizons at which the limestone is roughly laminated, and is full of fragments of a dichotomously-branched plant stem with prominent mid-ribs. At other horizons, there is evidence of deposition under calm and stable conditions so that corals appear to be still in their growth positions.

All the limestones within the sequence appear to have been deposited at depths within which rugose corals could live. In those beds rare in corals, such as the Woo Dale Beds and the thin limestones with chert of the Monsal Dale Beds (higher part of $D_2$ zone), there is positive evidence of extremely shallow-water conditions in the sporadic occurrence of thin layers of coal or coaly shale at a few horizons.

There are some exposures which give evidence of pauses in deposition or rather unusual conditions of deposition, and these are briefly described in stratigraphical order.

## 1. Woo Dale Beds ($S_2$ Zone)

The Woo Dale Beds (formerly Daviesiella Beds) are so named because they crop out in the core of the pericline and are reasonably well exposed near Woo Dale, east of Buxton.

There is a total exposed thickness of about 100 m. (300 ft.). These limestone are mainly well-bedded grey or dark grey microsparites, in which *Davidsonina carbonaria* (M'Coy) has been found in several localities. They are frequently dolomitized especially near the base of the section. The upper part consists of thickly-bedded calcilutites with minor microsparites, carrying the large brachiopod *Daviesiella llangollensis* (Dav.).

The upper part of the Woo Dale Beds is well exposed in the railway cutting on the north side of the Devonshire Arms, a little over a mile east of Buxton. Here, the calcilutites are not as dominant at this horizon as they are, for example, at the confluence of Great Rocks Dale and Wye Dale.

In this exposure (SK 803726), the bedding is highly irregular. One thick bed is loaded with specimens of *D. llangollensis*, some of which give evidence of fracture or abrasion prior to lithification. There is no suggestion of any preferred orientation of the shells in the sediment, which must have been laid down rapidly under turbulent conditions. The upper surface of this bed is irregular, pene-contemporaneously eroded, and is succeeded by wedge-bedded limestones which also contain *D. llangollensis*.

2. Chee Tor Beds ($D_1$ Zone)

The Chee Tor Beds [called the Chee Tor Rock by Sibly (1908) on account of the splendid exposure of these limestones at Chee Tor, 7 km. (4 miles) east of Buxton] show thicknesses between 100 and 130 m. (300-400 ft.). The limestones are almost exclusively sparites and micrites showing a $CaCO_3$ percentage of more than 98, and sometimes as high as 99%. The finest section presently existing is on the west side of Great Rocks Dale in the Tunstead Quarry of Imperial Chemical Industries Ltd. The immensely massive beds in the topmost 65 m (200 ft.) of this group contain four well marked clay bands. The clays are blue to grey in colour when unweathered, and frequently contain disseminated crystals of pyrite. The thickest bed shows almost 0·6 m. (2 ft.) of clay resting upon a highly irregular surface. When such a surface is bared, during quarrying operations, it is seen to contain innumerable potholes into which the clay descends, an appearance which suggests sub-aerial weathering. Whether or not it becomes necessary to postulate uplift prior to the formation of each clay band, such horizons undoubtedly mark major interruptions in the otherwise fairly tranquil deposition of the Chee Tor Beds. Each is a typical disconformity (Cope, 1939, p.61).

3. Miller's Dale Beds ($D_1$ Zone)

The Chee Tor Beds are surmounted, in the full succession, by the Lower Lava Flow of Miller's Dale; this lava can be examined along Miller's Dale near Raven's Tor (SK 150732), and in an easterly direction it is last seen in a small exposure by the mill-leat to the east of Litton Mill. This lava is succeeded by the Miller's Dale Beds which show a thickness of about 40 m. (125 ft.) in Miller's Dale. These beds consist of light-grey limestones frequently shelly and generally thickly-bedded or massive.

In general, the Miller's Dale Beds show evidence of fairly continuous deposition with winnowing of crinoid and brachiopod fragments by current action.

In Blackwell (Sandy) Dale (SK 132727) to the south of Miller's Dale there is a major break in the general parallelism of the beds. The dale has been cut through a large dome-like mass of limestones in which the dips are at considerable variance with those in the succeeding limestones (see Fig.1). The dome-like mass consists of light grey micrite and calcilutite having a discrete upper surface which, by its pitted nature, gives evidence of a certain amount of penecontemporaneous solution. This mass shows a rude but distinct bedding concentric with this upper dome-like surface; the limestones of which it is composed contain productids, some of giganteid type, and scattered corals including *Palaeosmilia murchisoni* (Ed. & H.). The succeeding beds show, adjacent to the northern side of the dome, a dip of about 9°N. There is some wedge-bedding and successive beds show overlapping relationships as they abut against the surface of the dome. They are mainly well-bedded micrites with abundant crinoid ossicles, echinoid plates, and productids. The limestones in the cliffs at the summit of this section dip eastwards at a low angle and, therefore, appear to be horizontal in the illustration. This clearly brings out the tendency for the beds abutting on to the dome to thin gradually as they approach it.

The dome-like mass is interpreted as a patch-reef, and it is evident that it stood up as a discrete mass, and was chemically weathered on the surface, before finally being buried by later deposits.

## 4. The $D_1 - D_2$ Junction

On palaeontological grounds the $D_1 - D_2$ junction in the Miller's Dale area has been placed at the top of the Miller's Dale Beds and base of the succeeding Station Quarry Beds (Cope, 1937, p. 192). This junction coincides with a well-marked disconformity which can be examined in several good exposures.

The fascinating section in the railway cutting just outside the eastern portal of the now abandoned Litton Tunnel (SK 167727) is now readily accessible. A sketch of this exposure made many years ago (Cope, 1933, p. 132) shows a cross-section of a wide channel cut into the upper part of the Miller's Dale Beds; the channel-fill consists of rather dark grey limestones with scattered chert nodules (Station Quarry Beds). The top of the Station Quarry Beds is marked by a thin band of clay which has been proved to be on the horizon of the Upper Miller's Dale Lava (Cope, 1937, p. 185). The base of the chanel-fill is a deposit of pebbles of dark grey limestone in a crumbly, calcareous, and pyritous matrix. The pebbles vary in size up to about 0·01 m. in diameter, and are frequently pyritous. Their form leaves no doubt whatsoever that the limestones from which they were derived were fully lithified at the time, and that they had undergone some transport.

Another good section showing similar erosion phenomena, lies within the goodsyard area of the now abandoned Miller's Dale Station (SK 138732). This exposure, which affords a cross-section of a channel in the upper part of the Miller's Dale Beds has been known for many years, but there does not appear to be any permanent record of it. This is regrettable as the exposure is now largely overgrown with willows, the roots of which have considerably disturbed the soft shaly channel-fill.

Upon entering the former goods-yard, the $D_1 - D_2$ junction is readily visible towards the top of the cliff on the north side. Throughout most of the section the lower Miller's Dale Beds are separated from the Higher Station Quarry Beds by a thin sale parting. About 150 m. east of the road, this shale suddenly expands to fill an erosion hollow, probably a channel, in the Miller's Dale Beds. The cross-section of the channel is like an inverted bell in shape, about 3 m. (9 ft.) in maximum depth, and rather more at the greatest diameter (fig. 2). The basal beds of the Station Quarry Beds thicken and sag slightly over the channel, the result of compaction of the fill. A solitary crushed specimen of *Gigantella* cf. *giganteus* (Martin) was found in the lowest bed. Lying in the bottom of the channel is a waterworn boulder of limestone, lithologically similar to the adjacent light-grey limestones of the Miller's Dale Beds. The greatest diameter of this boulder appears to be about 1·5 m. (4 ft.). Standing on the limestone bed of the channel, this boulder is covered and surrounded by soft grey shale containing a saucer-shaped 0·1 m (4 in.) layer of dark grey micrite with pyrite about 0·6 m (2 ft.) below the base of the Station Quarry Beds. The shale above this limestone layer is blue-grey in colour and is packed with segrations of pyrite cubes and small pebble-like fragments of pyritized dark grey calcilutite; it is almost unfossiliferous. The shale below the limestone band is grey and argillaceous, containing plant remains, fish scales, bivalves, gastropods, and brachiopods. All the fossils are crushed or broken, and it is difficult to retrieve anything more closely determinable from this now weathered and disturbed mass of shale.

There can be little doubt, in the light of these and other exposures, that the area of deposition underwent uplift in late $D_1$/early $D_2$ time, and that the Miller's Dale limestones were channelled by streams which brought in terrigenous material from non-calcareous terrains outside.

## 5. The Upper Miller's Dale Lava Flow

The Upper Lava of the Miller's Dale area attains a maximum thickness of slightly over 30 m. (100 ft.) around Knot Low and on Priestcliffe Lees, in Miller's Dale. It diminishes in thickness in all directions, but most rapidly towards the east and south-east.

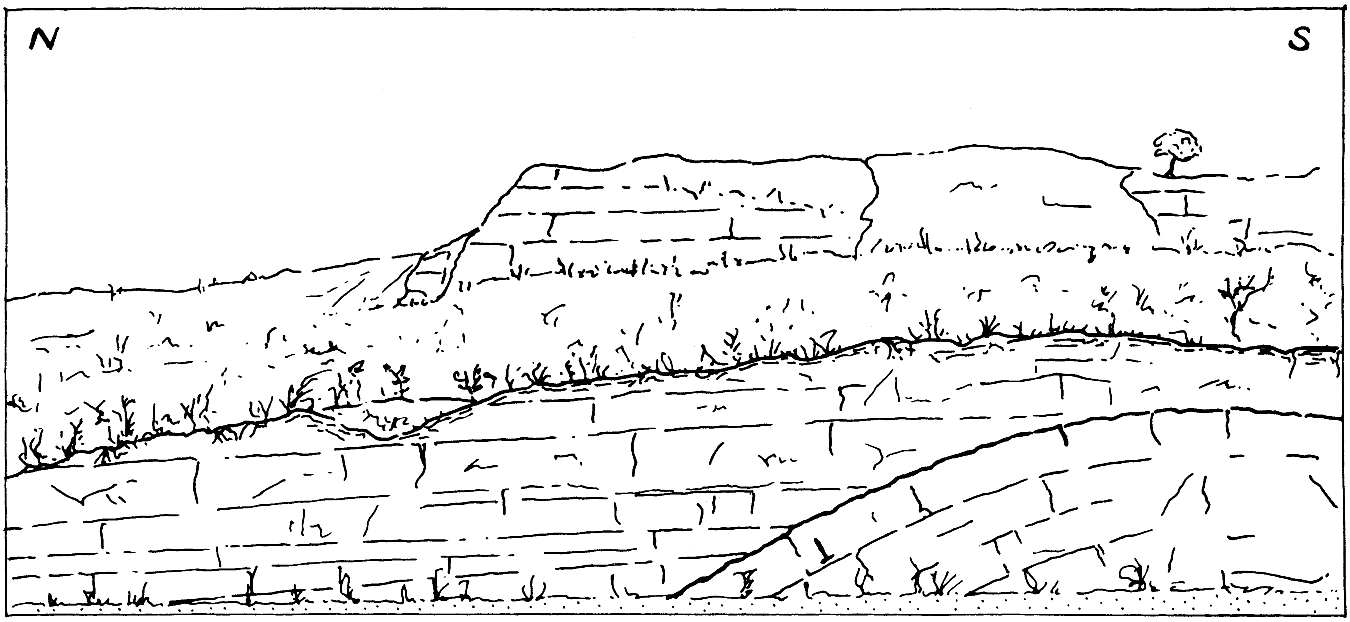



Figure 1. Sketch of roadside section on east side of Blackwell Dale showing patch reef in Miller's Dale Beds (approximate scale noted by hammer on bedding plane in patch reef on right).

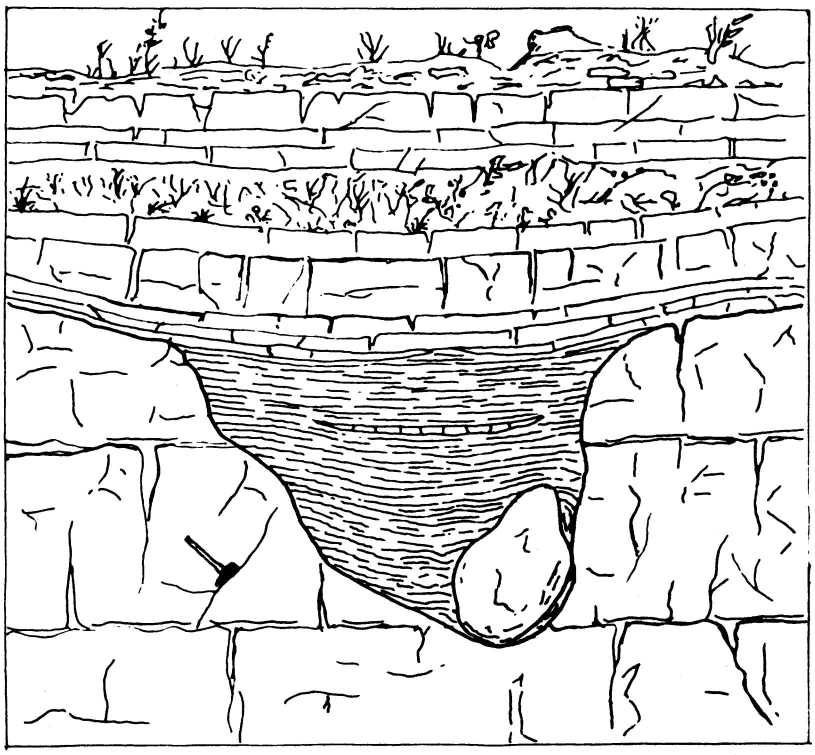


Figure 2. Idealized sketch of exposure showing channel cut in Miller's Dale Beds, Miller's Dale Station Goodsyard (abandoned).

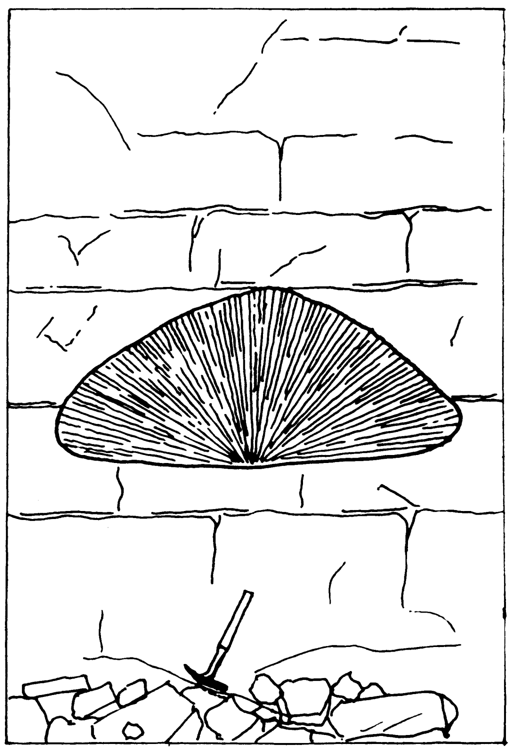


Figure 3. Section through corallum of *Lithostrotion portlocki*, Priestcliffe Beds, Miller's Dale Quarry.

The abandoned railway-cutting south of Tongue End in Miller's Dale shows the flow thinning rapidly to the east (Cope, 1933, p. 137), and at the western portal of Litton Tunnel it has been demonstrated that, beyond the area of its development, the lava is represented by a thin bed of clay, formerly a tuff (Cope, 1937, p.185). The slope of the lava front is surprisingly steep, showing a gradient of about 1 in 3, and in view of the presence of waterworn fragments of basaltic lava in the overlying limestone, immediately adjacent to the lava front, some erosion of the front might be reasonably assumed. In a temporary exposure near Taddington (Cope, 1937, p.187), now no longer available, flow-units in the lava showed a dip of $35^{o}$, and were approximately parallel to the sloping front of the flow where it was dying out. It would seem, therefore, that though erosion of the front of the flow may have occurred such erosion did not necessarily lead to a steepening of the front.

Wherever the front of the flow is visible, as in Miller's Dale, it is noticeable that the succeeding limestones are irregularly bedded, and are banked against the lava front.

It seems highly probable that the flow was extruded into the sea and it may well have been entirely submarine. Certainly, whenever the normal top of the flow is seen it is remarkably smooth suggesting marine planation rather than sub-aerial erosion. Deposition of calcareous sediments does not appear to have been resumed over much of the area of the flow until a considerable thickness had accumulated against the lava front.

6. Priestcliffe Beds ($D_2$ Zone)

The limestones normally succeeding the Upper Lava are the Priestcliffe Beds (Cope, 1933, p.134). They are well exposed in the insecure face of the abandoned Miller's Dale Quarry (SK 142731). A few feet above the lava-limestone junction in this quarry, a complete colony of *Lithostrotion portlocki* Ed. & H., in the growth position is exposed in section. The corallum is 0·75 m. (2 ft. 6 in.) in diameter and shows a maximum height of 0·5 m. (15 in.) (see Fig. 3). A bedding plane in the enclosing limestones makes a trace around the corallum about 0·05 m. (2 in.) above its greatest diameter. The upper surface of the corallum shows no features which might suggest erosion. All the relationships point to rapid sedimentation, with the bedding plane representing a very ephemeral break.

7. White Cliff Coral Band ($D_2$ Zone)

One of the finest sections of the White Cliff Coral Band which lies in the upper Monsal Dale Beds has existed until recently in a small quarry about 140 m. (150 yds.) WSW of the Crossdale Head Mine, on the west side of Castlegate Lane, Great Longstone. This section has now been deteriorating for some years as the quarry is being used for the tipping of rubbish, and it seems likely to become useless for study purposes within the next few years. This coral band shows a lower part with colonial corals such as *Syringopora* sp. and *Lithostrotion junceum* (Flem.), and an upper portion with large clisiophyllid corals. The latter appear to be lying prostrate, giving the appearance of being broken. Closer examination, however, shows that not only is there a distinctly preferred orientation of the simple coralla, but that the latter are bent almost parallel to the substratum, suggesting currents coming from a north-easterly direction. The almost prostrate position of the large coralla seems to indicate a very slow rate of deposition on the surface of the reef.

Professor F.W. Cope, D.Sc., M.I.Min.E., C.Eng., F.G.S.,
Department of Geology,
The University,
Keele,
Staffordshire.

## References


COPE, F.W. 1933. The Lower Carboniferous succession in the Wye Valley Region of North Derbyshire. Journ. Manch. Geol. Assoc., vol. 1, pp. 125-145.

1937. Some features in the $D_1$ - $D_2$ Limestones of the Miller's Dale Region, Derbyshire. Proc. Yorks. Geol. Soc., vol. 23, pp. 178-195.

1939. The Mid-Visean ($S_2$ - $D_1$) succession in North Derbyshire and North-West England. Proc. Yorks. Geol. Soc., vol. 24, pp. 60-66.

1948. Boring at Woo Dale. Abstr. Proc. Geol. Soc. Lond., p. 24.

SADLER, H. 1964. Conditions of sedimentation of the *Cyrtina Septosa* Band in the Lower Carboniferous of Derbyshire. Mercian Geologist, vol. 1, pp. 15-22.

SIBLY, T.F. 1908. The faunal succession in the Carboniferous Limestone (Upper Avonian) of the Midland Area. Quart. Journ. Geol. Soc. Lond., vol. 64, pp. 37-53.


Manuscript received 5th November 1971.

# RATES OF EROSION IN THE CATCHMENT AREA OF CROPSTON RESERVOIR, CHARNWOOD FOREST, LEICESTERSHIRE

by

W.A. Cummins and H.R. Potter

## Summary

The annual load of sediment being transported along Bradgate Brook and deposited in Cropston Reservoir is 7,600 cubic feet ($200\,m^3$). The immediate source of this sediment is stream bank erosion along the course of Bradgate Brook and its tributaries. Measurements along these streams led to an estimate of the total area of stream banks undergoing erosion and, from this, the mean annual rate of recession of all eroding stream banks was calculated and found to be 1.2 inches (30 mm). A special study was made of the large cliff of Keuper Marl in Bradgate Park. Here the mean annual rate of recession was found, by direct measurement, to be 1.0 inches (25 mm).

## Introduction

During a recent study of the sediments in Cropston Reservoir (Cummins and Potter, 1967), it was found that the mean annual rate of erosion of the catchment area was about 7,600 cubic feet ($200\,m^3$). Averaging this loss over the whole area would mean a general lowering of the surface by about 0.0005 inches (0.006mm) per year. In fact, of course, the erosion is not spread equally over the area but, as far as the immediate source of the sediment is concerned, it is localised along the course of Bradgate Brook, the stream supplying the water for the reservoir.

Erosion along Bradgate Brook is lateral and occurs along the banks, generally round the outside of meanders (see Cummins and Rundle, 1969, fig.3). There is no evidence that the bed of the stream is being eroded and the banks are generally low, cut into the alluvial deposits of the flood plain. Exceptionally, the stream cuts into solid rock along the edge of the flood plain.

The investigation of erosion along Bradgate Brook is recorded here in two parts. In the first part, an attempt is made to estimate the rate of erosion of the large cliff of Keuper Marl (SK 532099) situated between the settling ponds and the reservoir in Bradgate Park (Cummins, 1969, fig.1). In the second part an estimate is made of the total area of stream banks undergoing erosion along the streams flowing into the reservoir.

## The Keuper Marl Cliff

The cliff, about 200 feet (60 m) long at the base, has a surface area of about 8,000 square feet ($740\,m^2$). The cliff face is composite and can be divided into several zones composed of different materials, each with a characteristic slope (figs. 1 and 3). These are detailed below, starting at the top of the cliff.

The top soil is somewhat pebbly and forms a small cliff due to the binding action of the overlying turf. The mean slope of this zone is $73^{\circ}$ (range $55^{\circ}$ - $90^{\circ}$).

The weathered Keuper Marl is soft and crumbly, and forms a slope rather than a cliff. The slope may be fairly uniform (*e.g.* fig.1, profiles 7, 12, 15), or it may consist of an upper gentle slope and a lower steeper slope (*e.g.* fig.1, profiles 10, 17, 18). Where the slope is

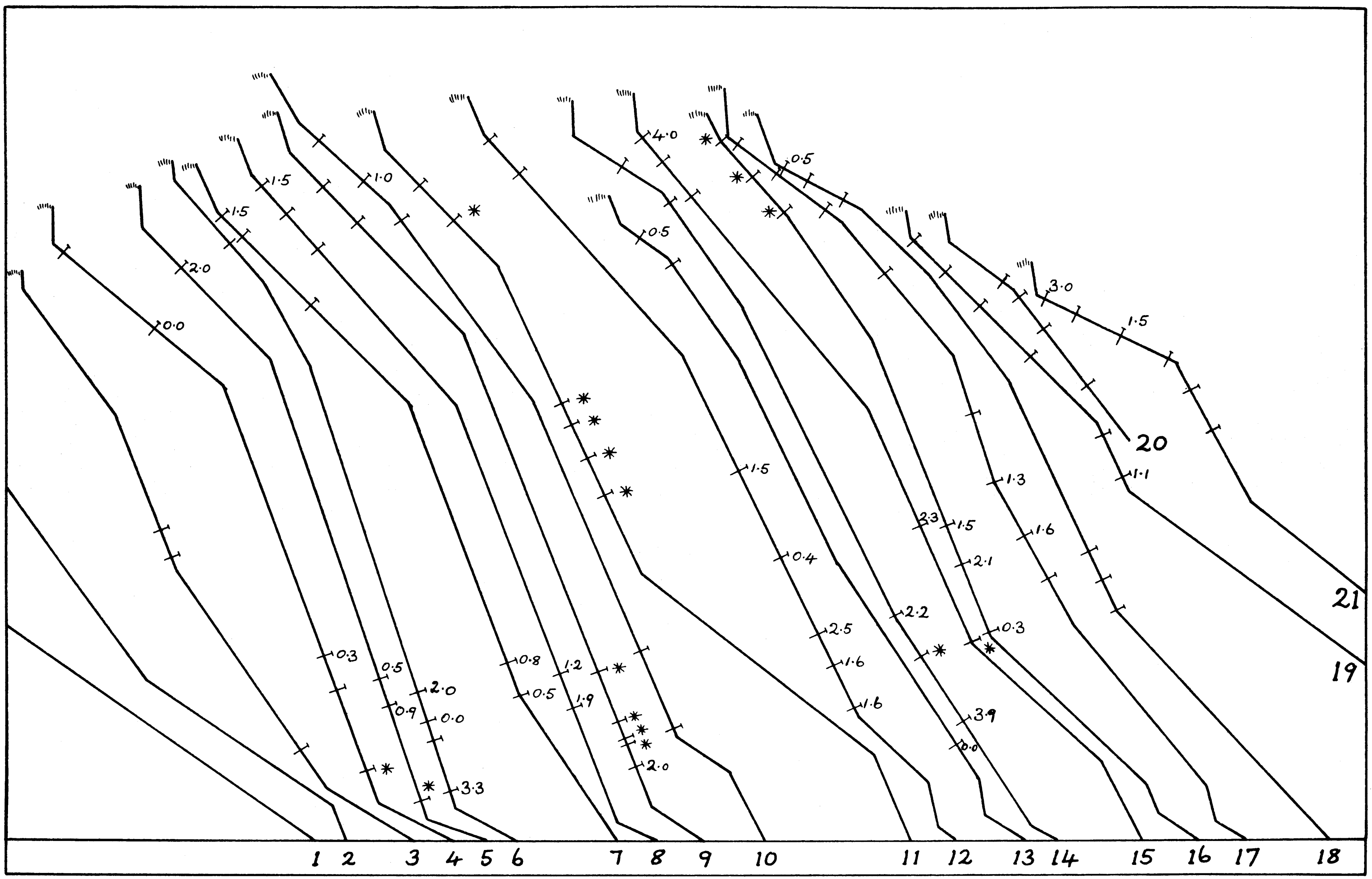



Figure 1. Profiles of the Keuper Marl cliff in Bradgate Park, as measured on the 17th and 19th January 1967 (profile 20 is cut short at the bottom of a gully which runs down the cliff at this point). The profiles are numbered from west to east. The positions of all the nails are shown, together with the measurements (in inches) made on them on the 16th January 1969. Nails lost in areas of obvious recent erosion are marked with an asterisk.

uniform, the mean slope is $46^o$ (range $40^o - 50^o$). Where the break in slope is present, the mean slope above it is $37^o$ (range $26^o - 50^o$) and the mean slope below it is $54\frac{1}{2}$ (range $51^o - 57^o$).

The fresh Keuper Marl forms the main part of the cliff, with a mean slope of $66^o$ (range $58^o - 72^o$).

The scree piled up at the foot of the cliff consists of the accumulated denudation products of the overlying zones. The mean slope of this zone which, unlike the others, has a depositional surface, is $38\frac{1}{2}^o$ (range $25^o - 55^o$).

The scree cliff is the result of stream erosion cutting into the scree deposits during periods of high water. This zone has a mean slope of $68^o$ (range $62^o - 80^o$). A further deposit of scree material may accumulate at the foot of the scree cliff. Examples of the scree cliff, with or without a lower scree deposit, may be seen in profiles 10 to 17 (fig. 1).

The rapid erosion of the cliff is indicated by the lack of perennial vegetation. The surface of the cliff is bare but for a few scattered annual plants such as willow herb. The soft, weathered Keuper Marl is easily eroded and is washed down over the edge of the cliff in little runnels with every shower of rain. The fresh rock below is worn back by alternate wetting and drying, and freezing and thawing. The debris accumulates in the scree at the foot of the cliff. The amount of sediment being removed by stream erosion at low water is negligible and so scree growth continues through most of the year. During floods, however, the stream erodes the scree in vast quantities, sometimes removing it completely and exposing the fresh cliff face.

## The measurements

One method of measuring the rate of erosion of the cliff would be to measure the amount of sediment being carried by the stream above and below the cliff, and take the difference. To do this adequately would have meant setting up automatic sampling apparatus in the stream above and below the cliff. We decided against this method because we felt (from experience in much less accessible sites) that such apparatus in a public park was almost certain to be interfered with.

The other approach is to make direct observations on the cliff itself. The method we finally adopted was suggested to one of us by a student, Miss S. Rutter, during a discussion of the problem in the Geology Department, Nottingham University. In essence, it consists of hammering nails into the cliff face and returning at a later date to measure the length of nail exposed.

On the 17th and 19th January 1967 we measured twenty two profiles of the cliff from stout wooden pegs hammered in at 12 foot (4.2 m) intervals along the cliff top. Along these profiles we hammered in a hundred 6 inch (152 mm) nails, forty eight in the weathered Keuper Marl of the upper (slope) zone of the cliff, and fifty two in the solid rock of the main cliff face. The distribution of these nails (fig.1) was controlled partly by accessibility and partly (on the main cliff face) by the difficulty of finding a place where a nail could be hammered in securely without causing the erosion it was intended to measure.

We had intended to return a year later but, owing to the restrictions on access during the epidemic of foot and mouth disease, we were unable to do this. We therefore postponed our return until two years had elapsed, and made our measurements on the 16th January 1969. By this time, the wooden pegs had long since disappeared, but the holes in which they had stood were easily found. After careful searching, we were able to find and measure only ten out of the forty eight nails in the upper weathered zone, and twenty six out of the original fifty two in the main cliff face. The measurements are shown against the profiles (fig. 1).

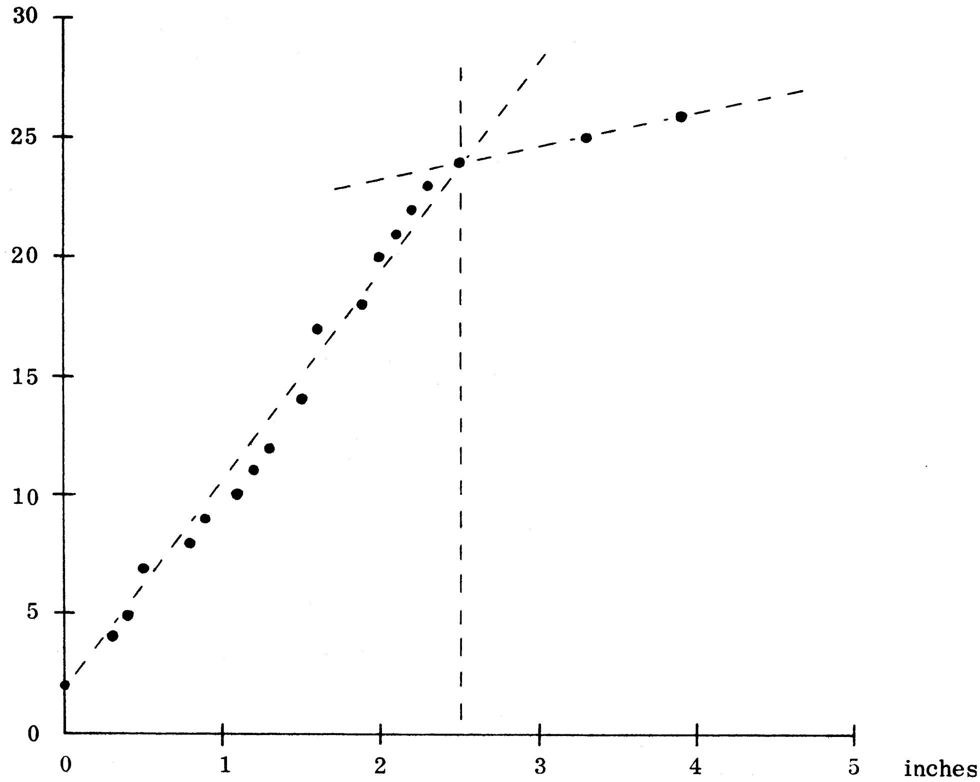



Figure 2. Cumulative curve showing the frequency distribution of exposed lengths of nails in the main cliff zone (see figs. 1 and 3) after two years erosion.

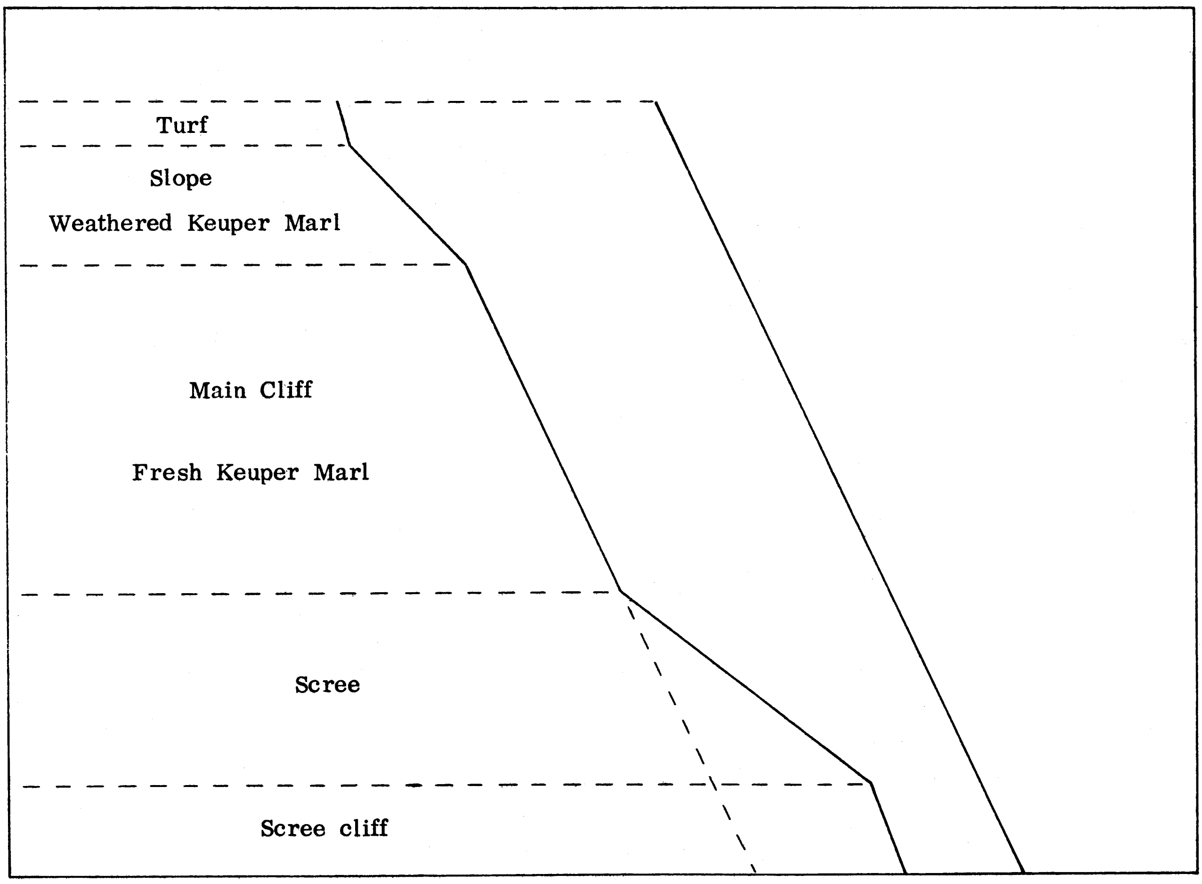



Figure 3. Profile No. 11 of the Keuper Marl cliff (see fig. 1) with the several zones of the cliff named. The model profile, used in calculating the volume of sediment removed from the cliff (p.153), is shown to the right of the measured profile.

## Rate of Erosion

The rate of erosion of the weathered upper zone of the cliff is impossible to determine with any degree of certainty from the results obtained. The mean exposed length of the ten nails measured was 1.55 inches (40 mm), which would represent a rate of erosion of 0.775 inches (20 mm) per annum. Of the remaining thirty eight nails, one was found lying on the surface and three had clearly been washed away in a newly eroded gully. Thirty four, nearly three quarters of the total, could not be accounted for. Some may have been covered by material washed down from above; some may have been washed out of position or disturbed by the deer, which often scramble over this part of the cliff; and some we may simply have failed to re-locate.

In the main cliff of fresh rock, the results were rather better. The mean exposed length of the twenty six nails measured was 1.44 inches (37 mm), which would represent a rate of erosion of 0.72 inches (18.5 mm) per annum. Of the remaining twenty six nails, seventeen were lost in parts of the cliff showing obvious signs of recent erosion. Only nine remain unaccounted for. The frequency distribution of the twenty six measurements from the main cliff have been plotted on a cumulative curve (fig.2). It can be seen from these plots that measurements are evenly distributed through the range 0 to 2.5 inches (63 mm) and that, furthermore, measurements over 2.5 inches (63 mm) are quite exceptional. From these observations it can be inferred that nails with over 2.5 inches exposed by erosion are generally unstable and liable to be loosened and fall out. This provides some basis for assessing the value of the lost nails.

The mean annual rate of erosion of the main cliff can now be calculated on a variety of assumptions about the value of the twenty six lost nails. The first assumption is that the nine nails, which are unaccounted for, would have shown no erosion and the seventeen, lost in areas of new erosion, would have shown between 2.5 inches (63 mm) and 4.0 inches (102 mm) erosion. On this assumption, the mean rate of erosion of the cliff would be 0.89 inches (23 mm) per annum. The second assumption is that all twenty six lost nails would have shown between 2.5 and 4.0 inches erosion. On this assumption, the mean rate of erosion would be 1.17 inches (30 mm) per annum. The third assumption is that all fifty two nails would have shown measurements evenly distributed through the range from 0 to 4.0 inches. On this assumption, the mean rate of erosion would be 1.0 inches (25 mm) per annum. It is of course possible that some of the lost nails would have shown more than 4.0 inches erosion, since this upper limit is merely the greatest measurement made on any of the nails which remained in position. In this case, the mean rate of erosion, on all three assumptions, would be slightly raised.

From the above discussion, a round figure of 1.0 inches (25 mm) would seem to be a fair estimate of the mean annual rate of erosion of the main cliff of fresh Keuper Marl. This, of course, controls the rate of recession of the upper, weathered zone and, thus, the rate of erosion of the whole cliff. For the purpose of calculation, a model cliff is used, which has the height of the real cliff, but the slope of the main cliff zone, uniformly from top to bottom. The mean annual rate of erosion of 1.0 inches for the main cliff zone can be applied to the whole surface of the model cliff, to calculate the volume of material removed annually from the real cliff (fig.3). The annual volume of detritus removed from the cliff is found to be about 560 cubic feet ($15.5\,m^3$). This represents about $7\frac{1}{2}$ percent of the total erosion from the whole catchment area.

## The streams

Bradgate Brook and its trubutaries supply the water (and the sediment) to Cropston Reservoir. The streams are floored with sediment, generally gravel except along the smaller tributaries. There is no evidence of downcutting and the bulk of the stream erosion must therefore be lateral. An attempt is here made to estimate the total area of stream banks undergoing erosion in the catchment area of the reservoir. For this purpose, eroding banks are taken as all steep or vertical, vegetation-free banks, including the parts above as well as

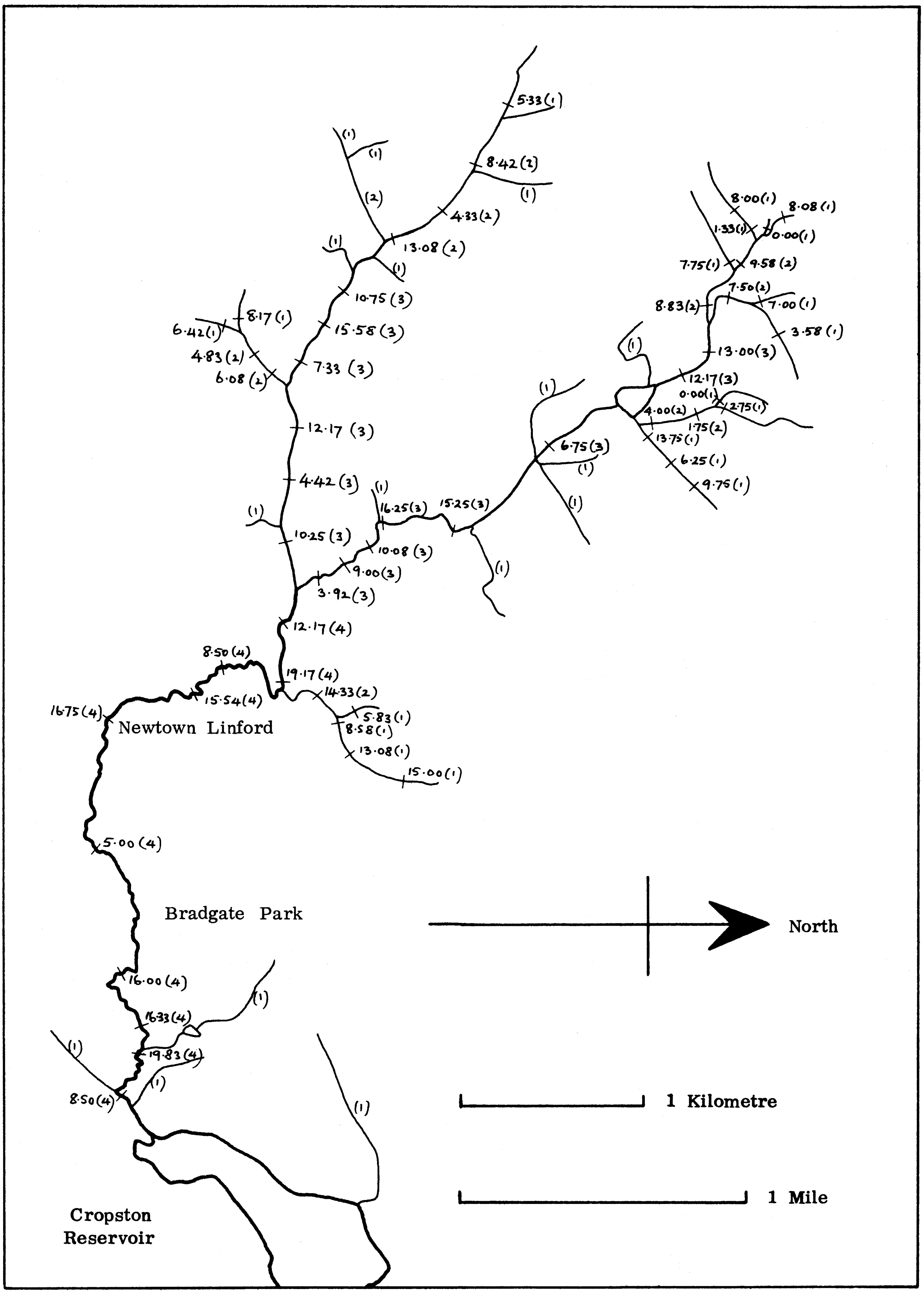



Figure 4. Map of the stream system flowing into Cropston Reservoir. Mean cross sections of erosion (arithmetic) are shown (in inches) for each series of ten cross sections measured. The figures in brackets denote the stream order (Strahler, 1957).

below water level. This definition excludes depositional stream margins, such as point bars of gravel, and all banks protected from erosion by walls, trees, shrubs, reeds, sedges, etc.

At any point along a stream, the cross-section of erosion represents the sum of the heights of eroding banks (and the widths of eroding beds, if any) at that point. The total area of banks (and beds) undergoing erosion in the stream is the product of the stream length and the mean cross section of erosion, which can be determined from a sufficient number of measurements made along the length of the stream. It was felt that the mean cross section of erosion of the main stream might be significantly different from that of the minor tributaries, so Bradgate Brook and its tributaries were classified by stream orders (fig.4), according to the system of Strahler (1957). The main stream flowing into the reservoir is a 4th. order stream and is 3½ miles (5.6 km) long. The two 3rd. order branches have a total length of 3½ miles (5.6 km), and there are 2½ miles (4 km) of 2nd. order streams and 8 miles (13 km) of 1st. order streams in the catchment area.

## The measurements

The measurements were made in the following manner. First, a point on the stream was selected and marked on the six inch map. The banks at this point were examined and the observations recorded in a field note book. If a bank was eroding, its height was measured and noted. If a bank was not eroding, a note was made of the nature of the stream margin. The width of the stream was also recorded. Similar observations were made at another point, ten paces from the first, and at another, ten paces from the second, and so on, until a series of ten cross sections of erosion had been recorded. Thus, while there may have been a subjective element in the choice of the first point (ease of access, quality of the banks, etc.), this was certainly not true of the other nine points at which measurements were made. Cross sections of erosion were measured in similar series of ten throughout the catchment area of Cropston Reservoir, and the mean cross section of erosion for each series is shown on a map of the area (fig.4).

The results of these measurements are shown in Table 1. As expected, there is a relationship between stream order and erosion. Higher order streams have a greater mean cross section of erosion than lower order streams. In detail however, the figures for the first order streams are rather anomalous. The percentage of the measured sections showing some erosion is significantly higher for first order streams than for second order streams; thus, in spite of the fact that the mean of the eroding cross sections is smaller for first order streams, there is very little difference between the mean cross sections of erosion (taking account of all sections, whether eroding or not) of the first and second order streams.

The reason for this anomaly is that many of the first order streams are artificially cut and maintained field drainage channels. Such streams might have been unable to cut their own channels and, if the present artificial cuts were not maintained, would choke with vegetation and the adjacent fields would revert to marshland. The fact that these ditches retain their straight courses shows that lateral erosion can not be rapid. On the other hand, the freshly cut sides of such ditches are probably more easily eroded than the natural stream margins would have been and they have therefore been measured as eroding banks, unless overgrown. This study is concerned with the streams as they are now and not as they might have been in the absence of human interference.

The total area of eroding stream banks in the catchment area of Cropston Reservoir (see Table 1) is found to be about 71,000 square feet (6,600 $m^2$). The mean annual rate of erosion of the catchment area is 7,600 cubic feet (200 $m^3$), of which 560 cubic feet (15.5 $m^3$) are supplied by the Keuper Marl cliff (p.153). If the remaining 7,040 cubic feet (184.5 $m^3$) are eroded from the stream banks, then the mean rate of erosion of these banks is 1.2 inches (30 mm) per annum. The actual rate of erosion is likely to be considerably greater for the higher order streams than for the lower order streams, but it is none-the-less interesting that the mean rate of stream bank erosion is of the same order as the rate of erosion of the Keuper Marl cliff (p.153).

Table 1. Data for calculation of area of eroding stream banks

| Stream order | 4th | 3rd | 2nd | 1st |
|---|---|---|---|---|
| Number of sections measured | 100 | 140 | 110 | 190 |
| Percentage of banks eroding | 43 | 44 | 36 | 44 |
| Percentage of sections eroding | 68 | 73 | 56 | 64 |
| Arithmetic mean cross section of erosion, in inches (eroding sections only). | 24.14 | 17.65 | 16.74 | 13.35 |
| Standard deviation | 13.78 | 9.15 | 10.12 | 7.64 |
| Mean of log. distribution of cross sections of erosion, in inches (eroding sections only). | 19.34 | 15.23 | 13.98 | 11.26 |
| Standard deviation | 2.08 | 1.76 | 1.85 | 1.85 |
| Mean cross section of erosion, in inches (all sections). | 13.09 | 11.20 | 7.88 | 7.17 |
| Length of streams, in miles. | 3.5 | 3.5 | 2.5 | 8.0 |
| Area of bank erosion, in square miles (to nearest thousand). | 20,000 | 17,000 | 9,000 | 25,000 |

Notes on Table 1.

1. The percentage of sections showing some erosion is roughly fifty percent greater than the percentage of banks (two per section) eroding. The reason is that the number of sections showing no erosion on either side is about double the number with both banks eroding.

2. The arithmetic mean is a poor average value (large standard deviation), due to the strong positive skewness of the data distribution. A logarithmic transformation of the data resulted in a more nearly normal distribution and a mean which gives a much better average value (smaller standard deviation). This (geometric) mean is used to find the mean cross section of erosion of all sections (including those showing no erosion) and, from this, the area of stream banks undergoing erosion.

## Conclusions

1. The mean annual rate of recession of the Keuper Marl cliff (SK 532099) in Bradgate Park is 1.0 inches (25 mm). This figure is based on direct measurement.

2. The mean annual rate of recession of all stream banks undergoing erosion in the catchment area of Cropston Reservoir is 1.2 inches (30 mm). This figure depends on a knowledge of the annual rate of sedimentation in the reservoir and on measurements leading to an estimate of the total area of stream banks undergoing erosion.

## Acknowledgements

We are grateful to Dr. P.K. Harvey and Mr. M.E. Badley of the Geology Department, Nottingham University, for their help with the analysis of the data summarised in Table 1, and to Mr. M. Harrison, Deputy Ranger of Bradgate Park for granting us permission to work in this area.

W.A. Cummins, B.Sc., Ph.D., F.G.S.,
Department of Geology,
The University,
Nottingham.

H.R. Potter,
Hydrologist,
Water Resources Section,
Trent River Authority,
West Bridgford,
Notts.

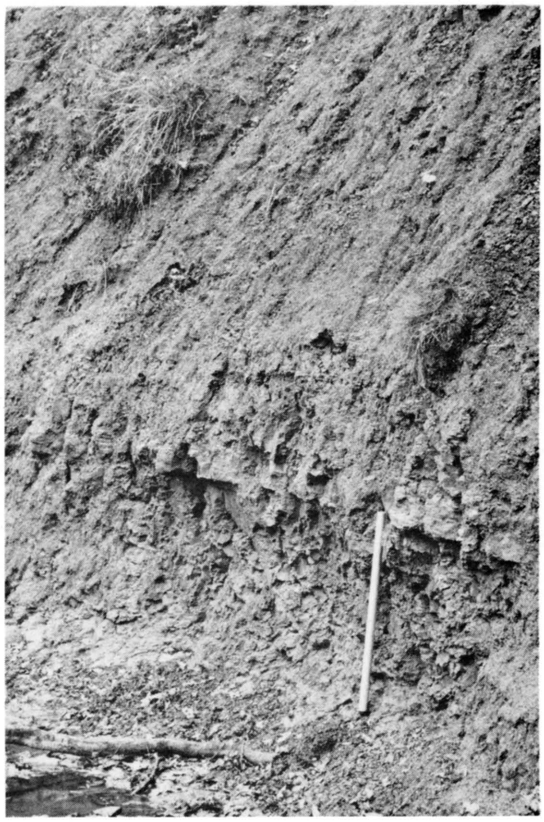
## References

CUMMINS, W.A. 1969. Keuper Marl detritus in the bed load of Bradgate Brook, Charnwood Forest, Leicestershire. Mercian Geologist, Vol.3, pp.39-49.

CUMMINS, W.A. and POTTER, H.R. 1967. Rate of sedimentation in Cropston Reservoir, Charnwood Forest, Leicestershire. Mercian Geologist, Vol.2, pp.31-39.

CUMMINS, W.A. and RUNDLE, A.J. 1969. The geological environment of the dug-out canoes from Holme Pierrepont, Nottinghamshire. Mercian Geologist, Vol.3, pp.177-188.

STRAHLER, A.N. 1957. Quantitative analysis of watershed geomorphology. Trans. Amer. Geophys. Union, Vol.38, pp.913-920.



**Top**: General view of the Keuper Marl cliff in Bradgate Park, as seen from the north. The main cliff of fresh Keuper Marl is slightly darker than the weathered zone above.

**Lower left**: The cliff face. The prominent drag marks are caused by masses of wet sediment and turf sliding down the cliff face. Note the detached masses of turf near the top of the cliff. The scree at the foot of the cliff has been entirely removed by recent erosion.

**Lower right**: Close up of the base of the cliff. The erosion which removed the scree has also cut back into the solid rock, forming a new, nearly vertical cliff at the base of the main cliff. Note the material beginning to accumulate at the foot of this new cliff. Note also the masses of turf (with grass), which have slid down the cliff but not quite reached the bottom. The metal rod is 2 feet (31 cm) long.

Photos by Mr. D. Jones, 11th November 1971

# THE MIDDLE JURASSIC OF NORTHAMPTONSHIRE

Leader: Mr. P.A. Pittham — Sunday, 5th July 1970

During this excursion, about 40 members and friends visited three localities around Northampton and examined exposures of Inferior Oolite and Great Oolite strata. The party assembled at Cranford St. John, on the main Kettering to Thrapston road at 11.00 a.m. and set off for the first locality on the north side of the village.

Locality 1. Cranford North Ironstone Pit (SP 9377).

This is an abandoned ironstone pit on the north side of the Cranford Brook valley. The exposure of the Middle Jurassic strata is in the north face overlooking the last gullet and spoil heaps. The overburden above the Northampton Sand Ironstone is about 60 ft thick. The strata exposed are as follows:-

| | |
|---|---|
| **Superficial Deposits** | |
| Chalky-Jurassic boulder clay. Variable thickness with thin overlying soil. | up to 8 ft. |
| **Solid Formations** | |
| Jurassic | |
| Great Oolite (Blisworth) Limestone. Well bedded mainly bioclastic limestone, with thin marls and clays. Fossiliferous. | 17 ft. |
| Upper Estuarine Series. Vari-coloured silts and clays with fossiliferous limestone and shelly marls in the middle of the sequence. | 22 ft. |
| Lower Estuarine Series. Variable silts clays and ganisters. | 15 ft. |
| Northampton Sand Ironstones. Oolitic siderite mudstone overlying oolitic ironstone with shelly bands (base not exposed). | 19 ft. |

A view of the gullet from the top of the spoil showed that only the Ironstone at the bottom of the workings and the Great Oolite Limestone at the top of the overburden were well-exposed. The estuarine beds were largely covered by slumped material. The well-weathered, oxidised, box-ironstone face was examined. Fossils collected from the ironstone included casts and moulds of bivalves (*Liostrea* sp., *Pholadomya* sp., and *Trigonia* sp.).

Climbing from the top of the ironstone over the slumped debris, members of the party were able to pick up a wide range of fossils from the Great Oolite Limestone and the estuarine beds. Examination of the Limestone outcrop yielded many fossils including brachiopods (*Kallirhynchia sharpi*, *Digonella digonoides* and *Avonothyris cranfordensis*), bivalves (*Modiolus* sps., *Liostrea hebridica*, *Pholadomya* sps., *Anisocardia* sp.,), corals (*Chomatoseris* sp.), and echinoids (*Acrosalenia* sp., *Holectypus* sp., and *Nucleolites* sp.). Variations in lithology of the Limestone were pointed out and specimens of crystalline bioclastic limestones and pseudo-oolitic limestones were collected.

The party left the quarry at about 12.30 p.m. and travelled by coach and car, via. Finedon and Wellingborough, towards Northampton. En route several abandoned ironstone quarries were seen from the road and printed notes issued to members of the party described these and other features of geological interest. Lunch was taken at the World's End Inn at Ecton, on the Northampton to Wellingborough road. The journey then continued via Northampton to Blisworth (SP 7153).

Locality 2. Blisworth Rectory Farm quarry (SP 715530)

This small quarry exposes the Great Oolite Limestone, which here is very fossiliferous. A complete section for this quarry is given by Torrens (1967, p.68).

Members of the party heard a brief explanation of the main features of the Limestone exposed and then examined the strata. From the floor of the quarry were collected specimens of *Kallirhynchia sharpi*, indicating the presence of the basal beds of the Limestone. The fissile detrital - shell limestones from the middle of the formation yielded *Digonella digonoides* in situ and ripple marks were observed on the bedding planes. The Coral-Brachiopod Bed, a rubbly limestone, contained large blocks with corals (*Isastraea* sp. and *Calamophyllia radiata*) and *Avonothyris cranfordensis*. Also found were specimens of bivalves including *Lima* (*Plagiostoma*) sp., *Pinna* (*Stegoconcha*) *ampla* and *Modiolus* sp. One broken specimen of the nautiloid, *Procymatoceras* sp. was collected.

The journey from Blisworth to Paulerspury passed through Towcester and the party arrived at the final locality at about 3.30 p.m.

Locality 3. Paulerspury Pury End quarry (SP 707459)

Here members of the party saw exposure of the Great Oolite Limestone from the basal *Kallirhynchia sharpi* Beds to the contact with the overlying Blisworth Clay. The abundance of the rhynchonellid, *K. sharpi* allowed members to collect a large number of specimens. Other fossils collected included echinoids (*Acrosalenia* sp. and *Holectypus* sp.), crinoid stem ossicles (*Isocrinus* sp) and gastropod and bivalve casts. The excursion finished at this locality and members left by coach and car at about 4.30 p.m. to return north via. the M1.

## References


TORRENS, H.S. 1967. The Great Oolite Limestone of the Midlands. Trans. Leics. Lit. Phil. Soc. Vol. 61, pp. 65-90.

## REVIEWS

J.F. KIRKALDY 1971: *The study of fossils*. Revised edition. London: Hutchinson Educational. 116 pp., 58 text-figs. £0.90.

F.A. MIDDLEMISS 1971: *A guide to invertebrate fossils*. Revised edition. London: Hutchinson Educational. 128 pp., 27 text-figs. £1.05.

RHONA M. BLACK 1970: *The elements of palaeontology*. Cambridge: University Press. 339 pp., 201 text-figs. Paperback, £2.25 (also available in cloth).

D.M. RAUP and S.M. STANLEY 1971: *Principles of paleontology*. San Francisco: Freeman. 388 pp., many illus. (numbered by chapter). £4.80.

For many decades, the palaeontologist has been ill served by textbooks: publishers have been reluctant to sponsor new works and outdated or unsuitable works have run through edition after edition, simply because no more palatable alternatives were available. At long last, the situation is changing. This is partly the result of a growing public interest in the general field of geology, but a much bigger initial factor has been the demonstration by Pergamon Press and Elsevier that there is always a reading public for scientific texts, however esoteric the subject, and that, if the price were scaled correctly, the publisher could scarcely fail to profit.

A second phase has now begun with the publication of series of inexpensive works, restricted in length and illustrated by line drawings rather than photographs. These series are aimed partly at students, partly at scientists who wish to learn something of a field outside their own specialism, partly at an amateur readership. The price is pitched generally lower than £2.00, to encourage purchase on the spur of the moment by the casual bookshop browser. The first two works here reviewed, and two more specialised books treated in the review which follows, exemplify this newer trend. The result of these two phases of publishing activity is that at long last the palaeontologist (professional or amateur, specialist or student) can find on the booksellers' shelves something designed to suit his particular needs - a happy reversal of his earlier position.

Kirkaldy's book, originally published in 1963 and now fully revised, is intended to introduce fossils to the biologist; however, it is equally suitable as a first text on palaeontology for schools or Adult Education courses or as a stimulus to a casual interest in the subject. The author's style is relaxed and lucid, refreshingly free from ambiguities of meaning and multi-claused sentences: the illustrations integrate well with the text. The presentation is straight-foward and sensible. After two chapters sketching in the geological background, the nature of fossils and their mode of preservation is summarised and a brief account is given of the succession of life through time, representatives of most major fossil groups being figured. It is good to see the inclusion of a brief treatment of micropalaeontology and palynology, though the author should remember that the latter topic covers a variety of other groups (chitinozoa, dinoflagellates, acritarchs, etc.) as well as spores and pollen. The treatment of trace fossils is unduly brief, in view of their importance, and a section on the collecting of fossils might have been helpful: but limitations on space probably precluded such additions.

A few errors may be noted. "Scolecodont" is mis-spelled in the caption to Fig. 11: and Fig. 11H seems to be a Tintinnid, not a radiolarian. Dr. Machin's illustrations are so economical in shading and detail as to be occasionally misleading; for example, the dentition in *Glycimeris* (Fig. 36B) is shown wrongly. On p. 30 it is stated that "in a few cases, complete carcasses of mammoths have been found" : the number of authenticated finds in fact approaches 30! The dismissal of d'Orbigny as a "catastrophist" (p.67) oversimplifies his attitude. These points are all minor : in general, Prof. Kirkaldy has admirably fulfilled his aims.

Less satisfactory is the companion volume by Middlemiss, in which more is attempted and less attained. To review the whole field of invertebrate palaeontology in a mere 128 pages, including illustrations, must clearly involve a great deal of selection and the author merits a great deal of sympathy in his attempt: even so, the virtual omission of the stromatoporoids and the complete omission of any treatment of such important groups as the blastoids, archaeocyathids and especially the ostracods is hard to excuse. The statement of page 51 that the brachiopods are "the largest and in many ways the most important of all the major groups of fossil animals" is downright astonishing! On page 18, the hystrichospheres are distinguished from, and stated to be of greater geological importance than, the dinoflagellates: however, it has been known for ten years now that the true hystrichospheres are in fact cysts of dinoflagellates and that the latter are of great stratigraphical importance in Mesozoic and later rocks, as are earlier forms once called "hystrichospheres", now designated acritarchs, in the Palaeozoic and late Pre-Cambrian. In the review of the arthropods (pp.101-103) the existence of such other fossil groups as the phyllocarids, brachiopods, and ostracods is not even mentioned: the implication (p.102) that king-crabs have no fossil history is presumably inadvertent.

The illustrations are attractively presented, but do not repay close study: their captioning also requires a drastic overhaul. To illustrate this, let us consider the illustrations of the bivalves (Figs. 14 to 17). The outline of *Arctica islandica* (Fig. 14) is incorrect. The *Nucula* illustrated in Fig.15 is not recognisably *N. similis* and the resilifer cannot be seen in this illustration or that of *Ostraea edulis*. The two illustrations of *Trigonia* (Fig. 16) both appear to represent broken specimens (why?) and their generic assignation is questionable: the excellently drawn "*Pteria*" is in fact an *Oxytoma*. In Fig.16, the *Arca* is excellently drawn whereas the *Carbonicola* is scarcely recognisable as such and the supposed "*Pholas*" is actually *Barnea candida*.

The text is clearly written and laid out: essential terminology is summarised; the reviews of the geologic range and importance of the groups are useful. However, I feel that the systematic errors will need to be eliminated and the illustrations revised before this work can be considered a satisfactory reference for the amateur geologists, school and first-year students for whom it was written.

No comparable major criticisms can be levelled at Rhona Black's *Elements of Palaeontology*, which treats at a more extended length with an even wider field. The illustrations are consistently of high quality - figures crisply drawn and clearly labelled, photographs excellently taken and reproduced very well, including four fine colour photographs. I noted no systematic errors in captions or text. However, there are a few faults in presentation: chapter 16 "Microfossils" is misleadingly titled, since it effectively deals only with foraminifera and conodonts, reference to other groups of microfossils being scattered through several other chapters. (Incidentally, there is no mention of the fossil dinoflagellate cysts, despite their stratigraphic importance). Trace fossils again receive too little attention. The author clearly saw no need to deviate from the tried and tested layout adopted in so many earlier works: originality of approach is perhaps difficult to attain in a systematic survey such as this. She has produced, in consequence, a worthy and useful work, precisely in the main stream of palaeontological texts for University and College students and enthusiastic amateurs, all of whom will find it a useful acquisition.

In complete contrast is Raup and Stanley's *Principles of paleontology*, whose authors have perceived the need for a complete rethinking of the method of textbook writing for palaeontologists to incorporate the wealth of new approaches now opening to the student of fossils. Their cover, an analog-computer simulation of the shell form of a gastropod, sets the tone for one of the most refreshing and stimulating palaeontological texts yet written.

The work is designed for use as a basic text in University teaching, though all palaeontologists of whatever level of attainment are likely to find something of value. It is divided into two parts: "Description and classification of fossils" and "The uses of paleontologic data". Early in the work, the scale of the problem facing the palaeontologist is made clear: given that there are around 4,500,000 living species, it is possible to calculate that there must have been around 982,000,000 species in existence in the 600 million years since the beginning of the Cambrian and, whilst many of these are of course not capable of fossilisation, it has been computed that, there have been at least 10,000,000 species of preservable, marine organisms alone.... No wonder palaeontology is often considered a science of names; no wonder so many students plump for the softer options of petrology, geophysics, etcetera.....

Having stated the problem, the authors detail the approaches adopted - the description of single specimens and of fossil populations; the characters used in identifying species; the methods of assessing ontogenetic variation and variation within populations, as a consequence of environmental controls and evolution (acting separately or together); the methods of taxonomy, the science of classification. Then, having explained how the data is assembled and classified they proceed to show how it is used, in assessing adaptation and functional morphology, in determining past environments, in demonstrating the course of evolution, in the relative and (to a restricted extent) in the absolute dating of rocks, in determining the degree of rock deformation during earth movements, and as an index to the composition of past seas.

Their deduction that the occurrence of vertebrate footprints in rocks from which no fossil bones have been recovered means that "tracks could be preserved but not skeletons" (p.6) is unjustified. A single living animal can produce, during its life, many thousands of tracks and there is a greater probability that some of these tracks should be preserved then that the single skeleton should survive. Their claim (pp.39-40) that the word "small" is meaningful in taxonomic descriptions is slightly overstated: despite their defence, such terms remain inexact in absence of further quantification, even when applied within restricted groups. A much greater fault - and a familiar one in texts produced by palaeozoologists - is that they make no mention, in the section on taxonomy, of the *International Code of Botanical Nomenclature* and seem unaware of its provisions, profoundly different in some respects from the zoological *Code* and much more adjusted to the needs of the palaeontologist.

They do not attempt the task which Rhona Black set herself, of describing the major groups of fossils, outlining their history and summarizing the morphological terminology applied to each. Indeed, these two books complement one another and together provide an epitome of the science of palaeontology as it is at present.

William A.S. Sarjeant.

J.S. RYLAND 1970: *Bryozoans*. London: Hutchinson University Library. 175 pp., 21 text-figs. £0.70.

M.J.S. RUDWICK 1970: *Living and fossil Brachiopods*. London; Hutchinson University Library. 199 pp., 99 text-figs. £0.80.

These two works form part of an attractively produced, and very moderately priced, series of textbooks, intended for biologists but in some instances of equal interest to palaeontologists. The series is edited by Professor A.J. Cain, of the University of Liverpool. The bindings are all attractive, the type-face pleasant to read, and the illustrations uniformly clear and well-labelled.

The first of the books, written by a zoologist, will only appeal to palaeontologists with a strong interest in living forms. Two chapters only (6 and 7) are of specific geological interest. The author adopts the current view, still disputed by many specialists, that the Entoprocta are unrelated to the bryozoans. In chapter 4, he gives an interesting account of the ecology of the Gymnolaemata and, on p. 67, lists the bathymetric distribution of colonial forms in present marine environments: unfortunately, very little is said about the palaeoecology of fossil bryozoa, despite the considerable amount of work done on this topic. (Some of the major works are listed, however). Some terms are defined inadequately (*e.g.* "reteparine", p.67: "lunulitiform", p.68): some references are incompletely cited: but in general, the text is explicit and most points are dealt with clearly. This book must be welcomed as the first inexpensive text on a group strangely neglected in geology courses, despite their wide distribution and stratigraphical importance; at the same time, its palaeontological shortcomings must be lamented.

Since the number of living genera of brachiopods is insignificant in comparison to their fossil representation, it is entirely proper that the second work should be written by a palaeontologist. Professor Rudwick acknowledges, in his introduction, his indebtedness to the *Treatise of Invertebrate Palaeontology*, Part H, *Brachiopoda*, a work to which he himself contributed This indeed was epochal in the study of this group, since it brought the first semblance of order into a prevailing situation of taxonomic chaos and also stimulated research on living forms by such palaeontologists as Alwyn Williams of Belfast and Albert J. Rowell, then of the University of

Nottingham. It is greatly to the credit of Professor Rudwick that he has written a thoughtful and original work on the brachiopods, instead of merely producing a potted extract from the *Treatise*. In particular, he has developed interestingly a number of themes concerning physiology and ecology - the senses of brachiopods, the ways in which they protect themselves, the modifications of the structure of the lophophore through time and the feeding habits to which these correspond, the relation of the brachiopod to its substrate - which well demonstrate how the palaeontologist can help the zoologist, and vice versa. This is an admirable work and can be recommended without qualification: it is to be hoped that similar works on other groups will follow in this series.

Leslie A. Riley and William A.S. Sarjeant.

J. CHALLINOR 1971: *The history of British geology. A bibliographical study.* Newton Abbot, Devon: David and Charles. 224 pp. £3.50.

Distinguished historians of geology are fairly rare birds; bibliographers are almost equally uncommon elements of the geological fauna and even more rarely distinguished. One of the very few who can claim to be distinguished both as geological historian and bibliographer is Mr. John Challinor, now in what is proving a very active retirement from the Senior Lectureship in Geology in the University of Wales, Aberystwyth. His publications include a series of bibliographies of Staffordshire geology, the familiar and useful *Dictionary of Geology*, and historical works: some of local Midlands interest, such as "Dr. Plot and Staffordshire geology" and "From Whitehurst's 'Inquiry' to Farey's 'Derbyshire': a chapter in the history of English geology" (*Transactions of the North Staffordshire Field Club*, 1944-45 and 1946-47), some of national interest, such as "The progress of British geology during the early part of the 19th Century" (*Annals of Science*, vol.26, 1970). It is an honour to our Society that he should be one of its Honorary Members.

The book here reviewed is clearly destined to become a basic tool for future geological historians. Pride of place is given to a chronological listing of primary literature. This begins with the earliest recorded observation on British stratigraphy, by John Leland (c.1538) and includes George Owen's manuscript account (1603) of the outcrop of the Carboniferous Limestone in South Wales. The familiar roster of papers by the "giants of geology", from Hutton through to Lyell, are all included: whilst the author concentrates on works of specifically British interest, he also lists some that were seminal in geological thinking without being directly relevant, *e.g.* Darwin's *Origin of Species* (1859). As he progresses through the later nineteenth century towards the present (the latest items included date from 1969), the author has had to decide what should be included from among an increasing flood of literature. His choice inevitably cannot include all works which any particular reader personally considers important (for my own part, I regret the omission of Arkell's "Standard of the European Jurassic", *Bull. Geol. Soc. Amer.* 1945, one of the most important of all contributions to stratigraphical thinking). The increasing emphasis on books in the period from 1955 onwards is surely undesirable, since books tend increasingly to lag far behind research and now rarely contain any truly original work. However, it is unfair to extend such criticisms. Many scientific historians seem to consider the minimum "safe distance" to be about a century of scientific development - their excuse, the need to attain "true perspective"; their real reason, I suspect, a desire to avoid controversy or the danger of making a false judgement. Mr. Challinor is to be congratulated for venturing so far beyond this boundary; his doing so may instil a greater courage of opinion into future geological historians....

Following the bibliography, there is an extremely interesting discussion of the major themes treated, in which the original authors are directly quoted wherever appropriate. Supplementary references (papers commenting on, or enlarging themes treated in, the papers in the main list, plus historical or bibliographical works) are also listed. Here again, there is (inevitably?) some element of selection : A bibliography of works on the history of geology, currently being prepared by my wife and myself, may ultimately supplement this.

The binding and dust-wrapper are attractively designed, the type-face readable, the price rather high but not impossibly so. Strongly recommended.

William A.S. Sarjeant.

## THE MERCIAN GEOLOGIST

### Journal of the East Midlands Geological Society

The journal first appeared in December, 1964. The following numbers have since been published:-

| | | |
|---|---|---|
| Vol. 1 | No. 1 | December 1964 |
| Vol. 1 | No. 2 | June 1965 |
| Vol. 1 | No. 3 | January 1966 |
| Vol. 1 | No. 4 | September 1966 |
| Vol. 2 | No. 1 | January 1967 |
| Vol. 2 | No. 2 | June 1967 |
| Vol. 2 | No. 3 | December 1967 |
| Vol. 2 | No. 4 | August 1968 |
| Vol. 3 | No. 1 | January 1969 |
| Vol. 3 | No. 2 | August 1969 |
| Vol. 3 | No. 3 | March 1970 |
| Vol. 3 | No. 4 | September 1970 |
| Vol. 4 | No. 1 | October 1971 |

The journal deals especially with the geology of the Midlands of England, but other articles have been accepted which are of current interest to geology generally. Manuscripts should follow the format of papers included in this number of the Journal and be sent to The Editor, "Mercian Geologist", Dept. of Geology, The University, Nottingham NG7 2RD. Please contact the Editor during MSS preparation if in any difficulties.

In Vol. 1, there are 25 original articles, 5 general papers, 2 Presidential addresses, 10 excursion reports and a number of book reviews. It comprises 383 pages, 24 plates, numerous text figures, an index, title page and cumulative contents list.

Vol. 2, has a similar content, except that the second number of this volume was devoted to a bibliography of the geology of the Peak District of Derbyshire compiled by Dr. T.D. Ford and Dr. M.H. Mason. It contains 450 pages and 25 plates.

Vol. 3, was completed in September 1970. It contains 26 original articles as well as excursion reports and reviews. There are 434 pages in the volume and 33 plates. Readers will note the change of size with the commencement of volume 4, to A4.

All parts of the journal, are available. It may be obtained by membership of the Society and by subscription as indicated below:-

| | | | |
|---|---|---|---|
| Ordinary Membership | £2.00 | (commencing | 1972) |
| Institutional Membership | £3.00 | ( " | 1971) |
| Joint Membership (Husband & Wife) | £2.25 | ( " | 1972) |

Single copies are supplied at £1.75 (£1.00 Ordinary Members; £1.50 Institutional Members). (Vols. 1, 2 & 3 are priced at £7.00 (£6.00 Institutional Members; £5.00 Ordinary Members) each complete with index, title page and cummulative contents pages.

Librarians in overseas institutions may care to take advantage of exchange agreements, whereby the "Mercian Geologist" is exchanged for other original geological journals. This exchange scheme is organised through the Department of Geology, University of Nottingham, England, and not through the Society. Write direct to Dr. F.M. Taylor.

All enquiries for current subscription rates and details of back numbers, should be addressed to:

Mrs. D.M. Morrow,
Secretary, E.M.G.S.,
54, Cyprus Road,
Mapperley Park,
Nottingham, NG3 5EB.
England.

Overseas subscribers may care to use facilities offered by B.H. Blackwell, Broad Street, Oxford, England, or through booksellers and agents in their own country.

## CONTENTS


| | | Page |
|---|---|---|
| F.M. TAYLOR | The Lower Carboniferous coral environments of Derbyshire and adjacent areas. | 81 |
| F. MOSELEY | Stereoscopic ground photographs in field geology | 97 |
| M.J. FISHER | Rhaeto-Liassic palynomorphs from the Barnstone railway cutting, Nottinghamshire. | 101 |
| R.J. HEATH | Recent discovery of a mammoth molar in the Middle Trent Valley Gravels near Egginton, Derbyshire. | 107 |
| T.D. FORD | Supplement to the bibliography of the geology of the Peak District of Derbyshire. | 109 |
| G.J. WILSON | A method for the recovery of mounted palynological residues. | 139 |
| F.W. COPE | Some stratigraphical breaks in the Dinantian massif facies in North Derbyshire. | 143 |
| W.A. CUMMINS<br>H.R. POTTER | Rates of erosion in the catchment area of Cropston Reservoir, Charnwood Forest, Leicestershire. | 149 |
| Excursion Report:- | | |
| P.A. PITTHAM | The Middle Jurassic of Northamptonshire. | 159 |
| Reviews | | 161 |