Journal of
The Farnham Geological Society

Volume 1 February 1981

75p

Message from the Chairman

Welcome to the very first *Journal of the Farnham Geological Society*. After seemingly innumerable Committee meetings and tenders from local printers, the first issue is at last a reality. As many long standing members will know, the Society has always sought to provide a medium for the publication of articles and original research by Society members through a regular *Newsletter*. However, with the ever increasing membership, the Committee have come to the conclusion that a more permanent and more widely distributed record of our activities is now needed. It is hoped that this *Journal* will act as an important bridge between the vital work carried out by amateur geologists in their local area and the research taking place within the I.G.S. and at various universities and polytechnics around the country.

The aims of the *Journal* are to impart in as pleasant a way as possible as much information and comment as we are able, not only through papers and review articles, but also about some of the lighter aspects of the Society's yearly activities. The *Journal* is intended to be broad in scope in terms of the range of earth science subjects covered. In this way, each issue should have something of interest to everyone so that Society members can take a leisurely browse through subjects which are perhaps beyond their immediate interests. Outside contributions are invited, especially from guest speakers at the Society's monthly meetings, although papers do not have to be read before the Society nor must authors be Society members.

As with all publications of restricted size, short papers of 2000 words or less will be published quickly especially those that are relevant to an understanding of the geology of Southern England. It is intended that longer contributions arising out of research by groups of Society members will be published in occasional Society Monographs with only a summary article appearing in the *Journal*. Notes for the guidance of potential authors can be found inside the rear cover of the *Journal*.

The onset of the new *Journal* has unfortunately been accompanied by a request from Mr. Noel Ream to be relieved of the onerous task of editing, a task that has meant many long hours with pen, paste and scissors to produce the society's *Newsletter* on time. I am sure the Society will join me in thanking Noel for all his efforts over the years on their behalf. His departure has, of necessity, meant that an Editor has had to be appointed to cover this first issue of the *Journal*. This job has fallen to yours truly at present although it is intended that an Editorial Sub-Committee be appointed as soon as possible so that the load can be evenly distributed. Meanwhile, I would welcome any suggestions Society members may have for improving our *Journal*.

My final plea is for members to put pen to paper - the future success of the *Journal* must be in the variety and quality of the articles and papers published. I hope this first issue meets with your approval and may it be the first of many.

January 1981 PAUL OLVER Chairman

Cover illustration by Dick Lilley

Published by Farnham Geological Society

Printed by Intergraphic Print (UK) Ltd, 51 Hounslow Road, Hanworth, Feltham, Middx.

Castleton - A Geological Crossroads

Lothar Neubert

This paper is intended to give an introduction to the geology and mining history of the Castleton area in Derbyshire. It is hoped that it will provide a basis for individuals to explore this most fascinating area of the Peak District.

1. Introduction

Situated in one of the more desolate and quite parts of England, Castleton is a village of Olde Worlde charm and beauty. It is of interest to both geologist and historian, and has become a very popular tourist centre for the peaks. The village itself consists of no more than a main street with a few offshoots. The houses are still the same outside as they were when they were first built. Apart from modern day necessities, Castleton has hardly changed. To the geologist it offers unlimited scope, ranging from the diverse fauna and mineral deposits of the hard Carboniferous limestone to the varied sedimentary structures of Mam Tor, locally known as the Shivering Mountain, where turbidites of Millstone Grit age outcrop in spectacular crags.

2. The Geology

Leaving Castleton, on the road to Man Tor 3 km away, is the start of a steady but ever steepening climb. To the south-west the high hills of the Derbyshire Massif mark the boundary of the Carboniferous Limestone outcrop (FIG.1). It is here that the numerous caves and potholes for which the area is famous are found.

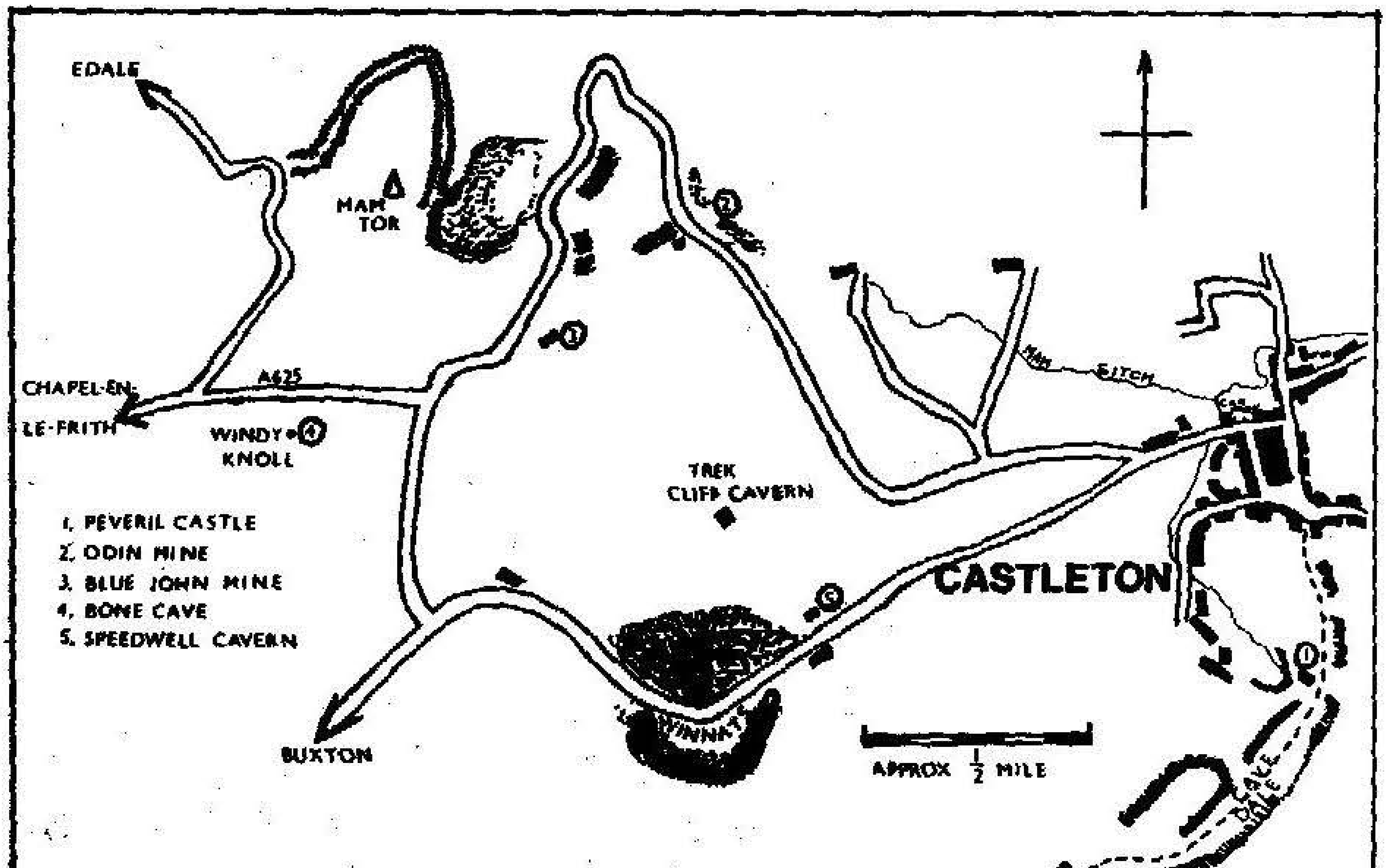

Fig. 1

The initial stage of deposition in the area, at the time of the Viséan transgression, laid down a sequence of limestones in dominantly clear water. The limstones accumulated over a very stable block of pre-Carboniferous rocks. These constitute the Derbyshire Massif and, being tectonically stable, did not subside as quickly as the surrounding basinal areas. As the sea areas adjacent to the Massif subsided, so the sedimentation thickened forming the basis of the Millstone Grit Series and Coal Measures of the mid-Pennines. Because of the instability of this area it was affected more by earth movements than the more stable Massif, consequently folding was more pronounced than in the limestones. The Massif did itself subside but at a rate consistent with deposition. It was not until late Carboniferous times that subsidence was greater than deposition.

The basinal facies can be seen looking northwards from Castleton towards the Edale Ridge (FIG.1). It offers a marked contrast to the Bee Low Limestone (D-zone) of the Massif. The north-west part consists of the Monsal Dale Beds, also a D-zone facies, which have at their base the Upper *Girvanella* Band, a prominent marker horizon. Banked against the northern edge of the Massif are well developed reef aprons which have been interpreted as being associated with former submarine cliffs and fault scarps (FIG.3). These reef apron limestones contain a Viséan fauna ranging from the Upper *Beyrichoceras* zone (B2) upwards into the Lower *Posidonia* zone (P1). Three typical representatives from the Castleton Viséan faunas are illustrated in Figure 2.

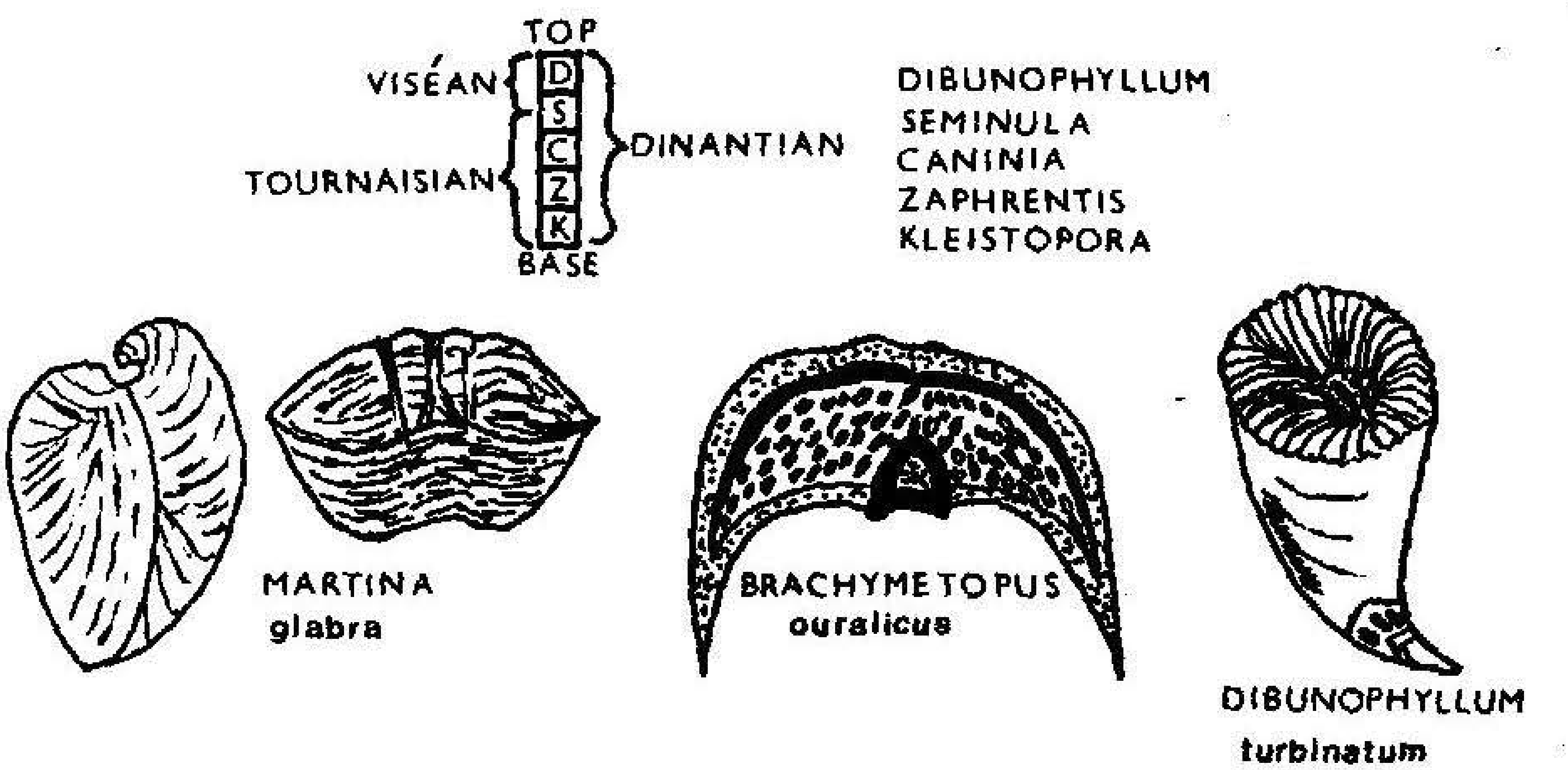

FIG. 2 The coral-brachiopod zones of the Lower Carboniferous (Dinantian) as defined by Vaughan (1905). At base, three typical members of the Viséan faunas found in the Castleton area.

3. The Castleton Mines

The first awe-inspiring sight on leaving the village is the remains of Peveril Castle. The castle was built by William Peveril, a son of William the Conqueror. Below the castle is the gorge-like entrance to Peak Cavern. At one time housed families whose job was to make ropes for use by the miners and many of the cottages were sited in the Cavern itself. The stream leaving the Cavern is fed by many underground streams which drain the land surface to the south-west of Castleton.

Some twenty metres from the cave entrance a stream emerges from the bank, this is from the Russet Well and joins the stream from the cave. This well has never been known to run dry and in times of drought has been pumped into the mains to supply the village. It is hard to believe that heavy rainfall causes this gentle stream to become a raging torrent of filthy brown water which has, on occasion even flooded the village. Superstition and tales about the cave dating back to the Middle Ages abound, the entrance being known locally as the Devil's Arse.

About one kilometre outside the village the road forks to the left and leads to Speedwell Cavern. This Cavern is occupied by an underground lake discovered in 1774 by miners who, driving horizontally into the hill in search of minerals, came upon rich ore only because the lake had washed out all the mineral veins. Speedwell is at the entrance to Winnats Pass (FIG 1), a wind gap, and from personal experience I can vouch for it! The formation of Winnats is open to question, the majority view is that it was once an underground cavern and that, after enlargements through water action, it could no longer support its roof which finally collapsed. About 0.5 km south of Speedwell, evidence of intermittent Carboniferous volcanic activity is present at the Speedwell Vent, choked with coarse vent agglomerate.

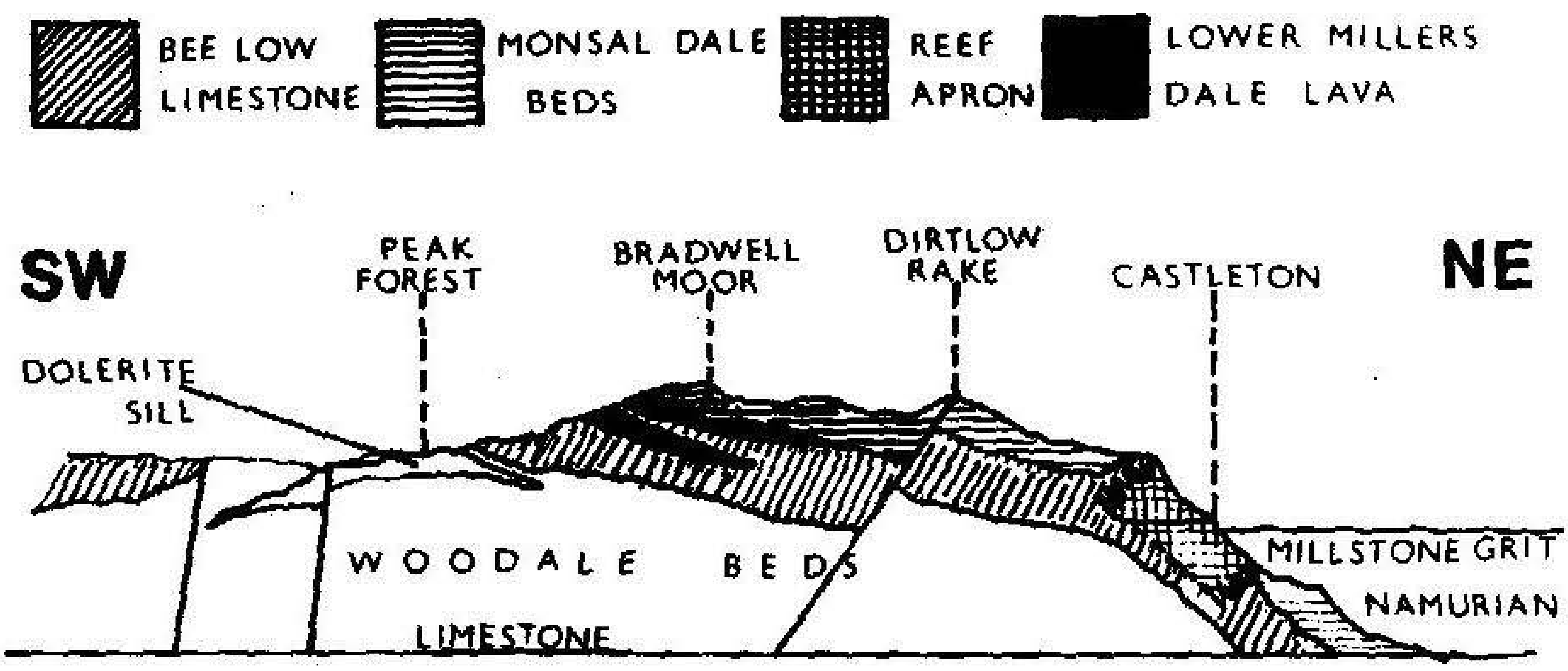

FIG. 3. NE - SW section across northern Derbyshire Massif. Adapted from I.G.S. 1:50,000 series (Sheet 99).

Taking the A625 the climb to Mam Tor begins, the Carboniferous Limestone crags dominate the road and from Trek Cliff onwards display almost vertical bedding planes. Trek Cliff Cavern is an underground cavern famous for its variety of fluorspar known as Blue John although the quality is not good as at the Blue John Mine itself. At Trek Cliff a good variety of brachiopods, gastropods and bivalves can be found (FIG 1).

The next major point of interest is the Odin Mine, north-north-west of Trek Cliff, which is situated within the area adminstered by the National Trust. This was one of the richest lead mines in the area which dates back to Saxon times when it was named after their chief god Woden. The deep gash in the hillside which marks the mine is situated on a fault line and this fissure was, in the geological past, filled with galena, the main ore of lead. The rock walls are smooth with horizontal markings, called slickensides, showing where movement on the fault has polished the cheeks of the vein. The lead of the mine was reputed to yield at least three ounces of silver per ton of ore.

On the opposite side of the road are the spoil heaps full of interesting rocks and minerals. The ore was brought out through an arched level by pony and cart. The spar and galena were when crushed by a millstone and metal ring which is still visible today. The millstone, pivoted from the centre of the circle was pulled round the iron ring by a horse. After sorting out the lead ore the waste spar was thrown onto the spoil heaps close to the road. Fluorspar, calcite, barytes and some galena can still be found today and you might even find a trace of silver if lucky.

Leaving Odin, the road to Mam Tor starts to twist and wind its way to the summit. Here we start to see a series of irregular surfaces and rough terrain produced as a result of the continuous landslips at the base of the mountain. The road at this point is always sliding away down the slope and must represent the most expensive stretch of road in Britain. The reason for this acute susceptibility to landslip is the occurrence of the competent Kinderscout Grits which directly overlie steep shale slopes of low resistance to flowage. This is particularly well seen at Mam Tor itself where the Mam Tor Beds overlie the shales and cause severe landslipping on the side facing the Odin mine. Across the road from the impressive Mam Tor scar is the entrance to the famous Blue John Mine (FIG. 1). A visit down this mine is a MUST! The large caverns extend some hundred metres below ground and were worked in Roman times for Blue John fluorspar. Throughout the mine at different levels are displays of the mining equipment used by the Romans. The fluorspar here occurs in a series of seven independent veins which are now only worked during the winter when the tourist trade ends. Although hardly a gemstone, the Blue John produced is valued nevertheless for its decorative appearance and considerable quantities of small pieces of jewellery are fashioned from it.

To describe in any more detail the mines of Castleton would spoil the reader's enjoyment of visiting the area for themselves. I hope this short study, however, has given the reader an appetite for this exceptionally beautiful corner of England. Good hunting to you all!

4. Acknowledgments

The author would like to take this opportunity to thank Cyril J. Potton for his continued support during the drafting of this paper and for his considerable work on the maps and diagrams.

5. References

AUTOMOBILE ASSOCIATION Book of Countryside Walks

BIRD, R.H. 1977. Yesterday's Golcondas: notable British metal mines. Moorland Publishing Co. Buxton. 140pp.

EDWARDS, W. & TROTTER, F.M. 1954. British Regional Geology: The Pennines and Adjacent Areas. H.M.S.O. London. 86pp.

VAUGHAN, A. 1905. The palaeontological sequence in the Carboniferous limestone of the Bristol area. *Q. Jl. geol. Soc. Lond.*, 62, 275-323.

WOODALL, B. Castleton - Pathways into History.

A Local Geologist of the Last Century

Tony Cross

William Curtis (1803-1881) was an Alton man interested in the local geology. This short paper provides the background to aspects of his interest in the subject and includes references by other workers to his important collection of local fossils.

Hampshire County Museum Service, Chilcomb House, Chilcomb Lane, Bar End, Winchester SO23 8RG.

Many people will be aware of the Curtis Museum in nearby Alton and the name of William Curtis, a resident of that town, may also be familiar as a Botanist and the founder of the Botanical Magazine in 1791. It is often thought that the Museum took its name from this famous Curtis, whereas in fact it was another William Curtis, a relative of the Botanist, who founded the museum in 1856. Following the death of the founder 100 years ago in 1881, the Mechanics Institution who were responsible for the museum decided that it should be known as the Curtis Museum in appreciation of the work of the man who was the fourth generation of a family of doctors who had practised at 4 High Street, Alton, since 1720.

Born in 1803, William had been taught by an uncle in a small private school on the borders of Epping Forest and after a medical training and returned to Alton to practise with his father. Like many educated men of his time he was interested in the natural science and the local area provided a wealth of interest despite his time-consuming medical career. Geology as a subject had only been established in the early part of his life and it is interesting to speculate on the effects of the growth of the subject on his active mind. Although the Geological Society had been founded in 1807, its early activities, it appears, did not interest those who were rather more local in their geological outlook. The foundation of the Geologists' Association in 1858 fulfilled such a need and Curtis was one of the original members. He was also one of the original members of the Palaeontographical Society founded in 1847.

Curtis' geological activities as one might expect were concerned with the local area which provided a range of rocks of Cretaceous age and he visited all the nearby pits and quarries forming a systematic collection of fossils, many of which found their way to the museum. His observations on the fossils yielded by the construction of the railway line to Alton through the Alice Holt Forest in 1847 were published in volume I of the Proceedings of the Geologists' Association after being read as a paper in 1861. Curtis' second published paper was a chapter on the geology of Selborne included in Thomas Bell's edition of Gilbert White's Natural History & Antiquities of Selborne (1877). Manuscripts of two undated and unpublished papers are recorded. One was read to the Provincial Medical Association and the other to the Mechanics Institute at Alton. The fossil material in the Alton Museum has since been used by various workers in their publications. Reference is made to the collection in Topley's classic Memoir on the Weald and also in the Memoir of the area around Alresford. Jukes-Brown's Memoir on the Lower Chalk also refers to William Curtis and his collection made from quarries around Alton between 1850 and 1860.

The Curtis Museum was presented to the District Council as a War Memorial in 1920, taken over by the County Council under the 1944 Education Act and now comprises part of the Hamshire County Museum Service administered by the Recreation Committee of the County Council.

Although no separate catalogue of the Curtis fossil material appears to have been compiled, I hope to be identify some of the material in question as I work through the geology collection. A representative display of local fossils may be found in the Curtis Museum and although plans for their re-display are in the process of formation, the financial situation in Local Government will no doubt delay their implementation for some time.

References

CURTIS, W. (1861). Notes on the fossils of the Gault from Alice Holt forest. *Proc. Geol. Ass., Lond.* I, 152-153.

CURTIS, W. (1877). The Geology of Selborne in Natural History and *Antiquities of Selborne* (T. Bell, ed.) 374--377.

FRIENDS OF THE CURTIS MUSEUM. (1980). The Curtis Museum, Crown Hill, Alton.

JUKES-BROWN, A.J. (1903). The Lower and Middle Chalk of England. *Mem. Geol. Surv U.K.*

OSBORNE-WHITE, H.J. (1910). Geology of the Countryside around Alresford. *Mem. Geol. Surv. U.K.*

TOPLEY, W. (1875). Geology of the Weald. *Mem. Geol. Surv. U.K.*

And yet more early geologists?

With apologies to the monks of Lindisfarne who carved this stone after a Viking raid on their Abbey in A.D. 793.

Some features observed in the Superficial and Solid Formations at Lower Froyle Quarry, near Farnham

Ian Carolan, Martin Dearsley, Paul Olver, Diana Smith & David Taylor

This paper is an original contribution to our knowledge of local geology by a group of Society members. It originally appeared in the September 1976 *Newsletter* but has been reprinted as further research on the Lower Froyle quarry is now in progress, the results of which will appear in the next issue of the *Journal*. The paper discusses in detail the occurrence of 'pipe-like' features in both the solid and drift formations within the quarry and suggests further lines of investigation.

1. Introduction

Lower Froyle village lies about half-way between Farnham and Alton, one kilometre to the north of the A31. The quarry is situated 0.5km to the north of the village along the road to Well. It lies wholly on Ordnance Survey 1:50,000 sheet 186 (Aldershot & Guildford).

The broad geological features of the locality are shown on the I.G.S. Basingstoke Geological sheet 284. The main aim of this research is to describe, for the first time, the varied superficial deposits lying unconformably on the Lower and Middle Chalk exposed in the quarry. These deposits owe their origin to periglacial, fluvioglacial and fluvial processes. Examples of similar deposits, associated with the Chalk, have been reported by several authors (Hodgson *et al* 1967, Thorez *et al* 1971, Chartres & Whalley 1975, Ward & Cooper 1975).

Lying unconformably on the eroded Chalk surface is a mantle of solifluction Chalk. Both the solid and the drift formations are penetrated by a number of 'pipe like' features containing a reddish brown infill. In the exposure illustrated in Figure 1 such a pipe in the Lower Chalk is covered by solifluction deposits, which are themselves overlaid by graded channel-fill deposits.

2. 'Pipe-like' Features

Exposures of these features showing their cross-sectional shape have yet to be found. However, longitudinal sections show that pipes are from 1 to 1.5 m in width and some are greater that 3 m in length. They are infilled with arenaceous materials, which range from silty clays to fine sands. They also include nodular flints, presumably derived from the Middle or Upper Chalk. The outermost 10 to 15 cm of infill is olive green in colour but grades inwards to a light reddish brown.

3. Exposure 1. South end of Quarry (SU762447).

In this section (FIG. 1) a near vertical pipe is exposed which penetrates the Lower Chalk. The Chalk here is indistinctly bedded with prominent vertical jointing and is dull greyish white in colour. The pipe at its widest point is 1.45 m, with an average width of 1.3 m. The contact with the surrounding Chalk is clear and sharp. Resting unconformably on the Chalk are deposits of graded chalky rubble which in part have been channelled and infilled.

The individual zones will now be described in detail (FIG. 1):

Zone 1. Lying directly on the chalk surface, this horizon shows a graded sequence of subangular and rounded chalk fragments. Only a small amount of clayey material is present, forming a reddish brown matrix.

Zone 2. This horizon, lying on an eroded surface of Zone 1 is similar to Zone 1 in size and appearance of its constituent rubble. As in the lowest zone the particle size fines upwards to a clay grade. A little brownish clay is also incorporated within this zone.

Zone 3. Coarse angular and subangular chalk rubble up to 30 cm in diameter form the basal layer of this zone. Fragment size fines upwards with the interstitial spaces being filled with fine chalky rubble and a reddish brown clay.

Zone 4. This horizon is on the south side of the exposure and consists of material similar in appearance to Zone 1. The succession indicates an infill channel of a later date, since Zone 3 has been truncated and the underlying solid Chalk has been eroded into a shallow channel form.

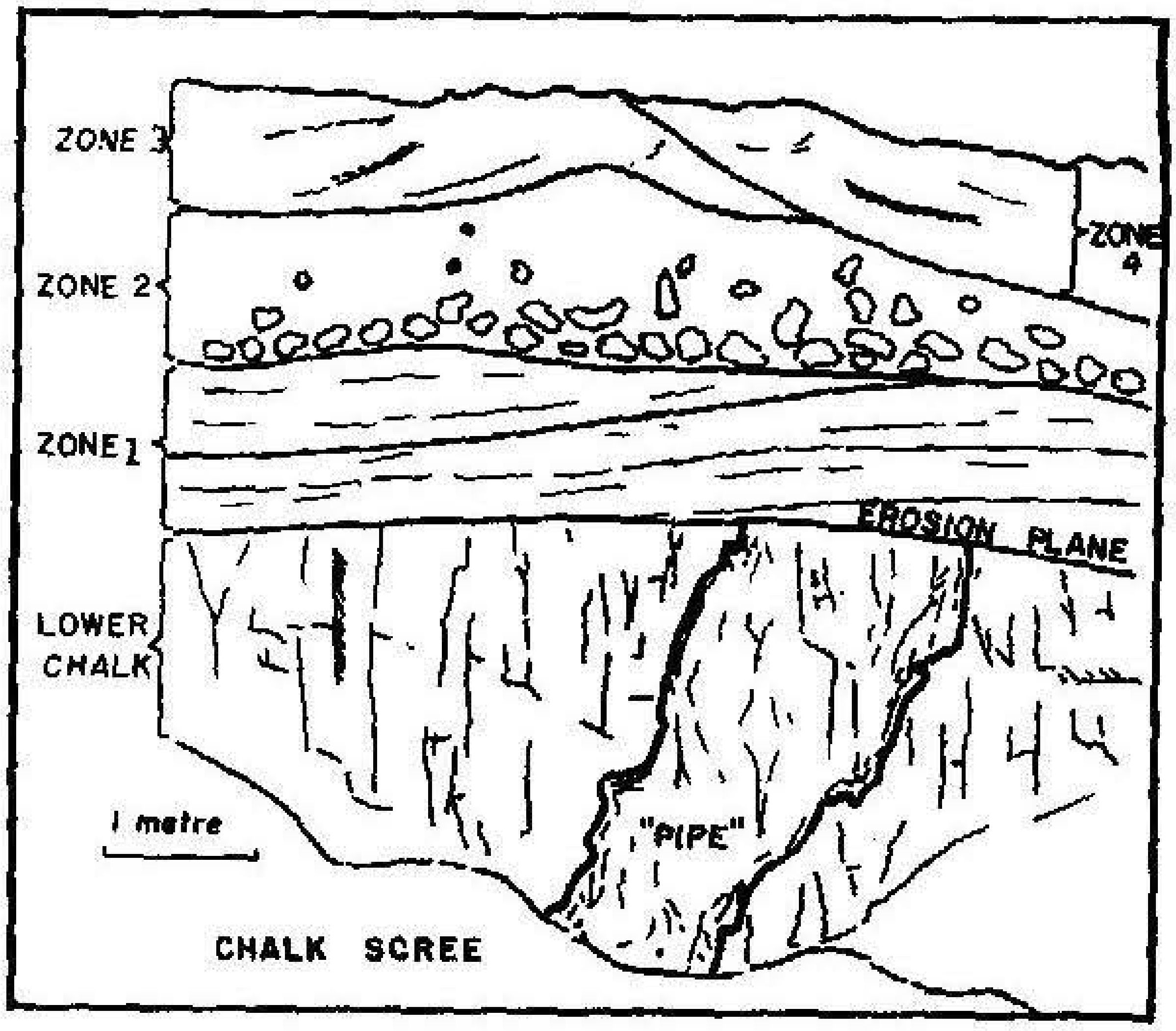

FIG. 1 A near vertical pipe penetrating the Lower Chalk. Exposure 1. South end of Lower Froyle Quarry (SU 762447)

4. Exposure 2. Upper Level of Quarry (SU 762448).

This exposure is situated in the upper part of the quarry. This face, consisting totally of solifluction Chalk, forms a small semicircular embayment on the northern side of the quarry. Two main features were studied (FIG. 2):

(a) A large near vertical pipe about 2 m in width containing a central mass of chalk, whose base has not yet been determined. Again, the pipe is infilled with material similar to that already described at Exposure 1. The infill is clearly zoned, with greyish clay at the contact with the Chalk grading inwards through brown to yellow at the centre.

(b) A discontinuous horizon of well bedded sands forming distinct lenses which outcrops adjacent to the pipe. This strongly suggests that these sands once formed a continuous horizon which has been segmented by the load pressure of the overlying solifluction Chalk. This deformation of the sand horizon could owe its origin to periglacial processes occuring within the active layer.

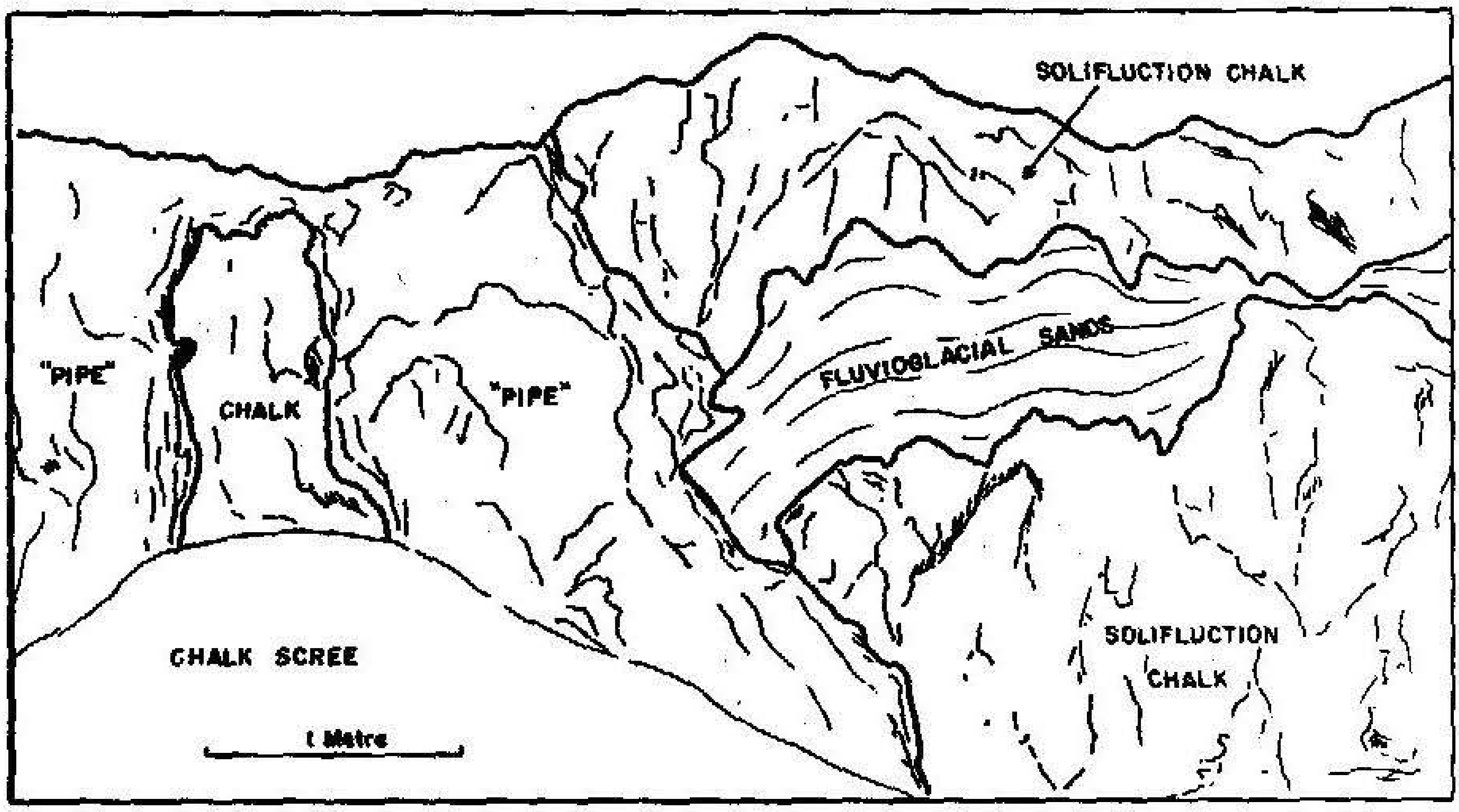

FIG. 2 Quarry face of solifluction Chalk showing large near vertical pipe with central Chalk mass (left) and fluvioglacial sand lens (right). Exposure 2. Upper level of Lower Froyle Quarry (SU 762448)

5. Future Research

The authors intend to follow up this research with palaeontological determination of the exact age of the Chalk within the quarry and an appraisal of the origin and age of the 'pipe-like' features. Important aspects of the latter bodies include their fossil content and their relationship to the solifluction Chalk, fluvioglacial sands and channel-fill deposits.

6. Acknowledgements

The authors would like to thank Renown Lime Quarries Ltd. for permission to study their workings at Well Lane, Lower Froyle.

7. References

CHARTRES, C.J. & WHALLEY, W.B. 1975. Evidende for Late Quaternary Solution of Chalk at Basingstoke, Hampshire. *Proc.Geol. Ass.*, 86(3), 365-72.

HODGSON, J.M., J.A. & WEIR, A.H. 1967. The Origin and development of Clay-with-Flints and Associated Soil Horizons on the South Downs. *Jour. Soil Sci.*, 18, 102.

THOREZ, J., BULLOCK, P., CATT, J.A. & WEIR, A.H. 1971. The Petrography and Origin of Deposits filling Solution Pipes in the Chalk, near South Mimms, Hertfordshire. *Geol. Mag.*, 108, 413-23.

WARD, D.J. & COOPER, J. 1975. Late Quaternary Solution of Chalk at Basingstoke, Hants. *Proc. Geol. Ass.*, 87(1), 101-3.

Calling all Competition Addicts!

As this is our inaugural issue, the cover design has had to be planned at short notice from already existing material. However, the Committee are anxious that a completely new motif be designed for use on all future issues. Any Society members wishing to contribute ot the 'new image' are asked to submit their designs on A4 size white card to the Editor by the 1st July 1981. Any design, of course must include the wording featured on the present cover. It's your ideas we want, so don't worry too much about the artwork.

The winning entry will be announced at the summer social and an appropriate geological prize awarded - *Editor*

A Field Trip to the Forest of Dean and North Wales

Charles Ives

A record of a typical geological excursion undertaken by Society members in April 1980. The exposures visited on this five-day tour range stratigraphically from the Pre-Cambrian Gwna Mélange of the Lleyn Peninsula to the Coal Measures of the Forest of Dean. Many lesser known exposures were visited in Mid-Wales and the full map references will help Society members to use this account as a field guide.

1. Aust Cliff and the Forest of Dean

The party left by coach from Farnham Station at 7.30 on the morning of the 9th April 1980 and arrived at Aust Cliff at approximately 11 a.m. A short walk brought the party to the beach of the River Severn almost beneath the first span of the Severn Road Bridge (ST 565898). The cliffs are highly colourful with red Keuper Marls at beach level, followed by Triassic Tea Green Marls and then the Rhaetic Westbury Beds which are black in colour. Contrasting with the Westbury Beds are the Rhaetic Cotham Beds which from beach level present a very pale cream colour before they in turn are succeeded by the darker shales of the Lower Lias.

Only the red Keuper Marls are accessible at beach level, fallen blocks providing the means whereby the other rocks may be examined. Soon the party was busy taking samples of the various rocks and at the same time keeping an eye open for the conglomeratic Aust Bone Bed. Some samples of this elusive rock type were eventually found containing large bone fragments and associated coprolites.

From Aust the coach carried us on over the Severn Bridge, through Chepstow, to deposit us close to the river once again. We then had a walk of just over a hundred yards along the shore which fortunately was reasonably dry. The exposure in the cliffs at this point was the Lower Old Red Sandstone (SO 653017). Most of the party who had been on the Pembrokeshire trip last year saw and recognised the abundant "race" of the uppermost red marls. Cross bedding and convoluted horizons within the sandstone units together with a basal intraformational conglomerate completed the section. Most people were soon busily engaged in the search for fish remains, Dr. Olver being called upon to identify the various specimens that were found. Several fish spines, preserved in white, were discovered and I believe one lucky person found part of the head shield of a fish. Our next stop was at the Cock Inn at Blakeney where most of the party were able to revive themselves with both solid and liquid refreshments. Breakfast seemed to be in the geological past rather than but a few hours earlier.

A disused railway cutting (SO 643087) provided the setting for our first stop after the satisfaction of the inner man and woman. Here the members of the Forestry Commission had cleared the cutting and in doing so had provided many fresh rock samples as well as a fine view of the Coleford High Delf coal seam. This coal seam is only about 400mm in thickness. When it was being deposited it was very close to St. George's Land which prevented the subsidence that usually accompanies the deposition of coal seams. In consequence, the cycle is not complete at Blakeney as there are no marine shales. However, below the coal seam was a fine example of fireclay which represents the exhausted soil underlying the Carboniferous coal forest. Above the coal seam are the Pennant Group of sandstones whilst below it are the Trenchard Group. These sandstones provide many examples of bark impressions of the coal forest trees as members of the group soon discovered.

Our next stop was to be at the Cement Works Quarry at Mitcheldean (SO 659183) and to get there we passed the Cannop Mills Stone Works where stands a fossil tree trunk complete with a short length of branch forking away from the main stem. The total length of the trunk is about 1.5m and it was visible from the coach as we passed by. The Carboniferous Limestone of the Mitcheldean quarry is in K Zone but extensive recrystallization has destroyed much of the fossil content. However, weathered surfaces show many fragments of brachiopods and crinoid ossicles. As we left this quarry, we felt our first spots of rain but we need not have worried for it turned out to be just an idle threat. From Mitcheldean we travelled onwards through Ross-on-Wye (memories of a honeymoon spent there) arriving eventually at our destination, the Graftonbury Hotel, about two miles from the centre of Hereford.

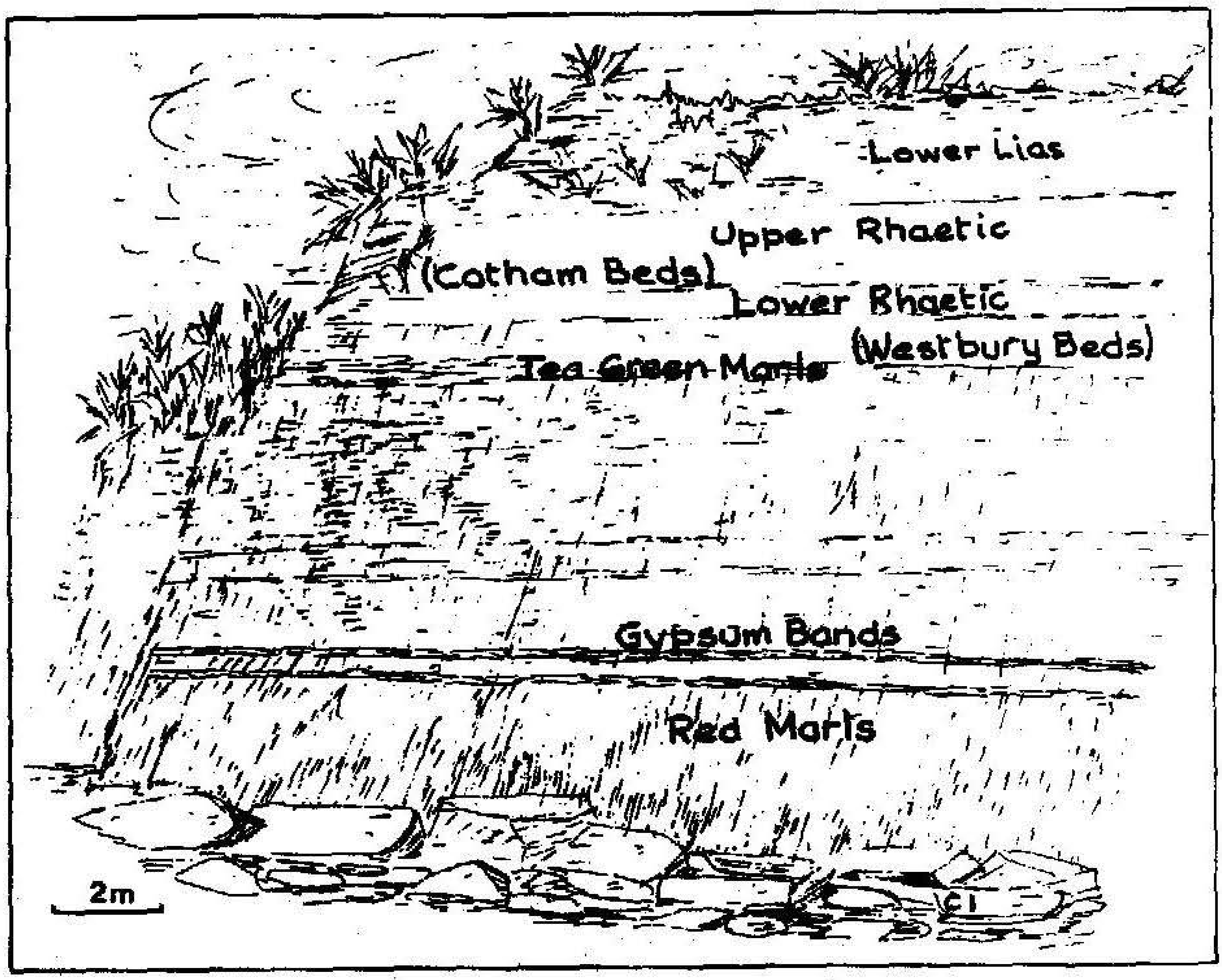

FIG. 1 Field sketch of Aust Cliff, Avon (ST 565898) with the main Triassic and Rhaetic horizons indicated

FIG. 2 Gravity slumping in near vertical K-zone Carboniferous Limestone Cement Works Quarry, Mitcheldean, Gloucs. (SO 659183).

2. New Radnor to Rhayader

After leaving the hotel, we travelled through part of Hereford catching a quick glimpse of the Cathedral before leaving the town and returning to our cross country route. We stopped first at a roadside exposure by the side of the busy A44 where we were to examine the Stanner Rocks (SO 262583) that consist of Pre-Cambrian dolerites and gabbros with the occasional quartz porphyry sill. We really shall have to provide Dr. Olver with a loud hailer for use at these road-side sites so that he can overcome the traffic noises. Across the road from this site was Worsel Wood - but we saw no groups practising their songs about combine harvesters. Having removed our quota of specimens, we travelled onwards to our next locality which was the Yatt Wood Quarries (SO 241581). This was the first working quarry of the trip - the familiar combination of stone dust and crushing machinery reminiscent of the Mendips excursion last year. Here Dr. Olver described the unconformity between the Longmyndian greywackes and the overlying Lower Wenlock Woolhope Limestone. Our own examination of the limestone yielded several specimens of *Favosites*, crinoid stems and brachiopods while the highly contorted greywackes displayed good examples of both competent and incompetent beds. Between the Longmyndian greywacke and the Woolhope Limestone is a time gap of 300 million years. The Longmyndian conglomerates contain pebbles of igneous rocks that are similar to those of the Stanner Rocks, this being taken as confirmation of their younger Pre-Cambrian age. There are no Ordovician rocks between the greywacke and the limestone.

Our first stop of the afternoon was at the Old Quarry on the New Radnor Road (SO 056519) where we saw the effect upon the Llanvirn shales of intermittent submarine lava eruptions. Even though the spilitic lavas had been erupted underwater, their retained heat had been sufficient to cause contact metamorphism to take place with the production of a localised hornfels in the underlying *murchisoni* Shales. It was noticeable that the cycle of shale, hornfels and spilites was repeated across the whole quarry showing that the periods of vulcanicity were followed by considerable periods of quiescence. Although the shales are graptolitic, I believe the little creatures were quite elusive despite an exhaustive search. Soon we were at Rhayader and on the road to the Caban Coch Dam (SN 924645) where we found that the water level was several feet below the top of the dam and this just at the end of the winter. Our visit was to examine the rocks in one of the quarries that had originally provided the building materials for the dam. This quarry presents a classic exposure of the pebble and cobble conglomerates of the local Upper Llandovery succession. Here we were seeing the result of highly disruptive and erosive turbidity flows that gouged out channels down the contemporary continental slope. These flows were extremely rapid with rock fragments of all sizes being carried in what was virtually a liquid solid. Because of the rapidity of the flow the larger fragments did not have time to settle so that they remained at the top of the flow to produce what is known as reverse bedding. The conglomerate, even in a small hand specimen, containes a rich variety of rock clasts including quartz, chert, coarse iron-stained grit and angular fragments of mudstone all set in a coarse grit matrix.

After taking photographs of the dam it was back into the coach again for the long journey across the rest of Central Wales to Barmouth where we were to stay for the remainder of the trip. As we moved further north the scenery gradually changed until we were in the mountains of North Wales. We arrived at the Marine Mansion Hotel at about 6.30 pm just in time for dinner.

3. Southern Snowdonia

Friday dawned bright and clear and after breakfast with plenty of toast and coffee we were off to our first stop which was a roadside cutting near Barmouth Bridge (SH 618156). Outcropping here were prominent bands of greywacke and grit which form part of the local Cambrian succession. As well as studying the rock structure we were able to differentiate both the bedding of the rocks and their cleavage. Although the dip of the rocks was fairly steep - measured as 74° - the dip of the cleavage was greater indicating that the succession was right way up. All these rocks are pre-trilobite and largely unfossiliferous, their cleavage having been impressed later at the close of the Silurian (420 Ma). A short walk back into Barmouth brought us to a small exposure in the slightly older Manganese Shales (SH 614156). These banded grey and greenish mudstones are characterised, on their weathered surfaces, by prominent bioturbation structures. These trace fossils can be used, in addition to cleavage-bedding relationships as a way-up criterion.

Our next stop was at the place that all those who fancied themselves as prospectors were looking forward to - the Bontddu Gold Mine (SH 669188). The trail left the road quickly behind and wound its way gradually upwards through pleasant woodland with a mountain stream for company, although at times the stream was lost except for its lively chatter at the bottom of a small ravine. Soon, after a good walk, the gold mine was in sight and with hammers ready we advanced rapidly towards the entrance only to be met by some claim jumpers who made it plain that there was no gold there for us. After some skilful negotiations by Dr. Olver an ultimatum was issued that we could examine their spoil heap for twenty minutes and then were to leave. Apparently the mine had featured in 'Jim'll Fix It' recently and was also the one that had supplied the gold for the Queen's wedding ring. It had in fact been reopened only about a year ago after many years of disuse. Everyone worked hard in the time available and gave a good impression of what a gold rush must have looked like. All members came away richer for iron pyrites, chalcopyrites and arsenopyrites but they are just not telling how much gold they got!

After lunch close to Llanelltyd, we paid a quick visit to the Maesgwm Forestry Commission Centre where there is a display of the processing machinery used in the latter half of the 19th century when Welsh gold mining was at its peak. Output culminated about 1900 after which the Dolgellau Gold Belt steadily declined and was largely defunct by the end of the First World War. Once again members of the party took the opportunity to do some prospecting amongst the quartz spoil included in the display. Our thanks go to our guide, Mr. Williams, who incidentally had spent several years at the Forestry Commission Laboratories at Alice Holt.

A short coach ride brought us to the Tan-y-grisiau reservoir and the C.E.G.B. power station where we first had to obtain the gate key for the road to the Stwlan Dam. At our first stop (SH 683454) we searched for and eventually found the Garth Grit, a spotted grey-weathering sandstone which sits unconformably on the local Tremadocian succession. We next examined a dolerite dyke (SH 680453) that intrudes the Arenig flagstones close to where the road passes a spectacular causeway. We learnt later from Dr. Olver that this steep causeway was the remains of a gravity incline that had been used to bring the slate down and that the associated quarry functioned during the last war as a safe storage place for the works of art now housed in London's National Gallery. Close to the dam at a bend in the road (SH 670444), a flinty microcrystalline rhyolite marked the base of the thick quartz-latite sill which dominates the crags just beneath the dam. As the party made its final ascent to the dam itself, this sill displayed multiple zones of flow banding and autobrecciation in roadside sections. A breathtaking panorama across the deep Vale of Ffestiniog to the Rhinogs beyond could be seen from the top of the dam wall while behind us desolate crags enclosed a tranquil lake whose level again seemed very low for so early in the year. Soon the recall whistle was blown and another day of visits came to an end for our next stop was to be back at the hotel where hot baths, refreshing drinks and good food awaited us.

4. The Lleyn Peninsula

Saturday dawned slightly dull but at least it was fine with the prospects of another good day ahead. After breakfast and safely aboard the coach again the first handouts of the day were soon circulating. Even the faces of those who have a smattering of Welsh blanched at Handout 15, the Ynyscynhaiarn Anticline. The first locality was a roadside cutting on the eastern limb of the anticline (SH 546396). The rocks here are of Middle Tremadoc age and consist of blue silty mudstones with thin greywackes. These Moel-y-gest beds are of deep water origin and now display a penetrating Caledonian cleavage.

We next stopped at Criccieth Castle (SH 500377) which is perched on the top of a rhyolite intrusion. Once inside the grounds our party rapidly advanced to the foot of the castle walls looking carefully for a good exposure of rhyolite. Most samples were weathered to a pale straw colour, some presenting a plain surface whilst others were speckled with the remains of feldspar phenocrysts. By now the weather was quite warm and after an assault on the castle itself most of the party stopped at a nearby ice cream parlour - even those who were in a state of temporary financial embarrassment managed to borrow the price of an ice.

Our journey now took us deeper and deeper into the countryside of the Lleyn Peninsula, through Pwllheli and onwards to Mynytho Common which will long be remembered by some of the party. It seems that there are no dull moments for those brave enough to embark on geological field trips. The first target was a small quarry (SH 302309) that delved into the local microgranite boss and it was reached by a short trek across heather and dwarf gorse much to the consternation of one adder that had just popped out for a little sun after a hard winter's hibernation. I think it is probably the only adder in Wales with grey scales after the shock of being pursued by nearly fifty geologists all armed with hammers and sticks. Little did he know how safe he was! The quarry face was considerably overgrown but once reached provided plentiful samples of fine-grained pink granite. of the local blue-black *bifidus* Shales I don't think we found a trace and so were not able to confirm the presence of any contact metamorphism. From the quarry it was quite a long hike across Mynytho Common to our next exposure of rarely observed riebeckite rhyolite (SH 299312). This rhyolite sill protrudes through the heather and is very reminiscent of the granite tors of Devon and Cornwall. Unlike some sites that are said to be fossiliferous but fail dismally to produce any, this exposure yielded some dark blue riebeckite at the first blow. A nearby rhyolite outcrop failed however to produce any riebeckite but was found to be of a much coarser texture. Whilst all this was going on the packed lunches were being demolished.

Our next appointment was at Trwyn Maen Melyn (SH 138252), the most westerly point on the peninsula, where we were to examine the classic exposures of the Gwna Mélange now thought to represent a Pre-Cambrian submarine slide breccia or olistostrome. These features occur in association with former subduction zones where the earth's oceanic crust at the edge of a colliding plate, tilts and slides under the opposing continental mass. This site was perilously positioned on the grassy slopes above the cliffs and it seemed that at times there was a considerable risk the members of the party would engage in their own particular slides to the sea. The Mélange consists of angular blocks of all sizes set in a green basic matrix. These blocks, some of which are the size of houses, consist mainly of dolomite, quartzite, limestone, phyllite, greywacke and pillow lava. Many samples were collected but I don't know whether anybody obtained a complete set. Certainly Ray, our coach driver, will remember our visit as the gate posts at the entrance to the National Trust area were too close together to allow the coach to get through and this meant backing it for about a quarter of a mile down a narrow twisting lane before he could turn it.

We next stopped at a roadside cutting close to Llanbedrog (SH 322314). This exposure was supposed to contain brachiopods, trilobites, bivalves and corals of Soudleyan age. Well, wonder of wonders, I actually found my first trilobite fragment as well as several brachiopods and corals. The above fossils were found in a blue-black, very much fragmented mudstone containing sandstone laminae. All the weathered surfaces have taken on a greyish brown colouration. On the opposite side of the road is a river which forms a boundary between the Caradocian sediments and a microgranite intrusion. Unfortunately, as is the case so often on our field trips, time defeated us and we were unable to explore the contact zone.

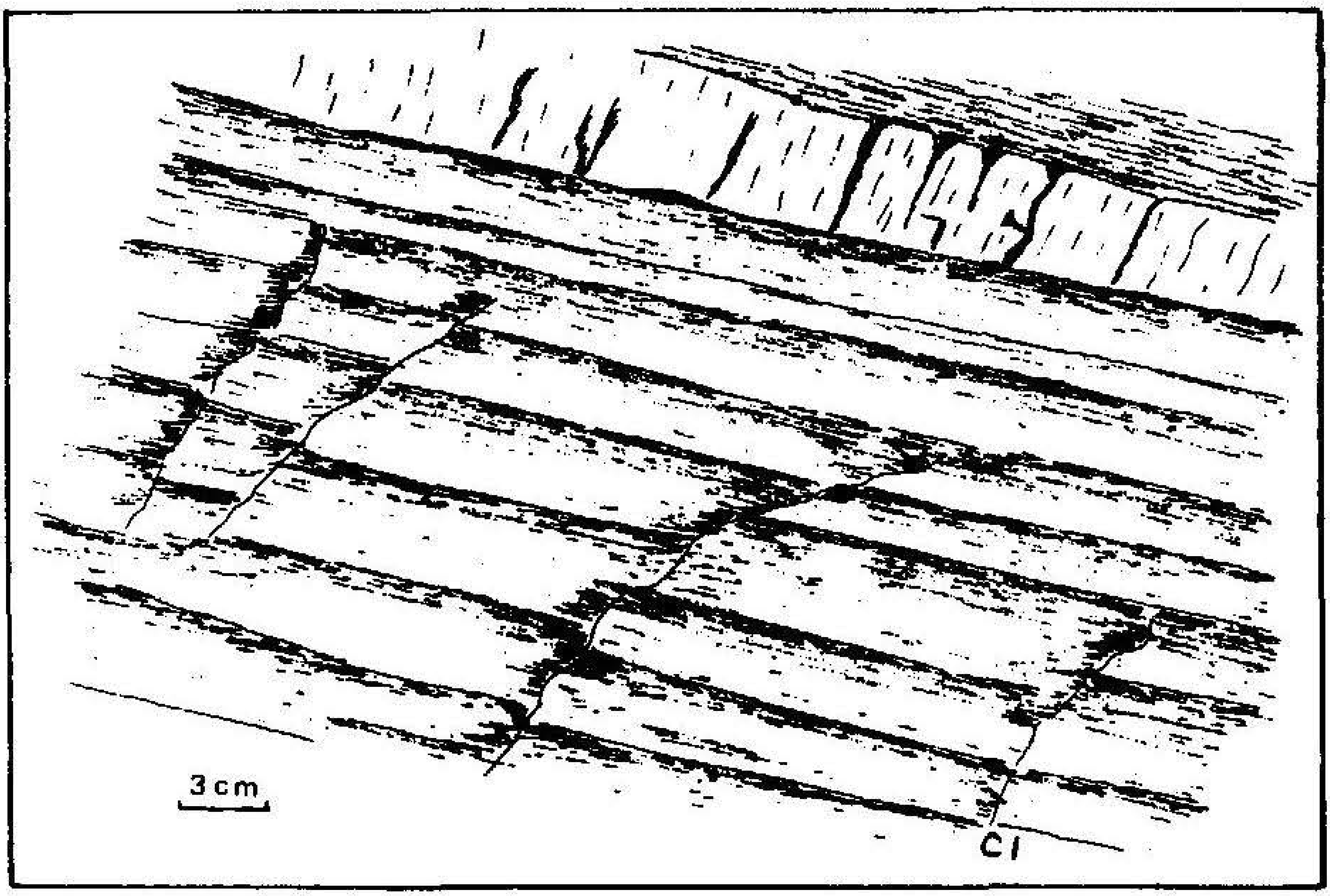

FIG. 3 Aberystwyth Grits of Silurian (Llandovery) age, north end of Aberystwyth beach, Dyfed. Turbidites show conspicuous ribbon banding due to alternating thin grits and shales.

5. Aberystwyth and home

Sunday morning was a testing time for the coach springs as all the rocks, fossils and gold were stacked away in the boot. Soon it was time for the staff to wave us away with sighs of relief and for us to began our long journey home. The coast at Aberystwyth was to be our first port of call where the Aberystwyth Grits were to provide a spectacular range of structural and sedimentary features. A veritable geologist's paradise was listed with mention of graded bedding, convoluted beds, load casts, flute casts, iron-rich concretions and the trace fossil *Palaeodictyon*. In addition the Aberystwyth turbidites provide many examples of small scale anticlines and synclines, competent and incompetent strata, slickensides, cleavage refraction and faults of all types including some spectacular thrust planes. This was a place in which the camera was worth its weight in gold and I am sure that many frames of film were exposed on the beach at Aberystwyth. Now it was really goodbye to Wales and we headed east on our long journey home, reaching Fleet at about 7.30 pm where the first people including yours truly left the coach.

6. Acknowledgments

The author would like to thank Dr. Paul Olver for organising a truly wonderful geological trip. For those Society members intending to revisit these areas a short bibliography follows.

7. References

CHALLINOR, J. & BATES, D.E.B. 1973. Geology Explained in North Wales. David & Charles. Newton Abbot. 214pp.

GEOLOGISTS' ASSOCIATION SOUTH WALES GROUP. 1971. Geological Excursions in South Wales & The Forest of Dean (ed. Bassett & Bassett).

MORRISON, T.A. 1975. Goldmining in Western Merioneth. Merioneth Historical and Record Society. Gomerian Press. Llandysul.

ROBERTS, B. 1979. The Geology of Snowdonia and Llyn: An Outline and Field Guide. Adam Hilger. Bristol. 183pp.

The Petrogenesis of Hyaloclastites: A Review

D.J. Taylor

Hyaloclastite is a term generally used to describe fragmental igneous rocks formed by the flowing of basic lava into an aqueous medium. This article describes the characteristics of these rocks and the circumstances under which they form.

1. Introduction

Hyaloclastite was a term proposed by Rittman (1962) to describe the features of some submarine lava flows in Sicily. He defined Hyaloclastite as being 'a deposit formed from the comminuted glassy shells of growing pillows of lava'. A more recent definition proposed in the American Geological Institution's Dictionary of Geology describes it as 'a deposit resembling tuff that is formed by the flowing of basalt under water or ice and its consequent granulation or shattering into small angular fragments'. In America, the term aquagene tuff is used synonymously with hyaloclastite.

The drastic quenching of fluidal basic lava either erupted onto the sea floor, or flowing into shallow marine, fluvial or lacustrine situations, or beneath glaciers results in the formation of a wide variety of fragmental rocks. Recently, examples have been described from Quadra Island, British Columbia, (Carlisle 1963) where pillow lavas are accompanied by hyaloclastite composed of abundant fragmental material. These pillow lava-breccia complexes resemble the subglacially formed 'globular basalts' and 'basalt-globe breccias' described in Iceland (Walker & Blake 1966). Recently, a hyaloclastite delta was filmed as it formed during an eruptive phase of Kilauea volcano, Hawaii.

2. Petrology

Hyaloclastites are essentially basic lavas which have been in part, chilled and fragmented to a basaltic glass, or sideromelane, breccia in contact with water or ice. The fragmentation results primarily from thermal shock as the basaltic lava is quenched. Such deposits are characterised by glassy fragments of varying size, shape and vesicularity, and usually accompanied by lava pillows. The shape of the fragments is essentially angular, with occasional curved surfaces. The particles are bounded by fracture surfaces and the rounded walls of broken vesicles. Hyaloclastite deposits are, therefore, different in appearance to the volcanic ash produced by subaerial volcanic activity, which typically has a vitroclastic texture resulting from the blowing apart of a vesiculating lava by expanding gas bubbles (Macdonald 1972). Occasionally, in such deposits, the pillows themselves may be brecciated, although it is only the chilled glassy rind of the pillows which is commonly decrepitated to form the hyaloclastite.

The relationship between the two components, lava pillows and glass fragments, may vary considerably from deposits which are almost totally pillows, with little or no breccia, to those which consist entirely of hyaloclastite breccia with no associated lava pillows. The middle member of this continuum, pillow lava-hyaloclastite complexes, represent the type of deposit most commonly encountered.

There are essentially three situations in which hyaloclastite may be formed: (i) the extrusion of basic lava onto the ocean floor, (ii) the flowage of basic lava into a body of water, (iii) the extrusion of basic lava beneath an ice sheet.

3. Extrusion on Ocean Floor

In this first situation, where the basic lava is extruded onto the ocean floor, or in deep water, pillow lava and hyaloclastite breccia accumulate about the vent or fissure, and are continually being pushed both outward and upward by the upwelling or increasingly massive lava at the centre of the complex (Fig. 1a). The initial formation of hyaloclastite breccia tends to blanket successive extrusions of lava so that the quenching effect of the aqueous environment is reduced. Very often the water is excluded from contact with new lava being emplaced at the centre of the complex, which is more massive and may exhibit columnar cooling joints. Long tongues, dykes or pipes of this more massive lava may form anastomosing structures which ramify the complex. Occasionally these structures may project right through the complex to extrude as a short stream of pillow lava on the flanks of the breccia pile. Rittman (1962) recorded instances of such structures, which he termed 'rootless dykes', in Sicily. These rootless dykes commonly have widths of up to three metres and are invariably brecciated to a hyaloclastite near the surface.

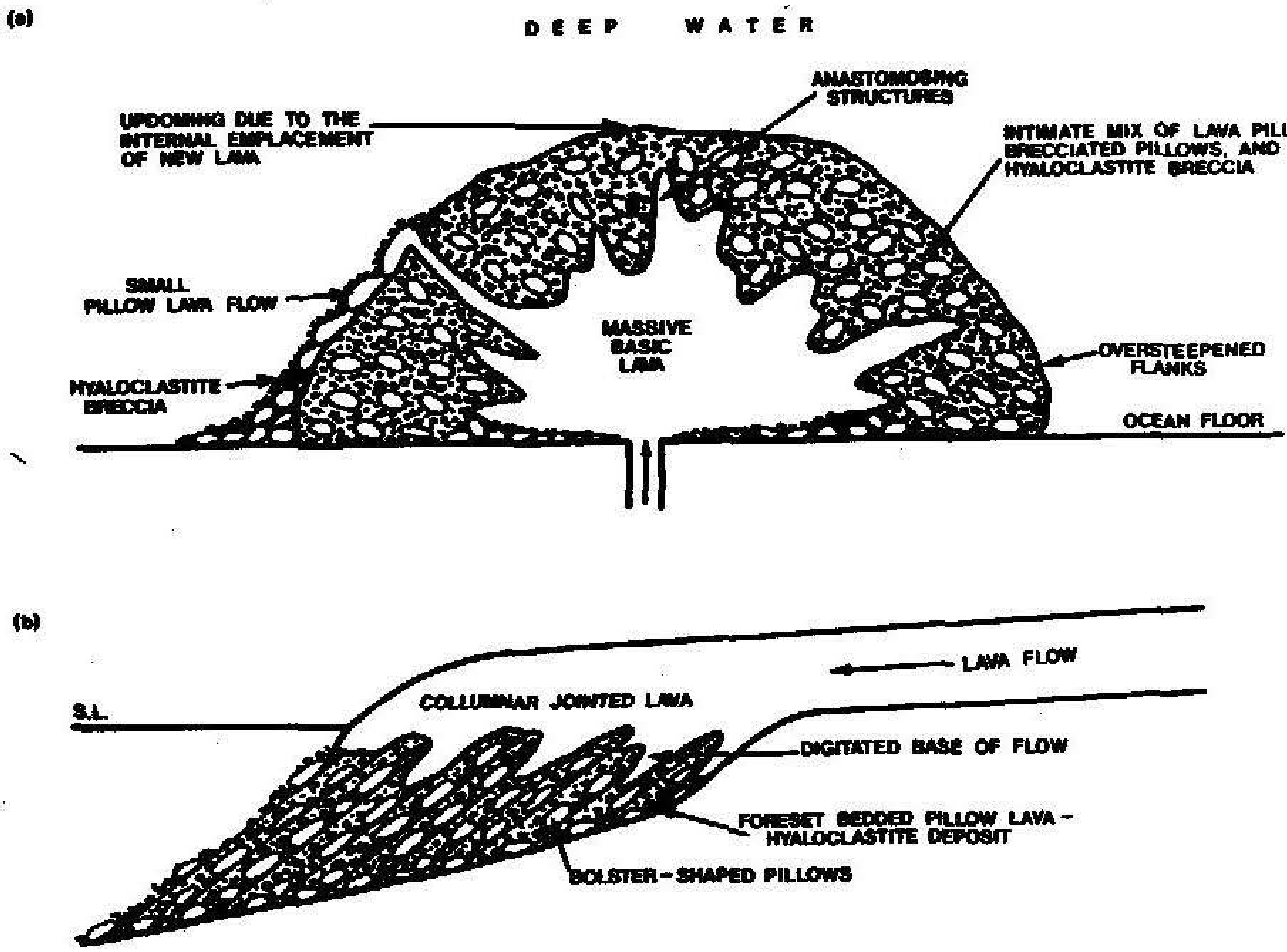

FIG. 1 Pillow lava - hyaloclastite complexes formed (a) by extrusion onto the ocean floor (b) by flowage of lava into a body of water.

Deposits of hyaloclastite may form at any depth in the oceans by the fragmentation of drastically chilled basaltic lavas. Williams & McBirney (1974) have recently suggested that the water depth at which extrusion occurs has a controlling effect on the character of the pillow lava-hyaloclastite breccia complex produced. They propose that the observed decrease of vesiculation with depth is, at least in part, responsible for the decrease in the proportion of fragmental material with depth. Hyaloclastites commonly form massive deposits with little or no trace of bedding. If the exposure is extensive, however, they can usually be seen to pass downward and/or laterally into pillow lavas and possibly even massive lava. Pillows and fragments of brecciated pillows are very often scattered throughout the finer granulated hyaloclastite débris.

Hyaloclastite breccias in an ocean environment are often widely dispersed by gravity flow currents to form the large archipelagic aprons found around the bases of many oceanic volcanoes and seamounts. One variety of seamount is the guyot. They differ from other seamounts in having a wave planated flat top and slopes locally as steep as 40°. This is far steeper than the slopes of basaltic lava cones, and it is thought that these 'cones' consist largely of fragmental material, either partly or wholly hyaloclastite. The occasional high-angle slopes might then be accounted for by the updoming of accumulations of hyaloclastite breccia due to the emplacement of fluid magma into the interior of the complex.

4. Flow into a Body of Water

Hyaloclastite and pillow lava complexes formed by the discharge of basic lava into fluvial, lacustrine, or marginal marine environments show very similar features to those produced on ocean floors. In addition, many display foreset bedding (Fig. 1b), and in some instances evidence exists to suggest that the loose granulated material at the advancing flow front has been penecontemporaneously reworked by wave and current action, and redeposited as tuffites with typical sedimentary structures. Hyaloclastite deposits of this nature usually occur in an association with massive, often columnar jointed lavas with an irregular, digitated lower surface overlying the pillow lava-hyaloclastite accumulations; a reverse of the relative positions realised in ocean floor complexes.

It has been concluded, from the study of ancient examples such as the Columbian River Basalts, and from recent filming of basaltic lava flows entering the sea off Hawaii, that fluidal basalt is suddenly chilled and granulated on entering water so that débris accumulates in advance of the lava flow forming sloping beds of pillow lava and hyaloclastite, similar to the foreset beds of a delta. Lava occasionally dribbles down the leading foreset to form either elongate bolster-shaped pillows, or finger-like projections from the base of the massive lava. Less commonly, more typical, bun-shaped pillows may bud from the flow front and become detached to accumulate at the foot of the foresets, ahead of the 'delta'. Once the foreset beds have built themselves up to the water surface the lava is able to advance across them as a normal subaerial flow, resulting in the usual flow structures and textures of basaltic lava. It is in this way that volcanic islands, such as Hawaii, are able to build themselves out into the oceans.

5. Extrusion Beneath an Ice Sheet

The table mountains of Iceland are basaltic polygenetic shield volcanoes that were built up beneath ice sheets during the Pleistocene. Their upper lava surfaces have the low angle slopes typical of shield volcanoes. They are, however, bounded by steep sides composed of pillow lava and hyaloclastite. During the glacial period Iceland was blanketed by an ice sheet. Iceland lies along the Mid-Atlantic Ridge, and the volcanic activity associated with its geological position continued throughout this glacial period.

It seems likely that the rise in the geothermal gradient associated with the onset of basaltic volcanism may have been sufficient to melt some of the ice. Lavas were extruded beneath the ice, melting that ice to form subglacial lakes of meltwater. As they were extruded, the lavas behaved as though they were erupting on the ocean floor, becoming chilled and granulated to form hyaloclastites breccias (Fig. 2). As the volcanoes built up a stage was reached when the ice above the volcanic vent melted through to the surface to form a lake upon the ice sheet. At this stage continued activity would be of the surtseyan type and waterlain pyroclastics would accumulate. Continued activity generally resulted in the draining of the lake. The débris-laden waters so displaced poured down the glacial

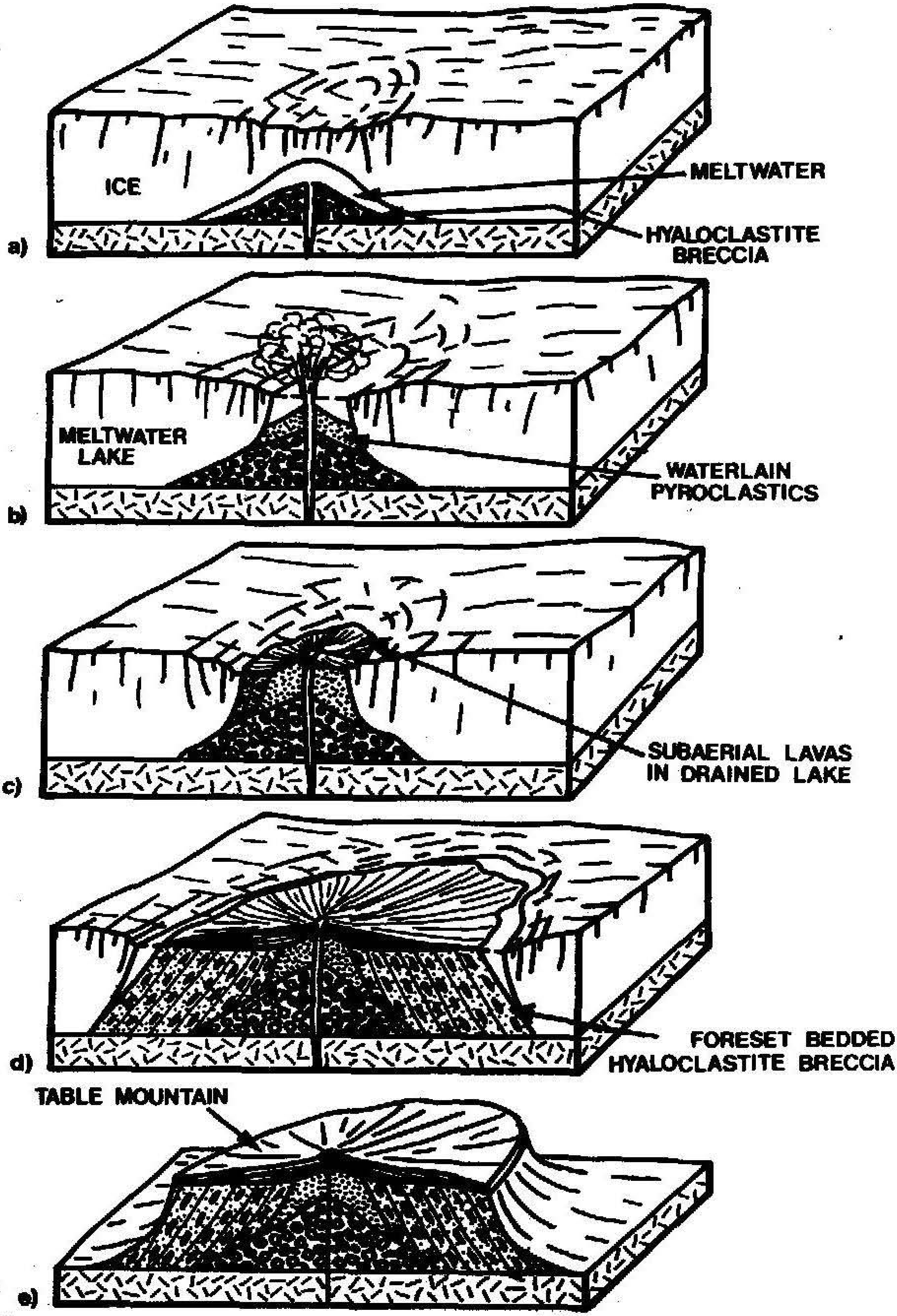

FIG. 2 Pillow lava - hyaloclastite complex formed by the extrusion of basic lava beneath an ice sheet (after Williams & McBirney 1979)

channels as a lahar. The lava subsequently erupted into these drained lakes formed a carapace of normal columnar jointed lava. Moats of meltwater almost certainly persisted about these emergent volcanoes as their lavas have developed foreset bedded pillow lava-hyaloclastite accumulations.

When the Pleistocene epoch closed these glaciers and ice sheets retreated leaving behind these lava-capped piles of pillow lava and hyaloclastite forming flat-topped mountains. Very similar table mountains have been described from British Columbia (Carlisle 1963) and an analogous origin for them has been proposed.

6. Palagonitisation of Hyaloclastites

It was formerly believed that palagonitisation was the result of reactions involving steam permeating the volcanic edifice both during and preceding volcanic activity. It is currently considered that palagonitisation is largely the product of normal aqueous weathering processes. Palagonite is a yellowish hydrogel, formed by hydration of sideromelane as a result of its exposure to either oceanic, lacustrine, glacial or ground water. A layer of palagonite approximately 10 mu thick will form on basaltic glass over a period of 10,000 years. Fine glass fragments, therefore, will become completely palagonitised is a very short time geologically. Palagonite is an extremely common component of hyaloclastite complexes, and imparts a bright yellow colour to the rock. The basaltic deposits of surtseyan ash cones and some strombolian cinder cones with their yellow bedded and fragmentary appearance can at first sight be confused with hyaloclastites. Careful examination of their fabric, however, clearly shows that they have a very different origin from hyaloclastites.

The pale brown, or reddish brown, sideromelane is far more susceptible to alteration than the black tachylyte glass. The colour of tachylyte is due to finely disseminated grains of magnetite, which are largely absent in sideromelane. The ease of alteration of sideromelane is thought to result from the retention of iron in solution. Much of the original Ca, Na and some Al and Si in the glass is removed during palagonitisation, and is generally reprecipitated as zeolite minerals in vesicles and in the interstices between the pillows.

7. Conclusion

All three of the situations described make up deposits which may truly be called hyaloclastite breccias. Unfortunately some volcanologists have used the term hyaloclastite to describe the rock type found in palagonitised surtseyan ash rings, and in some cases palagonitised strombolian cinder cones; both of these are totally unacceptable usages of the term.

8. Acknowledgments

The author would like to acknowledge the encouragement and lecturing of Dr. R.J. Fitch whilst at Birkbeck College, University of London. I would also like to thank Dr. P.A. Olver who first kindled my interest in geology.

9. References

CARLISLE, D. 1963. Pillow breccias and their aquagene tuffs, Quadra Island, British Columbia. *J. Geol.*, 71, pp 48-71.

MACDONALD, G.A. 1962. Volcanoes. Prentice-Hall Inc., New Jersey, 510 pp.

RITTMAN, A. 1962. Volcanoes and their activity. John Wiley & Sons, N.Y., 305 pp.

WALKER, G.P.L., & BLAKE, D.H. 1966. The formation of a palagonite breccia mass beneath a valley glacier in Iceland. *Q.J. geol. Soc. Lond.*, 122, pp 45-61.

WILLIAMS, H. & McBIRNEY, A.R. 1979. Volcanology. Freeman, Cooper & Co. San Francisco 397 pp.

Geoblanks

A geological quiz set by Charles Ives. All correct entries submitted to the Editor by 1st June will be put into a Prize Draw at the Summer Social.

1. Marble is . . . . . . that has been subjected to matamorphism.
2. Granite is an example of a . . . . . . rock.
3. The . . . . is the tree that helps to date the past.
4. The two main types of sedimentary rock are . . . . . . and . . . . . .
5. That marine sedimentary rocks can be elevated to great heights above sea level was first appreciated by . . . . . .
6. Snowdon is the remains of (a) an anticline (b) a volcanic vent (c) a syncline.
7. On either side of Lyme Regis are fine exposures of . . . . . . rocks.
8. The . . . . . . found in the Kent Chalk are thought to have been carried in the . . . . . . of marine saurians.
9. The first ammonoids were called . . . . . .
10. The Coal Measure forests included the huge . . . . . . of the club moss group and the giant horsetail . . . . . .
11. The brachiopod . . . . . . is a genus with a 400 Ma history.
12. The Ludlow Bone Bed is an example of a . . . . . . deposit.
13. Complete the following list of Jurassic stages:
    Aalenian, ... , Bathonian, ... , Oxfordian, ... , Portlandian, ...
14. Sea lilies are animals which belong to the phylum . . . . . .
15. An orogeny covers a period of time during which . . . . occurred.
16. Crescentic ones are called barchans, elongated ones are called seifs. They are both . . . . . .
17. The neritic zone extends from the . . . . level to the edge of the . . . .
18. Rock types to be found on the Lizard Peninsula include . . . . . . , ... and . . . . . .
19. What do the following areas have in common?
    New Radnor, Usk, May Hill and the Wren's Nest at Dudley.
20. A pebble with eroded angular flat surfaces is called a . . . . . . and has originated in a . . . . . . environment.
21. Wind transported fine-grained material is called . . . . . . which when reworked by river action becomes . . . . . .
22. Most geologists believe that polar wandering was caused by . . . . relative to the magnetic poles.
23. The supercontinent of . . . . . . was the site of the Permo-Carboniferous glaciation.
24. Match the following graptolite zones with their correct stages:

Didymograptus extensus	Caradoc
Didymograptus bifidus	Ashgill
Dicranograptus clingani	Arenig
Dicellograptus anceps	Llanvirn

25. Complete the following geological triads:
    Apatite . . . . . . Quartz, Eocene . . . . . . Miocene,
    Rhyolite . . . . . . Basalt, Slate . . . . . . Schist,
    Labradorite . . . . . . Anorthite, Bunter . . . . . . Keuper.

Congratulations!

We are very pleased to announce the award to Mrs. Diana Smith, our hard working Secretary, of a B.A. degree from the Open University. Well done, Diana!

CLASSIFIED
ADVERTISEMENTS

NOTE FOR THE GUIDANCE OF AUTHORS

Papers and article on any topic within the earth sciences are welcomed especially those of local interest. Short papers of 2000 words or less are preferred although longer papers not exceeding 5000 words can be accepted.

Two copies of the typescript should be sent to the Editor. Typescripts should be doubled-spaced, including references, on one side of A4 paper with a wide margin on the left and a narrower margin on the right. All pages should bear the author's name and numbered serially.

Papers and articles should be arranged as follows:

1. Title, brief and specific.
2. Name of author(s).
3. Summary: this should not exceed 100 words.
4. Address of author(s).
5. Main body of paper or article: subdivided into separate headings which are to be numbered serially.
6. Acknowledgements.
7. References.
8. Legends for text-figures and plates (if any).

Measurements should be given in S.I. units. Standard palaeontological and stratigraphical conventions should be followed throughout the text. Generic and specific fossil names to be italicised throughout. Localities referred to in the text should be precisely located by their Grid Reference or by an appended index map.

References should be listed alphabetically by author at the end of the paper. Attention should be paid to convention as regards the abbreviated titles of journals. Authors are responsible for the accuracy of their references.

Figures used to illustrate articles should be prepared at twice the size of their eventual reproduction. Any letters or numerals should not be less than 1mm high after reduction. It is suggested that white card or a colourless tracing medium be used with black indian ink and dry transfer lettering.

Typescripts, enquiries concerning editorial matters and all correspondence should be addressed to: The Editor, Journal of the Farnham Geological Society, Farnham & Ash Adult Education Institute, 25, West Street, Farnham, Surrey GU9 7DR.

PAUL OLVER Editor

FORTHCOMING MEETINGS 1981

March 13th:	**Coralline Algae and Reef Formation.**	Dr D. Bosence
April 10th:	Volcanoes.	Dr. J. Potter
May 1st - 4th:	**Field excursion to the Malvern and Abberley Hills.** Leader:	Dr. P.A. Olver
June 12th:	Marbles.	Mr. R. Roberts
July 10th:	**Members' Evening - recollections of Italy's volcanoes.**	

The Farnham Geological Society

This Society, founded in 1970, exists to promote interest in Geology and to extend knowledge of the science by research and by publication. It holds meetings for the reading of original papers and the delivery of lectures, organises practical demonstrations and conducts regular field excursions.

Candidates for election must be recommended by two or more members. Present Annual Subscription £6.00.

For Forms of Proposal for Membership, and further information, please apply to the Secretary, Mrs. D. Smith B.A., Farnham Geological Society, 21a Mount Pleasant, Farnham, Surrey GU9 7AA.

VOLUME 1 PART 1 1981