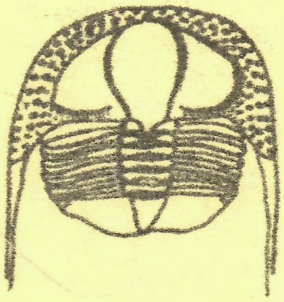
LIBRARY



CUMBERLAND GEOLOGICAL SOCIETY

PROCEEDINGS 1963 No. 1

TWO SHILLINGS AND SIXPENCE

ISSUE LABEL

DURATION OF LOAN—Not later than the latest date stamped below.

7. OKT. 1969

2 - JUN 1975

20. JULI 1963.

943 (1)

THE CUMBERLAND GEOLOGICAL SOCIETY

President:

E. H. Shackleton, F.G.S.

.....

Honorary Life President:

C. Edmonds, M.Sc., F.G.S., J.P.

.....

Proceedings No. 1, 1963.

Editorial ..... Page 1.
The Annual Dinner, January 4th. ..... 3.
The Annual General Meeting, January 10th. ..... 3.
Presidential Address "On the Age of the Earth", February 14th. ..... 5.
Visit to Barrowmouth, March 16th. ..... 19.
Visit to Marchon Anhydrite Mine, March 25th. ..... 19.
Visit to First Limestone, Brigham, March 31st. ..... 23.
Field Excursion to Goldscope Mine, Newlands, April 7th. ..... 25.
Brief reports of other activities. ..... 28.

The origin of the Earth and Chemical Elements. ..... 29.
Superficial investigations of the Borrowdale Plumbago Mines. ..... 34.

.....

Notes:

The Society was formed from the West Cumberland Geology Group.

The only qualification for membership is an interest in geology.

During each Spring and Summer, a series of field excursions is held to places of geological interest. Cumberland is one of the most fortunate of all the counties where geology is concerned. Many of the Geological Systems are represented. The Skiddaw slates and Borrowdale volcanic rocks are of Cambrian and Ordovician age. A belt of Silurian rocks runs from Shap to Millom, whilst Devonian rocks are to be found near Ullswater. These very old rocks of the Lake District are encircled by newer deposits of Carboniferous, Permo-Triassic and Jurassic ages. The county also possesses an abundance of fascinating mineral wealth, whilst on the surface the effects of the Ice Age are everywhere in evidence.

During the Winter, a programme of Lectures, Films and practical work is arranged, and meetings are held alternately at Workington and Whitehaven Colleges of Further Education.

Correspondence on Society matters should be addressed to the General Secretary,

R. E. C. Pearson, Esq.,

[redacted]

EDITORIAL

.....

I am not quite sure what has happened to this Society of ours over the last few months. By last December, the membership was 95; it is now 110, and less than six months of the year have run. A heartening aspect of the membership statistics is the increase in numbers of associate members, and what pleases me especially is the fact that a number of last year's associates now away at Universities up and down the land have maintained their interest in and support of the Society. We are very glad to see you at lectures and excursions when you "come down" during vacations. In order to cater for our younger members, the Council has arranged a number of afternoon excursions to places of interest where the emphasis will be on a simple approach to the geological features displayed. Reports of some of these visits are contained in the following pages.

Don't forget the Competition, open to all members (except the Council). You will of course have had details - valuable prizes will be awarded at the "Soiree" in September. Put aside the temptation to say "This is not for me, I don't know enough geology". Instead, get yourselves out during the Summer; look for specimens! survey your quarries! dig into the archives! draw your maps! write your articles! If you do get stuck, help and advice is free from the "experts".

I feel I must praise the work already put in by our Excursion Secretary, Mr. R. H. Hewitt, on the excellent series of Mine visits he has arranged. They have proved so popular that it was a case of firstcomers only. However, those of you who wrote too late to be included will be glad to know that more visits are to be arranged towards the end of the season. Despite his ever-cheerful countenance, our Excursion Sec. is a very worried man. Why do so many members leave it to the last minute to write to him requesting places on visits or details of excursions? Please make a Midsummer Resolution (of the unbreakable variety) to write to or 'phone Mr. Hewitt immediately on receiving details of visits if you require transport, or a place on a Mine excursion. It helps him no end ! You may like to start now: you will see from the slip enclosed in your membership card that there is to be a weekend camp in the Caldew Valley. If you intend going, don't just turn up on July 26th. Let Mr. Hewitt know, giving details of any equipment you can provide or require to borrow.

That the Society is rapidly extending its sphere of influence is evinced by the ever-increasing amount of correspondence attended to by our hardworking General Secretary, Mr. Pearson. He is being inundated by requests for Society publications, and details of its activities. It seems likely that we shall have to reprint last year's Proceedings. They may even obtain considerable scarcity value - who knows ?

Whilst on the subject of publications, I must mention the Secretary's pet bee in his bonnet. We print these Proceedings almost clandestinely. We have to beg, borrow or even steal the use of a duplicator for a few hours to run off the stencils. Those of you who have had dealings with duplicators will know that each machine has its idiosyncrasies. This one smears ink over your fingers or over every third copy. That one puts through six sheets at a time - to everybody's annoyance and frustration. The other one oozes ink all round the stencil, but not through it as it ought. The whole point of the sorry tale is this, IF the Society had its own duplicator, most of our problems of printing notices, proceedings, memoirs, sketch maps, etc. would be solved. The snag is that we haven't the money at present. However, our resourceful

secretary is not deterred by that. He talked his sister into producing some very artistic line drawings, postcard size. These he has turned into postcards, four to a set, one thousand sets (to start with). Admittedly this has cost a little money, but the returns, if they are all sold, will go far towards the purchase of our duplicating machine. How about it ? Pester your Secretary for these highly original, unusual and artistic postcards, 4d. each or 1/4d. the set, for yourselves and your friends.

Professor Hemingway, at the Annual Dinner, complimented us on not being mere "armchair geologists". Attendance at field meetings has amply confirmed that compliment, but quite apart from practical geology arranged by the Society, we are now in the happy position of having outsiders writing in for advice on such matters as water supply, subsoil drainage, and details of old mine workings. In connection with this type of activity, the Secretary will welcome details from members who have firsthand knowledge of any specialised topic so that he can build up a fund of experience and information upon which the Society can draw in future.

Last, but surely not least, our President. During last year, he was far from being well physically. In spite of his energetic appearances at excursions, those of us who saw a lot of him realised he was a very sick man, and it came as no surprise to us when he was whisked off to hospital at Newcastle at the beginning of Autumn. After a wearisome three month stay and several serious operations, he returned home in January to convalesce. Such is his physical toughness and strength of spirit that he turned out in very blustery weather on the Barrowmouth visit in mid March. Lesser mortals would have stayed at home to watch T.V.! We are very relieved that you have overcome your serious illness, Mr. Shackleton, and are pleased to have you back leading the Society.

The picture of this Society, then, after eighteen months of existence is a bright one. Membership, fieldwork, correspondence, publications are all on the increase. We welcome your active participation in future activities.

T. Shipp.

A.G.M. continued.....

Although the Society had little cash in the Bank at the end of its first year, the Treasurer in his report expressed confidence in its financial standing. Most of the income of the Society had been devoted to printing and postage. Demand was encouraging for the publications produced during the year, namely Proceedings Nos. 1 & 2, and The Limestone Series of West Cumberland. Stocks of these publications were held, and it would be possible to re-use the stencils for further printing, should the need arise.

The following Officers of the Society were elected for 1963:

President: E. H. Shackleton, F.G.S.
Vice president: G. S. Gowing, M.A., F.G.S.
General Secretary: R. E. O. Pearson.
Excursion Secretary: R. H. Hewitt.
Treasurer: T. Shipp, B.Sc.
Council: M.F. Burton, S. H. Gate, B.Sc., M.Sc., A.R.I.C.
D. C. James, B.Sc., A.M.I.Chem.E., H. A. White, B.A.

To mark his valuable support given to the Society, and his help and encouragement to individual members over many years, the retiring President, Alderman Edmonds, was made Honorary Life President.

In the absence, through illness, of the President, the Chair was taken by Mr. Gowing. Discussion took place on future activities, the welfare of Associate Members, and the possibility of purchasing a duplicating machine. The meeting was concluded at 9p.m.

THE ANNUAL DINNER

Held at the Commercial Hotel, Workington, on January 4th.

Forty five members attending this Society function were welcomed by the President, Ald. C. Edmonds, M.Sc., F.G.S., J.P. Guests of honour were Professor and Mrs. J. E. Hemingway of King's College, Newcastle.

After a most enjoyable meal, Professor Hemingway, addressing the Society, confessed he was bewildered by the invitation for him to be the principal speaker, but decided it was because of his long association with the only other County Geological Society - in Yorkshire. It was explained that before taking up his present appointment as Professor of Geology at King's College he had been Senior Lecturer in Geology at Leeds University.

The Professor went on to say that he had followed the progress of the Cumberland Geological Society and was pleased to see from the various publications that emphasis had been placed on active fieldwork. He regretted that too many Societies these days rely on armchair members. He then stressed that one should learn as much as possible from a chosen period of Geological History in order to become expert, in the belief that as knowledge increased, so did interest in the subject.

Thanking the Society for its hospitality, Professor Hemingway expressed hope that its rate of expansion and influence would increase.

Mr. Pearson rose to thank our guests for honouring the Society with their presence.

It was a bitter disappointment to our vice-president Mr. Shackleton that his doctors would not let him out of hospital in time to attend the Dinner. We were pleased, however, that his wife was able to be present, and his gift of wine enabled members suitably to wish him a speedy recovery.

Once again we are indebted to Mrs. Hopkin, our secretary's sister for her highly original and often amusing individual geological menu cards which have provided many members with a souvenir of a very pleasant evening.

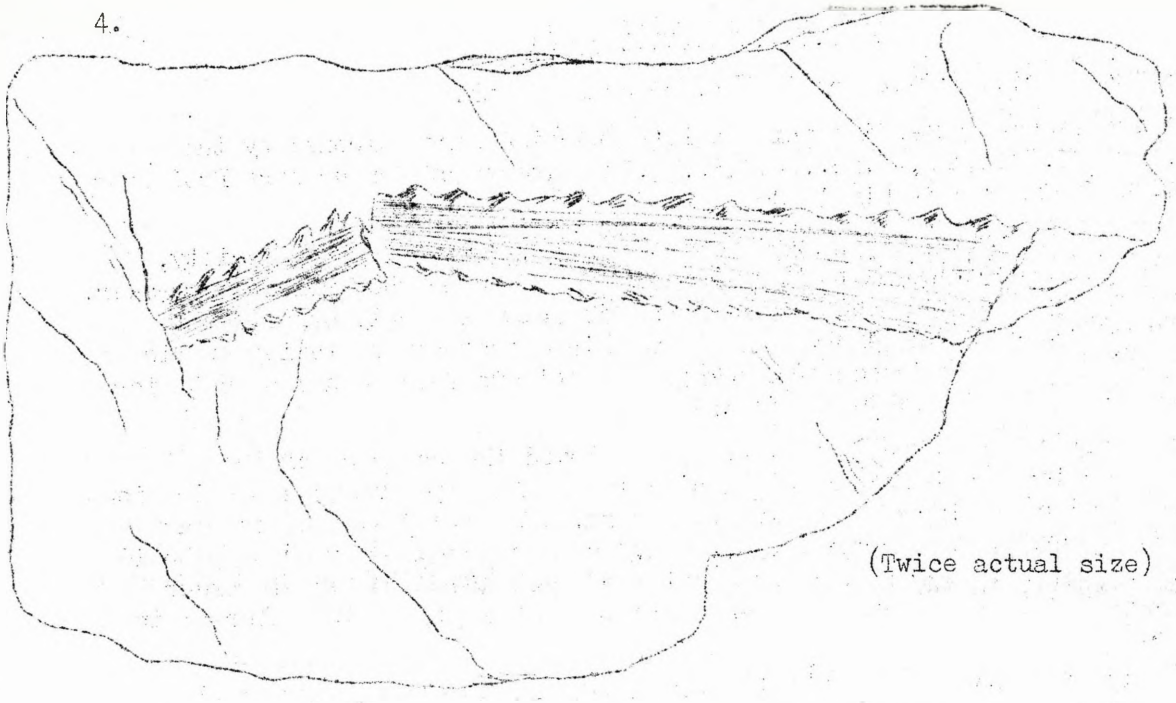
THE ANNUAL GENERAL MEETING

Held at the Workington Technical College on January 10th.

It seems to be a feature of democratically-run societies that the most poorly-attended annual function is the meeting at which leaders are elected and policies approved by the members. Such is certainly true of our Society, and it seems a pity that, whilst purely geological functions are generally well-attended, more members cannot turn up for the one meeting at which the year's activities are reviewed and in which the needs of the coming year are anticipated.

The General Secretary gave his report, indicating that membership during the first year as an established Society had risen from 45 to 95. Although he did not anticipate that the rise would be as striking in 1963, he hoped the trend would continue by the attraction of the many people who have some interest in geology and mineralogy, and who would like to share in the activities of the Society. Mr. Pearson then reviewed the activities of the past year, and stressed the emphasis the Society places on practical geology.

Continued opposite...



(Twice actual size)

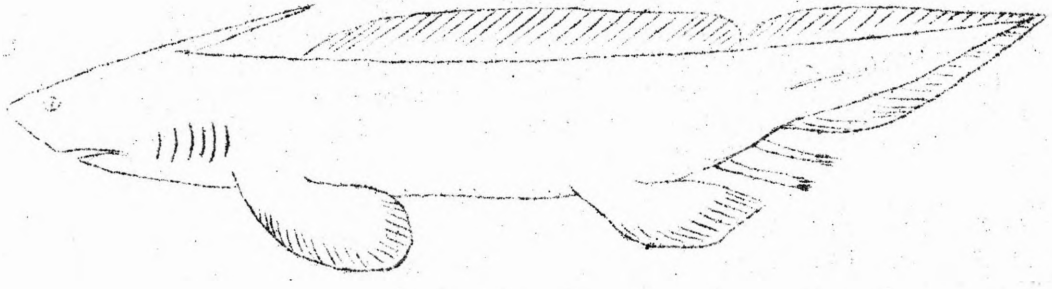
FOSSIL SPINE OF PLEURACANTHUS - IN COAL MEASURES SHALE.

The Society was presented with the fossil illustrated above by Mr. R. Burland of Workington. The fossil, which is very well preserved in hard black shale, came from St. Helen's Colliery, Workington.

The fossil is of the spine which was articulated to the back of the head of the primitive shark PLEURACANTHUS, which ranged from the Lower Carboniferous in Europe to the Triassic of Australia. The spine, seen in the illustration below, seems to have been capable of erection at will, possibly to ward off attack in much the same way that the present-day Stickleback uses its spines - as a defensive rather than offensive weapon.

The Pleuracanthus appears to have been quite common during Carboniferous and early Permian times. No doubt it evolved during the Devonian period, the 'Age of Fishes', finally becoming extinct during the Mesozoic era.

The specimen is in the keeping of the Society's President who will be pleased to show it to any interested member.



PLEURACANTHUS 1/10th. natural size.

Presidential Address, delivered at Whitehaven College of Further Education on Thursday, February 14th., 1963. Owing to the President's indisposition, the paper was read by Mr. T. Shipp.

ON THE AGE OF THE EARTH

This is not intended as a learned dissertation, and I intend to avoid technical language as far as possible, but in doing this, I am conscious of a difficulty. What was technical and abstruse several years ago may well have become commonplace today, for we are living in a technical age. I have to strike a balance by putting across my material in such a manner that some shall not be irritated, with others left floundering.

The age of the planet on which we live has exercised men's minds for thousands of years. To some of you this may seem a long time - and this brings us right away up against the problem of time and man's conception of it. The problem of time is shared by astronomers and geologists alike. For stellar processes, as for geological, a million years can almost be taken as a unit, and whilst geologists and astronomers talk quite glibly in terms of millions of years, it must be realised that to grasp the significance of the words we use is not easy. How much more difficult it must have been for the less scientifically-inclined minds of our predecessors.

When the Chaldeans proclaimed, some 5,000 years ago, that the Earth was two million years old, it is not so clear whether they meant just that, or whether they were really agreeing with Hindu thinkers who said the Earth was immortal. Yet these same Chaldeans knew our Solar System pretty well for they had worked out the length of a year in days at 365¼. They had calculated the cycle of eclipses to within a matter of hours and had a clear understanding of what was involved. Most remarkable of all, they understood the precession of the equinoxes (which is more than I myself do!) and had worked out the cycle at some 40,000 years as against our present-day figure of 26,000 years. Their shot at the age of the earth was probably no more than a wild guess, but it at least compares pretty favourably with guesses made by other peoples from time to time.

The Babylonians seem to have had little to say about the age of our planet, but they averred that mankind was 500,000 years old. A guess, no doubt, but a remarkably prescient one.

Those wonderful people the Greeks were, on the subject under discussion, very disappointing for they seem to have had no clear-cut ideas on the subject, and yet it is with them that there first arose a firm belief that there is an order in Nature. Their wonderful mythology should not be allowed to blind us to the best of their sober thought. Listen to this:

"The sea now covers vast tracts which formerly were dry land, and one day land will reappear where now we find sea. We must look on these mutations as following each other in a certain order and with a certain periodicity, seeing that the interior of the globe has its periods of vigour and decline"

Aristotle, to be sure, but it might have been written by Professor Arthur Holmes!

Greek science declined before it contributed any inspired guess about the age of the Earth, by becoming embalmed in Hebraic culture. The Jews were greater humanists than they were scientists; certainly they were

never geologists for their building material was brick, not stone, and their one contribution to Earth history was an exaggerated memory of a flood which they had from Abraham and Ur of the Chaldees. Unfortunately, what they lacked in science they more than made up for in blind faith, and their ideas completely held men's minds in thrall until after the Renaissance.

To say that men have only thought deeply about the age of the Earth in the last two hundred and fifty years would be completely wrong, as I hope I have shewn, yet it is only during that time that any real progress has been made. Previous to this all great thinkers put forward their ideas on the subject in the form of conclusions they had reached after communing with themselves, Having reached a conclusion, they then sought facts to confirm that conclusion, and it is remarkable with what ease man can follow this line, he always has been and unfortunately he is still quite capable of doing it. But the essence of our progress in later years has been the recognition that the opposite approach is the only rational one - first ascertain the facts, and then formulate a theory. Test your theory by further facts, by experiment and prediction - and this is the essence of Science and the scientific approach. No man or woman is worthy of the name of "Scientist" who has not grasped this approach with a clarity and understanding which makes its application second nature. I wish I could say we were turning out true scientists today with unfailing regularity. Unfortunately I have reason to doubt it. Man's knowledge has become so immense that the struggle to accumulate facts in order to pass examinations tends rather to crowd out of our curricula the underlying principles of science and the scientific approach.

By the eighteenth century men who studied the Earth had already begun to realise that the Earth must have a long history, but their minds and imaginations were still held in thrall by Hebraic ideas, dominated by the story of Creation and of the Flood.

To these early geologists was given the name "Catastrophists" because in any explanation of natural features, be they mountains, valleys, ravines or the rocks and their contents, they invoked some sudden and catastrophic happening.

It is easy to smile today at these ideas but it should be remembered that their ideas were at least based on observation. Man's memory is long and he does not easily forget devastating floods or the terror and destruction of volcanic eruptions and earthquakes. He knew, as who doesn't that has ever had to clean up the mess, that floods could shift enormous quantities of material and strew it far and wide, often over miles of the countryside. He had seen whole towns and villages devastated by earthquakes, with huge cracks opening beneath his feet, it was well known to him that whole cities had completely disappeared under the outpourings of ash and lava from volcanic eruptions. To account for all that he could see in the few thousand years that his Faith prescribed called for drastic catastrophic action, how else could it be done? Meanwhile the ecclesiastics in the person of Archbishop Ussher had made assurance doubly sure. Had he not meticulously checked the genealogy of Adam's descendants right down to his own day? On this basis, so the learned Archbishop averred, the Earth began its career in 4,004 B.C. He was even prepared to give the day and the hour!

It is difficult for us at the present time fully to appreciate the atmosphere of those days, or how difficult it was to think along other lines, but so long as man is allowed to think for himself, think he will, and whether from inspiration or sheer cussedness sooner or later fresh lines of approach emerge. The rumblings of dissent were focussed by a Scottish doctor called Hutton, who was also a geologist, in a book published in 1785 called "A Theory of the Earth".

From this book I am going to quote one single passage, and make no apology for the quotation either!

Hutton says, "Before attempting to assign dates to the leading events of the Earth's history, it is essential to consider the steps by which geologists have been able to arrange stratified formations in a continuous historical sequence and to interpret the conditions under which they were formed.

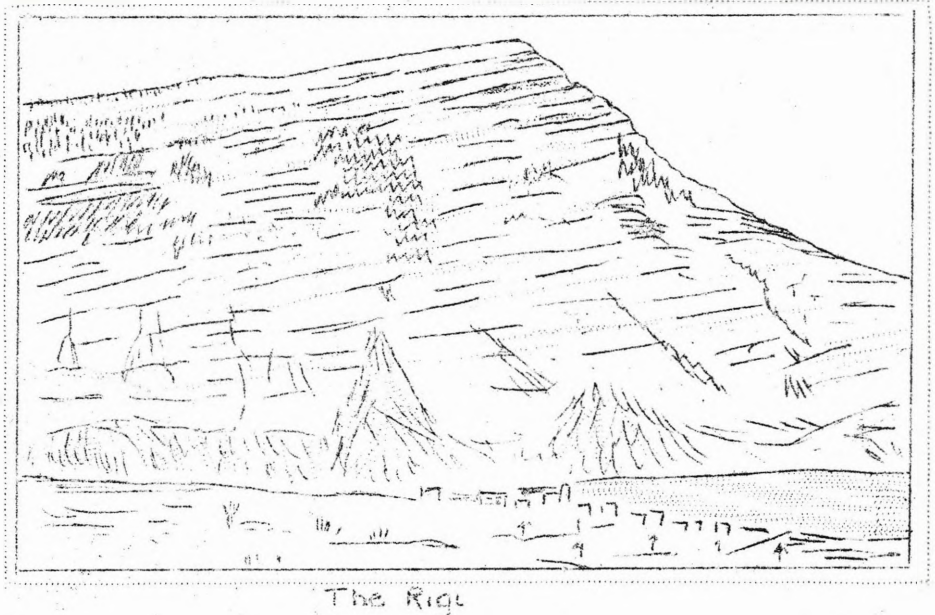
Whenever a satisfactory parallel can be drawn between the older formations and those being formed today, it is argued that the older rocks must have had an origin akin to that of rocks now in the making."

Hutton was stating quite clearly a belief that the course of Nature over long periods was a uniform one, that the key to the past was the present, and if we wished to understand how things come to be as they are we must carefully note this process of development as it is exemplified in natural processes still at work.

A few moments' thought will shew that Hutton's theory of the Earth was diametrically opposed to the Catastrophic theory of other geologists. His school of thought came to be known as the "Uniformitarian" school, and the battle between the Catastrophists and the Uniformitarians was one of the most bitterly contested fights that has ever disturbed the tranquillity of the Geological Society.

But what was it all about?

Let us make a break and take a look at some of the Earth's features and try and understand how the two schools interpreted what can quite clearly be seen.



The Rig

Here in this picture of a mountain in the Alps, we can see that the rocks of which it is composed lie one above the other in beds. The beds themselves are made up of different materials, some are composed of grains of sand cemented together, others of fine mud compacted, whilst still others are made of pebbles stuck together. Yes, said the Catastrophists, the result of a great flood in which these beds were accumulated; in time the debris set solid, and rain and rivers carved out the mountain. Quite, said the Uniformitarians, but how long did all this take? This mountain

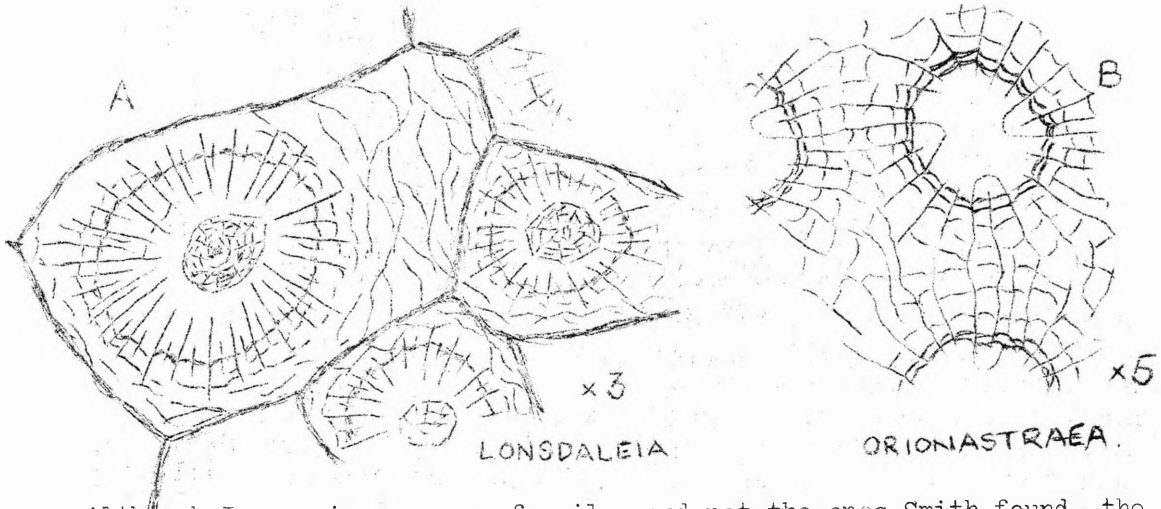
has been here for hundreds of years, and is little different today from what it was previously. Look again, and along the flanks of the mountain you can see heaps of rock debris removed by the weather from the rock face. This material is removed by rain, for do not our rivers run turbid after rain? What becomes of the mud and sand carried away by rivers? It is deposited in the lakes and gradually silts them up. You can, over a few years, see this process actually happening. The mud may be carried further to end in the sea where it is deposited layer above layer, just as you would see in the rocks of our mountain. Notice again the many layers of sediment, not one thick deposit as one might expect from the Catastrophists' Flood.

Again in the Alps, one can see magnificent gorges, through most of which run rivers. A good example is the gorge of the Aare containing a river at least the size of our Derwent. This, according to the Catastrophists, is the result of one of those sudden earthquakes which have been observed to split the rocks and open up the ground. The Uniformitarians countered this assertion by pointing out that the walls of the gorge were smooth and obviously water-worn. The gorge was obviously cut by the river.

And so the learned argument dragged on. Once such a conflict of hypotheses seizes the imagination of thinking men, more and more people are drawn into the arguments. Once the idea of "Look-see" catches on, the process of observation snowballs, and facts, as distinct from ideas, begin to pile up. We in Britain can be proud of our record in geological science, for it was here that the foundations were laid. Much sound thinking was contributed by a man of humble origin called William Smith, a surveyor by occupation, who had not time to go to school very often because he found quarries much more interesting.

Smith studied many limestone quarries, very similar in form to the ones we have in our own area. He pointed out that the beds or strata lie one on top of the other. Quite obviously the one at the bottom is the oldest, and that at the top is the youngest. Quite obvious indeed! An upper bed could hardly have been laid down before the one beneath it - why didn't somebody think of it before?

He also found that a single bed can quite often be traced across country, sometimes for miles. He also observed that where a bed contains the remains of creatures entombed at the time of deposition, these fossil remains are the same for the same bed, but usually different in other beds.

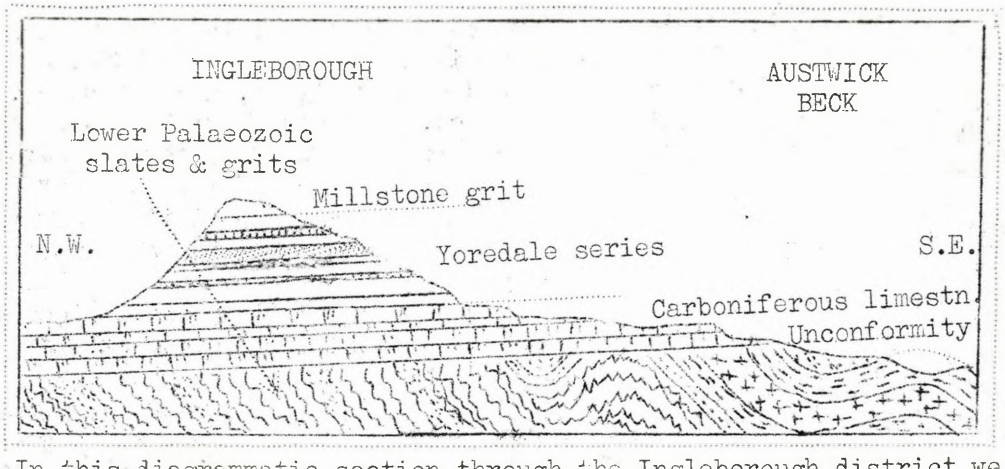


Although I am using our own fossils, and not the ones Smith found, the principle he outlined is the same. The fossil corals shown above can be found

in one of our limestone bands. By studying their exquisitely-preserved structures and comparing these with modern corals, much can be learned about creatures of this type living when any one limestone bed was laid down.

The specimen labelled 'B', Orionastraea, occurs in one bed only exposed in some of our local quarries, and I have seen its counterpart in many localities in Gt. Britain. I have also seen identical fossils from the limestones of the Moscow Basin in Russia. Nowhere is the bed in which this Orionastraea occurs much over two feet thick. It must be remembered that corals are sedentary creatures that spend their lives attached to the sea bottom. Once only at the beginning of the individual career are things any different; as a baby our coral is free-swimming for a very short time, not long enough to move very far from where it was born. If the accumulation of two to three feet of limestone took sufficient time for our coral to spread in short hops from here to Moscow (or the reverse)..... I think you will begin to see why even the first geologists were obsessed with time. The illustration, by the way, is of Orionastraea edmondsi, named after Alderman C. Edmonds who has done so much valuable work on the Cumberland Limestones.

Smith found, and other workers have amply confirmed, that once a creature dies out, its remains are never found again. In other words, many fossils are confined to distinct beds. He and other workers found that the older the rocks one examined the more primitive the fossils became, and conversely, the younger the beds the more like present-day creatures the fossils became. No wonder Smith has been called "The Father of Geology", for using his discoveries, geologists have been able to arrange all the beds laid down in water in a sequence, and to give to the different formations of this sequence names which are now known throughout the world. These names form a fitting memorial to our great pioneers, characteristically English names like the Devonian, after types of rocks exposed in Devon. Our geologists soon found that our sequence was far from complete or unbroken.



In this diagrammatic section through the Ingleborough district we have white limestones lying on darker beds, and whilst the limestones are lying almost horizontally, much as they were laid down, the other beds seem to be up on end. Lying on the truncated top of the lower beds, and at the base of the limestone one usually finds a bed made up of cemented pebbles. How are we to interpret this section? First the older beds which we now find in sweeping folds were first laid down horizontally. Later the consolidated muds of which the beds are composed were folded and lifted up above the sea in which they were formed. Then the weather set to work on them and gradually removed the tops of the folds until an almost flat plain was produced. Next the land sank and the sea spread over it, and in doing so produced the

pebble beds along its shore line, much as it does at the present day at St. Bees or Allonby. Finally the land sank completely below the waves and beds of limestone accumulated. Such a broken sequence is known to geologists as an 'unconformity' because the upper beds do not lie conformably upon the lower ones. What such an unconformity signifies is time - time in long, long aeons, time for all these changes to take place. To stand, as I have often done, with one foot on the older rocks and one on the newer is to bridge between my two feet a gap that can be reckoned only in millions of years.

And so we see early geologists, having settled their quarrels about catastrophies, becoming more and more troubled about time. Time in large lumps was the only answer for them, for all the various changes suggested by the evidence of the rocks. Of no use at all to them was Ussher and his few thousand years! Science in those days was in some ways more of a unity than it is today, in other ways less so, and whilst the geologists were busily engaged with their rocks and fossils, other scientists had begun to consider the Earth and its past history. Someone had pontifically announced, after a close study of our Solar System, "What the Sun is, the Earth once was, what the Moon is, the Earth will become." Right, agreed the physicists, taking this to be so, we can soon dispose of the vexed question of the age of the Earth. All we need to do is to measure the rate at which our Earth is losing heat. We know the temperature of the Sun, so it is simply a matter of mathematics. So much for the theory, but execution proved a little more difficult. After much research and counter-research Lord Kelvin announced that the age of the Earth could not be less than twenty million years or more than two hundred million years. Taking everything into consideration he decided that a hundred million years was a reasonable figure. That was that! The whole business was settled on no less an authority than the word of Lord Kelvin, and he was by far the most distinguished scientist of his day. And were the geologists happy? Not a bit of it, the disreputable rascals still harped on about time, time, time. The best thing to do of course was to leave these Doubting Thomases to stew in their own juice! After all, you could not apply mathematics to geology, whilst physicists used mathematics all day and every day.

I wish we had sufficient time at our disposal to tell the whole story of the various attempts made by the 'never-satisfied' geologists to find an answer to the problem, but to do that would occupy nights, and not hours. I can only mention one or two lines of attack. One was this: we know that the total thickness of the water-laid rocks is approximately three hundred and sixty thousand feet. If we could find out how much of the land surface is worn away in how long..... This started a hive of activity and research, and finally it was agreed that the Thames removes from its basin between one and two million tons of rock waste each year, and at this rate would lower the land surface at the rate of one foot in three thousand years. Since the average height of the land was roughly three hundred and sixty feet, this meant that in one million years..... Oh dear! That was not what our geologists were expecting at all. Then someone, just to be awkward, pointed out that, far from the land surface falling in this area, there was a good deal of evidence to show that the land was in fact rising. "All right" said the lads, "we will tackleit the other way round." Archaeologists had found that since Rameses II three thousand years previously, mud had accumulated in the Nile delta at the rate of one foot in five hundred years. Three hundred and sixty thousand multiplied by five hundred equals one hundred and eighty million years. The geologists felt much happier until someone pointed out that whilst the Principle of Uniformity was alright so far as it went,

there were limitations. Looking back over the long, long history of the Earth as told by the rocks, the present day is not really representative of the past. For one thing, some thirty million years ago began one of the greatest periods of mountain building our Earth has seen, and as a matter of fact, these movements are still continuing. As a result the Earth is girdled by enormous mountain chains, the Alps, the Himalayas, the Rocky Mountains, indeed all the great mountain chains of today. And what has this to do with the case? Just this, that since the average land height is much greater now than it was for long periods in the past, the rivers flow faster, water circulation is greater, and so is the rate of erosion. Just to complete the confusion, it can be pointed out that we are now emerging from one of the Earth's periodic Ice Ages, and as a result, vast areas of the Earth's surface are swathed in sheets of clay and stones left by the melting ice. If we have any keen gardners as readers, I have no doubt that they will know all about that in this part of the world. But removal of clay and stones is one thing, the removal of solid rock is quite another. The fact is, we are completely unable to say what is, or ever has been, an average rate either of erosion or deposition. Even Man himself with his multifarious activities has contributed to a state of radical unbalance. He does things unthinkingly, or sometimes because he thinks he knows all the answers when in fact he does not - like cutting down forests only to find that the soil, no longer protected, rapidly disappears.

Halley, the same fellow who discovered the Comet, suggested in 1715 that the amount of salt in the oceans might be used as an index of the age of the Earth if only we could compute the rate at which salt was carried in from the land. This suggestion was taken up by Professor Joly in 1899, and after much work and much controversy it was concluded that the oceans were eighty one million years old. Then someone else, I think Arthur Holmes, pointed out that the amount of salt alleged to be removed from the land was in fact more than the rocks contained. Let us leave our geologists in their quandary - still obstinately convinced that they had not proved enough time - and take a look a little further afield.

In 1896 a Frenchman called Becquerel was very interested in the new developments taking place in what we now know as photography. One day he unwrapped some new sensitised plates in his darkroom, extracted one, rewrapped them, and looking round for something handy to keep the wrapper in place, picked up a piece of mineral lying on his bench and put it on top of the plates. Later, when he came to use the plates he found on development that they were all spoiled, marked by queer dots and splotches. What happened next clearly illustrates the difference between the scientific approach and that of the ordinary man. Most of us would probably have said rude words because the plates, expensive and difficult to come by in those days, were spoiled. We might have blamed the makers and left it at that. No so Becquerel. He remembered that his first plate from the same batch was alright. What then had happened in between? His eye fell on the piece of mineral, could that have anything to do with it? He decided to experiment. Wrapping a new plate in black paper, he again picked up his mineral, but this time he placed a metal cross between the mineral and the wrapper. When he developed his plate, he found that the area covered by the cross was transparent whilst the rest of the plate had been blackened.

Not long before this, Röntgen had produced X-rays. X-rays could produce just such a result, but why - why should a stone do this? Becquerel had made a far-reaching discovery, he had taken the first steps

towards establishing what has today become almost a science in itself, radio-activity.

It is impossible to follow all the steps in this story, but if you want a tale packed with adventure, thrills and pathos, read for yourself the story of M. and Mme. Curie and how they extracted from Becquerel's dull piece of pitchblende the much more active radium.

Before leaving Becquerel and his metal cross, I have just one remark to make. Discoveries like these are often said to be made by accident. Accident my foot! The only thing accidental was the placing of a piece of pitchblende on some photographic plates. With most of us, there it would have ended, in the dustbin, with rude but unjustified remarks. But not with men like Becquerel whose first reaction is "Why? What has happened?" Every succeeding step is a careful, logical process, and this is the real difference between the ordinary and the scientific mind. The scientist, in a sense, never grows up, he keeps intact his sense of wonder, he everlastingly wants to know, and things which more blasé people would pass unnoticed, he questions.

If all this began abroad, the focus soon shifted to England, for here a young New Zealander called Rutherford had lately arrived looking for a topic for a Ph.D. thesis. He seized upon the new discovery and wrung from it as the years went by more and more information about the atom, and more about the constitution of matter than man had ever dreamed of. First at Manchester and later at Cambridge he gathered round him a galaxy of the most brilliant minds this century has known. Soddy, Cockroft and Walton, the Braggs, father and son, with this team, and pink string and sealing wax, he uncovered one secret after another of the constitution of the atom. What they could have done with the resources at present given to science I do not know, but I cannot resist telling you a story of those days which I had from one of Rutherford's laboratory assistants.

At the height of Rutherford's fame he was visited at Cambridge by America's most distinguished man of science, Professor Millikan. While taking him round the Cavendish, Rutherford stopped to have a word with a fellow who was sitting in a dark cubby hole patiently turning a bicycle wheel. As he came away, Rutherford was heard to say something to the effect that - yes, yes, the pump would not be long now, he had contacted someone who would provide one. Millikan asked, "That one of your lab. assistants, Professor?" "Oh no", said Rutherford, "that is Professor Bragg." Pink string, sealing wax, and any odds and ends they could lay hold of to construct their apparatus. And yet, year after golden year, these men produced the most startling discoveries, and in this we are for ever in debt to the Professor.

Let us look a little more closely at the meaning of these discoveries which in the early 1900s poured thick and fast from the researchers. It was known that the active element in the mineral pitchblende was uranium, it makes up about 60% of the substance. From the mineral the Curies isolated the then new element radium. To extract one ounce of the new element they would require to treat one hundred and forty tons of the original mineral. Perhaps from this you will understand why the Curies had such a bitter struggle and why the cost of radium is so very high.

Radioactive elements are so called because they all emit radiations. Checking these radiations Rutherford and Soddy found that they were of three kinds.

1. Alpha rays, which are actual particles with a positive charge, and mass of four units on the atomic scale.

2. Beta rays which again are actual particles with a range one hundred times as great as that of alpha particles. Their mass, however, was only 1/1840 that of a hydrogen atom. They are electrons with a negative charge.

3. Gamma rays, which are very powerful X-rays.

It was found that an alpha particle with a mass of four would pick up only two electrons, and when it did so it was then indistinguishable from the inert gas helium. In 1902 Rutherford and Soddy predicted that helium should be spontaneously generated by the radioactive elements. In 1903 Ramsay & Soddy, after careful research, proved this to be the case. In this same year the Curies made an important pronouncement; they had found that radioactivity was always accompanied by the production of heat, and that this heat was due to the high energies with which particles were discharged. This produced cheers from the geologists. Why? Because they at once saw that this knocked the bottom out of Kelvin's oracular pronouncements. Minerals containing uranium are by no means so rare as popular imagination makes them out to be, in fact they are much more common than gold. If the rocks contain disseminated through them minerals which spontaneously generate heat, what became of Lord Kelvin's calculations?

Someone prepared this table to shew in a rough and ready way what the effect would be:-

Proportion of heat lost attributed to radioactivity.	Period of cooling required to reach present conditions.
0	20 million years.
1/4 or 25%	40 " "
1/2 or 50%	120 " "
2/3 or 67%	580 " "
3/4 or 75%	1600 " "
4/5 or 80%	7200 " "

It is not possible in the time at our disposal to trace through the whole of these fascinating discoveries, but sticking to uranium, it was shown that the element goes through five transformations before it reaches radium, that after eight further transformations a stable element radium G is formed, and that this element is chemically indistinguishable from lead. Out of these thirteen transformations it was found that helium was given off at no less than eight, so you could write out an equation like this:-

1 atom of uranium	------	8 He	+	1 Pb	+ energy.
weights	238	32		206	

In the days of my youth, atoms were described as little discrete particles very much like extremely tiny billiard balls. As a matter of fact they are often still thus depicted in models of crystal structure. This was the picture of the atom proposed by John Dalton, the founder of the atomic theory. But Rutherford's researches had shewn that, far from being little balls, atoms were mostly empty space with an inner structure very much like our planetary system in miniature.

In the centre was a minute particle, the nucleus, which despite its relative smallness, made up most of the mass of the atom. Round this nucleus

circled the tiny electrons, just as the planets circle the sun.

Rutherford's investigations carried him into the realm of the nucleus itself, for he clearly demonstrated that radioactive phenomena emanate entirely from the nucleus. The nucleus consists of protons which are charged positively, they are positive hydrogen ions, and the simplest atom consists of one proton with one circulating electron. Heavier atoms contain in their nuclei several protons, together with neutrons, each having the same mass as a proton but no electrical charge. Thus helium has two protons and two neutrons in the nucleus, with two electrons circulating outside to balance the protons and make the atom electrically neutral. The mass of the helium atom is four - two protons plus two neutrons. And so we could go up the chemical scale until we get to uranium which has a very complicated nucleus, with ninety two protons, one hundred and forty six neutrons and of course ninety two electrons to balance with their negative charge the ninety two positive protons.

To that important feature, the charge on the nucleus, Rutherford gave the appellation ATOMIC NUMBER, but since atomic number equals the number of protons with their positive charge, it must also equal the number of circling electrons with their negative charges to balance them.

From this description of matter a great many things became clear. If an atom loses one or more of its electrons, it will immediately try to make up the deficiency from somewhere else. This is the basis of all chemical reactions, which involve the movement of electrons, and usually only electrons in the outer shell of the atom. If an atom like helium for instance is already perfectly balanced with positive and negative charges equal, normally it will not enter into chemical reactions at all. The inert gases helium, neon, argon, krypton and xenon are all of this kind.

I think Democritus was the first to put forward the idea that all things are made from some universal basic substance, and scientists had long toyed with the idea. Proust, I think it was, who suggested that hydrogen was this universal stuff, a remarkable guess, but his theory was rejected because if it was correct all the atomic weights should be whole numbers. Unfortunately, as any schoolboy knows, this is not the case. Chlorine, for instance, has an atomic weight of 35·46.

If, as Rutherford had demonstrated, neutrons can enter into the composition of the nucleus, then clearly you could have atoms of different atomic weight but with the selfsame chemical characteristics. Ordinary chlorine was shewn by Frederick Aston to be a mixture of two kinds of atoms, one with atomic weight 35 and the other 37. To these atoms with differing atomic weights but the same chemical affinities Rutherford gave the name Isotopes.

A great many elements were shewn to be a mixture of isotopes. Amongst them was our old friend uranium:

Uranium I - atomic weight 238 - ends in lead 206

Uranium II or Actinium as it used to be called, is the rarer kind of uranium of which you have all, I am sure, heard in connection with atomic bombs. It is uranium 235 which ends in lead 207.

Madame Curie had also discovered another radioactive mineral, Thorium, and this also ends in lead, but lead of atomic weight 208. No wonder that ordinary lead, which is of course a mixture, has the unlikely looking atomic weight 207·21

These researches answered an awful lot of questions, the answers to which scientists had been seeking for a long time, but there was still much to learn. For instance, what was the time scale of radioactive transformations? If these

transformations had been going on since the world began, their rate must be slow. How could we find it out?

Two lines of approach were suggested. Since alpha particles were given off with considerable energy, it might be possible to transform this energy into something that could be measured. Since alpha particles, once they hooked a couple of electrons, became helium atoms, it should be possible to find out how much helium was produced from one gram of radium in one year.

Both methods were used, and both gave approximately the same answer. In 1,590 years radium would decay until only half of the original amount was left. To this Rutherford gave the name "half life period", and it was shown to hold for individual elements, whatever their amounts and whatever the conditions of temperature and pressure to which they were subjected. Thus if one gram of radium became half a gram in 1,590 years, in 3,180 years only one quarter of a gram would be left.

It was found that uranium had a half life period of 4,350,000,000 years, and it was at this point that Rutherford threw out his famous aside that radioactive minerals might possibly be the "clocks" that the still disgruntled geologists were looking for!

At that year's British Association meeting was a young geologist called Arthur Holmes, and Rutherford's remark so fired his imagination that he dropped all other work and devoted his time to research along the suggested lines. Holmes found, as might have been expected, that if the theory was simple, its application was full of snags. For one thing he found that uranium minerals almost invariably contain thorium, so he had to find out what was the half life of thorium. It worked out at 13,000,000,000 years. Eventually he evolved this formula:-

$$\text{Time} = \frac{\text{He}}{\text{U} + 0{\cdot}27\text{Th}} \times 8{\cdot}8 \text{ million years.}$$

Work by Lord Rayleigh on pitchblende from Joachimstahl and on thorianite from Ceylon shewed that 280,000,000 times as much helium was present as was generated in one year. So the minimum age must be 280,000,000 years.

As lead is the end product of all radioactive decay, it is also possible to use the uranium/lead ratio as a cross check according to the formula:-

$$\text{Time} = \frac{\text{Pb}}{\text{U} + 0{\cdot}36\text{Th}} \times 7{\cdot}6 \text{ million years.}$$

When this was done it was found that it did not agree with the determinations made by the helium/uranium method.

Deep gloom descended, and for many years the method which had looked so hopeful was just left neglected.

Holmes, however, persisted and closely examined the assumptions that had been made:

a. that the material was free from helium in the first place,
b. that there has been no escape of helium,
c. that the rate of disintegration has remained constant throughout geological time.

Point a. presents no difficulty provided that the mineral crystallised at or near the earth's surface. Point b. is certain to be untrue for any weathered mineral, and is very doubtfully true for any very strongly radioactive mineral, because as time goes on, the helium concentration may reach ten cubic centimetres per gram, when the considerable pressure would certainly cause loss by

diffusion. After much experiment it was concluded that point c. was unlikely to be untrue. Nothing that man could do by way of altering external conditions of temperature and pressure would affect the rate of disintegration of radioactive elements.

It was realised that the best chance of success lay not with minerals that were highly radioactive, but with feebly radioactive ones. This meant that very very small amounts of helium would have to be detected, and the means were just not available at the time.

In 1930 Professor Paneth of Berlin perfected a method of helium detection which he clearly demonstrated to be capable of shewing helium in concentrations, if I may so misuse the word, of one part in one million million. Holmes seized on this method and with it worked out the age of the Whin Sill of the Pennines. This worked out at 196,000,000 years. As we know this sill was intruded during very late Carboniferous or early Permian times, this dating was applicable to this particular period of earth history.

The lead method is free from some at least of the objections that have been made against helium. Lead is not very likely to be lost by diffusion, but there was the objection that some of the lead present in radioactive minerals might not be radiogenic lead at all, it might be just ordinary lead that was present in the first place.

Not until we knew a great deal more about the isotopes of lead and had perfected means for their detection and analysis were we in a position to meet this objection, but eventually it was found that of the isotopes that mattered, for there are a great many, the order of abundance was practically reversed as between common lead and radiogenic lead.

Common lead - isotopes 208, 206, 207.
Radiogenic lead - 206, 207, 208.

This settled, determinations got under way in many parts of the world. Holmes in England, Urey in America and Paneth in Berlin tackled a wide range of rocks and minerals from all over the world. Not always did these determinations of age agree, but it is now recognised that where many of them made by various methods on rocks and minerals from the same formations agree, it is unlikely that the result is far from the mark. What conclusions have been reached as a result of this work?

GEOLOGICAL TIME SCALE

Recent		Present day
Pleistocene	began	1,000,000 years ago
Pliocene		15,000,000
Miocene		35,000,000
Oligocene		50,000,000
Eocene		70,000,000
Cretaceous		120,000,000
Jurassic		150,000,000
Triassic		190,000,000
Permian		220,000,000
Carboniferous		280,000,000
Devonian		320,000,000
Silurian		350,000,000
Ordovician		400,000,000
Cambrian		500,000,000
Pre-Cambrian		2-3,000,000,000

The first rocks to shew readily recognisable forms of life have been assigned to the Cambrian system, named by Sedgwick after the rocks exposed in Wales. The commencement of the system 500,000,000 years ago pleases most geologists worried by time, but below the Cambrian there is everywhere a marked unconformity, and although the rock systems below this are chaotic and confused, with no fossils to help correlation, several further unconformities are evident. If the rocks containing traces of quite highly developed living creatures take us back 500,000,000 years, we think this time is small compared with the time that must have elapsed before these rocks were laid down.

Are geologists insatiable? Well, not quite, but all along you will be kind enough to remember that our doubts were not all compounded awkwardness. It so happens that in the 1920's were found in British Columbia some fossil trilobites in such a marvellous state of preservation that their whole anatomy could be worked out. To our great surprise we found that their state of development had reached a stage of advancement never previously guessed at. Complete with circulation, digestive tract, renal organs and large compound eyes, they were as far removed from Poo Bah's "Pre-Adamite, protoplasmic, atomic globule" as man is from them!

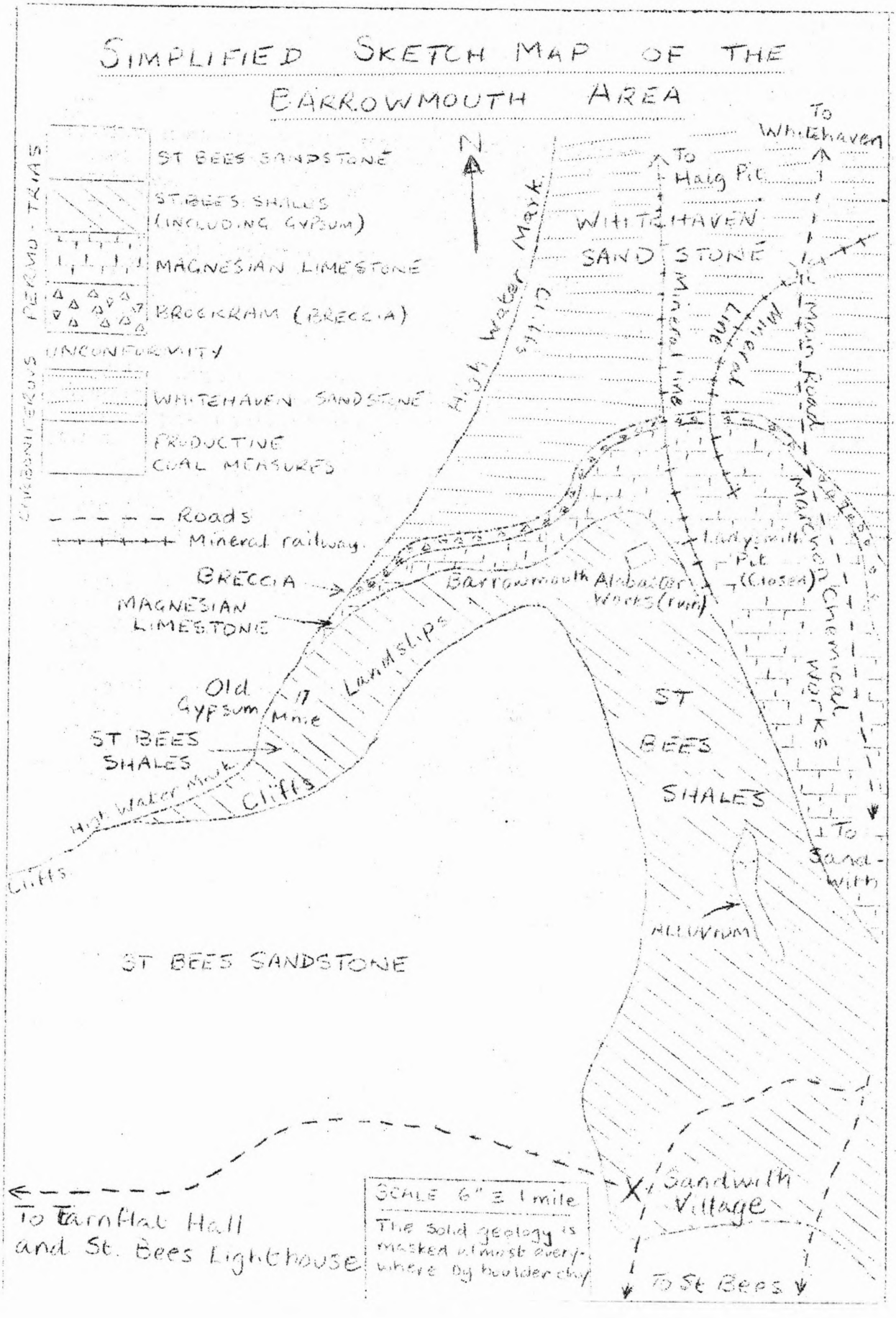
First steps in evolution are slow and halting, and if it has taken five hundred million years from trilobite to man, perhaps we are not really being awkward in demanding at least the same time from the first living creature to the trilobite.

However, radioactivity has given us atomic energy which demands large supplies of radioactive minerals. As it happens, most of the world's supply of these is drawn from rocks of the Pre-Cambrian Shields, and so radioactive determinations of the ages of these are coming in thick and fast. The oldest rock dating I have come across so far is one from the Great Bear Lake region of Canada with an age of 2,800,000,000 years. I shall not be surprised if someone tells me I am out of date!

Meanwhile, Professor Holmes, from calculations based on the relative abundance of the various isotopes of lead, has placed the probable age of our earth at between three and four thousand million years.

E. H. Shackleton, F.G.S.

Simplified Sketch Map of the Barrowmouth Area



VISIT TO BARROWMOUTH, March 16th. 1963.

Another visit was planned to this classic exposure primarily for the benefit of members who were unable to take part in the last visit two years ago. In the event, very bad weather deterred all but a dozen members from attending, but an improvement in conditions rewarded those who were prepared to "take a chance". It was a pleasure to have the company of Mr. Shackleton, now recovering from his recent serious illness.

The St. Bees Shales were examined in the exposure behind Barrowmouth Farm, and the party descended the old wagon way to the site of the old gypsum workings beside Barrowmouth Bay. Specimens of Gypsum and Anhydrite were examined, and mention was made of the very large deposit of anhydrite now being worked by the Marchon Company at its Mine a short distance away. Further reference to this mine will be found in the account following of the visit made to it on the 25th. March.

Proceeding along the top of the low cliff which fringes the shore, evidence of recent slips in the shales was noticed. The well-known exposures on the beach proved a source of much interest. The Whitehaven Sandstone forms the highest member of the Carboniferous system, and marine erosion has worn it here into a wave-cut platform, on which the characteristic purplish tint is clearly seen. Resting unconformably on it is the Permian Brockram, here no more than six feet thick, and presenting the appearance of a coarse concrete. It represents the conglomerate fans washed down by occasional or intermittent torrents which eroded the arid mountainous landscape of early Permian times, and contains Carboniferous fragments including "derived fossils". The Brockram passes conformably upwards into the Magnesian Limestone, here only some ten to fifteen feet thick, and probably representing the extreme western extension of the Zechstein Sea. The corresponding development of Magnesian Limestone east of the Pennines reaches a maximum thickness of 800 feet.

Above the limestone was noted the conformable passage to the argillaceous sediments of the St. Bees Shales, probably laid down in a gradually shrinking sea. These shales are, of course, important for the chemical precipitates they contain, though these do not outcrop along the shore. It is significant that this site at Barrowmouth compresses into a few feet a range of deposits from Upper Carboniferous through the Permian to the Triassic, which elsewhere is represented by many hundreds of feet of strata, notably in the Eden Valley and in Durham.

On the return journey up the steeply-sloping, slumped surface of the shales, the rapid growth of Marchon's rubbish dump was noted. If tipping continues at the present rate, it seems possible that the extremely interesting exposures on the shore at Barrowmouth may be obliterated within a very few years.

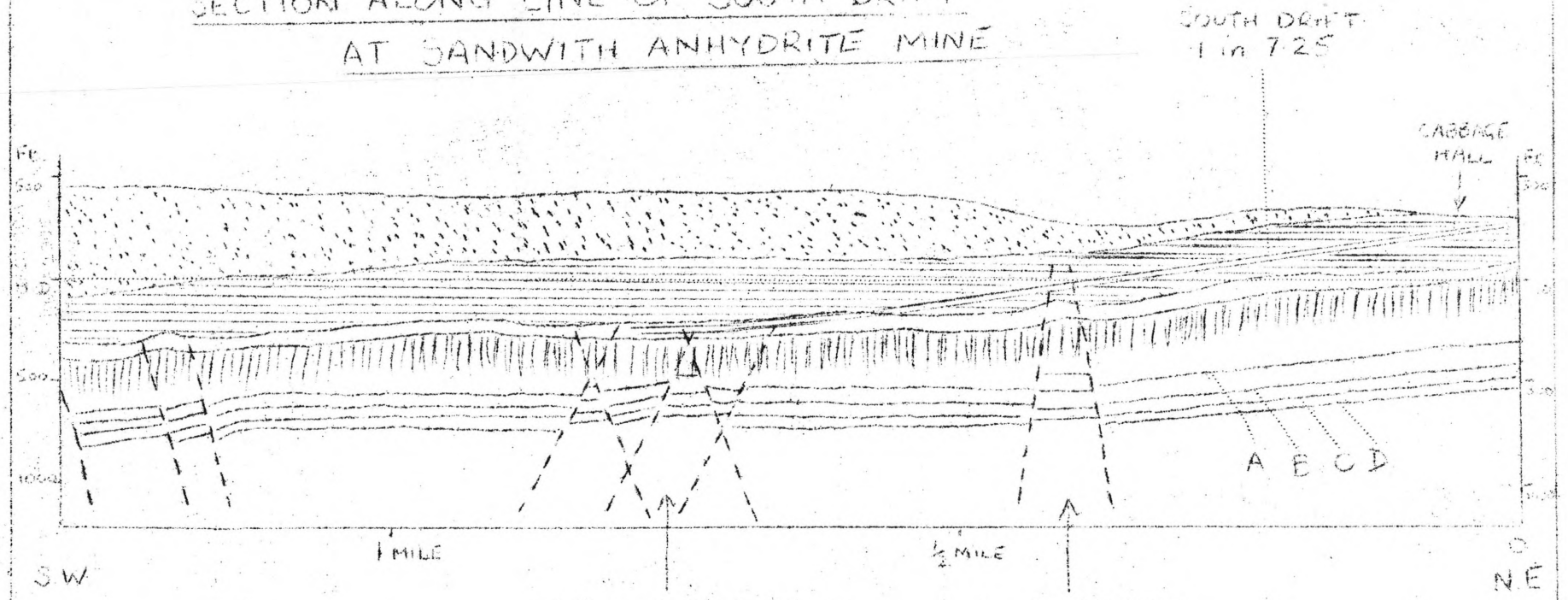
H. A. White, B.A.

VISIT TO MARCHON ANHYDRITE MINE

On 25th. March a very interesting visit was held to the anhydrite mine which supplies the raw material for the Marchon sulphuric acid and cement process. The party of 25 members was very kindly met and conducted by Mr. Charlton, who also gave an introductory talk.

The anhydrite is in Permian rocks which follow immediately on those of the Carboniferous period. At this time, marine conditions followed by deltaic coal-forming forests preceded the onset of more arid conditions with great deserts and completely land-locked seas. Over a long period of time the seas dried up

SECTION ALONG LINE OF SOUTH DRIFT AT SANDWITH ANHYDRITE MINE



ST BEES SANDSTONE
ST BEES SHALE
ANHYDRITE
COAL MEASURES.

A – UPPER METAL BAND.
B – PRESTON ISLE
C – BANNOCK BAND
D – MAIN BAND.

TYPICAL SEAM SECTION

ST BEES SHALE	
TOP ANHYDRITE 16'	
SHALE 6'	
BOTTOM ANHYDRITE 32' 9"	
COAL MEASURES	

just as the Dead Sea is doing today. This led to a concentration of the sea water, and eventually crystals of the dissolved salts precipitated and formed layers on the sea bed. The least soluble salt crystallised out first, then the next, and so on. Where two isomorphous salts were present, for example, calcium carbonate and magnesium carbonate, they would crystallise simultaneously as, in this case dolomite or magnesian limestone. The order of deposition of the various minerals as they crystallised out was:

1st. Dolomite and calcite $CaCO_3.MgCO_3$ & $CaCO_3$
2nd. Gypsum and anhydrite $CaSO_4.2H_2O$ & $CaSO_4$
3rd. Rock salt NaCl.

These would be followed, if present, by polyhalite $K_2SO_4.MgSO_4.2CaSO_4.2H_2O$, kieserite $MgSO_4.H_2O$, and finally carnallite $KCl.MgCl_2.6H_2O$.

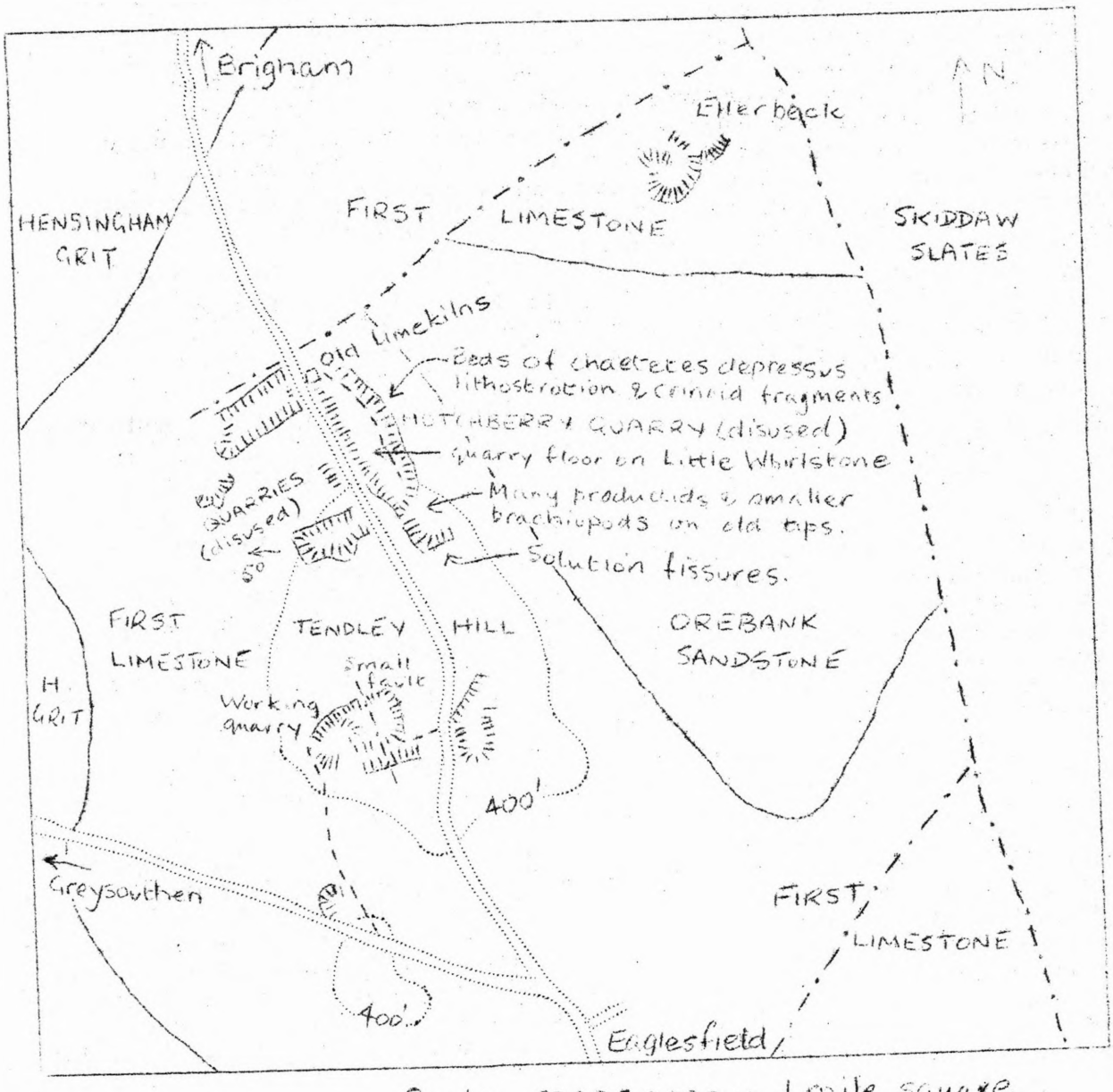
Unfortunately, possibly due to subsequent erosion, the rock salt which would have been very profitable to the Whitehaven district is missing, and lying directly on top of the anhydrite is St. Bees Shale, followed by St. Bees Sandstone. Had the rock salt been present, a vast industry would have developed, making a great many chemical products.

As can be seen from the section, the anhydrite dips gently in a south west direction at about 4°. The St. Bees Shale above it outcrops conveniently inside the factory, and thus a drift shaft dipping at about $7\frac{1}{2}^{\circ}$ penetrates the easily worked shale until it meets the anhydrite. A parallel drift shaft has a conveyor belt carrying the rock directly into the factory. The shafts are approximately a thousand yards long to the workings which are about three hundred feet underground. The deposit of anhydrite appears to be in the form of a large lens which thins out in a north east direction under Cabbage Hall. The first borehole proved anhydrite seams 12 and 17 feet thick, with a thin intermediate layer of shaly material in between them. The seams thicken in a regular manner towards St. Bees where they total 80 feet in thickness, and continue under the sea.

The rock is of the compact, granular variety, in the main opaque and slightly bluish. Some specimens were obtained which were pure white, translucent, and of the theoretical specific gravity, 2.93. Actual crystals are said to be rare, but have been found. The hydrated form, gypsum, is stable below 25°C., whilst the anhydrite is stable above 25°C. On the observed evidence, it is probable that all the calcium sulphate was deposited as anhydrite above 25°C. in a permanently hot sea capable of maintaining its temperature in winter as well as summer. Any gypsum found was of the satin spar variety in the form of bands in the shale or on the outer edges of the anhydrite seam. This can be fairly safely accounted for as due to subsequent redeposition in our cold wet climate. There is also a small amount of thin gypsum along bedding planes and fissures, due to hydration from water seepage in the anhydrite rock itself. There is no outcrop of anhydrite at nearby Barrowmouth, but there are old gypsum workings, now worked out, which belonged to a Plaster of Paris company. Probably they worked out into the anhydrite which would be useless to them.. A point of interest is that the Stassfurt deposits in Germany consist of alternating bands of anhydrite and gypsum which probably represent deposits put down during a progression of summers and winters.

On returning to the surface, the party expressed thanks to Mr. Charlton and his two colleagues who had answered so many questions and helped to make the visit such an interesting one.

R. H. Hewitt.



SKETCH MAP OF TENDLEY HILL LIMESTONE QUARRIES.

EXCURSION TO QUARRIES IN THE FIRST LIMESTONE BETWEEN BRIGHAM & EAGLESFIELD

Sunday, March 31st. 1963.

.....

About thirty members met by the old limekiln at the northern end of Hotchberry Quarry, which has been worked extensively in the First Limestone, but is now practically worked out and used for dumping building waste. The track into the quarry is of interest, being founded on the Little Whirlstone which separates the First and Second limestones. The low quarry face on the left of the track contains many lenticular masses of Chaetetes depressus, a fossil of a rather lowly type of tabulate coral. Also from here specimens of Lithostrotion junceum, and odd fragments of Crinoids were obtained.

The higher (southern) part of the quarry shows well developed solution fissures in the joint cracks of the face. The rubble tips were thoroughly explored, and yielded specimens of Productus latissimus and Dialasma sacculus, together with odd specimens of Lonsdaleia floriformis laticlavia.

The party next proceeded across the road to the Tendley Hill Quarry, at present being worked for limestone rubble. The quarry is very well maintained, the floor being kept spotlessly clean, with the broken lumps of dark limestone in neat stacks awaiting removal. The north wall of the quarry is being worked back, and a freshly blasted heap furnished beautiful specimens of Chaetetes depressus, Gigantellas, and Lonsdaleias, the latter often showing by their mud-filled calices that they had been killed off by one of the sporadic inrushes of muddy water which have left thin beds of black shale between the massive limestones. The quarry floor, again the Little Whirlstone, shows two small parallel faults, two to three feet apart and with a total throw of perhaps eighteen inches. Where the fault enters the quarry face, a great deal of earthy material, brought in by water trickling down fractures in the limestone, was seen. Dotted about the otherwise smooth floor of the quarry were odd small knolls made up of colonies of Lonsdaleia floriformis laticlavia - this could be visualised as the bottom of a Carboniferous sea at one time.

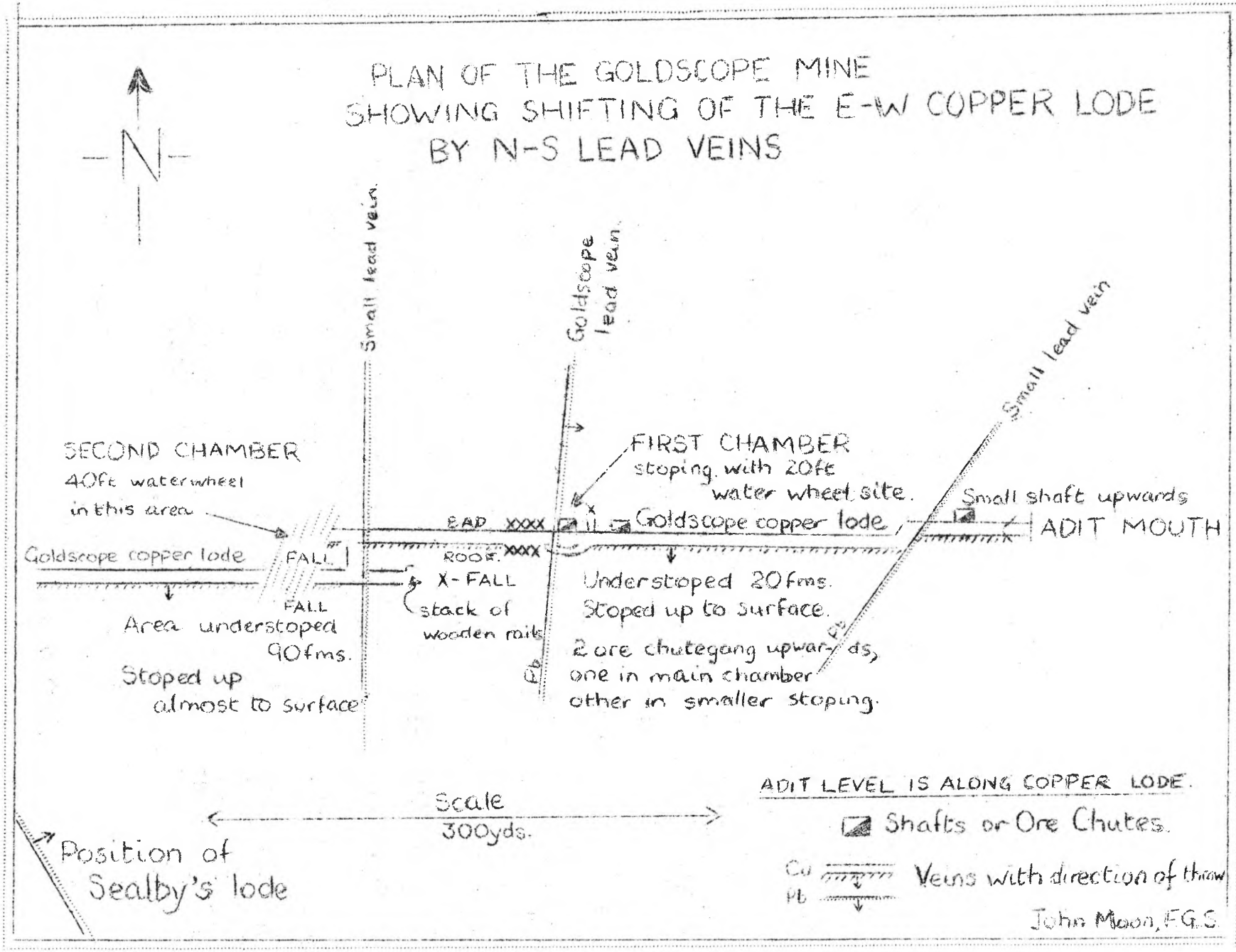
On the way out of the quarry the bank of limestone on the southern side was examined. This contained many sections of Gigantellas, showing well the concavo-convex structure of the valves, together with their tremendous thickness. A detached block contained a very large Gigantella with perfectly preserved muscle scars on the inside cast of the ventral valve.

In this spot, besides the ubiquitous Productids, were found other brachiopods, Rhynchonella sp. and Spirifer sp., and also an Orthoceras.

Having compared and contrasted the disused and the working quarries, the excursion was concluded.

Finally I would like to express the Society's thanks to Thomas Armstrong Ltd. for kindly allowing us access to their quarries.

T. Shipp.


PLAN OF THE GOLDSCOPE MINE
SHOWING SHIFTING OF THE E-W COPPER LODE
BY N-S LEAD VEINS
N
Small lead vein.
Goldscope lead vein.
Small lead vein
SECOND CHAMBER
40ft waterwheel
in this area
FIRST CHAMBER
stoping with 20ft
water wheel site.
Small shaft upwards
ADIT MOUTH
LEAD XXXX
Goldscope copper lode
Goldscope copper lode
FALL
ROOF XXXX
X-FALL
stack of
wooden rails
Understoped 20fms.
Stoped up to surface.
FALL
Area understoped
90fms.
Stoped up
almost to surface
2 ore chutes going upwards,
one in main chamber
other in smaller stoping.
ADIT LEVEL IS ALONG COPPER LODE.
Scale
300yds.
Shafts or Ore Chutes.
Cu
Pb
Veins with direction of throw
Position of
Sealby's lode
John Moon, F.G.S.

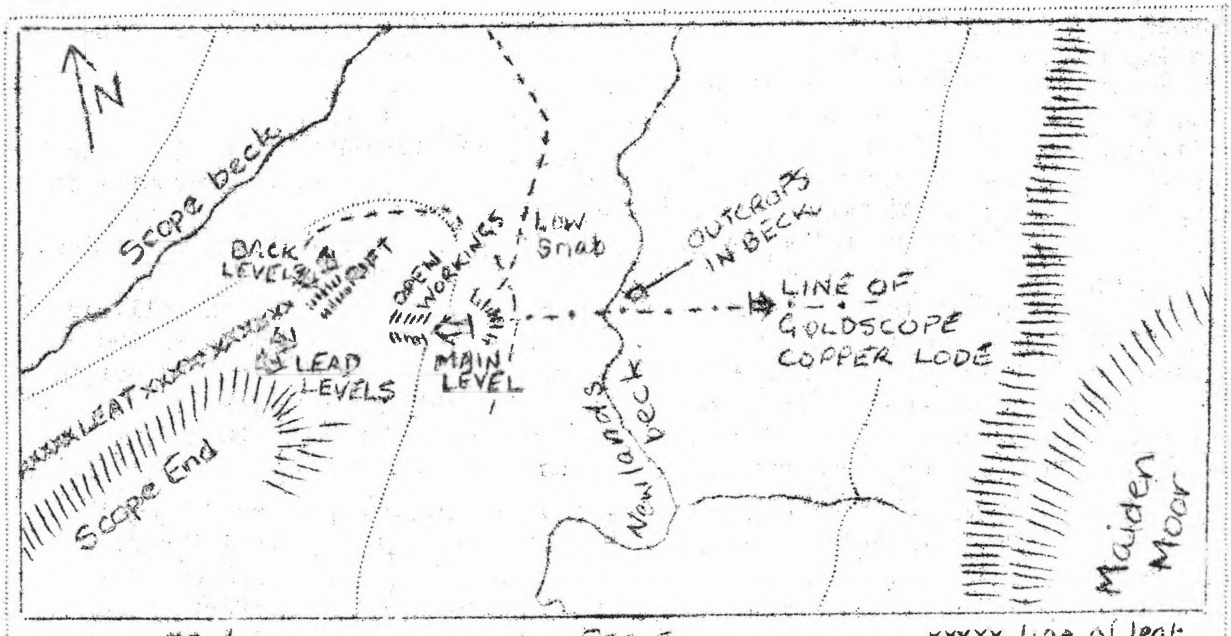
FIELD EXCURSION TO THE GOLDSCOPE MINE, NEWLANDS VALLEY, 7th. APRIL 1963. LEADER, J. MOON, F.G.S.

.....

Historically the Goldscope Mine is very old. It is specifically mentioned in the 'Close Rolls' of Henry III in the thirteenth century. In the sixteenth century it was more fully exploited by German miners who with their leader Daniel Hechstetter had been brought to this country from Augsburg. Queen Elizabeth, whose guiding hand may be seen behind her factor Thomas Thurland, was very interested in the sources of natural wealth available in England. She fought a legal battle with Thomas Percy, Earl of Northumberland, over the ownership of the Goldscope, so rich was its potential. The Earl had quite naturally claimed it, as it was on his lands. The Queen won her legal fight on the argument that all gold found in the kingdom belonged to the crown, and gold in small quantities was unquestionably found in the Goldscope. The Earl could not agree with the findings of the court, and used this as an excuse to raise a revolt against the Queen. As war was still the only real occupation for a gentleman, he did not really need much excuse. Unfortunately he lost his fight outside the court also and was beheaded at York, his head being displayed on one of the spikes provided for the purpose on top of the City gate.

The Goldscope was worked almost continually from this time until the Civil War when the mines were closed and the miners drafted into the Parliamentary Army. It was not worked again until the reign of William III when, after a brief period of activity, the mine fell once more into disuse.

The final period of activity came during the mid-Victorian era. The Mine was reopened by a syndicate who spent a great deal of money on it and for quite



SKETCH MAP SHOWING APPROXIMATE POSITIONS OF LEVELS AND OPEN WORKINGS IN THE VICINITY OF THE GOLDSCOPE COPPER LODE

a time made a good profit. However, domestic upsets within the partnership ended the working, the Mine was closed for the last time and abandoned about the year 1864.

In spite of Elizabeth's law suits and troubles, the main minerals found at this Mine were those of copper and lead, though small amounts of silver and smaller amounts of gold have undoubtedly been obtained there.

.....

The following notes describe features of interest to be seen in and around the Goldscope Mine. See also the accompanying sketch map and plan.

1. The open workings of the "Old Men" which follow the vein over the hillside above the mine level. By following these down the fellside and lining them up with the open level on the other side of the valley, the point where the vein crosses Newlands Beck can be found.

2. The tips show two definite periods of activity, one from the open level, and the other from what has probably been a lower adit. Possibly, though, the lower tips are of material that has been brought round the fellside from the back levels, the road to which can still be traced.

3. The open adit level.

Entrance. This at one time has been roofed over to prevent debris from falling down from the higher 'open' workings. The holes for the stemples or cross pieces can be seen in the right hand wall.

Mine level. This follows the Goldscope Copper Lode through the fellside. This lode can be seen in variable thicknesses at intervals through the Mine. Just inside the entrance is a small shaft going up to the higher level. Beyond this is the first of the lead veins crossing the copper lode and displacing it a short distance.

The level itself shows two distinct periods of working:-

i. the "stope and feather" workings of the old miners

ii. the way in which later miners have heightened and straightened the tunnel.

Near the entrance of the first chamber are two very small workings, about 1 ft. wide by 18 inches high. In spite of the thickness of the vein here, a very thin subsidiary vein has been worked out, probably a very rich ore was obtained from it.

First chamber. In this chamber the cuttings in the front and back wall can be seen where the 20 ft. water wheel was. Copper staining has run down the walls. The upward stoping and shaft are to be seen - these were worked out to the surface and are known as "Pan holes" on Postlethwaite's section*. Much thick timbering has been used for supports, and some working has been done below the main chamber, whose floor is of stacked deads.

The area beyond this chamber is behind a very rough area of roof and side collapse, and it is behind the fall that the second chamber is positioned. This contained a 40 ft. water wheel and stoping up and down. Hereabouts is the third cross lead vein that shifts the copper lode. A little further in to the left of the main level can be seen a stack of "wooden rails". The level finishes in a roof collapse.

* "Mines & Mining in the Lake District", J. Postlethwaite, F.G.S.

Goldscope Back Level.

This is to be found by following the track round to the other side of the fell, where there are two parallel levels, both fallen in after a short way. The main Back Level is easily recognised by numerous iron bolts in the top of the ledge running alongside the entrance.

The rifts. Above the back levels are to be found two large rifts where the ore was got out both by stoping up from the back levels and also by excavating down from the surface. One of the rifts is 110 ft. deep, going down at just off the vertical with clean walls about 10 ft. by 3 ft. The other has been worked open down to about 50 ft., where it was probably holed into by the stopings up from below. About 30 ft. down from the bottom of this rift can be found an old working (stope and feathered)* This working was for copper, traces of which ban be found on the hanging wall of the stoping. Both rifts are joined by a level at the bottom which is a continuation of the main level.

Lead vein levels. There are two of these. One is inaccessible, full of water, and appears to end after about 60 ft. The other has a wet entrance, but can be waded.

This is about the most interesting level in the area. In it was found the first old miner's clay pipe we have found in the Lake District. Also, stuck in a piece of clay on the wall, was a stump of a candle used by the old miners. At the furthest end of the level can be found wooden rails still in situ.

The level follows the lead vein in a matrix of sugar quartz, with two stopings going upwards.

The Leat. The leat, or channel, by which the water for driving the two water wheels in the mine was carried, can be traced for a considerable distance round the fellside. This leat is about the largest we have found in the district, and it brought water from the top end of the valley to the back entrance of the mine.

John Moon, F.G.S.

* Stope and Feather.

Old mining implements, used for tunnelling into the rock before the days of gunpowder and blasting charges. A hole was chiselled into the rock, and into this was inserted the "feathers", two thin pieces of iron each flat on one side and round on the other. The flat sides would be together and parallel to any cleavage of the rock. A thin wedge or stope of similar dimensions to the feathers (about 6inches long by $\frac{1}{2}$ inch wide) was driven between the flats to split off the piece of rock. This must have been very laborious work, for the old miners took good care to make their tunnels no wider than was absolutely necessary.

The last excursion of the Society to the Newlands area was on May 20th, 1962. See the report in the Society's Proceedings, No. 1, 1962.

Whilst as full an account as possible is given in these Proceedings of the activities of the Society, reports of some events must inevitably be curtailed. The following activities have taken place, but are not reported fully.

On March 7th., 25 members visited the Solway Colliery at Workington. Thanks were given to Mr. Dixon and his colleagues of the Safety Department for their assistance and courtesy.

At Workington Technical College on March 14th., a lecture and film programme on the Coal Measures was given by R. E. O. Pearson, Esq., who also had many of his own specimens on display. The films were shown by kind permission of the National Coal Board.

At Whitehaven College of Further Education on April 11th., a lecture on Crystal Shapes and Classification was given by S. H. Gate, Esq., B. Sc., M. Sc., A.R.I.C.

On April 26th., a party of members visited the Florence Iron Ore Mine at Egremont. A report of a previous visit on February 23rd., 1962 is given in Proceedings No. 1, 1962. The Society wishes to thank Mr. Casson, the Underground Manager, for escorting us round the workings, standing up to a barrage of questions, and providing some fine mineral specimens.

On May 4th., the Society visited Bransty Cliff. The stratification of the Whitehaven Sandstone was seen, also a good selection of Calamite fossils. The excursion finished with a look at the Glacial overflow features near the New Road, north of Whitehaven.

On May 19th., a full day excursion was held to the famous Lower Silurian section at Skelgill. This was led by R. H. Hewitt, Esq., and was intended as a follow-up of the Society's last visit to the locality, reported fully in Proceedings No. 2, 1962. On the return journey, members visited an excellent exhibition at Ambleside, arranged in connection with National Nature Week. Some very good representative specimens, drawings, maps, etc., of the geology of the Lake District were on display.

A visit to Clints Quarry, Egremont was arranged for May 25th., primarily intended for Associate members as a demonstration of limestone scenery, stratification and fossils. However, in view of inclement weather, the Cup Final, and school examinations in the offing, the only members to turn up were the Secretary and his son, and the Treasurer.

THE ORIGIN OF THE EARTH AND CHEMICAL ELEMENTS.

It is very doubtful whether anyone will ever be able to prove how the Earth was first formed or how new stars are created, but by careful observation and experiment some very good ideas can be derived on how these things have happened.

The theory which follows fits all the facts known at present and is called the "Theory of Continuous Creation". It was put forward by Professor F. Hoyle.

It is believed that new atoms of hydrogen are being created out in space at the rate of one atom per pint volume of space per 100,000 years.

This does not sound very much, especially when you consider that it needs 6,060,000,000,000,000,000,000,000 atoms of hydrogen at N.T.P* to weigh two grams and have a volume of 22·4 litres. However, space is so enormous that it is difficult to imagine. For instance, when you look up at the stars on a nice clear night, even the nearest ones are about ten light years away. This means that the light you are seeing now left the star about ten years ago, and it has just got here. As light travels 186,400 miles every second in space, the nearest stars are thus about 58,790,000,000,000 miles away. If you now think that in all directions around us there are stars which are hundreds of thousands of light years away, then space begins to look pretty big.

On this basis, even one atom per pint per 100,000 years amounts to an enormous amount of hydrogen being produced in space.

If we imagine a small piece of space a few light years across, and every pint of it contains one atom of hydrogen, then a two light year cube would contain approximately $9{\cdot}87 \times 10^{22}$ tons, i.e., 98,700,000,000,000,000,000,000 tons. This is in so-called empty space. One of the properties of Mass is Gravity. The self-imposed gravitational force or attraction begins to pull hydrogen atoms together to common centres in space. You know that when you drop a rubber ball from a height of one foot, it is not travelling as fast when it hits the floor as it would be if you dropped it from two feet. In a similar way, the atoms of hydrogen travel faster as they approach the centre of a cloud of hydrogen.

We know that heat is due to the movement of atoms or molecules, and the faster they are moving or vibrating, the hotter we say the substance is. So when atoms of hydrogen get near to the centre of the cloud, their speed becomes enormous and the temperature of the cloud of gas rises to millions of degrees centigrade.

At these fantastic temperatures, the collisions between the atoms are so violent that all the electrons round the outsides of the atoms are "knocked off" and the atoms turn into a jumbled mixture of protons, electrons and other particles. This mixture is known as "plasma".

In this plasma, the speed of the protons (hydrogen nuclei) is so great that they can overcome the usual repulsive forces which exist between them and they collide so violently that they combine. When this happens, a large amount of energy is released in the form of heat. This keeps the plasma hot, thus enhancing the collisions and further combination of nuclei with the release of still more heat. This process is known as "fusion" and is an entirely different meaning of the word from that usually intended. We can now say that a new star has been formed.

There are now several possibilities which can happen. First, as the star travels through space, it will draw towards itself by gravitational attraction any hydrogen atoms within quite a large distance and so leave a tunnel of space behind with no hydrogen atoms in it. The star thus assures itself of a continuous supply of fuel.

*N.T.P. is short for 'Normal temperature and pressure', a temperature of 0°C., and a pressure of 76 cms. of mercury, one atmosphere.

Let us now suppose instead that the star happens to be travelling through some region of space where there are no hydrogen atoms, or at least insufficient to keep the star going. It will ultimately run out of fuel after a few thousand million years.

Now the reaction which was mentioned earlier in which the nuclei of hydrogen atoms fuse together to form helium nuclei will only take place at temperatures of twenty to thirty million degrees centigrade. It is further possible for the nuclei of helium atoms to fuse together to form heavier elements such as carbon, nitrogen, oxygen, etc. This happens if the temperature is much higher, about sixty million degrees centigrade. As before, when they do fuse, huge amounts of energy are released. In other words, the "ashes" of the first reaction become the fuel of the following reactions.

Let us see how this is accomplished. Imagine that all of the hydrogen fuel has been fused into helium, carbon, nitrogen, oxygen, etc. The star continues to radiate heat and therefore begins to cool down. Because of this it contracts, and the atoms, pulled by gravity, accelerate towards the centre and the temperature rises. Since the star is now smaller, the losses of heat by radiation are less, which causes it to lose heat at a slower rate. Ultimately, due to this shrinkage, the temperature becomes high enough to start off the third reaction in which nuclei of carbon, nitrogen, oxygen, etc. are fused together to form elements in the middle atomic weight range, i.e., aluminium, silicon, phosphorus, sulphur, etc., liberating huge amounts of energy in the form of heat. This heat keeps the reaction going.

The star will continue this process, getting continuously smaller and hotter. This is one way to explain the existence of stars we call "Blue dwarfs". They are formed by the process described here from "Red giants".

There is a limit, however, to the time for which this process can continue, because once the manufacture of bigger and heavier atoms reaches a certain stage, the new, heavier atoms formed absorb energy in their formation, instead of giving out energy. This absorption of energy takes place with all elements heavier and more complicated than iron.

We can now imagine what happens when this stage is reached. The star has used up nearly all its existing fuel, and begins to collapse. The temperature rises abruptly, perhaps to hundreds of millions of degrees centigrade, and new, even heavier atoms begin to be formed, such as caesium, barium, the lanthanides and rare earths, gold, thorium, uranium, etc. But in their formation, these atoms absorb heat, so the interior cools and this in turn accelerates the collapse or inward rush of the remaining atoms.

The collapse now becomes catastrophic, and all the material of the star meets at the centre to produce a gigantic explosion. So gigantic in fact that when this happens, which is approximately once every five hundred years, we can see in the sky a huge flare lasting for as long as a few days. The astronomers call this a "super nova", and it means that the star has literally blown itself to bits, and the bits are scattered over vast distances which make our solar system very small by comparison. The whole collapse appears to take place in less than one second. It is thus an implosion followed by an explosion. The last super nova to be observed was on 10th. November in 1054 A.D. and was reported in Chinese writings. It made the night brighter than day and the remains of this exploded star can still be easily seen in the sky. It is called the Crab Nebula.

An exciting new discovery reported in "Nature" on the 16th, March 1963 supports the Hoyle theory, and also a new theory put forward by Professor Hoyle and Professor William Fowler only four weeks earlier. This theory was that when a giant star went through the processes described above, it would become so dense and compact that it would cause the galaxy it belonged to to implode and then explode.

One galaxy where this extraordinary event is now happening appears to have been identified. In Australia, astronomers C. Hazard, M.B. Mackey and A.J. Shimmins, using a 210 foot radio telescope near Sydney, studied an intense radio star called 3C-273. They fixed its position accurately by watching it disappear behind the Moon and then reappear, and they found it was a double object. One part, called by them "B", had a central core emitting very intense radio waves.

Next, astronomers at Mount Palomar, California, pointed their 200 inch optical telescope at the position given by the Australians and obtained photographs. On the plates they saw a thirteenth magnitude star with a luminous jet out of one side. This jet corresponded with the part which the Australians had called "A". It is now thought that 3C-273 is actually a galaxy which is imploding.

To understand how Earth was formed we must now consider some other facts. Theories put forward in the past have suggested that two stars passed close to each other and the gravitational pull of each pulled out some of the star material into space where it cooled and condensed into planets.

There are several objections to this theory. The first is that the relative composition of our Sun, (if we were 'drawn out' as suggested) is not, so far as we can tell, the same as the composition of the Earth. The Sun does not appear to contain any of the heavy elements which we find on Earth. Secondly, if this were the case, the distribution of the Planets would be roughly the reverse of what it is, i.e., the heavier Planets, Neptune, Jupiter and Saturn should be nearest to the Sun. What we believe really happened is that originally we were part of a binary system, that is, two stars which revolve round each other somewhat like a South American Bolas when it is thrown. There are quite a lot of these binary stars in the Galaxy.

One of these stars exploded, most probably on completing the cycle of events just described. The other star (our Sun) still survives. The white hot or blue hot vapour of the exploded star began to condense into droplets. Some of these would escape into space and others fall into the Sun. Other droplets which had the right speed and direction would remain in orbit round the Sun and become the Planets. Under these circumstances the Planets with the greatest mass would also have the greatest velocities and the largest orbits. In time, the Planets would cool down, but it must also be remembered that when our collapsing star manufactured all sorts of atoms, it also manufactured all the radioactive ones which we are now discovering and calling Radioactive Isotopes. The Earth must have been very radioactive for millions of years, far too radioactive in fact to permit life as we know it. But in time the radioactivity would gradually disappear, with the exception of one or two radioactive elements which have a very long half-life, and which remain in small quantities until the present. These elements are principally Uranium and Thorium.

At this stage the way was paved for the next great step, that of Life.

The Beginning of Life:

Once again it must be stated that it is extremely difficult to prove the theories which follow. It is believed by a large number of scientists that what happened was something like this.

When the Earth had cooled down sufficiently and the radioactive elements had decayed, there existed oceans and an atmosphere. This atmosphere was very different in composition from the present one, and consisted of a mixture of such gases as nitrogen, ammonia, methane, water vapour and hydrogen sulphide. These compounds will combine to form many complicated substances in the presence of sunlight, atmospheric electricity and radioactivity which act as the driving forces. The

chemical reactions forming the complicated substances are improbable. This does not mean that they are unlikely to happen, but that they will happen very occasionally, whilst more common chemical reactions occur more frequently.

Among the chemicals formed will be amino acids which are the unit building blocks out of which all living substances are made. Many of the amino acids have now been made in laboratories all over the world under conditions resembling those by which they may have been made in nature in a strange, lifeless, chemical world.

Amino acids can combine together to form giant molecules called nucleic acids, and some of these under the right conditions can reproduce other molecules the same as themselves out of raw materials. This could be termed the "Dawn of life".

It is known that all life is controlled and perpetuated by nucleic acids composed of many amino acids joined together in countless millions of different ways. All living matter, plant or animal, has some of these giant molecules of nucleic acids in each cell of its body or structure. The very smallest and simplest forms of life, though simplest is hardly an apt word since they are still extremely complicated, are the viruses. These are peculiar in that they behave like complex chemicals, and yet at the same time can reproduce themselves like living creatures. Yet they appear to consist of just a single giant molecule each, in other words, they are the "Bridge" between chemicals and living things. They are in fact responsible for many of our present-day diseases, not the least of which is the common cold.

So, to "manufacture" life we must first make amino acids and then join many of these amino acid groups together to form a nucleic acid (or virus) which is able to reproduce itself.

How could this come about by accident ? We now think we know.

If the process done in the laboratory is scaled up to cover the major portion of the whole surface of the Earth, there would be large amounts of amino acids formed. These amino acids dissolve in water, and the oceans would be capable of holding large quantities of them. One might almost call the oceans a "soup" of chemicals, including amino acids.

Since all molecules are in constant motion, it is very probable that one amino acid molecule would collide with another. In fact, statistically, given a certain time and conditions of temperature, the number of collisions can be accurately calculated. If the molecules collide under the right conditions, they will combine chemically. In the large amount of time available, which is all too evident, the probability of such types of amino acid reactions becomes extremely high.

Thus it is now only a matter of time before that "million to one" chance actually happens and we get sufficient amino acids combining to form a nucleic acid. One or more of the many nucleic acids is able to reproduce itself. "Living" matter has been created.

In 1960, Dr. A. Kornberg of Stanford University was given a Nobel Prize for demonstrating this phenomenon in the laboratory. To a solution of sugar and phosphate he added a mixture of amino acids manufactured in the laboratory. To this solution he added an enzyme and a trace of a nucleic acid called Deoxyribonucleic acid (DNA for short). Soon the DNA was "breeding" combining the raw materials in the solution into new molecules exactly like itself.

S.L. Miller, a student of Urey at the University of Chicago, produced in 1953 a variety of complex organic compounds, including amino acids, by passing an electrical discharge through a mixture of methane, ammonia, water vapour and hydrogen.

The first flicker of terrestrial life probably appeared some four billion years ago in warm, quiet waters, perhaps in the form of DNA-like molecules. These were strange compounds, "naked genes", newcomers in an inanimate world. They made copies of themselves, but not always perfect copies. Errors occurred, mutations, and certain mutated molecules may by chemical accident have surrounded themselves with protective shells or membranes thus becoming living cells.

From now on it becomes a matter of evolution. This is the manner in which this rudimentary life modifies and adapts itself to its surroundings and environment, how some cells adapt themselves to perform one specific task and sometimes perform this task in conjunction with other cells in a colony, all of which are interdependent for their survival. Such colonies still exist today, and a good example is the Portugese Man o' War.

As the single cells developed and the colonies developed, the earliest fish life appeared. In all this development, the sorts which were not best suited to their environment either died or were killed by other organisms. This was, very strictly, a case of the survival of the fittest.

There is one other possibility which, incidentally, has been proved. That is that viruses can have reached Earth from space. They could come in on meteorites or dust, and experiments have shown that some viruses can withstand extremes of temperature and pressure and still survive. Such viruses have in fact been picked up in space by satellites.

But if this is how the Earth was first colonised, the fact still remains that the viruses must have originated from somewhere where similar conditions prevailed to those on Earth.

By continuing adaption to changing environment our present species have evolved. There is one step which has not yet been confirmed. This is the transition from viruses to cells or bacilli. It is concievable that not only could this happen but also that it would take a very long time, millions of years. This is much longer than the time spent in observations or the time we can afford to wait.

All of this work is really extending Darwin's Theory of Evolution backwards to the very beginning. Many people have argued that this theory is anti-Christian and sacrilegious. This is not necessarily so; let us suppose that both points of view are true. Life could have evolved as we have suggested until one species reached the state we call "Human". This species has an intelligence developed which can appreciate the existence of unseen and unknown things, in other words, a God. Once the stage of development reaches this point, God makes Himself known to man in many ways.

The making of Heaven and Earth in six days in Genesis could be merely the manner in which the foregoing is described to a simple intelligence. Perhaps the time scales are different, one day to the Creator being billions of years on Earth. Why not ! The more one finds out about Nature, the more one realises that beneath the apparent chaos and disorder lies a simple symmetry of structure and conception.

The technical and scientific effort required to find the fundamental facts is enormous and ever increasing, but the fact that matter does obey certain strict conditions and has certain properties does seem to indicate that matter was created by an intelligence, and these properties were "built in" during its making.

C. BANNER and R. H. HEWITT.

Superficial investigations of the Black Lead, Graphite or

Plumbago Mines above Seathwaite (Borrowdale)

on Saturdays, 8th. October 1960 & 2nd. December 1961.

1. Lowest separate Mine (shown on the 6" Map NY 21 SW at NY/233/124 grid reference) is south west of Newhouse Gill or Newhause Gill, but no adit or shaft is now visible at the spoil heap forming a grassy flat tabletop. Tiny tree plantings, unseen from a distance, are growing on this tabletop and the supporting red-grey scree, and are protected by four lines of fellside fencing, crossed diagonally by the original stone wall. This very young plantation is apparently to form a future screen for this spoil heap only. The ruined building ahead of the flat tabletop already harmonises with the hillside as viewed from higher levels.

2. Spoil heap at NY/233/126 is the lowest on the north east side of Newhouse Gill, approached by the graded ascent path. A small ruined building having a short flight of stone steps is situated at the grassy table-top here. An entrance found (for chamber to adit) is somewhat reduced in headroom by accumulated material, being roughly 3' 0" wide by 1' 6" high at its most restricted part.

3. Spoil heap, next above in this group, is derived from an adit, now an entrance only 2' 0" wide by 2' 3" high, with a small waterfall at the side.

4. Spoil heap at the main working is very approximately at NY/232/127. The entrance to the adit is 5' 0" wide by 9' 0" high on average, with embedded floor rails, leads through to daylight where the dangerous shaft plunges down at a steep angle towards an inner adit. The daylight is provided by another unfenced but steeply-inclined entrance having holly and rowan trees inside.

5. The next tier, above old wallings and fainter upper zigzagged paths, has an adit about 4' 0" wide and 6' 0" high. The tunnel goes into the fellside about 40' before becoming low-ceilinged. This adit is situated beside the stream.

6. Spoil heap has an adit 4' 0" wide by only 2' 0" high, also placed beside the stream. Here two eyeholes in rocks communicate.

7. Spoil heap has slit opening about 2' 0" wide by 6" high, having a stone lintel, and is situated above the walls of ruins.

8. Upper quarry hollow with spoil heap found beyond the intervening uppermost unbroken stone wall has no visible adit.

9. Topmost spoil heap from diggings also shows no adit. This merged with the natural outcropping features and is indicated on the 2½" Ordnance Map NY 21 at grid reference NY/230/129 with an elevation of 1,450' O.D.

C. Moore.
Morecambe, Lancs.

It is hoped that this description by Mr. Moore of the remains of the once-flourishing Plumbago Mines will prompt interested members of the Society to delve into the history and geology of the area. The Editor will welcome further articles on this topic.

T.S.

LIBRARY

