HEREFORD ROCKS

By

George West

An eccentric's view of Life, the Universe and the Rocks of Herefordshire, edited and with a new introduction.

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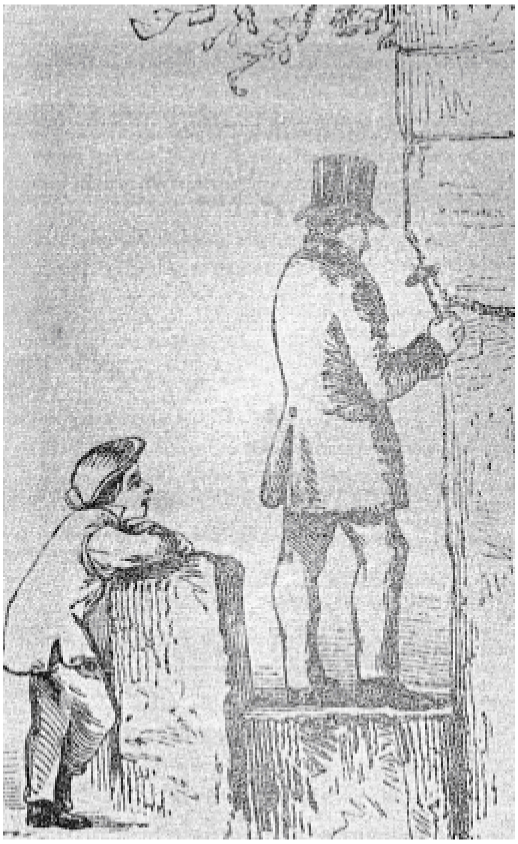

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‘Life has grown from the rock and still rests upon it; because men have left it far behind, they are able consciously to turn back to it. We do turn back for it has kept some hold over us’.

Jaquetta Hawkes “A Land” 1951

INTRODUCTION

I Setting the Scene

The world in the spring of 1945 was amazingly different from that of 2007. The war in Europe had just officially ended, although it would continue savagely in the Far East for another three months until hostilities were terminated by what were naively hoped would be the ultimate peacemakers – the atomic bombs – which were dropped on Hiroshima and Nagasaki. Much of Europe was bankrupt and in ruins, and in the preceding six years, between 40 and 60 million people had died before their time, while millions more were displaced persons and refugees. Everybody over the age of 40 had seen their world shattered not once but twice, and veterans of the first global conflict were under few illusions that the world would be a better, fairer or happier place now that the second war was over.

People in Britain were comparatively fortunate: the civil, social and political systems, although battered, were functioning; rationing, dreary and boring though it was, worked and meant that no one starved or was deprived of the necessities of life. However nowhere was unchanged and few people were undamaged even when there were – as in places like Herefordshire – relatively few external scars. The era of austerity was firmly established and perhaps it is fortunate that few people realised that it would be a full decade before all restrictions and shortages disappeared, by which time Britain's journey from being Top Nation to Also Ran was well advanced.

Television, in its infancy in 1939, had not restarted. The wireless, newspaper and cinema were the main sources of information and entertainment. The majority of households had neither refrigerator, telephone nor car, and to most people the word "computer" if it meant anything at all, referred to a posh adding machine in an office.

In geology absolute dating of rocks by measuring radio-isotope decay had not been developed. Consequently opinions relating to the age and history of the Earth and universe varied enormously according to which theory was adopted and how the calculations were done. Plate tectonics and continental drift were, to all except a very few scientists, unproved and improbable theories. And, of course, there was no satellite information to assist in understanding landforms and structure.

This then is the scenario when in early June 1945, George West donated to Hereford Museum his collection of local rocks together with a lengthy manuscript which not only described the specimens, but set out his own ideas concerning the state and history of the world and the universe. It will be clear that he was undoubtedly an eccentric character but it is important to assess West and his work in context and as a product of that particular period.

II George West

Obtaining factual information about George West has proved a challenge. The period of residence in Hereford over 60 years ago is just too far back for there to be people who remember him personally. Although he says he was a wartime visitor, we don't know where he lived or for how long he was in the area. Neither are the dates of his birth or death known. It is clear from the letter which accompanied the donation of his rock collection and manuscript to the Museum that there had been previous communication with Mr Morgan, the Librarian and Curator, but no record of this remains.

What is known of his career can be summarized as follows. In June 1904, George West was appointed botanist and photographer to Murray and Pullar's Bathymetric Survey of Scottish Fresh-water Lochs.[1] All his traceable publications, bar one, refer to this project. In 1906 he was appointed assistant lecturer in botany at University College, Dundee (then part of the University of St. Andrews), and in December 1911 was promoted to lecturer and assistant to the Professor of Botany. Towards the end of 1925 he told the University that he intended to resign owing to ill-health ("bronchial catarrh") and officially retired in September 1926, after which he left the area.[2] In June 1945 he gave an address in North West London, to which he had presumably retired.

West does not appear to have served in the armed forces during World War I as his only publication apart from the Scottish Lochs Project, "Practical Principles of Plain Photo-Micrography" was privately published in 1916 where he describes himself as lecturer in botany. By 1945 he must have been at least in his late sixties or early seventies and his writing style would tend to support that view.

The picture is further confused for two reasons. Firstly, the British Library Catalogue entries for publications under his name credit him with being an F.R.S.E. (Fellow of the Royal Society Edinburgh), but this august body denies any knowledge of him.[3] It seems that two of West's papers were published in the Transactions of the RSE, but it is most likely that he was invited by a member of it Scottish Loch Survey (probably Laurence Pullar who was himself a Fellow) to read the papers as a guest at meetings of the Society; hence the mistake. In fact, nowhere is there any reference to West having a formal academic qualification, not even a first degree. This is quite possible as at that time a person could progress to the position of lecturer from being a demonstrator or technician. The second reason for confusion is that partly contemporary with our George West was George Stephen West, also an academic botanist who became Professor of Botany at Birmingham, but he died in 1919. Whether there was a family connection is not known.

Academic style has changed immensely since the 1940s, but even then West was something of an anachronism. He affected the rather ponderous pedagogic style characteristic of the late Victorian and Edwardian periods. He sprinkled his text liberally with literary quotations and allusions – and also snippets of unattributed, rather bad verse, presumably composed by himself. His occasional attempts at humour are rather heavy handed. However his approach was not substantially untypical of the period and the reader should keep this in mind as otherwise there is a risk of the style distracting one from the substance.

At times West gives the impression of being a largely self-educated man. A good example of this occurs when he refers to Pliny's account of the eruption of Vesuvius and destruction of Pompeii. Rather than cite the work itself, he refers the reader to the entry in the "International Library of Famous Literature" which seems to be a typical example of the self-help, home education compendia popular in the early part of the twentieth century. Many other references and allusions are incompletely identified. This being said, it is plain from the List of Sources and References in Appendix 4, that he was concerned to relate to the wider fields of academe, not just his own speciality. Two quotations by Locke and Ruskin[4] used in earlier papers reflect his thoroughly worthy hopes and aspirations.

George West was a skilled photographer as can be seen from the illustrations to his work on the Scottish Lochs, and his 1916 book 'Practical Principles of Plain Photo-Micrography" demonstrates a high level of skill and expertise. Unfortunately West did not seem to have much of what nowadays might be termed "academic clout". His somewhat desperate appeal in the "Open Letter to Diatomists" which appears at the end of the photo-micrography book (Fig.1), for backing to enable the publication of another work, would imply that he could not rely on financial or promotional support from academic colleagues or his own institution at Dundee.

Fig. 1 ***An Open Letter to Diatomists***

Univeristy College
Dundee
March 1916

Sir or Madam, -

The Author of the *"Practical Principles of Plain Photo-Micrography"* has in hand a publication on the Diatomaceae of Scotland, which will be issued in parts. The first part will, he hopes, be ready by the end of 1916.

In this work an endeavour will be made to describe, discuss, and illustrate every species as fully and accurately as possible. A limited number of microscopical slides will be issued in illustration of the species and gatherings dealt with. These will be offered in three forms, viz.:- Type slides, Species slides, and Strewn slides.

The price will be such as to bring the work within the reach of the ordinary student.

The British Diatomaceae, as everyone knows, have been greatly neglected during the past 50 years, and it is the aim of the writer to do something to fill this gap in our literature. The task, however, is a gigantic one for a person, who like the writer, can utilise his spare hours only for the work. Under these circumstances he will be glad to receive assistance from those who are interested in the subject, and he requires those who are able and willing to collaborate to communicate with him.

The writer has prepared for his own use a Genus Index to the *"Atlas der Diatomaceen-Kunde"* by Adolf Schmidt and his successors, posted to the last issue, which carries the work to *Tafel* 316, published just before the Great War began. This index is so useful that the writer imagines that others who possess, or consult this work in libraries, would be glad to have a copy. If 20 persons would offer to take a copy at about 2/- each the cost of printing would be covered, and the work could be put in hand at once.

A Complete Species Index to the same work from the last part included in *"Fricke's Verzeichnis"* to the most recent issue has also been prepared, and is, of course, most useful. This will cost about £5 to print, and would, therefore, cost 20 persons 5/- each.

The writer has also on hand a more or less complete Bibliography of the Diatomacaea brought down to date. This is naturally a much larger item than either of the foregoing, and to print a few copies would cost £40 to £50. If 40 or 50 subscribers would offer 20/- each, or double the number 10/- each, this useful work could be printed.

The limited sale that any of the above-mentioned works would command is not a sufficient inducement for the writer to start printing unless he can be assured of enough subscribers to cover most of the expense.

Diatomists are requested to communicate with the writer on the various points mentioned in the foregoing appeal.

Yours truly,

GEORGE WEST

It would be very easy to write off West as nothing more than an eccentric of modest scholasticism with a number of bees in his bonnet. Certainly he is vigorously anticlerical and against organised religion as he makes plain in his introduction: he is sternly moralistic towards what he regards as "vice" particularly as manifested by idleness, indulging in futile activities and drinking in public houses. He also feels that environment strongly influences personal ethics:

> "The predominance of grass-like associations over the mountains and moors instead of heather, has had great influence on the flora of the lakes….. Not only that, but the pastoral life induced thereby stamps the inhabitants with characteristics different from those of people living in localities that are chiefly devoted to sport, and engender a higher type of ethics and a superior social organisation amongst the rural folk"[5]

and he feels that collecting and studying rocks is one means of distracting young people from vicious behaviour. His 'immediate' identification of a stone with a hole in it, which he found at the Portway glacial moraine, as an object associated with prehistoric sun worshippers and his subsequent disquisition on Babylonian and Biblical numerology may seem a wild flight of fancy, but as the object has disappeared there is no way of knowing if it was, in fact, some kind of artefact whose significance was inflated by an overactive imagination.

West's cosmological calculations and synopsis of Earth history are particularly mind-boggling, especially as he does not say how, or on what basis his figures were obtained; but 60 years ago with absolute dating of rocks and radio astronomy being in their infancy; and, of course, no Hubble telescope, to some scientists his ideas would not seem unusually outrageous. Even now in 2007, figures, theories and periods of geological history are constantly being reviewed, revised and restated. In his text West does show an awareness of potential ecological and environmental problems which are currently at the front of worldwide concern. He refers to the effects of natural catastrophes on the environment, the limited supplies of fossil fuels and resources, and the problems of over-population, which are forcefully expressed during his description of specimen No. 133.

One suspects that George West may not have been the easiest of people to live with or work with. He was never backward in describing his own problems and struggles (see his introductory letter). Indeed, he was a 1940s "grumpy old man". But on the positive side he did compile a useful local geological collection and he did his best to explain and describe the specimens which is something no one else has done for the county to date, and for that we should thank him and perhaps forgive him his foibles.

III The Collection

The Museum Day Book entry for 11th June 1945 reads "A very large collection of specimens of local rocks and minerals. Given by Mr G West, 10 Chevening Road, London NW6" and a note found among the geology collection states

> "each specimen bears the collector's pocket book number usually not seen by visitors. The specimens are arranged more or less in chronological order, and thus numbered for the

public to match to a description. Each of such numbered labels bears on its reverse side the pocket book number; hence there can be no confusion".

This last statement proved to be 100 percent wrong! The collection of 253 items was not formally accessioned for over 30 years, in 1976, by which time the labels, together with accompanying map and other information, had disappeared. It is clear that the person doing the accessioning has tried to make the accession numbers correspond with West's specimen numbers, but he has only been partly successful.

To add to the confusion, by 1976, the collection was being referred to as the Clark(e) and West(on) Collection, and the boxes labelled "The Stratigraphy of Herefordshire". A belief seemed to have arisen that the collection had been a collaborative effort between George West and the Rev. B.B. Clarke of the Woolhope Club, although there is no evidence to substantiate this or even to suggest that the two men knew one another. Enquiries within the Woolhope Club have not brought any new light on the subject; nor are there any references in the Woolhope Club Transactions. In a letter written in 1949 to the Museum Curator, Miss P. Morgan, from her predecessor Mr L. Bickerton, he says "I am very pleased to hear that the geological manuscripts have come to light and I am sorry that I did not remember lending them to Mr Clarke". So it seems that Clarke had consulted West's manuscript and possibly used the rocks in the course of his own research or for display. The original manuscript and letter are now stored at the Hereford Records Office, and a facsimile is held at the Museum Resource Centre.

Over the years the collection languished somewhat apart from the occasional specimen being removed, presumably for educational or display purposes. There are references to a major exhibition of Herefordshire geology some years ago but the details are not available although it is most likely that the West collection would have figured prominently. The bulk of the material has remained together even though various items have turned up in unexpected and unaccountable places within the Museum's Natural History collection, but there are still a small number of missing items.

Since 2004 the collection has been consolidated and inventoried and a provisional catalogue compiled correlating individual specimens to West's itemised description, which forms the bulk of his manuscript, but some inconsistencies and omissions remain. As this year, 2007, will see the completion of the new Natural History store at the Museum's Learning and Resource Centre in Friar Street, and two hundred years of British geology is being celebrated nationally, it seems appropriate that by the year's end, West's collection will be properly and accessibly stored ready for consultation by anyone who is interested in local geology and petrology.

Herefordshire and the Marches are world famous as the stamping ground of the great nineteenth century pioneers of geology such as Murchison. Perhaps it is only fair that George West should also be remembered and have his own small place among the giants.

Notes

1. p.2 Bathymetrical Survey of the Scottish Fresh Water Lochs. Directed by Sir John Murray, KCB., FRS., DSc, LL.D. etc. and Mr Laurence Pullar FRSE, Vol. 1 1910

2. p.2 Personal communication from Mr K Baxter of University of Dundee Archives, Record Management and Museum Services. March 2007.

3. p.2 Personal Communication from the Royal Society Edinburgh Archivist 2004.
The Rhynie chart fossils are Devonian in origin and include some animals.

4. p.2 Quotes:
   a) "Yet methinks it is not unreasonable to propose, that words standing for things which are known and distinguished by their outward shapes should be expressed by little draughts and prints made of them….. Naturalists, that treat of plants and animals have found the benefit of this way; and he that has had occasion to consult them will have reason to confess that he has a cleverer idea of opium or ibex from a little print of that herb or beast then he could have from a long definition of the names of either of them".
   John Locke, quoted at the end of "A Comparative Study of the Dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Seven Loch Areas of Scotland" 1905.

b) "The greatest thing a human soul ever does in this world is to see something and tell what it saw in a plain way".
John Ruskin, quoted at the end of "A Further Contribution to a Comparative Study of the Dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Scottish Lakes" 1908.
Silax is an obsolete term for silica.

5. p. 4 "Bathymetrical Survey of the Scottish Fresh-Water Lochs" Vol. 1 p.212.

NOTE ON THE TEXT

The text is a transcription of the holograph manuscript which is now held in the local collection at Herefordshire Record Office. The author's use of capitals, punctuation and grammar have been left unchanged as far as possible except for a few instances where correction was necessary to ensure clarity of meaning. The omissions are where facts or examples have been repeated. All editorial interpolations are within square brackets, and the notes and appendices are by the editor. George West hoped that his manuscript would be published; and in fulfilling his wishes a type face appropriate to the period, Times New Roman, has been used.

It must be remembered that George West was writing in a pre-decimal age. His use of Imperial units has been retained, and in this context a billion is one million million (10^{12}) rather than the one thousand million (10^9) which is almost universally used today. Horsepower is a unit of power equivalent to approximately 750 watts or 550 ft/lb per second.

MR WEST DONATES HIS COLLECTION

22.v.45

Dear Mr Morgan,

In a former letter I think I stated that the M.S.S. on the rocks would be finished at the beginning of the New Year, and near last Christmas it was nearly ready. Unfortunately I counted my chickens before they hatched, and the cold weather about Christmas time gave me a chill, which settled in my back about the kidneys. I was taken ill in the night with violent pains that started severe nervous trouble to the whole system. My mental organ would not act properly, while legs and feet became so swollen and painful that I could scarcely stand, and I am only now getting out of the doctor's hands.

This trouble was brought about by the restricted war diet, especially lack of fruit, as well as by the cold. Our house is heated chiefly by electricity, and owing to the current being required for war factories the supply was greatly reduced to householders. The coal shortage reduced fires to the dining room where I had to sit well wrapped up. Then the few days warm weather in April greatly helped me, and I actually began to sort out my papers which had been packed up in my study. But a return of cold weather drove me away as the electric fire would not heat the room to more than 56°-58°, and I can't endure less than 64° when sitting at writing or reading.

The recent week or so of warmer weather enabled me to finish the job and herewith the m.s.s. is enclosed. I had intended to re-write it, but am still not strong enough for the work. Moreover I have seen far worse m.s.s. in the printers hands, some of which [I could] not read.

The Introduction has been written in simple words such as a person unacquainted with science could understand. The description of the rocks is not altogether a dry account of each kind, because in many cases a simple explanation of phenomena connected therewith has been given.

Before a person can understand rocks he requires some knowledge about the conditions of the young Earth and something regarding the relationship to the Sun and to distant stars, as well as some notions about Space which never had a beginning, nor can it ever end.

For thousands of years mankind has been guided by Moses not merely in morals, but in knowledge of secular items also. We have scanty information about Moses, but it is clear that he was not a naturalist, and in his account of the origins of man he simply followed ideas of a score or more of other tribes on that subject, that have been revealed by investigators.

You may not realise as I do the present deplorable state of Ethics in our Land. The majority of younger folk are no longer governed by religion as formerly, and now have no fear of the priests' Hell, nor hope for the joys of his Heaven. Consequently the transient evil pleasures of wrong and vice rule the lives of millions, at the same time they lack mental power to realise that -

Heaven and Hell are earthly and home made
According as we each with Ethics trade.

Many lack the reasoning power of the higher apes. Now monkeys are fond of beer and spirits, but after one of them has been made drunk he will never touch such drink again.

After schooldays the majority of humans have no occupation for spare hours, and squander life in vicious practices, for, as 'tis said in Scotland – "Deil gies wark ta ilka idle han'." An evening visit to a popular tavern, or to one of the police courts, show the way folk are drifting, and personal wrong is followed by personal degradation, while that must lead to national debasement and extinction, as evil parents can rarely give origin to sound children. Rulers of the past recognised such Natural Laws, and endeavoured to check their advance, chiefly by some form of religion. An example of this is the Roman Constantine I, himself the murderer of his wife, son, and other relatives. Yet he gave the early Christian priests instructions to make folk good at all costs. History records how those priests made wealth during 1,200 years, by the power Constantine gave them over the populace, compelling people to believe and pay, or suffer at the stake or dungeon.

I am not a religious zealot, but I fear the debasement so active around, and which both law and religion fail to stay. For that reason I gathered the collection of rocks, and have written an account of them in an endeavour to do something against what leads to national decay. When a young person can be interested in something for his spare hours, he is less likely to fall into evil habits than when idle, and any Natural Science is of great value in that respect. You may regard the matter from a business aspect, and consider me a fool, because you may not realise as I do the present state of Ethics in our Land.

We must consider what is to be done with this m.s.s.. In letters you have made some reference to the journal of the Woolhope Club, but it is too long, too popular and otherwise unsuited for publication in that journal. That publication is very little known beyond Hereford, and my composition will interest many folk in all parts of the country.

Perhaps the best plan is to get the "Hereford Times" to print the pamphlet, enclosed in stout paper covers, 8vo or large 8vo size, issue it to booksellers in the City, and elsewhere and distribute copies in the usual way for journals to review. They could probably be sold to the public at 1/6 [7½p] or 2/- [10p] each and your library could have them on sale. Possibly your Council would insure the printer against loss to the extent of say £20,[1] and I could offer another £10. I have lost much income on account of this shocking war, and rates and taxes and cost of living will continue to take more for a long time. If you had secured the paid service of a geologist to collect the samples, trim, clean, label and arrange them in a show case, then write a simple guide that a school boy could understand; the job could have cost you £200 instead of nothing. Consequently I consider your Council might well lend a hand with a guarantee against loss to the printers. I have written several publications, all of which have been kindly received. I gave you two on the Lochs of Scotland, now out of print. One book on photomicrography[2] issued at 4/6 [22½p] was all sold in a few weeks

A book, if in your library, would interest naturalists is "Bathymetrical Survey of the Scottish Fresh-Water Lochs" Directed by Sir John Murray and Mr Laurence Pullar. Edinburgh 1910. Vol. 1 21/- [£1.05] pp 156-260 with 9 plates are by myself. Lea. Bound.

Please think over the issue of my pamphlet. I hope to be able to do the proof reading, and could write an article for the Hereford Times advising the publication of it. I trust this will find you in good health, with a renewed pleasure in life now that the Hun is crushed, while we all taste sorrow at the loss of so many of our people. With kind thoughts, Sincerely Yours,

G. West

p.s.. Sir John Murray was the well known explorer and philanthropist killed by a motor accident. Mr Laurence Pullar was a member of the well known dyeing firm of Perth. His son was interested in the natural history of Scottish Lochs, and was drowned by accident. To commemorate him his father placed a sum of money for Sir John to continue the son's investigations, which were ultimately published in 6 handsome volumes.

To [the] enclosed I may add that in this district we have suffered heavily from the bombs, and slates of most houses have been injured by the concussions from explosions. 200 yards E. of this house 3 similar houses were entirely destroyed, while 150 yards S., 4 similar houses were also entirely destroyed. About ½ a mile E, 3 streets were demolished, and the same distance from us W., 4 streets suffered the same fate. In the two last-mentioned cases about 50 persons were killed and many injured in both instances. Then within ½ a mile all around us a great number of houses have been entirely wiped away or injured. Our house has suffered to the extent of about £10. You can imagine that life under such circumstances does not induce folk to offer the Huns the forgiving schemes of old Jesus; and if the politicians lend, or rather give, them a vast sum of the taxpayers money, as in1918, there will be a big row.

Notes

1. p.8 It is worth remembering that in 1945, an agricultural labourer earned just under £4 per week, and that £10 per week was a professional salary. This puts West's estimate of costs into context

2. p.9 'The Practical Principles of Plain Photomicrography' by George West, Lecturer in Botany, University College, Dundee. 1916. Privately printed for the author.

GUIDE TO THE ROCKS OF HEREFORDSHIRE

(Illustrated by 253 Specimens in the City Museum)

INTRODUCTORY REMARKS

John Ruskin, the elegant writer on Art and Ethics told the teachers of humanity – "All other efforts in education are futile till you have taught your people to love fields, birds, and flowers." By these words he doubtless meant the whole realm of Nature that immature minds are able to understand. That remark, although tinted with exaggeration, includes a general truth, and our teachers are not yet guiding their pupils on that path which leads to meditation and ethical habits. On the other hand many philosophers consider that the cramming of facts useless for young minds to founder on, so common in our State education, drives the juvenile from reflection to the manners of the street, thence to barbarism and vice. A few evening minutes spent in a popular tavern shows where a considerable portion of our Race is drifting, - on the track that leads to their own ruin and the annihilation of their Nation.

The writer of these notes, a war time visitor to Hereford, having experienced the advantages received by the mind from the contemplation of the works of Nature, and the Laws by which they were and are produced and governed gathered these specimens of rocks in Herefordshire to assist other folk in gaining some idea of what they live amongst. From the notion they may be led to pry into Nature with their own eyes and mental ability, to gain therefrom a satisfaction for life not otherwise obtainable; for without some intellectual pursuit the mind and character must certainly deteriorate.

A human mind that lacks sane thought
On things the Laws of Nature wrought
But creeps absorbed in self's own plan
Glides from the moral code of man;
And then becomes quite capable
Of deeds with right scarce possible
While brains that feed in their spare time
On local rocks, from vice will climb
Then, leaving man's degrading ways
Reflect on them uplifting rays;
And deaf to deadly roar fools give
Show them a better way to live.
To rocks grant thought, and mind gets back
A peace that flows on Ethics' track:
Hence, common ways oft leave alone
Your mind with Nature's Law to tone.

The short notes on the specimens which follow page 41 are all that can be given at present, but when the existing predatory nations are incapable of inflicting their abominable crimes on peaceful humanity a more adequate description of each specimen may be supplied. Meanwhile the books in the library may be consulted, not forgetting the Encyclopaedias – Chambers' and Britannica – under Geology and related subjects, as well as to the articles they refer to.

The Synopsis which follows on page 40 will aid in giving a general idea of the gradual construction of our world, and the place in its history to which the rocks of Herefordshire belong. These, or some among them, are marked at the left margin of the Synopsis by a black line. [not in fact indicated (ed.)]

There are numerous cases of evidence in Herefordshire that during former times, many thousands of years ago, a long period of arctic conditions of climate prevailed, and glaciers flowed through the country bringing with them rocks and stones from North Wales. Although a considerable quantity of such foreign material has been removed from the land to improve it for agriculture, and for use as road metal and building, an abundance still remains. We must consequently consider how this period of cold could have occurred and the facts revealed by Astronomy assist in this matter, as well as that of several other similar cold periods endured by portions of the Northern and Southern Hemispheres which now have a temperate climate. These visitations of cold are proved by the masses of broken and worn rocks and stones often foreign to the districts where they now rest, carried there doubtless by ice and incorporated in various Northern and Southern countries with the main strata known to have been formed at various epochs of the world's history from very early times onwards. When considering the Southern Hemisphere regarding such glaciations, a glance at a map of the world will show that very little land now exists as near the South Pole as Herefordshire is to the North Pole, i.e. within reach of South polar glaciers, yet there is evidence of former glaciations in the Southern Hemisphere. Then the existing vast extent and depth of the Southern oceans tend to modify the climate towards the north to milder conditions than what prevails over the great areas of land in the Northern Hemisphere. In opposition to the foregoing it must be kept in mind that cold oceanic currents from the S. reach N.E. to about 45° Latitude, and often carry Antarctic ice, while the climate of all Western Europe is at present softened by the warm water of the Gulf Stream. Meanwhile we must remember that there may be an Antarctic continent[1] as explorers have suggested. If so it is covered with ice and snow, usually presenting at the margin a border of ice about 150 to 300 feet in height above the sea. This ice makes it difficult for explorers to find a landing place, and on the few occasions where such have been discovered they have seldom been able to advance owing to the rugged and forbidding nature of the surface behind the ice cliff. However, in the early years of the present century, 1911, Captain Amundsen reached the South Pole and deposited records there. In the following year these were found intact by Captain Scott. Previously Captain Shackleton had reached 88° South. These expeditions started from near Mount Erebus, a volcano 12,000 feet high, situated in a great arm of the sea which penetrates the ice barrier to the South of New Zealand. Unfortunately many members of these expeditions lost their lives including all members of Captain Scott's party, owing to the cold and hardships suffered.

To assist the mind in gaining a slight grip on this subject, we must give some attention to what our Earth is at present doing and its relation to its surroundings in Space. We can understand that a space exists between Britain and Australia, but our minds fail to really comprehend the meaning of the Space in which our world and the stars appear to float. We guess that this Space must be eternal, without beginning, ending or limit, and that the various matters and energies moving and acting in it are capable of enormous change in form and position, yet cannot be destroyed. We must consequently cast from the mind the common notions regarding Time and Distance which human experience has gained because

Life is short, yet makes dust active
    Time began not, nor can finish
But eternally is passive.
    Life in dust from dust doth vanish
To Distance, quite imperceptive
    By Life that Earth still may nourish

The portion of Space which, by means of modern instruments, we can see from Earth and learn something about, is represented by a spherical part between 63 and 64 x 10^{40} miles in diameter. This means 63 to 64 followed by 40 ciphers or 0s and is readable as 640,000 trillions of trillions of miles. But Space having no limit, this vast spherical portion cannot be expressed as a fractional part of it. Some persons have imagined that Space has a limit, and have even expressed themselves regarding its shape; yet, strange to tell, they forget to remark upon what is exterior to the Space they have conceived as limited. The 63 to 64 x 10^{40} miles first mentioned represents to us a sphere with Earth as its centre (do not imagine this to mean that Earth is the centre of the Universe), so that the most distant stars known are at their radius from us, i.e. About 31-32 x 10^{40} miles away. Some idea of this distance is gained by a consideration of the time taken by light from such stars in reaching us. Light travels through Space at about 186,283 miles a second, and takes a little more than 8 minutes in reaching Earth from the Sun, which is about 92-93 millions of miles distant, according to the position of the Earth in its oval orbit. But travelling at the same rate from the most distant stars visible with the largest telescopes it occupies about 5,442 x 10^{25} years, i.e. 54, 420 millions of trillions of years in reaching Earth. Compared with this time the 3,500 or more millions of years calculated, and subsequently explained, for the existence of our world is insignificant. The conditions of such distant stars must be very different now to that when the light left them. With regard to the Sun the telescope shows us what happens on it a little more than 8 minutes after the occurrence instead of 54,420 x 10^{25} years.[2]

Our Earth is one of the small planets of what we name the Solar System; it is the third from the Sun, and its diameter is about 7,912 miles, that of the Sun being about 864,100 miles.

The outermost large planet of our System is Neptune with a diameter of 33,900 miles. Earth and Neptune are respectively about 93 and 2,800 millions of miles from the Sun, so that Neptune is more than 30 [times] farther from the Sun than Earth, but they vary somewhat in this respect according to their position in their oval orbits. The most distant planet is a small one named Pluto, also known as Lowell's X, and is about 3,836 millions of miles from the Sun. A still more distant planet has been reported, but not properly confirmed. Earth travels on its journey around the Sun at about 19 miles a second and Neptune only 3. As a result of faster speed and smaller orbit the Earth completes its journey around the Sun in a fraction over 365 of its periods of axial rotation we term days, while Neptune with slower speed and greater orbit, takes 60,181 of Earth's days for its journey around the Sun, Thus a year for Neptune is a little longer than 165 of Earth's years. Each of the other planets also varies in this respect as well as in most other matters.

In addition to the movements just mentioned the whole Solar System is travelling through Space at the rate of about 12½ miles a second, or 1,080,000 miles a day. The diameter of our Solar System is about 8,000 millions of miles and it travels through Space on an oval orbit the circumference of which is about 79×10^{15} miles, i.e. 79,000 billions of miles. The short diameter of this orbit is probably about 259×10^{14} miles and the long diameter about 261×10^{14} miles. Around this orbit the Solar System completes its journey in about 200,007,600 of our years. By this journey the Earth, every 20 years, advances through Space at about 80×10^{8} miles, i.e. 8,000 millions of miles. On its passage through Space the Solar System must be kept free from the injurious influence of other Stars, and probably no large Star should come nearer its circumference than Proxima Centauri, which at present is the nearest star to the Solar System, and is about $25{,}284 \times 10^{9}$ miles distant from Pluto, already mentioned; those figures read as 25 billion 284 thousand million. With us a million is a thousand times a thousand, a billion is a million times a million, while a trillion is a million times a billion.

Probably it would be injurious to our System if any large Star such as Epsilon Aurigae (three times the diameter of our Sun) approached much nearer than the distance from Proxima Centauri, while one the size of Antares (over 451 times the diameter of our Sun) would certainly cause a great disturbance. It will, consequently, be seen that our System needs a vast clear area beyond its orbit to keep it safe from the harmful influence of other Stars. The probable end of our Solar System will be its attraction to, and fusion with, some big star when the Sun has lost more of its heat and power. When considering the power of the stars, it is their volume we must reckon as more important than their diameter, while the hot and self-luminous stars, such as our Sun, are far more powerful than ones like our Earth and Moon. The diameter of a sphere being known its volume is readily calculated by the formula $^4/_3$ ðr³ (ð = small Greek letter pi). A few examples will serve the reader better than mere words but as exact figures of diameters of stars are impossible, consequently, such calculations from them must be considered as approximate.

[Table 1]

	Diameter in miles	Diameter compared with Sun	Volume in Cubic Miles	Volume compared with Sun
Earth	7,912 (mean)	109 times less	$2{,}428 \times 10^{8}$	1,391,777 times less
Sun	864,100	-	$3{,}378 \times 10^{14}$	-
Epsilon Aurigae	2,592,000	3 times greater	$9{,}118 \times 10^{15}$	27 times greater
Antares	390,000,000	451.3 times greater	$31{,}059 \times 10^{21}$	91,950,000 times greater

The three last mentioned, being fiery stars, exert through surrounding Space far more influence than merely their size, which compared with our cool Earth, would suggest. Epsilon Aurigae is easily recognised on a clear, moonless, winter night. It appears as if bordering the Milky Way on the Pole Star side, and is nearly in a line with the head and hindfoot Stars of the Great Bear constellation. A small scale example of the influence just mentioned is well exhibited by our Moon upon the oceans of the Earth, producing the spring and neap tides of each lunar month. The Moon, however being a small and cold satellite can exert only a minute fraction of the power of a large hot star, even such a comparatively small one as our Sun. Then there is the example of the last-mentioned on its distant planet – Pluto. From Pluto the Sun would probably appear less than one fortieth of the diameter it is to us, and can afford the planet little light and heat. Yet the Sun maintains Pluto in its position notwithstanding its energy being diminished by the great distance.

The Sun's surface continuously radiates into all directions of Space around its spherical mass various forms of energy, of which light and heat are recognised by humanity without the aid of instruments. At the distance of the Earth, the total amount of energy is calculated to be more than 470,845 trillions of units of horse-power (i.e. $470{,}845 \times 10^{18}$). An imaginary sphere around the Sun at a distance of the Earth from it would have a surface of about 108,687 billions of square miles (i.e. $108{,}687 \times 10^{12}$) receiving that energy. The portion of our world getting light and heat from the Sun at any moment is about 98,281,000 square miles. Each of these square miles of the Earth receives an average of about 4 millions of such units when the Sun shines fully on that area. At the equator the energy is more for each hour of daylight than in temperate regions, and diminishes again as the Poles are approached. Thus the Earth receives only one portion of the Sun's energy from the 1,106 millions of such portions it distributes. This may be put in a form more readily understood by stating that each square foot of the South of England, under the conditions mentioned, receives energy from the Sun sufficient to raise 42 hundredweight at the rate of one foot per minute. It is this energy from the Sun which governs the Solar System, somewhat after the manner of a piece of iron brought slowly near the magnetic needle of a compass. Our natural senses utterly fail to recognise the energy between the iron and the magnetic needle, while of that between Sun and Earth our natural ability can acknowledge only light and heat. Nevertheless, when under certain conditions of ill health we feel the beneficial effect of other radio-activities from the Sun when we expose ourselves to them, even when attired in our usual raiment. Scant wonder the Sun was formerly worshipped by mankind! In time men will probably discover better methods of employing the powers from the Sun for their mechanical and other purposes. At present some of the former products of that energy, like coal and oil, are their great mainstay for power, but at the present rate of consumption these products cannot last beyond another 150 years or so. Far back in the days when coal could be produced in what are now temperate and cold regions (see Carboniferous Epoch in Synopsis p. XX) the energy from the Sun was greater than at present, and the climate of Britain probably resembled what Cuba now has, fossils of animals, such as Corals, and of coal-plants prove that. Fossils of plants that produced coal have often been so beautifully preserved by silica that thin slices of them reveal their minute structure by means of the microscope, almost as perfectly as living examples. Excellent British specimens occur even as far North as Rhynie[3] in N.W. Aberdeenshire.

It is fairly easy for us to grasp that the movement of the planets around the Sun, and the rotation of the moons around their planets, is due to the magnetic-like power radiated from each of these globes. These initial thoughts help us when we consider the maintenance of these ponderous spheres, with countless others in Space beyond our System, and their passage through it at enormous speeds, such as our Solar System, and we have to let our minds roam into Space beyond the orbit of our System as far distant as stars can be recognised. Then with that help we can more readily comprehend it is doubtless the mutual radiations of these distant stars, and all others, with those of our own Solar System that account for their support in apparently empty Space and their rapid movements in it. We, then, can also realise that slow change is continuous and never ceasing; and that there has never been a general beginning nor can there ever be such an ending, for that would imply the destruction of matter which is impossible. For an example consider hydrogen dioxide, which sunlight apparently destroys. It is found in snow and rain as a natural product, and can be prepared by a chemist. It consists of 2 atoms of hydrogen and 2 of oxygen, Light cannot really destroy it, but merely liberates one of the atoms of oxygen so that the 2 atoms of hydrogen can hold only one of oxygen, and thus become plain water, while the other atom of oxygen becomes a gas. The H_20_2 is used for bleaching and cleaning (it makes dark hair sandy coloured), and under certain conditions is liable to explode. Consider also plants and animals – when Life has passed from them they decompose on the ground, and the particles of their bodies mingle with those of the ground, in other words they manure the soil. The roots of plants absorb the particles from the ground in liquid form for the nutrition of their own living substance. Herbivorous animals eat the plants for their own development. Carnivorous animals nourish themselves by devouring the herbivorous, while omnivorous man employs both herb and beast for the same purpose. Thus there is no destruction, only change – resurrection follows death as a concomitant necessary for the continuance of life. Man endeavours to hinder this natural circulation of material by keeping the bodies of his departed friends from contact with the regenerating soil, and maintains the cherished desire for a different restoration where plants no longer flourish.

When on a clear, dark, winter night we look carefully at the star-spangled Blue, and contemplate upon the stupendous grandure [sic] of the glittering orbs and their movements, even the oldest and most sedate among us should feel more than a mere pleasure. And as they continue to observe and meditate they will feel youth and energy returning. Thus they may experience the thrilling sensations of Longfellow's Holy Archbishop and Saintly Cardinal when those austere gentlemen watched Preciosa, the Gypsy Lass dance before them. A scene which so restored their juvenescence that they sprang from their seats, threw their bonnets into the air, and shouted with hilarious enthusiasm for the pleasing display, although the Pope had sent them to condemn it.

Owing to the power radiated from other stars the orbit of our Solar System is probably not an even curve but often with undulations when it passes within the influence of a big star. At such times our Earth may be drawn further from the Sun and at occasional periods, possibly only once for any great time during the 200,007,600 years previously mentioned; its greater distance from the Sun might then produce a Glacial Epoch over parts of the North and South Temperate regions. A general lowering of 40 degrees of temperature below the present average would suffice, but in the past more would have been necessary as the Sun has been losing power. In addition to drawing the Earth farther from the Sun the approach towards a big star in certain directions relative to the plane of the Earth's orbit, might possibly alter the position of the Earth's axis. This might occur by the attractive power of the star having more influence on the great extent of land in the Northern Hemisphere than in the oceans of the South. For instance the great Valdivia Deep far to the S. of S. Africa, between longitude 20ºW and 50ºE., and latitude 50ºS. and the Antarctic circle the general depth of water is between 4 and 5 miles. In a small area S. of the island of Guam in the N. Pacific the depth is only 66 feet less than six miles. The great extent and depth of these oceans afford reason for us to consider they have occupied their present position for a vast period, possibly from the beginning. A gradual change of position for the Earth's axis would bring the North Pole Southwards and the S. Pole northwards with corresponding changes of climate in temperate regions. A shifting of the Earth's axis to any considerable extent appears far less probable than a change of position for the whole Planet further from the Sun; although a few degrees in change of latitude would suffice for glaciation on regions now temperate. The last Glacial Period, named the Pleistocene, probably lasted about 150,000 years; and the strata plainly show that during that long time a few milder intervals alternated with the colder. That may be explained by the Solar System, during that number of years, coming successively within the influence of more than one external star. During 150,000 years the Solar System travels about 60 billion miles, and in that distance of Space it may pass within the influence of several external stars that would from various directions, cause the Earth to vary its distance from the Sun, and, consequently, alter the heat received from the Sun . Thus the oceans of the tropical regions would be cooled and that would affect the temperature of the North and South, lowering it a few degrees as a help towards glaciation. The plants that now flourish near the coast of Sutherland, Caithness, and down to the Moray Firth afford direct evidence of the mild conditions induced by the warm Atlantic current which, after rounding Duncansby Head turns Eastward at Nairn and Elgin. In addition to the last or Pleistocene Glacial Period, remains of which are so evident in many parts of the N. Temperate region, including Herefordshire, there are remains that are doubtless of glacial origin in at least 8 groups of Epochs of the Earth's history, here arranged from the beginning, in succession, to the last series of strata deposited by the agency of water or ice, (vide Table II). The figures are mere calculations from possibilities, hence use the tables simply as a guide for thinking, -

> "Reading furnishes the mind only with materials of knowledge; it is the thinking that makes what we read ours. So far as we apprehend and see the connection of ideas, so far it is ours; without that it is so much loose matter floating in our brain" – John Locke, 1632 – 1704"

Of these eight cold periods the Pleistocene is by far the most evident, as an abundance of its remains are still at the surface, even in Herefordshire; while the more ancient remains have been more or less covered by succeeding deposits or by water. In many districts, especially of the North Temperate regions, strata of previous Epochs have been uplifted by surface movements of the Earth and partially denuded away exposing the old glacial remains in the strata containing them. Examples of the earliest in Britain occur at Ross and Sutherland in N.W. Scotland where, resting on gneiss, an igneous rock, is a great thickness of Torridonian Sandstone, mostly a reddish-brown strata belonging to the Pre-Cambrian Epoch. This Sandstone has, perhaps, never had any other strata deposited upon it, or if so, such has been completely denuded away; it may be in its original position or possibly pushed up by the gneiss below. It is one of the earliest of Earth's sedimentary rocks and contains the remains of Glacial action that occurred probably about 1,400 millions of years ago, or more. This reddish sandstone is probably the result of sand thrown out from volcanoes and falling into the ancient sea during a vast period of time. No strata is known from which this sandstone could have been derived by ordinary denudation.

From various sources of partial evidence, it appears probable that the Earth was thrown off from the Sun in a more or less gaseous state about 3,000, or more millions of years ago; and that about 1,150 millions of years after that period its surface had cooled sufficiently for the gaseous hydrogen and oxygen to begin combination, and settle on the cooling surface as water. When, in time this fluid hadaccumulated to a considerable extent it began to act in combination with the atmosphere, and the loose particles of rock, by wearing away the cooled igneous rocks which, like granite, are mostly very hard.

Table II

Groups of Epochs more or less allied	Serial Order of Epochs	Original thickness of strata in ft. (approximate)	Strata formed at 1ft. in years stated (approximate)	Millions of years ago when Epoch began (approximate)	Millions of years Epoch lasted (approximate)
1.	Igneous	Unknown	-	Cooling at surface about 3,000	1,150
2.	Early Pre-Cambrian	64,000	5,000 from igneous rocks	Seas established 1,850	320
	Later Pre-Cambrian	120,000	2,800 from igneous sedimentary and early Pre-Cambrian	1,530 1st Glacial that strata record 1,400	330
3.	Cambrian Ordovician Silurian	140,000	2,550	1,200 2nd Glacial 3rd Glacial	350
4.	Devonian Carboniferous	125,000	2,200	850 4th Glacial 5th Glacial	275
5.	Permian	65,000	2,150	575	140
6.	Triassic Jurassic Cretaceous	120,000	1,950	435 6th Glacial	235
7.	Eocene Oligocene Miocene Pliocene Pleistocene or Last Glacial	111,000	1,800	200 7th Glacial 8th Glacial	200 3/20 of a million or 150,000 years 1/5 of a million or 200,000 years
8.	Post-Glacial			50,000 years ago	Still Continues

The finer remains of this process were subsequently deposited in deep water and the coarser in shallower places, as still continues to be done. Then to such reduced igneous rock must be added the frequent volume of dust, ash, sand, etc. thrown out from volcanic vents, as still continues, but probably less frequently as the Earth's interior has been gradually cooling. Those earliest sedimentary remains are still of great thickness although much has been worn away for the formation of more recent strata. As the cooled igneous rock thus worn away were of various kinds, so the remains that now form the most primitive sedimentary strata also vary. These early rocks contain no evidence of living things as fossils within them and are grouped under the name of Early Pre-Cambrian. They are succeeded by the Later Pre-Cambrian strata of much greater thickness and containing in its more recent layers a few items that are perhaps fossils of very small and simple living things. The Early and Later Pre-Cambrian strata were obtained chiefly by the wearing away through the agency of the atmosphere and water, of hard, igneous rocks, and the process must have been very slow. With the advance of time more and more of the softer sedimentary strata, uplifted to form dry land, became available for denudation; consequently the formation of new strata gradually became somewhat faster. The first sedimentary rocks were probably formed at the rate of 1ft. in about 5,000 years, and the more recent at 1ft. in about 1,800 years. The most rapid extensive deposits now being laid down occur at the lower areas of the River Nile, but there the conditions are very exceptional.

The tropical seasonal rains of Abyssinia flood the River and load it with reddish sediment; while the rivulets that help feed the Nile have worn deep ravines, in some cases over 4,000 ft. deep, in the slopes from the elevated tableland. The wind of the rainless areas of Northern Egypt carry the desert sand into the river from both West and East. The results of these additions to the usual materials that great rivers gain, cause the Nile to deposit sediment about its estuary at the rate of 4½ inches a century. This equals 6ft. in 1,600 years or 9¾ ft. in 2,600 years, or 12 ft. in 3,200 years; but such thicknesses would be somewhat less when consolidated by time. On the other hand the high plateau of Abyssinia is being worn away by the atmosphere and water, while the deserts through which the river flows are being denuded by the winds.

The eight periods, mentioned above, in which glacial remains occur, seem to indictate that a period of glaciation visited the temperate parts of the Earth during approximately each revolution of the Solar System on its orbit in Space since the Earth's surface was consolidated. This gives ground for inferring that the glacial remains in the Pre-Cambrian strata were deposited there more than 1,400 millions of years ago when that strata was being laid down. The seven succeeding glacial deposits, along with the strata that separate them also leads to the conclusion of a similar period of cold in temperate regions during each revolution of the Solar System on its orbit; or once during each period of about 200 millions of years. When dealing with these long ago times we must remember that the young Earth probably rotated on its axis, and around the Sun somewhat faster than now; a day and a year were, consequently, rather shorter in duration; moreover the power of the Sun, Moon, and other Planets was more effective than at present, because all have gradually been losing heat which must have reduced their other radiations.

About 70 percent of the Earth's surface is at present covered by the oceans, besides which a considerable area is below the water of the large lakes. The kinds of strata thus covered with deep water are not completely known, but investigation has shown that new strata are being deposited on the floor of all seas and lakes. In the deeper water such new strata consist largely of the remains of minute organisms such as Polycystina, Diatomacea, Foramenifera, etc. that flourish in the upper parts of waters where they can obtain sufficient radioactivity from the Sun for the functions of life. These minute units of living matter have a protective shell of siliceous or calcareous substance which they accrete from the water that holds these minerals in solution. After their short life they gradually sink to the bottom where their shells accumulate, and with other matters from strata which may ultimately [be] uplifted by surface movements of the Earth, form terra-firma. An extensive example of such dry strata formerly laid down chiefly by the calcareous shelled Foramenifera is in the Chalk of Southern England and other countries. A thin slice of Chalk rock examined with a microscope shows the remains of the organisms in abundance. Siliceous rocks similarly produced by Polcystina and Diatomacea are plentiful, but such strata being less conspicuous and less massive than the Chalk are not so widely known in Britain. The minute particles of Silax[4] and their fine grain make some varieties of such siliceous rocks useful as sharpening stones for tools, but the best razor hones are altogether different, and some owe their sharpening ability to microscopic grains of garnet.

The total vertical thickness of the sedimentary strata scattered over the Earth's surface above the oceans, and remaining after long ages of denudation, appear to be only remnants of the original thickness as from 50 to 90 percent must have been worn away to produce the bulk of the strata of subsequent Epochs. This process of denudation has been never ceasing from the earliest time of the cooled Earth until the present day.

The surface of the greater part of Ireland, for instance, is Lower Carboniferous Limestone, or of older rocks. From the Carboniferous strata a vast amount of coal has been worn away leaving only occasional remnants of the former coal deposits. Some of this remaining coal is in the North and Central area, but more is in the S.W. and S.E. districts. The bulk has been removed by denudation and now is probably below the more recent deposits of nearby seas. The atmosphere, water, ice, surface movements of the Earth, and other natural agents are continuous in wearing away every variety of strata. Such remains may be from one kind of strata, or, more commonly a mixture of several varieties of rock; and are transported by one or more of the many natural agents to varying distances for the formation of new strata. The Nile, for instance, carries the disintegrated strata from East Central Africa, Abyssinia and Southern Egypt, mixed with the sands blown from the deserts on each side of its course northwards and deposits the mixture about its estuary; all the minerals thus removed being mixtures of varieties from long antecedent strata.

With regard to sedimentary strata it is plainly evident that at first only the hard igneous rocks were available for the atmosphere and newly formed seas to slowly wear away. Consequently the first few thousands of feet in thickness of sedimentary rock, although helped by dust, ash, sand etc. from volcanic outbursts must have occupied a vast period of time for their accumulation. As time went on, so more and more of the softer sedimentary strata would come under the power of the agents of denudation, so that the time required for every succeeding thousand feet of new strata would gradually lessen. Thus the reduced primary igneous rocks of the Earth have been the main source from which the sedimentary strata have been derived; for very little new material has been added to the Earth's surface since the first seas settled upon it, and through the ages the original substances have been employed over and over again. The deposits of Carbon, Calcium and Silax by animals and plants are merely Earth's original substances transformed, as subsequently explained. The chief new Carbonaceous materials brought to the Earth's surface since the beginning are coal and peat, the carbon of which plants has accumulated from the carbon-dioxide of the atmosphere, and thus purified the air for animal respiration and their progressive evolution. Following that purification of the atmosphere the advance of vertebrate, air breathing animals was remarkable during Triassic and subsequent epochs. Plants also reduced the carbon-dioxide thrown into the atmosphere by volcanic action in gradually diminishing amounts from the beginning to the present times, as well as that ejected by animal respiration. New material reaching the Earth, in the form of meteoric substances, has probably been insignificant, and chiefly iron in various forms. In the Gault, a blue-grey clay below the Greensand of the Cretaceous Epoch and called "blue slipper" by the local inhabitants, frequent small groups of ferric-disulphide nodules can be found on the sea shore at low water when the clay is exposed. These nodules are about the size of walnuts and like them wrinkled and darker brown on the exterior, but fibrinous and sparkling within when newly broken. They occur in groups about the size of a dinner plate and resemble in arrangement eggs in a nest. The shore-folk call them "thunder-bolts", and they are probably from the "Blue". Somewhat similar items occur on the floor of many seas but scattered, not in definite groups, and of much smaller size; these are termed pyritous nodules. They appear to arise by sulphuretted hydrogen from decomposing organic matter, with the sulphides and sulphates dissolved in the water, combining with the iron in the water, while microscopic organisms, such as Bacteria, are supposed to be concerned in the action.

The Gault at the coast, when forming the shore, is worn away by the waves until the Greensand above is undermined. In time the weight of the latter and the Chalk above is more than the slipping clay can uphold, and down they fall into the sea. In this way the so-called Undercliff of the Southern coast of the Isle of Wight has been formed. A second Greensand cliff a mile or so inland, and due to the coastal part sliding on the Gault towards the sea, with the Chalk rising to several hundred feet above it, and facing South, renders the climate mild and attractive to invalids. In some parts of the Undercliff fallen rocks of Greensand remain in their original position, while the masses of Chalk that must have been with them have mostly disappeared. In other parts the fallen rocks have been cleared away to make areas for houses and cultivation. This Undercliff affords an excellent example of one extensive method of land destruction in comparatively recent times.

At a part of the Undercliff coast near Bonchurch, the Chalk has brought down over the Greensand, a great mass of yellowish clay containing flints in their white, weathered coating. Most of them are ordinary grey and blackish flints, but many of them are different and contain fossils of former animals resembling sea-anemones and sponges; the former are really Choanites which are related to sea-anemones [West probably means choanocytes, which are collar cells in the walls of sponges]. These stones are often beautifully coloured, and such tinted areas are frequently associated with portions of clear or delicately tinted chalcedony. Such stones are the remarkable Isle of Wight pebbles, and make beautiful ornaments when cut into slices and polished. Along the shore below the clayey cliff the flints are in their white coating, and the coloured specimens are difficult to find although they often exhibit peculiar rough patches on the exterior. The sea current rolls these flints along the coast eastwards. When nearing Shanklin, a submerged ledge of rocks extends from the shore seawards, and this directs the current outwards so that sand only forms the shore of this pleasant town. The flints are rolled along the coast below low-water mark until they enter the projecting curve of Sandown Bay where they form a beach. There they have lost the white exterior coat, and appear as rounded pebbles of varied size. By strolling along the shore where the pebbles are wetted by the sea, the colours can be seen, and a good specimen sometimes secured. These flints at Bonchurch and Sandown afford another example of denudation by the loss of their coats through being rolled along by the sea current; while the sand at Shanklin beach is the result of fragments from the flints and denudation of the Greensand etc. Another example of similar denudation is the Chesil Beach near Weymouth. Its pebbles are mostly of Permian and Triassic rocks from the coast W. of Sidmouth. The cliffs there are broken by the sea and the rough fragments are rolled along Eastward below low-water mark until they reach Portland Isle. This seaward S.W. projection of late Jurassic Limestone reverses a part of the Eastward current to the Westward and most of the rounded stones from the West are carried back along the shore towards their site of origin. At Portland the origins of the Chesil Beach thus formed consists of rounded pebbles often several inches in diameter. As they gradually roll Westward they become reduced in size until after a journey of 20 miles along this wave-exposed coast they have been worn down to sand. These examples are within easy reach of the Hereford holiday seeker; while similar beaches occur buried in ancient strata at various parts of the world.

The flints of the Chalk, and some of the Jurassic Limestone, consist of two forms that are intimately associated, viz – a crystalline and almost insoluble silica combined with a non-crystalline silica soluble in caustic potash. The flints may be white, semi-translucent or pale grey; when dark grey or nearly black the colour is usually due to forms of carbon. Organisms are often preserved in silica as in the Isle of Wight pebbles and the Carboniferous [sic] plants at Rhynie. The combined silicas are slightly soluble in water containing Carbon-dioxide as ordinary waters, both fresh and salt, usually do. From such weak solution certain animals such as sponges and Polycystina, and plants like Diatoms and Horse-tails *(Equisetum)* obtain their supply. Fossil animal shells, worm tubes etc., originally of calcareous matter are often found converted into a siliceous substance, an alteration that has occurred by a long process of chemical interchange. Such traces of soluble silica occur in rain water after it has entered siliceous rocks because it contains traces of CO_2 from the atmosphere, [and] it gradually takes up some of the soluble silica. This water permeating downwards slowly binds together loose sandy strata as the water evaporates; while any that may enter a limestone lying beneath the sand gives it a hard crystalline form.

Lime i.e., Calcium, is one of the most abundant minerals; yet does not occur naturally in a free state, but always in combination with other substances such as Oxygen, Carbon, Silica etc. When an atom of Calcium is combined with one of Carbon and three of Oxygen it forms the mineral Calcite ($CaCO_3$). In this form it is slightly soluble in water containing carbonic acid (CO_2) as most natural waters do, and in this soluble condition living things obtain it for their shells, skeletons, calcareous coatings etc. Numerous aquatic flowering plants extract lime from the surrounding water, and deposit it on their exteriors as a coating, while many lower types of plants act in a similar manner. Some microscopic species of Algae, for example, adhere to submerged stones, and coating themselves with lime give their supports a rough whitened appearance. Higher Algae such as *Corallina,* which grows in tide pools on rocky shores as well as below tide marks is related to the Red Seaweeds; but the lime with which mature plants cover themselves, entirely masks their nature so that they resemble coral. There are several allied genera on British coasts, all of which are sometimes used for liming soil. The peculiar *Characeae* or stoneworts, green plants intermediate between the green and brown Algae, and thriving in fresh or brackish water, resemble Horse-tails in shape. They are often made conspicuous by coating themselves with lime from the waters in which they live. A good example of these plants forming a deposit of lime on the bottom of lakes occurs in the three lochs on the Isle of Lissmore, off the N.W. coast of Argyll. This island is entirely of a Pre-Cambrian Limestone, narrow areas of which occur at the surface of various parts of Scotland from E. to W. It is sometimes called the Lock Tay Limestone because a zone of it fertilises the land on the northern side of that Loch below Ben Lawers. In the Lissmore Lake varieties of *Chara aspera* are forming an appreciable deposit of lime on the bottom. The vast masses of varied Limestone in all parts of the World are often mostly the product of animal and plant energy and the time occupied in the productions of such thicknesses of strata must have been enormous. Fossils of once living things have often been first preserved by Calcite ($CaCO_3$) and frequently by silica or such as were at first calcareous may become siliceous as mentioned above. Rain water, which gains Carbon and Oxygen in passing through the atmosphere, takes up some of the calcite when entering Limestone Strata, and percolating downwards binds closer together the pastiche of which that rock consists as the water evaporates. It may also penetrate to Sandstone below the Limestone, binding the grains of quartz more firmly together and making the rock a more or less calcareous Sandstone. Such rock is often termed Cornstone because the lime in it favours agricultural crops. This is frequent in Sandstone strata that once had Limestone beds about it, but which are now denuded away save for the lime they passed down to produce the Cornstone. Such Cornstone occurs in parts of Herefordshire and it is probable that in former periods the Lower Carboniferous Limestones, such as still occur near Symonds Yat, overlaid the Old Red Sandstone of Herefordshire. The presence of Cornstone affords some evidence for this suggestion.

There is not part of the Earth where all various strata are known to overlie one another in their order of formation. In some districts the most ancient rocks are at the surface with nothing above them save perhaps the vegetation and its few inches of soil. Such is the case with the Torridonian Sandstone of N.W. Scotland in Ross and Sutherland, [and] on a much smaller scale, the Pre-Cambrian strata of the Malvern Hills. In other places such ancient rocks are covered by the next in order of time or perhaps with an orderly succession of two, three, or sometimes more kinds. In other districts the earliest may be immediately below recent formations; any intermediate strata having been either completely denuded away, or never deposited in that area. The regular Chronological Order of the rocks is known by the study of any one formation in various districts of the world when compared with the strata below and above, and by fossils it may contain. Thus in Herefordshire we have at the surface a considerable extent of the Old Red Sandstone [O.R.S.] that lies next above the Upper Silurian, as clearly proved in the Mordiford district. Now the O.R.S. is an upper portion of the Devonian System, the lower portion being exposed at the surface of a considerable part of Devonshire, and other places. These early Devonian rocks differ completely from the O.R.S. as a glance at the strata about Ilfracombe, Lynton and other districts immediately show. This extensive series of strata lie between the Upper Silurian and the O.R.S. yet they are absent in Herefordshire. In the S.E. of Herefordshire strata of the Permian and Triassic Systems overlie Cambrian rocks, and the vast series of the Ordovician, Silurian, Devonian and Carboniferous Systems are absent; perhaps denuded away before Permian and Triassic times, or never deposited there. Another example, not very distant, is that of Haldon Hill and district, altitude 700 to 800 feet, to the W, of Exmouth. This is Reddish Sandstone of the Lower Permian System (allied to that of S.E. Herefordshire) yet scattered over it are flints from the Chalk. These prove the Cretaceous rock that was above it has been denuded from the site while the Upper Permian, Triassic, Liassic, Oölitic and Lower Cretaceous are absent, the hard flints being the only remains. A little to the West, however, there is a small area of Upper Greensand which is Cretaceous rocks that normally lies next below the Chalk. That will disappear within the advance of time.

It must be kept in mind that strata of any age formed in various parts of the world during the same Epoch are likely to differ greatly from one another in thickness, colour and materials. Such matters depend largely on the nature of the old rocks worn away to form the new. If the old rocks are soft they may be more quickly worn away than harder strata, and yield thicker deposits. These different conditions of surroundings in the various areas suck up ocean currents, great rivers, deserts giving their wind-borne sand and volcanic vents that supply grit, dust, ash, etc. over extensive areas of sea and land. Such matters with many others cause strata of the same age to differ in the various parts of the world. The main tests for the age of any deposit are partly in its relations to strata below and above, and partly to the general features of the fossils it contains, because biological evolution has produced new varieties of plants and animals in every Epoch of Earth's history. The useful study of fossils requires a considerable knowledge of both Botany and Zoology. Consequently a beginner with Geology lacking such knowledge will find the rocks alone sufficient for his initial program [sic]; any fossils gathered could be put aside in paper for future study with a note stating date and exact locality where found.

In some countries, as in Switzerland, whole series of strata have been turned upside down so that the older lie above what is more recent. At the present time surface movements of the Earth that cause such results continue, but usually on a scale that does not injure Human affairs. Yet, occasionally it happens that such movement is violent, as in the case of the Sea of Japan which a few years ago had a considerable portion of its bottom lowered about 600 feet. This was accompanied by serious earth-quakes and changes in the level of adjacent land. Such movements seem to be due to various causes that are always difficult or impossible to exactly specify. Explosions of steam due to water reaching heated portions of the Earth's interior; the cooling and consequent shrinking of the same regions; the thrusting upwards of ash, sand and molten matter, as in volcanic outbursts, are probably the chief reasons for the movements. One of the last mentioned, the most extreme in modern times, was at Krakatoa, a small island between Java and Sumatra.

In the foregoing pages some of the substances ejected by volcanoes have frequently been mentioned, and readers unacquainted with such matters may fail to realise the distance such substances as dust sand, and ash, etc. may travel from the site of origin; a few verified examples may therefore be of service. Previous to recent years there are few reliable records preserved in ancient literature. On that account Vesuvius and Etna have been entered first on the short chronological list. But since the beginning of the world's crust we may truly suppose that great volcanic eruptions have been at least as frequent as during the last 100 years, and there is abundant evidence for such and far more. In former times, at least to the Permian Epoch, there were many active volcanoes in Britain, but all are now extinct, although remains of scores still exist, particularly in Scotland. It is not supposed that the Earth's interior is now one molten mass, but that such substance is restricted to wide channels in more solid material. It is fortunate for us that vents for the escape of gaseous and molten matters are not now required on our country! It appears that the south of Italy and Iceland afford outlets for the volcanic substance sufficient for Western Europe.

1. Etna, long known for its volcanic activity, which probably began before civilised humanity originated, is a mountain nearly 11,000 feet high near the N.E. coast of Sicily. An eruption in 1169A.D. destroyed Catania and 15,000 inhabitants. In 1537A.D. an outburst overwhelmed two villages and their inhabitants. Sixteen eruptions have been described for the nineteenth century.

2. Vesuvius, adjoining the Bay of Naples is an offshoot from an adjoining mountain named Mons Summamus, and [known] for its volcanic activity long before the Christian Era. During A.D. 79 an eruption from Vesuvius destroyed Herculaneum and Pompeii, burning them under ashes from 40 to 100 feet deep. These cities were resorts of wealthy Romans. The Younger Pliny, born A.D. 62, was in Pompeii with his invalid mother when the outburst began, and he wrote a description of how they escaped through the fall of ash, and also of the terror of the inhabitants. As the beginning of the fall was slow, the people had warning so that few lost their lives, but all lost their property save what they could carry in hasty flight. Since that time periods of repose and eruption have continued, but no outburst has equalled that of A.D.79; the most formidable since then was probably during April 7th – 10th 1906. The destructive power of Vesuvius, however, has never reached the extent of volcanoes hereinafter mentioned. Pliny's account, chiefly deals with the terror and escape of the people; it has been translated into English and partly reproduced in the "International Library of Famous Literature" Vol.III p.1039. This short account is sufficient to make the reader thankful he was not there with his invalid mother. Excavations during the past 100 years have verified the above account, and recovered many valuable relics.

3. In 1783 Skaptár Jokul a volcano in southern Iceland ejected a stream of lava that covered about 670 square miles of the surface. During the same year a submarine volcano about 30 miles S.W. from Iceland threw out pumice which floated on the sea for about 150 miles around and made the navigation of ships difficult. Hecla, not far from the first above mentioned, is over 5,000 [feet] high, and is one of the most destructive of the many volcanoes of this island. During 1845 – 46 an eruption of Hecla lasted more than a year. From the outbursts in Iceland ashes, sand and dust have been scattered over N. Scotland as well as the Orkney and Shetland Islands, more than 500 miles distant.

4. In the same year as Skaptár Jokul in Iceland a volcano called Asama-Yama in Japan, 8,260 feet high, gave enormous eruptions which caused great damage, and disturbed the atmosphere of the whole world.

5. During 1814, and again in 1888, Mount Mayan near Manilla in the Philippine Islands, a volcano about 9,000 feet high, gave an exhibition of volcanic power comparable with those above mentioned; there are several other active volcanoes in these islands.

6. In April 1815 Mount Tambora in the Island of Sumatra E. of Java in the Indian Ocean, ejected ashes, cinders etc. estimated as sufficient to cover the whole of Germany 2 feet deep. In addition to vast destruction the dust caused 3 days darkness for 300 miles around, and upset the atmosphere of the whole world.

7. At Mt. Pichincha, nearly 16,000 [feet] high in Ecuador, [and] also at the Babujan Islands, enormous eruptions occurred during 1831. These again disturbed the atmosphere of the whole world, while the dust obscured the Sun so much at places so wide apart as Africa, Paris, Odessa and the United States, the Sun could be observed all day with the eyes unprotected.

8. Following a short earthquakes on July 15th 1888, a mountain in Japan called Bandai-San was blown into the air and obliterated. The amount of material was estimated to weigh 700 million tons, and it devastated 30 square miles of the surrounding country; killing 600 people, and destroying the property of many more.

9. During August 26th to 28th 1883, an island between Java and Sumatra called Krakatoa, 1,400 feet high, was almost completely blown away, leaving a cavity 1,000 feet deep below the surface of the sea. The wave thus produced was 50 feet high, and this reaching Java and Sumatra, carried a Dutch warship 2 miles inland, and left it 30 feet above sea level. The wave was several feet high at the south coast of Africa, 6,000 miles away, and its energy reached the English Channel. The noise of the explosion was heard at Rodriguez , an island 3,000 miles distant, situated in the Indian Ocean 900 miles E. of Madagascar. By the gigantic waves and by other means 40,000 people perished by this outburst. The air waves from this explosion travelled seven times round the world. The dust surrounded the globe being at first 20 miles high, and after a year descended to 10 miles. This dust caused extraordinary sunset glows which elderly folk in Britain still remember.

10. The Island of Vulcano, N.E. of Sicily, was in volcanic activity from August 3rd 1888 to March 22nd 1890. During that period three of the outbursts were very violent.

11. During February, 1890, the Island of Bogoslof in the Behring Sea was in volcanic activity; it was thus raised about 1,000 feet, and in the surrounding sea three small islands were created. Ashes were distributed to about 40 miles around.

12. From May 8th to 20th, 1902, Mont Pelée in Martinique and Soufrière on St. Vincent, both islands of the S.West Indies, were simultaneously in great and destructive eruption . These with other eruptions of this year, produced a world-wide haze in the atmosphere, reducing the solar radiation received by the Earth.

13. In the Island of Great Sangi, S. of the Philippine Islands, a volcanic outburst on June 7th 1892, scattered an immense quantity of ash over the whole Island and adjoining ocean. The noise of the explosion was heard 500 miles away; while thousands of people perished. 1,400 miles N.W. from this Island and S. of the Marianne Islands, the ocean is 31,614 feet deep (nearly 6 miles) which is the greatest depth known.

14. The mountains of Santa Maria, in Guatemala, Central America, gave a destructive outburst on October 24th 1902, ashes from which covered an area of 125,000 square miles, while pumice stone with ashes from 8 inches to several times that depth extended over 2,000 square miles. The weight of this material crushed a great number of houses, and over 6,000 persons perished. The whole side of the mountain was blown away, leaving a cliff 7,000 feet high. The dust rose to a height of 18 miles, and the noise of the explosion was heard 500 miles distant.

15. During February and March, 1903, the volcano of Colima in S. Mexico, 13,000 feet high, gave twelve enormous outbursts, during which the dust rose to a height of 17 miles.

16. Mount Katmai in S. Alaska during June the 6th and 7th, 1912, gave great eruptions which resulted in prolonged haziness in the sky. At 100 miles away ashes fell to a depth of 12 inches. The world-wide haze produced by such outbursts reduce the heat Earth receives from the Sun by about 10 percent. The maximum Sun-spot cycles, about every eleven years, also reduce its heat to Earth but to a lesser degree.

Atmospheric volcanic dust collected from the instruments in the astronomical observatory on Mt. Wilson, altitude 6,000 feet near Pasadena, California, U.S.A., and analyzed by Dr. Pogue, was found to consist chiefly of microscopic grains of volcanic glass and feldspar; white quartz and kaolin occurred sparingly.

If the reader will think over these volcanic matters he will readily see the importance of volcanoes in building up the strata of the Earth, and especially of the bottom of the oceans, perhaps now dry land, in every Epoch of the past; for volcanoes are nearly always situated at no great distance from the sea; wherefrom water is obtained for conversion into steam as one of the agents of explosion.

"To apprehend thus,
Draws us a profit from all things we see"

Cymbeline, Scene III, about line 20

More information can be found on volcanoes in that very attractive book – "Principles of Geology", by the late Sir Charles Lyell. Tenth revised edition Vols. I and II, 1867 and 68. Secondhand copies only can now be obtained.

With regard to the actual origin of life on our Planet we are still unable to go much further, practically, than Lucretius, who with great skill wrote his metric "De Rerum Natura" 60 years before the Christian Era. In this work he summarised, often with approval and discrimination, the ideas of the Greek philosophers on this cryptical subject; although he frequently relates what to us appears as rubbish. Discovery is hindered in this direction by our inability to imitate Nature, because test-tube cultures of micro-organisms must be on a system opposed to the natural.

Living things owe their existence to a continuation of the Laws of Chemistry and Physics that govern the self-luminous stars and the planets, which millions of such stars in limitless Space, probably like our Sun, possess. At present men have only a restricted knowledge of a part of Space represented by a sphere about 62 to 64 x 10^{40} miles in diameter. Within that sphere the laws that govern the better known Solar System appear to be exactly the same. Compared with the diameter of the sphere just mentioned that of the Solar System is about 7,673 millions of miles, or about 8,211 x 10^{28} times less. The most ancient remains we can recognise as fossils of organisms were living about 1,300 millions of years ago; but still more simple forms of life incapable of leaving recognisable fossil remains must have existed before that. At the present day there are a great number of living things ranging in size from the $^{1}/_{50,000}$th of an inch to the $^{1}/_{50}$th in diameter, all of which require a microscope used with skill, and sometimes with chemical reagents, for their recognition, and observation on their mode of living. Some of such probably resemble the earliest forms of life on our Planet. From a variety of such minute beginnings the Laws of Evolution with [?] ……tation to environmental and Natural Selection have doubtless produced, usually with great slowness, all the extinct and existing higher forms of life. At present man is able to produce with comparative rapidity new variations of plants and animals by the same Laws of Natural Evolution with artificial Selection etc.; the results of which surround us on every hand, Man himself, however, is very liable to degenerate owing to his great ability in neglecting and opposing the Natural Laws of Ethics, which govern his correct procedure. The results of this wrong are unfortunately too abundant in human society.

Assuming the probability that in former periods of Earth's history, if not now, the more energ[et]ic radio-activity of the younger Sun originated, by chemical and physical properties, microscopic particles of Proteid[5] by drawing into unison varying proportions of atoms of Carbon, Nitrogen, Hydrogen, Oxygen, with perhaps sulphur and other elements, to produce microscopic particles of Proteid. Proteid and Albumen are very simple and elementary gelatinous matters very closely allied; a big example of which is the "white" of an egg, the mother bird having obtained the substance for it, as well as the calcareous matter for the shell, from its food. On that account the shell of eggs in many parts of the country is thin, owing to the natural lime in the soil being scanty. By chemical attraction such proteid units would draw to themselves similar, or other chemical elements, for nutrition on which to thrive. Life would thus become established, and such natural productions would probably first originate in damp or wet places of equatorial regions. These first origins of life must have been of microscopic dimensions similar to thousands of existing forms having plant-like and animal-like tendency, and possibly still produced in natural places by the Sun. It is also certain that plant-like forms appeared first, because such can exist in inorganic substances, while the animal-like forms must have organic matter for their maintenance. Some of such microscopic particles getting into changed environments would gradually become inclined to vary in accordance with the Universal Laws of Evolution and adaptation to surroundings. Thus with time many of them would increase somewhat in size, and become more plant-like and animal-like according to their mode of nutrition. The history of Life represented by fossils in the rocks illustrate the gradual evolution of forms in a beautiful and remarkable manner. In Pre-Cambrian strata no fossils have been found that can be recognised as former living things perhaps because the minute forms, possibly then existing, were incapable of leaving fossilised remains. In the Cambrian System certain fossils that may be low forms of aquatic plants occur, as well as very low types of animal life. The Ordovician Period (formerly called Lower Silurian) exhibits somewhat more advanced examples of both plants and animals. The earliest fossil organisms with what represents the animal backbone occur as low types of fish in the Silurian rocks, but terrestrial creature with a backbone are absent. Towards the end of the Silurian Epoch terrestrial plants of a low type begin to appear, and forms of these greatly advanced during the Devonian times. Improved offspring of these gradually produced the extensive forests of Cryptogamic (i.e. flowerless) plants of the Carboniferous Epoch, much of whose remains are now coal. These trees and smaller plants built up their bodies by absorbing the Carbon from the Carbon Dioxide (CO_2) of the air, and thus prepared [the] atmosphere for the evolution of air breathing animals of the land. These began to appear towards the end of the Carboniferous Epoch, and developed to an enormous extent during the subsequent Epochs until man gradually appeared among them. The evolution of this biped is still far from complete, because at present his elementary brain leads him to fighting, and other evil actions, instead of goodness, peace and happiness.

Returning to the Carboniferous Epoch, we readily recognise that from the first cooling of the Earth's surface the atmosphere must have been heavily charged with carbonic dioxide, given off from that surface, and from innumerable volcanoes. At the same time there were no, or very few, green terrestrial plants to absorb the carbon and release the oxygen, as the more advanced green leaved plants still continue to do, otherwise terrestrial animal life would cease to exist.

Returning to the primitive microscopic units of life, we can realise that as such evolved into slightly more advanced forms, certain of such units would get into more or less uniform surroundings that would tend to induce in them stability of general form; as for example, the minute Foramenifera of the oceans, and the microscopic Diatomaceae of both fresh and salt water; representing respectively animal-like and plant-like organisms that have not produced any higher forms of life. In addition to the minute organisms just mentioned as examples of stability, larger plants such as Red Seaweeds, Fungi, Characeae, Lichens, Mosses and others may be enumerated among plants; while among animals there are Corals, Sponges, Starfish, Polyzoa, Mollusca and others that have developed no higher forms of animals. Other units that continued in changeable surroundings would tend to vary in structure, and gradually produce more advanced types, while such evolutionary progress would continue to advance. On the other hand many examples during the geological past have become highly organised and subsequently declined in structure, size and life habits; such as the numerous trees of the Carboniferous Epoch, now represented by herbaceous plants like *Equisetum* and *Lycopdium*, or have become entirely extinct. Amongst animals hundreds of types, found as fossils appear to have advanced for a certain standard, and then become extinct. Other animals progressed in organisation until the monkey type was reached in the Tertiary i.e. Eocene Epoch. From these the higher forms of Anthropoid apes originated, and the most remarkable of them, so far as is yet known, is the *Pithecanthropus erectus*, or ape-like man found as a fossil in Java. This organism was doubtless one of the forefathers of wild man who appeared a few millions of years subsequently. What that wild man was like we do not yet know, but probably resembled a lower form than the existing natives of Australia or of Tierra del Fuego. In addition to such evidence of man's origin, the anatomical structure of civilized man is clearly a modification in close resemblance with the existing forms of apes, and not very different from other Mammalia. What creature will replace man in the distant future we cannot now conjecture!

Reverting to the primitive units we can readily understand that upon reaching a certain microscopic size the power of absorption would cease, as in forms now living. After resting for a long or short period they would split into two or four equal portions, each of which would repeat the process of absorbing and splitting, without the aid of nuclear matter as in higher forms, and just as microscopic units do today. From time to time a few of such units would get into somewhat different surroundings, and adjustment to environment would produce some slight modification in form for the process of absorbing and splitting. This, in turn, would tend to some slight change in other ways and ultimately result in a somewhat different particle of protein, that is to say a different variety or species. A continued evolution from a plant-like unit would slowly induce a different mode of absorption in some varieties, so that instead of absorbing the crude chemical elements, other proteid units would be used for nourishment, and thus the organisms would gradually become animal-like. Hundreds of such plant-like and animal-like proteid particles are known to naturalists.

From more recent investigations regarding the origin of living things we know that many existing varieties of plant-like organisms entirely destitute of green chlorophyll are, however, able to obtain inorganic carbon, and certain of its inorganic compounds. These substances they employ for their nutrition; some can do so even without the energy supplied by light from the Sun, although other of its activities may reach them. Such colourless specks of life, visible only with the most powerful microscopes, are apparently allied to the earliest of living things that needed nutrition, without which there can be no life. Even with man, life, in the ultimate analysis, is merely an interchange and readjustment of chemical substances, that enable his mental and physical powers to think and act in a multitude of ways – from mumbo-jumbo to the construction of intricate mechanisms. The minute organisms mentioned above can obtain their inorganic carbon directly or indirectly from the universal carbonic acid (CO_2). (Do not confound this with carbolic acid ($C_2 H_5 OH$) otherwise known as phenol, and deadly to life.) Thus from the molecule CO_2 the atom of carbon being absorbed by the organism as food, the liberated oxygen may unite with some other substance, producing its oxidation to a molecule of different matter. For example – Nitrous Acid (NHO_2) absorbing one atom of oxygen becomes NHO_3 which is Nitric Acid, two very different substances. Among many common materials in the ground that are readily oxygenated in a similar manner, without the aid of Sunlight, are iron, sulphur, hydrogen, ammonia, methane, etc. The last mentioned is marsh-gas produced from decomposing organic matter; it is also known as the fire-damp of coal mines, being liberated from the broken coal seams, and liable to explosion by contact with the atmosphere. Petroleum is chemically related to methane. Chlorophyll by which ordinary plants obtain inorganic carbon from the CO_2 of the atmosphere or water in which they live, by the aid of Sunlight, is a very complex, commonly green material that may have substances of other colours associated with it. This may be observed in Red and Brown Seaweeds; many shrubs with leaves other than green, while blue-greens and yellow-greens colour thousands of species of minute, low types of plants that flourish as incrustations on rocks, walls, bark of trees, wooden fences, damp places and in water,: many of which may be observed by a stroll in the country. It is probable that Nature still continues to preserve elementary forms of Life by chemical and physical combinations such as those first mentioned. The same process has probably taken place on other worlds that may have had, or still possess, chemical and physical conditions similar to those of our Earth; and the evolutionary processes may have produced organisms somewhat similar to those on Earth, including man, or may have resulted in the production of entirely different plants and animals. Regarding these matters in other worlds we are ignorant and shall probably ever remain so.

Returning to the advanced protein units, it is clear that some of them in time began to absorb from the surrounding water more Calcium (i.e. lime), and deposit some of it upon their exterior to form a minute protective covering. At first such microscopic shells were probably a mere simple layer of calcium, but, with time, such covering became thicker in some parts than in other spots, thus allowing exchange with the surrounding water. In that way a pattern was produced by both the outer shell and the inner plates of some of these Foramenifera (pore-carriers) of which hundreds of species now lie in the oceans. After life the shells fell to the bottom and formed a calcareous deposit, an ancient example being the Chalk. Casts of simple forms of such minute organisms occur sparingly in rocks of Cambrian age, while through the past ages to the present day more complex forms gradually appear in the strata. The rocks of the Devonian Epoch, especially the O.R.S. being the poorest for their tiny remains, as well as for fossils of other forms of life. The conditions of the areas where Devonian rocks were deposited appear to have been unsuitable for the abundant development of living things.

Similar minute animal-like units of protein have, for some unknown reason absorbed Silica (example – flint) from the water, and employed it for the construction of minute shells, such resembling those of the Foramenifera. These also abound in the sea, form deposits on its bottom even at depths of over five miles and have produced in the past deposits that are now rock. These are known as Polycystina – a family of the Radiolaria, but have less range in time than the Foramenifera, and date from the Jurassic Epoch. The so-called "Barbadoes Earth" of the S.West Indies consists largely of their remains.

Somewhat similar plant-like units of protein also each produce a pair of shells from Silica dissolved in water both fresh and salt. Like the Foramenifera and Polycystina, these also form deposits at the bottom, some of the past being now rock. Their range in time, however, is even less than that of the Polycystina. Each unit having a pair of shells instead of one has [been] given here the name of Diatomaceae (the shell cut through). Any good book on the microscope will give illustrations of each of the three above groups, as well as of the more simple forms without shells, such as Bacteria, Amoeba etc. The fine grained siliceous rocks formed by such minute organisms are sometimes cut into slabs to make hones for sharpening tools, but the best razor hones usually owe their ability to minute grains of garnet in fine grained primitive rock derived from igneous material.

It must be kept in mind that all these rock constructors, as well as the many larger forms that have left their shells and bones during the ages gone, obtained the calcium and silica from former strata by means of the slight dissolving power of water acting slowly on those minerals.

Carbon is one of the chemical substances necessary for both plant-like and animal-like forms of living things. It is only plants, however, that can in general obtain carbon directly in a suitable form, while animals get their supply from plants either directly like sheep, or indirectly like foxes. Plants usually secure it from the CO_2 (carbon dioxide) of the atmosphere, or from the water in which they live. This cannot be done during the night, because Sunlight and radio-activity are necessary. A few plants however, like Mistletoe obtain a portion of their supply by being parasites on other living plants. Then the very varied and peculiar plants called Fungi (e.g. moulds, blights, toad's-tools[6], mushrooms etc.) get their carbon by being parasites on other living plants and animals, or by absorbing it from dead and decaying organisms of both kinds. Thus the difference in securing nutrient substances by plants and animals lies in the fact that plants in general build their own protein from the crude carbon combined with other chemical substances, by using the energy of the Sun; while animals obtain their supply directly or indirectly from plants. It consequently follows that plant-like forms of living things became established on the young Earth before animal-like forms could exist.

From various sources we can readily conclude that the atmosphere of the earlier epochs of Earth's history contained more CO_2 than it now has. This continued as remains from the primary igneous conditions of the world, while the abundant volcanic ejections during Pre-Carboniferous times would partially replace what the atmosphere lost. The surface air of the world, impregnated with this gradually lessening gas, was insufficiently pure for the unimpeded evolution of terrestrial life higher than the simple forms of plants and animals. From the Devonian Epoch however, the slowly improving atmosphere induced a gradual development of higher forms of plant life, fossils of which in external form and internal structure, resemble those now existing in such types as Horse-tails *(Equisetum)* and Club Mosses *(Lycopodium)* both being slightly higher in type than Ferns, but lower than the Flowering Plants, which did not arise until much later in Earth's history, in fact not until the Cretaceous Period. As the Carboniferous Epoch gradually replaced the Devonian, the still-improving atmosphere allowed the comparatively leafless Horse-tail and Club-Moss types of plants to evolve slowly to trees of considerable size. In time these formed forests even in parts of the World now temperate or cold, but then more or less tropical even so far North as Greenland. Such vegetation flourished for many millions of years, and their remains formed the Coal, which man has used so extravagantly. This extensive vegetation absorbed a vast amount of CO_2 from the atmosphere, using the O for the maintenance of its own respiration and life, and the C for construction of its bodies, which are now coal. Such reductions of atmospheric CO_2 gradually became antagonistic to the existence of *those* tree-like comparatively leafless plants, because they failed to develop broad surface leaves such as those of Sycamore etc. In consequence of that failure, their almost leafless bodies could not obtain sufficient C from the diminishing atmospheric supply with which to form the wood their large frames required. In that way they gradually became reduced in size, and minor details, until they are now exemplified by the herbaceous Horse-tails and Club Mosses, represented respectively by *Equisetum Limosum*, recent, 2-4 ft high, and *Lycopodium clavatum*, partly creeping, 1-3 ft. long. But remnants of the Carboniferous types lingered on and with other plants formed small beds of coal in succeeding Epochs. During the long Carboniferous period the abundant vegetation gradually reduced the atmospheric carbon and rendered the air suitable for the respiration of more advanced forms of terrestrial animals, which gradually made great evolutionary progress subsequent to Carboniferous time. Plants also advanced and in Cretaceous times trees with large spreading leaves flourished in the purer air, keeping it clean as the advancing animals fouled it by their respiration. These opposing operations of the life of plants and animals still continues adjustable to one another; while from the earliest times until the present day the light and other radiations from the Sun have been an absolute necessity for such functions. Our own ancient forebears, probably 100,000 years ago or more knew their personal dependence on the Sun, although ignorant of those Laws of Chemistry and Physics we now recognise. At periods when cloud hid the Sun from them for several successive days its reappearance would renew felicity which its absence had deranged: scant wonder the Sun was mankind's first god!

*At the Portway Glacial Moraine the quarrying operations at one side had left an inclined face to the deposit up which one could climb. The writer was extracting a desired stone, with the point of the hammer, from an upper mass of sand and rubble about 2 or 3 feet below the grass at the top. Suddenly a barrow load of the deposit fell away, and as it slid down the incline a ring was observed to fall from it. This was secured and proved to be made of a very fine-grained greyish-drab sandstone about three inches in diameter, being in fact about the size and shape of an old fashion wooden curtain ring, and beautifully made. It was at once seen to be an object connected with the prehistoric worship of the Sun. In the British Museum there is a tablet from Babylon erected about 900 years B.C. with references to another 3,000 years previously. This represents a man, probably a King, sitting in a shrine, and holding in his right hand a ring and a rod, with his fingers and thumb distinctly shown within the ring. The length of the rod represents ð (pi) i.e. the circumference – diameter ratio of the ring, on the ancient standard of $^{22}/_{7}$. Before him is an image of the Sun's disc which he is worshiping, also three priests in the same attitudes of adoration. Above the King, on the right, are circles that portray the Moon, the Sun and Venus, the latter representing all the other stars as being the brightest among them at times. These objects received numbers for name – Moon 3, Venus 7, Sun $^{22}/_{7}$. The numbers multiplied together produce 66.6. The early Christians appeared to have known this ancient Trinity, and adored it, for in their Book – Revelations XIII. v.18. it receives a nasty name translated as "Beast" in the Bible, which also states the number – "and his number is Six hundred three score and six".[7] The decimal point being ignored as in other cases. This perfect stone ring in the Upper Glacial Drift shows that mankind, holding the religious notions connected with it, roamed about Britain near the close of that Epoch; probably during one of the milder intervals. They also built circles, or open temples (often miscalled Druid's Circles) bearing in secret the numbers of their gods. Near Callanish in N.W. Lewis, a hamlet or clachan, 15 miles W. from Stornoway, a thriving fishing town of 4,000 inhabitants, there are six small circles and one large one; the last in nearly perfect condition on which the arrangement of the great vertical stones exhibit the numbers mentioned.

Being acquainted with a man who gave attention to Antiques, I showed him the ring and explained its interest. He requested the loan of it to show an antiquarian friend. Forgetting for the moment the sound advice given in Psalm, 140 v. 3[8] I readily granted this. Unfortunately the two gentlemen between them "lost" this valuable find, consequently the public are deprived of the sight of it. Previous to lending it, a man well known in Hereford had examined it and can verify the discovery.

[The passage from * is interpolated here from a separate sheet according to the author's instructions]

When pondering over these complicated matters it must continually be remembered that the various plants and animals, from primordial microscopic units to Bacteria, moulds, seaweeds, orchids, oak trees, etc. on the one hand; and Protamoeba, jelly fish, crabs, birds, sheep, monkeys, man, etc., on the other hand, are [?] not supposed to form two chains the links of which are closely related, and progressively of a somewhat higher type. In opposition to such popular notions scientists consider that the numerous natural orders (i.e. allied living things in groups) have gradually originated and evolved from various, more primordial sources, during the past hundreds of millions of years. A type thus established in elementary form would slowly tend to vary as it adjusted itself for the different conditions of environment to which it was subjected. Man, for example, exhibits a temporary change in habits, food, clothing etc. in order to become more fitted to the environment of summer or winter. Should either become fixed for a long period, temporary change in man would tend to become permanent. It must be kept in mind that in all natural order of plants and animals several species in every order have become extinct, and left merely their fossil remains many of which have been discovered in the various strata, especially in that of the Epochs since the Devonian Times. Consequently if we imagine a sequence of organisms to be represented by the letters of the alphabet, instead of our knowing the 26 of them that establishes the sequence we know only 15, all the others having vanished from life; in the case of the extinct organisms, leaving merely here and there parts of their bodily remains as fossils.

On that account from an impression on a rock, from a position of a shell, from a few teeth, from a few remnants of bones, from what may have been a piece of bark or wood, and such like remains we have to imagine what the organisms were like when alive and from these fill the gaps extinction caused in the still living groups.

Do not, therefore, be misled by popular notions such as the poet Browning wrote in his long account of Prince Hohenstiel-Schwangau, Saviour of Society (line about -1950):

“Will you have why and wherefore, and the fact
Made plain as pikestaff?” modern Science asks.
“That mass man sprung from was a jelly-lump
Once on a time; he kept an after course
Through fish and insect, reptile, bird and beast,
Till he attained to be an ape at last
Or last but one. And if this doctrine shock
In aught the natural pride ….Friend, banish fear.”

The ideas expressed in Browning’s unmelodious verse differ entirely from the cautious philosophy of Darwin, who, after stating his observations on “The Descent of Man” in over 600 pages remarked “The main conclusions here arrived at, and now (1871) held by many naturalists who are well competent to form a sound judgement, is that man is descended from some less highly organised form.” There is no reference to “jelly-lump” and the most advanced apes are referred to as man’s nearest representatives among the animals; while fossil remnants of intermediate forms were unknown to Darwin and naturalists of his day. In more recent times, however, a few such remains have been discovered the most important being the so named *Pithecanthropus erectus*. This was found in the tropical island of Java, off the N.W. of Australia, and probably represents the ancestral stock from which the aboriginal savages of that continent evolved.

From investigations into the natural chemical and physical phenomena of the world it is evident that living things, such as we recognise as plants and animals have been produced from substances that are devoid of life. These living things, however, are only transient combinations of the inorganic, to which they commonly return after a period of living. But in the case of the lowest forms of Animal and plant existence there are no reproductive organs, and life is continued by the whole individual dividing usually into two or four similar individuals, but smaller. These soon grow to the normal size and after a short period the process of division is repeated. This increase depends on the conditions of environment remaining suitable. If this becomes adverse many of such organisms enter into a state of repose and regain activity when conditions are favourable. Such changes occur with many forms of the green and yellowish-green incrustation that often cover the stone of walls. Some such flourish only on limestone, or on the cement used for building the walls, while others do not require lime and will grow on almost any rock or other solid substance such as flower pots, trees and wood fences. During winters and damp periods the activity of such incrustations flourish, but in dry periods they rest. These numerous plant-like and individually microscopic organisms are lowly members of the lowest group of plants known as Algae, and are among the most simple forms of that extensive group. Examples are – *Gloeocapsa,* [?], *Chroococcus, Asphanoeapsa, Pleurococcus, Pulmella,* etc., which often alter the natural appearance of the rocks they encrust. With somewhat higher living things minute portions termed spores are divided off from the individuals, and each spore may ultimately produce directly a new plant or animal With still higher forms the spores give origin to an intermediate organism that exists only for a short period and this usually produces sex organs. When a female spore from such an organ has been fertilized by fusion with a male spore it gives origin to an embryo that grows into a mature individual. Examples of this kind are easily studied in the common Ferns; in which sexless and sex[ual] forms of generations alternate, thus producing an example of the phenomenon termed alternation of generations. All the higher plants and animals produce sex cells that fuse to produce a new individual. These are minute structures comparable with the spores of low grade organisms.

Opposed to the usual ephemeral existence of the organic individual, there is the eternal existence of the inorganic, which the organic has only borrowed for a relatively short period. All inorganic things are eternal, because they cannot be destroyed. They can be changed into items that appear quite different, yet such may again assume the original form. Water, for example, can readily be converted into steam, which may again become water. The external portion of the Sun is entirely of gaseous matter which can be analysed by means of suitable instruments. By such methods it is found that the Elements of the Sun, in the form of incandescent gas, are similar to the elements of the Earth’s crust in cold solid form. Some rare minerals of the Earth were first discovered in the Sun by the use of such spectroscopic instruments. Thereby we have direct evidence, independent of astronomical and mathematical reasons, for the notion that the Sun and its planets was formerly one star.

Most subjects of instruction taught to youth by schools lead mind to memorise rather than meditate. Such early guidance commonly generates a habit that clings to the adult and weakens the mental capacity for dealing with matters from an unorthodox aspect. This habit also tends to produce in *Homo sapiens* more self-complacency and other forms of credulity than any of his thinking companions are held in bondage by, say, for example, by the unrestricted acceptance of Aristotle's gamut of speculations. In comparison with scholastic topics the Natural Sciences such as chemistry, physics, astronomy, geology, botany and zoology train the mind in seeing and thinking as well as in memorising; the latter, however, being considered of secondary value. The product of ordinary pedagogism is content with the information that the rocks he may see are limestone, sandstone, clay, granite, basalt etc. or that a fossil is the remains of a byssiferous Mollusk of a peculiar genus. Such mere names, however, fail to satisfy the seeing and thinking mind; it wants to know among many other matters, the structure of the rocks, how they were formed, how they came to their present positions, where they came from and how old they are compared with others. While for the fossils it asks inter alia, how life originated, why its undeveloped simple form occurs as fossils in the older rocks, as well as in more recent strata that contain remains of the complex quadrupeds and bipeds? Why is there a perceptibly increasing advance of structure in plant and animal remains from the early rocks to those of more recent formation? Are the various forms of such fossils new creations, or did they gradually originate from more primitive types in response to slowly changing conditions of their surroundings? If so, why did the surroundings change? Such desire for information has led thinking minds in all departments of Nature to lay aside old speculations destitute of evidence, along with their personal credulity which may have accepted them, and make original observations with investigations. The great mass of facts thus revealed have resulted in the demolition of many thoughtless notions of the past and crushed the blight of various superstitions that have cursed humanity for thousands of years. The zealous trust in matters which the senses fail to substantiate, is commonly a result of this thoughtlessness that induces certain psychological conditions in portions of the brain and render it submissive to mesmerical phenomena. Persons thus unconsciously troubled always possess an easy going credulity.

A study of human behaviour, and its changes during the few recent decades, shows that vice is increasing among most nations including our own. Thousands of years ago the rulers of nations discovered that the vice of individuals degenerates them so that they not only become worthless to their race but highly injurious to it; because their vice spreads to others, and a race that thus becomes depraved in its habits tends to collapse and disappear. This being against the ambition of rulers they introduced Laws for the suppression of vice; while instruction in ethical behaviour was inaugurated for the same purpose, as by Confucius in China about 600 B.C. which is an excellent example of good deportment. In most cases some form of religion was introduced in support of ethics, and thus postulated for each individual a future and eternal existence. Then as rulers desired their own nation to continue for ever, instead of being annihilated by vice, the promised eternal life, in spirit, of those they governed was assured to be either in the enjoyment of pleasure, or in suffering pain, according to behaviour during life in the flesh. The priest of the god of the Japanese thus offers everlasting joy to Jap. soldiers who die by fighting for their country, and this promise makes them disregard the present life. With the more advanced races, however, religion has not been a success as Italians so fully prove, and the many modifications to the same religion in our own Land has not succeeded in checking the progress of vice, as police courts in every town abundantly display.

Science, like religion, cannot destroy vice, but the sound truth it demonstrates can greatly help by aiding folk to be honest through honesty; honest to themselves as well as to others. This virtue will stay idleness and thoughtlessness, which are the main foundations of vice; while a stern application of Law to replace its existing slackness, through false mercy, is also necessary –

By mercy loathsome crime doth crouch
To gather strength for fresh display
In truth which honesty can vouch
Must lead to national decay.

The truths of Science assist the mind towards honesty, along with mental expansion and general utility, and for this purpose nothing can excel the so-called Natural Sciences. As a help in this direction a series of Herefordshire rocks have been collected and arranged to illustrate an introduction to the science of Geology; and folk will improve their minds, their bodies and their ethics by making a similar collection themselves.

On a previous page the ancient Latin writer Lucretius has been mentioned as the author of a long account of the things of Nature. In this poem he gave an exposition of his own notions, largely culled from the Greek philosophers, on the first principles of the origin of all things of which men were then cognisant; and in many obscure matters he reached general conclusions, by mental analysis, approximating those now obtained by instrumental observations and experiment. Lucretius, however, failed to free himself from many current opinions of his day. For instance, although he maintains that infinite Space can have no centre, because it has no boundary, yet he considered the Earth as the centre and on this assumption alone he has penned numerous conclusions which to modern thought are simply rubbish. The first thinker who approached modern scientific ideas was probably the Greek philosopher Thales who lived about 600 years before Lucretius, while between the two came a long series of deep thinkers. When examining the writings of such men, and their teaching, it must be kept in mind that they did not possess any instruments of precision, while practical experiments such as we are able to conduct were quite unknown. The world they lived in was the same as ours, but mankind in general was different in modes of life and thought. All were crushed under the heel of their rulers, and were terror-haunted by superstitious beliefs and religious dogmas: while the parasitism of insatiable priest-craft drove from them every aspiration of culture of mind and body. Lucretius fully recognised these conditions and unceasingly endeavoured by his science, to open the minds of mankind in order that they might release themselves from such tyrannies. Mankind, however, rejected his efforts, because of their general ignorance and fear, preferring to remain in the torments they allowed others to make for them, as well as in those they created for themselves. No Shakespeare then existed to give Patroclus the words to tell his companion Achilles

> " O, there, beware;
> Those wounds heal ill that men do give themselves:
> Omission to do what is necessary
> Seals a commission to a blank of danger;
> And danger, like an ague, subtly taunts
> Even then when we sit idly in the sun."
>
> Troilus A.III S.iii

Scant wonder the mind and pen of Lucretius constantly condemned current theology; and after relating how a King, acting on the advice of his priests, sacrificed the life of his affectionate daughter in order that his departing ships might be blessed by the gods he wrote –

> "tantum religio potuit suadere malorum"

which means to us – "To such degree religious intoxication incites calamity"

At a later date it was told that another King acted in a similar way with his son for a somewhat analogous purpose. Today the facts are plainly revealed that neither science, religion or politics, which men have trusted in, can give the ease and happiness they have shouted and fought for during thousands of years past. The remedy lies in Honesty through Honesty; but everywhere the evil lusts of mankind never cease in constraining them to DO WITHOUT IT. All the writer can do is to urge the reader to be as Honest to himself and others as earnest endeavours can make him, and employ the truth which Nature and its rocks teach as a helpful guide.

When dealing with rocks it will constantly be necessary to recognise Sandstone and Limestone, as such substances form the bulk of the sedimentary strata of the world's crust. Sand is commonly some form of an original igneous mineral of the Earth named Quartz. This is an extremely hard substance which readily scratches glass, it is semi-transparent and colourless when pure, but is generally associated with other minerals that give it various colours – white, grey, drab, brown, and reddish tints being most common. Its original state is in massive form, and the grains called sand have resulted from the breaking of the mass by various natural agents. Examples of such agents are – crushing due to surface movements of the Earth's face, as in earthquakes etc.; volcanic eruptions which blow the masses to scraps; the action of ice, water and atmosphere which break the masses and move them about as in the flow of glaciers at mountains and cold regions; currents and water from the smallest streams to the great oceans; wind at all deserts, coastal sand dunes etc. During such movements the grains rub against one another, and other substances which tends to round them from the angular form they had when first broken from the mass. When a lens shows the grains are angular or but slightly rounded one knows they have not been subject to much movement. Sand that remains for a long period in one place, without being disturbed, tends to harden into sandstone by various agencies. Thus quartz is slightly soluble in water during the course of ages, when the water contains carbon-dioxide. Water thus charged with the silica from quartz, and penetrating through a mass of sand tends to bind the grains together as the water slowly evaporates, and thus a Sandstone is produced. Other minerals may act in the same manner, Calcium or Lime being one of them. In that way a Calcareous Sandstone results, sometimes called corn-stone. Such corn-stones occur in parts of Herefordshire, and it is probable that in former periods the Lower Carboniferous Limestone of the Coal Epoch such as now remain in Symond's Yat, overlaid the Old Red Sandstone of Herefordshire, and possibly with Coal above such Limestone as now in Monmouthshire. From such Limestones the rain water would carry calcareous matter to the Sandstone below, and the presence of corn–stone in Herefordshire affords some evidence for this suggestion. Then there is the fact that from 50 to 90% of the original deposits of each Epoch have been denuded away to form the strata of succeeding Epochs. A big example of this is in Ireland, where three fourths of the surface is Carboniferous Limestone and Millstone Grit. From these a vast amount of Coal has been denuded away, leaving only remnants of its former abundance. The bulk has been reduced to granular matter and dust, and now probably rests below more recent deposits at the bottom of nearby seas. Such denudation and redeposition are the chief methods by which the various strata have been formed since the beginning, as new materials reaching the Earth's surface have been infinitesimal, save coal and peat and these have been derived chiefly from the carbon of the CO_2 of the atmosphere by plants. Then the vast deposits of calcium and silax formed by animal and plants are not new materials for the Earth, but merely Earth's original minerals transformed. Most natural waters both freshwater and salt, contain traces of CO_2 obtained from the respiration of organisms that lie within them, and from the atmosphere. By means of this addition calcium and silica are very slightly soluble in water, and living things can extract these minerals from the water for their varied requirements while the larger organisms obtain their supply from the same source.

Calcium or Lime is another of Earth's original and abundant minerals. It does not occur in a free state but is always in combination with other substances such as carbon, silica, oxygen etc. When an atom of calcium is combined with three of oxygen and one of carbon it forms the mineral calcite – ($CaCO_3$). In this form it is soluble in water containing carbonic acid, as most natural waters do, and in this soluble condition living things obtain lime for their shells, tubes, skeletons etc. The vast masses of limestone in all parts of the world are often more or less the product of such remains of former living things while fossils of them as rocks have usually been preserved by calcite. The natural water in limestone and chalk districts always contain a certain percentage of this mineral, while boiling the water drives off CO_2 leaving the CaO or lime which immediately crystallises upon the sides of kettle or boiler. Pendulous, conical structures are often seen hanging from bridges and limestone caves. These have been formed by slowly dripping water containing $CaCO_3$ because the atmosphere absorbs from it the CO_2 and the CaO forms the pendulous conical stalactite. Should the water drip rather fast the atmosphere cannot absorb all the CO_2 so that the $CaCO_3$ is in the water that reaches the floor of the cave, and there the CO_2 is absorbed and a so called stalagmite is formed; vide specimen No. 187. [A piece of broken off stalagmite]. When a piece of snail shell is placed in nitric or hydrochloric acid the lime is dissolved, and the horny organic foundation remains. This consists of more than one layer each having lines in a different direction from those of other layers, as shown by the microscope. Calcite makes drinking water "hard" and less palatable than "soft" water which is without the lime. There is little of it in the water of Hereford public supply, because the source of this supply has very little calcareous strata. Then the shells of fowl's eggs produced around this City are thin and break readily, because the hens obtain insufficient lime. The Chalk of England and other countries is largely composed of the cells of Foramenifera, and a thin section of that Chalk, examined by the microscope, distinctly exhibits such fossil shells. Calcium also unites with another substance to form various minerals such as Dolomite, Gypsum, Anhydrite, Apatite, Fluor-spar, etc. Limestones are also formed by the precipitation of calcium in seas and lakes when such waters become super charged by inflowing rivers and other agencies, as water can hold in solution only a slight percentage of the mineral. With such precipitants other substances are often included which give the limestone deposit a darker colour, greyish tints being most common. Fossil shells of Mollusca, etc., that were originally of calcareous matter are often found converted in to siliceous substance. This alteration has slowly replaced calcite atom by atom.

Limestones are usually seen to be finer in grain than Sandstones when examined by a lens. In case of doubt a small drop of acid, such as dilute hydrochloric acid, placed on the specimen and examined with a lens will settle the question. If the acid sinks into the rock and fails to produce effervescence, a sandstone is in hand. If the drop freely originates bubbles the specimen is limestone, and the bubbles are carbon dioxide. If bubbles are given off tardily the specimen is probably a cornstone. A little strong vinegar answers the same purpose without damage. A small bottle with a pointed match pushed into the cork, by which to apply the drop of vinegar, serves the purpose well, and can be removed from the specimen by the tongue.

The most readable book on geology for a beginner is – "Lyell's Principles of Geology", 2 vols. Tenth revised edition 1868. These volumes deal with general principles and not much with the rocks themselves. Although somewhat out of date it is mostly sound, and will ever remain as a classic of geology. Then there is "The Student's Lyell" which is a reduced form by Professor Judd 1896. This contains some account of the rocks, and is a very handy little book. A larger and more valuable book is the "Text-Book of Geology" 2 vol. Fourth and revised edition 1903. It treats both of principles and rocks. Author Sir Archibald Geikie. The Encyclopaedias such as Chambers' and Britannica contain much on geology and should be consulted. There are also many books on geology in general, and on its various departments. The present "Guide" is merely [an] introduction to geology for those who are unacquainted with the subject.

<u>Notes</u>

1. p.11 West must surely have been aware of the Antarctic as a continent i.e. that the ice is underlain by rock, as he refers to the expeditions of Scott and Amundsen where mountainous terrain is frequently described. It is possible, however, that he believed that the mountains were no more than volcanic islands rising from the sea bed.

2. p.12 At no time does West give the source of his statistics or the evidence by which he arrives at these figure.

3. p.14 The Rhynie chart fossils are Devonian in origin and include some animals.

4. p.19 Silax is an obsolete term for silica.

5. p.27 Proteid is an obsolete term for proteins.

6. p.30 An interesting and idiosyncratic rendering of "toadstools".

7. p.30 "Here is wisdom. Let him that hath understanding count the number of the beast: for it is the number of a man; and his number <u>is</u> Six hundred threescore <u>and</u> six".
   Rev. 13. v.18 A.V.

8. p.32 "They have sharpened their tongues like a serpent: adders' poison is under their lips". Psalm 140 v.3 A.V.

SYNOPSIS OF EARTH'S HISTORY

This scheme is offered as an aid to thinking as well as seeing; thought should supplement each of the five natural senses. It is the lack of that function of the brain that brings so much crime, misery and sorrow to the lives of humanity. The Scheme conveys nothing dogmatic regarding Time, or other items, but affords some idea of the vast ages our Earth has passed through. It thus opposes the old notion still held by some folk, that the Heavens and the Earth were all made in Six Days.

The strong lines completely across these pages divide the Epochs into 8 Periods [in fact he list 18 Epochs] each of which has oft been named in various terms; these merely add confusion, hence numbers from 1 to 8 are more simple [in the manuscript no numbering is given. At the start the author identifies Epochs A-C then abandons the practice. [D] to [R] are interpolated to give continuity and points of reference.] Such divisions lead one to suppose that each group began and ended at a certain time. That, however, is quite remote from the facts, and simply means to convey the idea that at one time the Pre-Cambrian, Carboniferous, Cretaceous or other Epoch was a dominant feature in Earth's history. All the Epochs overlap one another considerably, thus Coal is now being deposited about the deltas of some tropical rivers, as the Amazon; Chalk is being laid down at the present time on the floor of the Atlantic; while the Igneous still lingers on and gives us volcanic matter and surface movements. Likewise with the history of man, as stone instruments are still employed by some tribes.

With the history of rocks it must be kept in mind that the early sedimentary strata had to be formed chiefly from materials resulting from the hard igneous strata, slowly destroyed by waves, weathering and occasional ice. The substances from other sources, such as volcanic were mostly local and limited. In those early times there were no plants or animals to add their remains. For such reasons what we still are able to study of the early sedimentary strata must have taken a vast time for their formation. As time advanced the growing abundance of sedimentary strata gave more soft materials for denudation, so that new strata could be formed at a somewhat quicker rate than at first. This is indicated in the 4th column from the left.

The seven pages of the synopsis are included as fold-out charts

Synopsis of Earth's History

EPOCHS or PERIODS For vast ages our Sun with its Planets was a gaseous,incandescent and molten mass, forming a brilliant star.Gradually it cooled somewhat and portions were thrown off to form the Planets,Earth being one of the smaller of them;but it still retains internal heat that causes volcanic action.	APPROXIMATE ORIGINAL THICKNESS OF STRATA IN FT. But probably an average of between 50 & 90% has been worn away to form subsequent strata.On this assumption the original thickness stated has been based.	A FEW EXAMPLES OF THE VARIOUS ROCKS,or strata,of the different Epochs that still remain in different parts of the world	ORIGINAL THICKNESS of strata formed at the rate of one foot in the number of years stated (app,)	MILLIONS OF YEARS ago when the Epoch began (approx.)	MILLIONS OF YEARS. the main period of the Epoch lasted (approx,)	A FEW OF THE PLACES IN BRITAIN where such rocks occur at or near the surface.Consult the large geological map of the British Islands!
A IGNEOUS EPOCH From a more or less gaseous and molten state to cooling with a firm surface at least in some parts	The foundation rocks of the Earth's surface thickness unknown.All produced by the cooling of molten matter	1.Granite,2.Rhyolite 3.Syenite,4.Diorite,5.Gabbro 6.Diabase,7.Picrite,8.Basalt 9.Pitchstone,10.Gneiss,etc.	Thickness unknown.All cooled from molten: state i.e.igneous but sometimes fused with the lower sedimentary as in some Gneiss	3,000 or more	1,150 or more	1.Aberdeen,2,The Wrekin,3.S.Jersey 4.Nuneaton,5.Cuillin Hills in S. Skye 6.Dolgelly in N.Wales,7.Inchcolm Island, S.Fife,8.Edinburgh,9.Arran Isle 10.Malvern Hills [and] Hebrides.(In same order as examples given)
B EARLY PRE-CAMBRIAN There were frequent igneous (volcanic) outbursts during this Epoch.But the surface became cool enough for vapour to condense upon it and thus gradually form seas,with their deposits.Subsequently the latter with the igneous rocks were partly worn away by seas and weather.	Original 64,000 No fossils	The above with others and their remains which have also often been altered by heating or crushing into various Gneisses, Schists,etc.associated with volcanic overflows of Lava, Pitchstone,Tuff,Ash,etc.and often mixed with sedimentary strata such as Limestones, Shales,and Sandstones,the last often altered into Quartzite.(Altered rocks are classed as Metamorphic)	5,000 For all including igneous,sedimentary,and the latter when affected by heat/i.e Metamorphic.	With seas established about 1,850	320	More typical and more recent examples of Tuff,Lava,Ash,Basalt and other volcanic abound in Fifeshire.Primitive Gneiss in the Hebrides and N.W.Sutherland.Later Gneiss and Schist in Central and N. Scotland,N.W.Ireland,N.W.Wales and Malvern Hills.Pre-Cambrian Sandstone in N.W.Sutherland and Ross-shire [also apply to Section C].Shale,Quartzite, Limestone etc.in areas from Moray Firth to Islay,Kintyre and N.W.Ireland.Pre-Cambrian rocks are at the surface of large areas in all continents.
C LATER PRE-CAMBRIAN Much like the Early Pre-Cambrian but with far more sedimentary strata.No fossils beyond a few items that may represent very low forms of living things and only in the more recent of these rocks	Original 120,000	Much volcanic strata but with vast areas of sedimentary deposits such as Sandstones, Limestones,Clays,Shales etc. which have often been altered beyond ordinary recognition into rocks resembling the Gneisses, Schists etc. This has been due to heat and crushing by the Earth's surface move ments such as earthquakes.	2,800	1,530 1st.known Glacial remains 1,400	330	[As for Section B] other strata having either not been deposited over them or completely denuded away
D CAMBRIAN **[E]** ORDOVICIAN (formerly called Lower Silurian) **[F]** SILURIAN	Original 140,000	Less volcanic and altered sedimentary.Enormous masses of Sandstones,Conglomerates Grits,Shales,Slates,Flagstones,Quartzites,Limestones, and Greywackes,also other rocks in less abundance. The Ordovician and Silurian have similar forms of rocks. Some of these contain much fossil remains,while in the Silurian low types of fish appear.	2,550	1,200 2nd.Glacial 1,200 3rd.Glacial 1,000	350	Cambrian abundant in N.W.Scotland,N.W. Wales,also in Shropshire,Isle of Man, S.E.Ireland and a few other places including the Malvern Hills. Ordovician and Silurian cover most of Wales except S.E.,part of Cumberland and Westmorland,large areas of Scotland S.of Girvan and Biggar,N.E. Ireland,and occupies about 20sq.miles about S.E. and N.W.Herefordshire,but this is Silurian only

DESCRIPTION OF SPECIMENS

Short descriptions of geological specimens of Herefordshire strata exhibited in the show-case. The numbers on the left margin of these pages correspond with those given to the specimens on a slip of white card. The visitor should take no notice of the other numbers that may appear attached to the specimens, as these are merely reference numbers from the collector's note book.

[The original show-case and specimen labels have disappeared. The specimens were allocated Museum accession numbers in 1976, and it seems that the item numbers were intended to correspond with the collector's specimen numbers. However, there are a number of discrepancies and unidentifiable items. A catalogue has been compiled using the information available.]

1. A rather coarse-grained primary grey-black Gneiss from the S .Malvern Hills and consisting of various minerals associated together by volcanic heat. This must have cooled slowly from the molten state, a fact recognised by the crystals of the various minerals which thus had time to form. In this instance, the molten matter was thrust up from the Earth until it reached the overlying Lower Hollybush Sandstone, some of which was partially fused or burnt by the molten Gneiss (see specimens 9 – 11). This proves that the Sandstone, which has been produced by sediment from water, was formed at this place before the up-thrust of the Gneiss. The fine-grained Gneiss specimen No. 5A was formed at another part of the same hills. The fine grain of this proves that it cooled too rapidly to form large crystals, and was solidified near the atmosphere if not actually exposed to it. Other forms of Gneiss and Igneous rocks are found scattered on the surface, and in Glacial deposits, about the valley of the River Wye. These are probably from the ancient volcanic area now exposed N. of Builth, near which flows the Wye, and its former glacier brought the volcanic stones to central Herefordshire.

2. As No. 1 but with more abundant pink orthoclase and white quartz. This and others to No. 16 are also from the S. Malvern Hills. In all parts of these Hills the strata have been much disturbed by surface movements of the Earth, most of which have probably been due to the various up-thrusts of igneous matter during a long period.

3. As No. 1, but with a large vein of white quartz, ad some pink orthoclase distinct from the other minerals.

4. As No. 1 but of much finer grain, and paler grey in colour. The pale tint is partly due to the abundance of orthoclase scattered through it in small granules.

5. As No. 1 but from a vein of quartz in the Gneiss, with which other minerals are associated.

5a. A very fine-grained Gneiss which cooled too rapidly for the production of large crystals similar to those of No. 1. Two specimens of the same on the right of this show the outer surface has changed in colour to a mottled drab tint. This has been caused by long exposure to the atmosphere whereby chemical changes of the minerals occur. Alterations of this nature occur with all kinds of rocks, and is termed weathering. In this case the process goes on with extreme slowness, as with Granite and many other igneous rocks, while the weathered substances remain fairly hard. In other instances as with various Limestone and Sandstones of many buildings and walls in Hereford, the process is comparatively rapid; and the weathered minerals are reduced to powder. This, may be plainly seen at the Cathedral opposite [the Museum], and at neighbouring walls and houses.

6. A form of Quartzite consisting of quartz grains and other materials of various tints. Quartz differs from Sandstone chiefly because its grains are so firmly associated that they mostly break where the rock is split by a hammer, whereas in Sandstones the grains usually part from one another when the mass is broken. This is from the Lower Cambrian strata of the Malvern Hills.

7. Another variety of No. 6 but lighter in colour as it contains less dark mineral matter. From the same district as No. 6.

8. A fine-grained dark grey silky Phyllite (pro. fil'ît) from the Lower Cambrian series of the S. Malvern Hills. The basic material of the rock is extremely fine grained siliceous clayey matter, with which are other minerals, including mica, in microscopic atoms. The last mentioned mineral gives it the silky appearance. It is rock intermediate in structure between roofing slate and forms of mica-schist. Such schists are absent from Herefordshire but abound at the surface of large areas in the Highlands of Scotland.

9. A very fine-grained dark grey sandstone with occasional narrow seams and scattered areas of quartz grain. This appears to be Lower Hollybush Sandstone of the Middle Cambrian Epoch, but it has been fused by the Gneiss rising from below, hence the quartz grains and dark colour.

10. Fine-grained mottled grey-drab Sandstone with several little cavities resembling those of pumice-stone (a kind of volcanic lava). This is lower Hollybush Sandstone altered by heat from the Gneiss below. Middle Cambrian Epoch.

11. Another sample of the same rock as Nos. 9 and 10, also modified by the hot Gneiss. Some samples have particles of Gneiss that has been burnt into the Sandstone.

12. A fine-grained yellowish-drab Sandstone with narrow seams of light and dark tints. This is normal unaltered Hollybush Sandstone of the Middle Cambrian Epoch.

13. Upper Hollybush Sandstone. A fine-grained yellowish rock paler in colour than No.12. It consists chiefly of minute angular grains of white quartz, associated with minute patches of uncrystallised bright-yellow substance which is probably a form of ferric oxide, (iron rust) but needs analysis. This rock was deposited in rather deep water, as also were Nos. 9 to 12 as their fine grain indicates. The scraps of ferric oxide were particles of volcanic origin and rusted from scraps of iron or a substance containing it, while the angular quartz grains may have had the same volcanic origin. Middle Cambrian from near White leaved Oak.

14. A very fine-grained siliceous shale, slightly micaceous, yellowish-drab tending to become blackish. Doubtless deposited in rather deep water. It is Bronsil Shale of the Upper Cambrian Period. It came from the N.W. side of Chase End Hill. Shale is a rock that readily splits into thin layers, but is formed of material quite different from slate.

15. A fine-grained flaggy Sandstone of a grey colour, but weathering to dark-brown and almost black. The grains are angular which shows they have not been rolled about much either by wind, as in deserts, or by water, for movement by such agents tends to round the hardest mineral grains. This rock consists of various minerals most of which are quartz. From the S.W. side of Chase End Hill. Probably of the Upper Cambrian Epoch.

16. Similar to No. 15 but in thinner flags and differently coloured. (Flag means rock formed in rather thin seams, like pavement stone, but thicker than slate or shale). This does not weather so dark a colour as No. 15. From Coal Hill which is W. of Chase End Hill. The rock here resembles that of certain Carboniferous strata and at one time led to fruitless digging for coal, but is probably Upper Cambrian Sandstone.

17. At the S. end of the Malvern Hills, at about Bromsberrow, the very early rocks we have been considering are overlaid by far more recent strata of the Permian and Triassic Periods which are those characterised by distinctly red sandstones, which are often soft and sand-like, while below these are possibly remnants of Carboniferous strata. Next above the Cambrian of the Malvern Hills should be the Ordovician, but no strata of this Epoch is at the surface of Herefordshire, and the nearest thus seen occupies a large area of N. Wales. On that account we leave the Ordovician, Devonian, Old Red Sandstone, Carboniferous, Permian and Triassic and pass to the Silurian which lies next above the Ordovician and next below the Devonian. (See Table of Strata at end). [Not provided, but see

Appendix 2]. This is well exhibited in parts of Herefordshire, especially about the districts of Mordiford and Woolhope, and No. 17 represents a very fine-grained sandstone, slightly micaceous, from N. of Upper Littlehope Farm, near Mordiford; one of the pavement-like slabs of the Early Silurian Epoch. These rocks are much cracked vertically, and when parted at the cracks the surface appears dark because mineral matter in aqueous solution, such as iron-oxide, has filtered in and discoloured the stone. This rock was probably formed near a muddy sea-shore, while the marks on its surface appear as the tracks of small crawling animals. Since these rocks were deposited they have, in this district, been subjected to great disturbance by Earth's surface movements that have lifted them into hills from their original more or less horizontal position.

18. A fine-grained calcareous (i.e. limey) Sandstone from the same district as No.17, but this was probably laid down in deeper water. In this case pink Calcite and Quartz has filled a crack by entering in aqueous solution from the strata above and slowly crystallising as the water evaporates. (When considering waters of the oceans it is well to remember it varies in depth from a few inches near shores to nearly 6 miles in the deepest parts. See "The Depths of the Ocean" by Sir John Murray and others, 819pp, 575 illus., 1912). Thus fine grains only of minerals find their way into deep water from shore, but shells of minute organisms sink to the greatest depths when the creatures that live near the surface die. Examples of such shells are Diatomaceae (plants), Foramenifera and Rhizopoda (animals); all of which are still forming rock at the bottom of oceans, while rocks previously formed by them are now at the Earth's surface in many places.

19. A fine-grained brownish-drab Sandstone with minute veins of quartz, scraps of other minerals and traces of lime. From near Lower Littlehope, Mordiford. Above this sandstone there is a zone of lime mentioned under No. 20 below. This substance has whitened the exposed surface of rocks nearby, including this specimen, but the lime has been cleaned free from it save at one end. Lime, probably from a similar source whitens roadside banks, and that above a path to a cottage near the New Cemetery at Mordiford.

20. Many years ago the Silurian limestone of the Lower Littlehope district South of Mordiford, was burnt in order to obtain the lime for building, agriculture and other purposes, the abundant local wood being used for fuel. The waste material from this process was deposited in the neighbourhood, and in time became overgrown with grass which concealed it. Near a foot-track on the hill-side a bank had recently slipped and exposed some of this waste lime. The exposure exactly resembled natural seams of white Coral lime a few inches thick alternating with thinner seams of the [same?] material darkened by some foreign grains and scraps of various sizes resembling substances frequently ejected from volcanoes, but really derived from this burnt wood. To a stranger ignorant of the former limestone burning and waste, the material of this slip would appear as a natural Coral lime deposit with alternating seams discoloured by scraps of volcanic substances; and the ancient volcanoes North of Builth would suggest the source of the dark material. This old volcano is known to have been active in Silurian times by its ejected minerals being found in rocks of that age, and its distance from Littlehope is only about 38 miles which is a trifling space even for modern volcanoes to distribute dust and ash through the atmosphere.

21. A blue-grey crystalline Limestone from N. of Upper Littlehope (the colour is only seen on the underside). It contains much quartz and is partly coated with a yellow-brown sandy deposit without lime. This specimen was part of a larger piece, and was doubtless a stone in the shore mud of an ancient sea below the tide-marks. The upper surface is covered with worm-tubes which arise from the rock below the brownish coating. The tubes are now siliceous, but when constructed by the worms they were probably calcareous. Such interchange of material has been frequent through most of the geological epochs. It is a gradual chemical interchange of substances whereby the calcium is replaced atom by atom by silex. Thus the fossil shells of Mollusks, originally of lime, are often found to be of silex (see No.45). Those worms enjoyed the comfort of their tubes probably about nine hundred millions of years ago.

22. A very fine-grained bluish-grey crystalline limestone associated with a somewhat coarser drab calcareous sandstone which formed the uppermost layer. The grey is up to about 2ft. thick while the drab is merely a few inches. This rock indicates that after a long period during which the grey was deposited, there came a somewhat sudden change bringing quite different material for the old sea-bottom. Such change may have been due to various phenomena altering the levels and conditions of the land, rivers and seas. When fossils abound some idea may be gained regarding such alterations, but in the present case the evidence of fossils is almost valueless. In those past times a rock such as this and 30 inches thick would probably occupy from 5,000 to 6,000 years for its formation. From the Lower Littlehope district, but above the lime mentioned in No. 20.

23. A medium-grained brownish Sandstone composed of colourless half-rounded quartz grains associated with others of different tints but mostly yellow. This is called May Hill Sandstone, and is well displayed at that place, which is 6 miles S.E. of Ross, but seams of it occur about Haugh Wood and district where this specimen was obtained.

24. A grey crystalline Limestone with veins of quartz from the Middle Silurian at Scutterdine.

25. A semi-crystalline Limestone containing numerous fossils that are chiefly shells of Mollusca. Middle Silurian, from near Mordiford.

26. Highly-crystalline Limestone mostly light to dark grey in colour and termed the Woolhope Limestone. This is so crystalline that it frequently resembles some forms of Gneiss, but it has not been altered by heat, and is very hard and tough. It is liable to be overlooked, because on the outside it weathers to a dull drab tint resembling many other rocks. It is also called the Petalocrinus Limestone, because it is sometimes found with very rare fossil Starfish[1] of the name; so far as is known this fossil occurs only in the Woolhope district, and in the *Niagra [sic] Series of the Silurian strata of N. America. This starfish was a small one and had ten arms, it also lived on a stalk secured to a rock under water. Modern Starfish commonly have but five arms and no stalk, but creep about on the sea bottom; consequently the fossil more resembles one of the allied creatures called sea-lilies, but the anatomical points that distinguish each division cannot be followed in the fossil. The Petalocrinus was probably an evolutionary form between the two modern divisions making a start about 900 millions of years ago.
*[He probably means Niagara]

27. A fine-grained greyish crystalline Limestone very hard and tough. It occurs in flags one to three inches thick, and in weathering it changes the exterior to a dark colour. It was probably formed in rather deep water subject to occasional change of level. Of Middle Silurian age from N.E. of Upper Littlehope about Haugh Wood near Mordiford.

28. A very fine-grained slightly micaceous drab Sandstone. (see under No. 29)

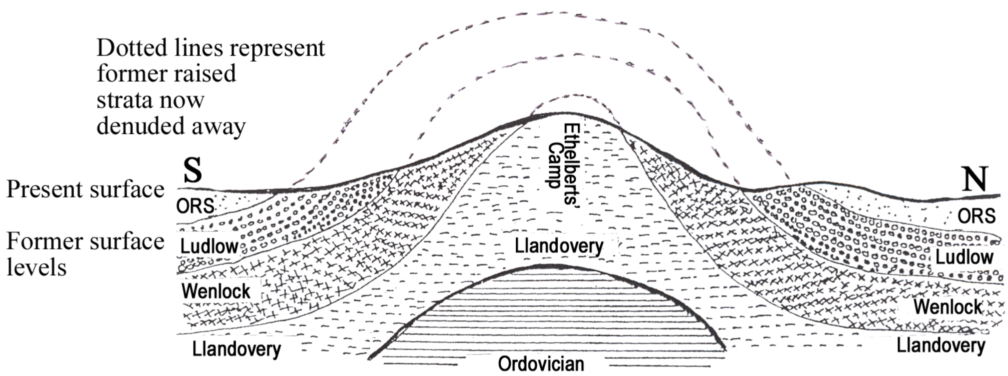
29. A similar rock to No. 28 but with more mica. The seams of both these strata vary in thickness from 1 to 6 inches, and have been considerably inclined from two directions which probably date from when Haugh Wood was raised. Obtained from an exposure at a lane above the Pentaloe Brook at Mordiford, and of Middle Silurian age.

30. A grey nodular crystalline Limestone with veins of quartz. From near Nash Scar Hill, S.W. of Presteigne, 20 miles N.W. from Hereford. It much resembles the earlier Woolhope Limestone (No.26) but the Wenlock Shales lie between them.

31-34 Opposite the New Cemetery at Mordiford the road leading to Haugh Wood has been cut through a deposit of rubble that resembles Glacial Drift, save that the exposed face has been whitened by time from an overlying deposit (see No. 20). The only evidence of ice action consists of the rounded and worn stones along with their variety. They appear to have been derived from the higher land of the district. This exposure begins a little past the "Moon" Inn, and is hidden by the cemetery wall, but is exposed eastwards from the wall. The road here is some 155ft above sea and the normal surface of the nearby Rivers Wye and Lugg about 140ft., while much adjoining land is several hundred feet higher – Haugh Wood 616ft. above sea, Ethelbert's Camp 738ft., Seager Hill 892ft. From much of this higher ground ice could have drained down the valley in former times as the Pentaloe Brook now does. On the other hand the Brook may have had a greater volume of water at a former time, and drained into a pond or lake situated at this place. In that way the deposit of rubble could be accounted for without the aid of ice action. Attention is directed to the geological maps hanging near the specimen case [These maps and any information about scale, content and whether they were Hand-drawn or BGS have been lost] – On the right side of map 8, continued on map 9, the Mordiford to Woolhope district is shown. This is all Silurian strata, which during a former period has been raised by Earth's surface movements far above its original level; perhaps before the Old Red Sandstone (dark pink on the map) now surrounding it was deposited. A conspicuous feature on the map is a dark blue horse-shoe open towards the N.W. while around it are narrow, waved and puckered lines of the same tint. All this represents strata of the Middle Silurian period termed the Wenlock.. The pale blue surrounding it is the Upper, or more recent Silurian named the Ludlow, through which the Middle or Wenlock has been pushed, including the main horse-shoe and higher than it belongs to the lowest Silurian Series termed the Llandovery. This has been pushed uppermost through the Wenlock and Ludlow, and subsequently denuded considerably. These matters are known from the study of the strata in other districts where they lie in normal positions. The upset means that the Llandovery has been thrust up through the others more than 1,000 feet above its original position. When we consider these movements we cease to wonder that the rocks are cracked and broken, or that they often lie away from what should be their normal position.

The annexed diagram [figure 1] represents an imaginary vertical section from Oldstone and the River Wye at the S. to Western Beggard at the N., and may assist the reader in understanding this upheaval of Silurian strata. The Ordovician is next below the Silurian, and is at the surface of a large area of Wales. O.R.S. indicates Old Red Sandstone.

Figure 1



[Illustration of Uplift as described in relation to Specimen No. 30]

31. A coarse crystalline Limestone associated with rounded fragments of quartz and some organic remains.

32. A piece of fine-grained drab Sandstone associated with quartz which had probably formed in a crack in the Sandstone.

33. Pale grey crystalline limestone containing rounded pieces of the same (shown in front) that much resemble quartz.

34. A sample of Pink Calcite perhaps mixed with quartzite with remnants of a drab Sandstone in a cleft from which the Calcite doubtless developed.

The specimens 31 – 34, except where broken by the hammer to show their structure, have all been rubbed down and rounded as if by the action of water or ice as previously mentioned. Many other varieties could be obtained at this site.

35-39. Five kinds of Upper Silurian Sandstone all without lime from near Flintsham, about a mile S. of Titley village, 17 miles N.W. from Hereford. The Old Red Sandstone overlies these rocks a little further towards the S.E. and S.W.

35. A pale grey micaceous Sandstone, mostly of half-rounded medium and small sized grains of grey quartz associated with a few grains of either colours and small lumps of a very fine-grained grey Sandstone.

36. A fine-grained dark brownish grey Sandstone, consisting of grey, bronze, white and colourless quartz grains, associated with more numerous grains of darker tints and a few mica grains. An uncommon rock!

37. A rather fine-grained greyish drab Sandstone occurring in thin flags. In consists of minute rounded quartz grains of various tints but mostly grey, no mica.

38. A pale-grey medium-grained Sandstone with small lumps of a fine-grained sandstone, or a mudstone (see No. 93). The quartz grains are half-rounded and mostly pale grey, but other colours occur.

39. A rather coarse-grained Sandstone. The grey and white rounded quartz grains are dark as in No.36. The mixture gives the rock a mottled appearance. There are scattered grains of mica.

40-46. Are from an old quarry at Perton, 1 mile E. from Dormington, and 5 miles E. from Hereford, that has been long disused and is now overgrown with brambles and weeds. It is in the Ludlow series of the Upper Silurian, and overlaid by the Lower Old Red Sandstone. This reddish strata, covers the valley between Perton and Shucknall Hill, save for the alluvium deposited by the River Frome during periods of flood. The last mentioned Hill is another uplift of Silurian strata similar to that of the diagram on p.47, though on a minor scale. The student should examine this district as an example of the overlaying of strata, keeping in mind the vast period of time between the Old Red Sandstone and the recent alluvium (see No. 67).

40. This shale consisting of fine-grained, greyish, slightly micaceous Sandstone, associated with numerous carbonised fragments of plants, and discoloured by ferric matter. It was probably deposited in water below the influence of waves.

41. Below the shale (No.40) there is a seam of hard, tough yellowish Sandstone a foot or so thick. It consists of rounded colourless, grey and yellowish quartz grains, with a sprinkling of other minerals all bound together with a yellowish siliceous cement. This hard tough rock has not been so much reduced by weathering as the softer strata above and below; consequently it stands out beyond them and is the most conspicuous seam in the quarry. It would make a useful building stone, although its toughness would render it rather costly in labour for our ephemeral, jerry-built private structures.

42. Below No. 41 there are numerous thin layers of rather soft greyish and yellowish shales, and with them are seams of harder sandstone resembling No. 41 save that the layers are thin and shale-like. These thin seams are altogether about 6 to 7 feet thick. Such strata indicate sedimentation in somewhat tranquil water of changing depths due to numerous variations of the bottom level, and alternating currents bringing materials from different districts during a long period of time. Shales are the main feature of this quarry as of the Upper Silurian in many other districts. The grey sample shown is a very fine-grained Sandstone, slightly micaceous, associated with minute granules of carbonised material and ferric matter.

43. Under the last mentioned set of shales lies a narrow layer of yellowish, micaceous Sandstone, which contains many carbonised fragments of plants. Such remains are probably from both the sea-weeds, and the low grade land plants which flourished during that Epoch. In mineral substance this rock resembles the above No. 41, save that its grains are much finer, and that it has more scraps of green glauconite – two features which indicate its formation in deeper water. This layer of rock may represent the Downton Sandstone (No. 96), and its position below the O.R.S. is about right for that rock. It begins to appear about 15 feet from the N. side of the quarry and gradually rises towards the S. (2 specimens).

44. Samples from layers of shale, altogether about a foot thick, that [lie] between Nos. 43 and 45. These resemble 43 but are much finer in grain and of a more olive tint. The grains are so minute that they require considerable magnification before the individuals can be seen, the most conspicuous being the tiny grains of mica. The rock might be mistaken for marl, but there is no lime and is actually fine-grained Sandstone. When stroked by hand it has a soft-greasy feel similar to one variety of the quarry-man's "Soapstone". That rock, however, is a variety of magnesium silicate named Steatite, and the real thing does not occur in Herefordshire (see also No.93). The thin expansions of brownish and blackish tints occurring at parts of the rock, result from ferric matter, which was probably introduced between the thin layers long after the rock had hardened. This fine-grained shale must have been deposited in rather deep water. (2 specimens).

45. Below No. 44 runs a bed of hard, grey, slightly micaceous, siliceous Limestone, associated with a yellowish-grey siliceous rock without lime, but of a similar structure. Together these form a bed a foot or more thick. Both varieties contain broken pieces of the shells of Brachiopods, which are the evolutionary forerunners of Mollusca living in shells formed of lime. Most of these shells have become siliceous by slow chemical interchange of silax for lime (see Nos. 21 and 48). The minute black particles scattered throughout appear to be carbonaceous matter, probably from plants. This rock was doubtless deposited in fairly deep water, and the yellowish portion indicates a period when for some reason, say change of currents, the calcareous portion of the sediment was withheld.

46. This is from a seam of rock that is partly grey associated with yellowish-grey material similar to No. 45, but has more lime and less of the siliceous binding substance. It contains similar shell fragments and carbonaceous matter. The differences make it intermediate between Mudstone and Rottenstone. It is fairly hard, dry and brittle, but lacks fissility (that is breaks readily in any direction, and the freshly exposed surface is irregular). It appears to be a forerunner of the seams above it, laid down under different conditions which varied considerably in response to changes elsewhere. This rock overlies more seams of shales and sandstones. It first appears here from the bottom of the quarry to the right of where No. 43 is first seen, and, like the other strata, rises upwards to the right with the original up-thrust of the hill on the S., i.e. toward Wooten. Towards the N. it dips below the River Frome and rises again towards Shucknall Hill; the intervening distance being overlaid by the Lower Old Red Sandstone, and the comparatively recent alluvium of the River. Hence, as previously mentioned, this district is interesting for a beginner in geology to carefully study.

47-51. The strata about Ethelbert's Camp, situated between Mordiford and Dormington, appears to be mostly the Llandovery series of the Silurian Epoch (see diagram on p.47). The top is at present 738ft. above sea, which is probably between 1,000 and 1,500ft. above its original plane of deposition. The uplift which raised this Hill has disturbed and shattered the strata to a considerable extent. This, together with the lack of exposures of the rocks, and the surface covering of vegetation gives difficulty placing the strata in their exact position of the original series. At the period of uplift there were probably lying above the present Hill, the remaining shattered zones of the Silurian strata to the thickness of several hundred feet, but these have been denuded mostly away. The remaining cleft and broken strata, exposed on the eastern side of the Hill top, are locally known as Adam's Rocks. In addition to the rough treatment these rocks have endured, their nature is further masked by the weathering to which they have been subjected for unknown ages. They are also much overgrown with Lichens, Mosses and Liverworts (i.e. *Hepatica*) which thrive in this exposed situation. From this site a clear atmosphere affords splendid views to please both artist and geologist. The last mentioned will be attracted to the Woolhope Valley lying at his feet. This Silurian dale is well-cultivated with farm crops, while the bordering hills are clothed with forest.

47. From a thin seam of Crystalline Limestone, several of which occur in these rocks alternating with shaly sandstone. This Limestone is heavy, hard and tough varying in colour from bluish-grey to drab. This is known as the Aymestry Limestone because it occurs more abundantly about that district, which is 17 miles N. x W. from Hereford. The seams there being far thicker, are worked for commercial purposes. The rock contains certain substances that make it valuable for manufacturing a cement that dries and hardens quickly and sets even under water, so that it is largely employed for hydraulic work.

48. A piece of the same rock as No. 47 with the fossil shell of a Brachiopod belonging to the genus Pentamerus. These creatures had shells resembling those of some Molluscs, but the animals are of lower organisation (see Nos.21 and 45). About 3,000 species are known from Silurian rocks and a few still flourish in warm seas. They possess an extension from each side of the mouth which serves for both respiration, and the production of a current in the water, to drive food particles of various kinds into the omnivorous stomach.

49. A sample from one of the shale-like seams of which these rocks are largely composed. These seams vary somewhat in colour from yellowish to olive. They consist of a very fine-grained slightly micaceous Sandstone with traces of lime. Most of the seams are rather hard while others of similar composition are softer.

50. In some of the rocks there is a layer of conglomerate consisting of rounded and partly rounded stones of varieties both similar to adjoining rocks and others different from them. This sample was broken to reveal its nature, which is similar to that of No.47. In past-time the conglomerate was probably part of a sea shore formed from the local rocks when, for a period, they were elevated to within wave influence while other kinds of stone may have been brought by a change of current. In those early times alterations of level and current were not uncommon and such changes still continue, sometimes suddenly. A few years ago, for instance, the Sea of Japan had part of its bottom raised several hundred feet, while another portion was lowered, and earthquakes altering levels are of frequent occurrence. The Earth's interior has been cooling since the earliest times, probably from about 3,000 to 4,000 millions of years ago, yet the still cooling molten matter and the shrinking surface can often produce extraordinary superficial changes that frequently destroy numerous members of humanity and their works. From such facts we glean notions regarding the enormous surface changes of past ages which the strata of all the various Epochs confirm.

51. The uplift that produced this Hill has split the rocks in many places. Some clefts are wide enough for a boy to enter while others are merely a fraction of an inch. The narrow clefts often become filled with Calcite, Quartz and other minerals. This occurs by the mineral, in solution in water, entering the cracks, and as the water gradually evaporates the mineral becomes deposited in crystalline form. In this specimen cracks of two widths have thus become filled.

52-55. At Cockshoot a little N.E. from Old Sufton, at a bend of the road from Priors Frome to Checkley, 4 miles E. x S. from Hereford, there is an old quarry at about 400ft. above sea. This has a northerly exposure, and the face of the rock is more or less covered with lichens and moss. In addition to brown and grey layers of strata there is a conglomerate about 2ft. thick. The strata are mostly inclined to about 20° from N.W. up to S.E., and this is doubtless due to the original uplift that formed Ethelbert's Camp. The upper 2 or 3 feet are much weathered and broken. Where the two colours are associated, the grey occupies the lower zone, as usual in this district, but in neither case were fossils observed.

52. A sample of the dull grey rock which is a crystalline limestone.

53. Similar to No. 52 but finer in grain, more drab in colour, and not as highly crystalline.

54. A Limestone similar to No.52 but pale grey. This is a common feature with these strata, and records a rapid change of the calcareous material that was probably due to a change of current in the sea.

55. Rounded stones from the conglomerate. These are of similar material to Nos. 52 and 53 above, and were probably a result of the breaking down of like strata in the district. The formation of a stony beach would thus occur during a period when shallow water prevailed, compared with the tranquil depth beyond wave influence necessary for the production of Nos. 52-54.

56-61. At Old Sufton ¾ mile N. from Mordiford, there is an extensive roadside cutting which was formerly a portion of a quarry. A part of this fell across the road in 1940 causing considerable damage. The road is about 170ft. above sea, and the face of the exposure is about 20-25 feet high. The strata are inclined about 15° upwards from the road and this inclination induced the fall of a southern portion of the rock. A vertical crack 4 to 6 inches wide indicates another slip in the near future.

56. A rather coarse Sandstone of rounded and angular grains of greyish quartz. With such there are fragments of other minerals, and numerous blackish patches which are probably fine volcanic matter blown from a considerable distance – say from Builth. Minute scraps of green may be glauconite, and a far more abundant yellowish amorphous substance is probably the result of ferric oxide. There is no lime in the rock, which occurs in thin flags.

57. This is also a Sandstone in thin flags. The quartz grains are mostly of a paler grey hue, more angular and variable in size; their features give a partly broken surface a sparkling appearance. In addition there are the minerals mentioned with No. 56, and traces of time.

58. Another Sandstone resembling No.56, and also occurring in thin flags and in even thinner layers like shales. A peculiar feature is that the first or last or both deposits in each layer are much darker in colour. This is due to dark quartz grains and other minerals deposited for a time in greater abundance than the material in lighter colour, and may have been caused by volcanic outbursts or change of current bringing different items for the sediment, or to both agents.

59. A fine-grained grey, micaceous Limestone, hard and tough. There are only a few thin seams of it that are mingled with a brown sandstone in the lower part of the exposure. This, like the Sandstone, appears to lack organic remains.

60. A Limestone resembling No. 59 associated with a very fine-grained brown sandstone above and below. At one side of the specimen a form of fluor-spar has crystallised in a crack from an aqueous solution, in a way similar to quartz, calcite, etc., already mentioned.

56. A fine-grained brown micaceous sandy Limestone with narrow veins of opal and quartz. This has abundant organic remains, chiefly shells of Brachiopods and worm tubes. It was associated with No. 58 above mentioned. Probably formed in shallow water.

62-63. From an old quarry at Prior's Frome, 4 miles E. from Hereford. The strata are Upper Ludlow of the Silurian, and not far below the Old Red Sandstone which overlies it a little to the W. The rocks of this quarry are mostly of grey and drab shales, rather soft and brittle, and often with fossils. These shales frequently weather white owing to the lime some of them contain. With the shales there are seams of dark brownish micaceous Sandstone about 8 to 12 inches thick. The Sandstone is hard but brittle, and the exterior tends to become whitened by lime from the shales. The strata are highly inclined toward the N.E. and this probably represents the original uplift that raised Ethelbert's Camp. The road up the hill has been cut in these rocks, and they compose the foundation of it.

62. Specimen of the medium-grained brownish Sandstone mentioned above. The grains of quartz are of varied tones of grey and yellowish., along with a variable abundance of darker grains, and a blackish material similar to that of No. 58, and probably derived from the same source.

63. Sample of the fine-grained, grey, siliceous shale which is rather soft and brittle. It contains minute flakes of mica and traces of lime. There is also a few fossil Brachiopods in this example, while some of the seams contain them in abundance.

64-66. From the cliff exposed on the S. side of Common Hill, N.E. of Fownhope, 5 miles S.E. from Hereford. This exposure consists of yellow, drab and grey shales as well as several thicker seams, all of the Upper Silurian Series; some are hard and tough, others soft and friable. These strata are variously contorted and cracked as a result of the Upheaval they have undergone; while the cracks have frequently become filled with quartz etc. in various conditions and tints. Some of the grey rock has numerous fossil shells of brachiopods, but good specimens are scarce as usual in strata so much disturbed.

64. A drab sandy Limestone with cracks in various directions that have become filled with quartz, while in many instances ferric-oxide has given a yellow discolouration.

65. A highly crystalline Limestone that has weathered drab on the exposed exterior, while this has in places been stained yellow by ferric-oxide.

66. From a wide crack in a sandy Limestone similar to No. 64 that had become filled with quartz and other minerals in fragments; it was subsequently stained yellow like the foregoing specimens. The small piece is another example having the Quartz less crystalline through being mixed with a greater proportion of dull calcareous matter from the limestone (2 specimens).

67. A very fine-grained, slightly drab Sandstone with remnants of fossil brachiopod shells, and partly stained yellowish by ferric-oxide. From the S. side of Shucknall Hill, altitude about 250 feet above sea. This strata is upper Silurian and is overlaid by the Lower Old Red Sandstone a little farther S. The latter extends across the valley to Stoke Edith, being covered in the lower parts by alluvium from the River Frome. (see Nos. 40-46)

68-69. Came from about Gladestry which is 20 miles N.W. from Hereford, and is near the western side of an oval area of Upper Silurian, which is surrounded by Lower Old Red Sandstone strata that has been mostly denuded from it. At the eastern side of that area lie Huntington and Kington, from near which the O.R.S. is continuous at the surface to the S. of Eardisley. (see Nos. 82-89)

68. A very fine-grained, dark grey crystalline Limestone, hard, tough and heavy, and formed in flags or thin seams 1 to 3 inches thick. The crystallisation of this rock has been assisted by the infiltration of silica in aqueous solution from adjacent Sandstone. On both upper and under sides of this seam of Limestone there are remains of greyish-brown sandstone without Lime, and doubtless the origin of silica in the Limestone.

69. A fine-grained Sandstone of a medium grey colour, hard, tough and heavy, occurring in thin seams. Compared with the above Limestone the grains of this are just visible to the unaided eye. It consists mainly of minute grey and translucent quartz grains, with which are a few grains of the same material tinted brownish, all being more or less angular. The rock also contains numerous black specks which may be carbon from plants or possibly volcanic dust, but cannot be identified without careful analysis.

A sprinkling of mica grains, and a mere trace of lime here and there also occur. All the items are united by a siliceous cement. Both 68 and 69 if in thicker seams would be valuable for building stones. They each indicate formation in deep water, no fossils were seen in either.

70-75. Along the ancient lane running N. x E. from Old Sufton to Dormington, 4 miles E. from Hereford, there are a few poor exposures of strata belonging to the Upper Ludlow Series of the Silurian. Over this on the N.W. lies the early strata of the Old Red Sandstone extending at the surface for several miles, save that it is here and there covered by the alluvium of the nearby Rivers Frome and Lugg. The following specimens came from this lane.

70. About the lower part of numerous exposures at this lane there are thin seams of a hard grey rock. This much resembles a Limestone, but it is a very fine-grained Sandstone associated with a few minute flakes of mica, the whole being bound together with silica that penetrated the rock in aqueous solution. Some of the silica is thinly spread over the surface of the layers, and is the white substance seen on [the] specimen. With other examples it has entered cracks and formed quartz crystals therein. No fossils were seen in this rock.

71. By the lane N. of Prior's Frome Farm there is an exposure of rock very similar to 70, and is probably a continuation of the same. The present example, however contains numerous fossil Brachiopods (see Nos. 45 and 48). In this case most of the calcareous shells have disappeared leaving but a cast of the creature that lived within, but remains of the shells can be seen with a lens about the casts; the latter still bear the impressions of grooves that radiate from one end of the shells. These casts project as rounded and oval swellings from the split surface of the rock as shown by the specimen. In places this rock has traces of lime that probably came from the decomposed shells. The fine grain of the rocks (Nos. 70 and 71) indicate they were deposited in fairly deep water, beyond the influence of currents that could transport larger grains.

72. A fine-grained siliceous shale occurring at a somewhat higher (i.e. Later) geological horizon than Nos. 70 and 71. The shaly seams of this rock have a tendency to show their production was in a series of very thin alternating zones, which were probably due to changes of current, perhaps seasonal as by a river in flood, in water below wave influence. In this respect it resembles the Downton Sandstone (Nos. 96 – 100). When considering seasonal changes we must bear in mind that seasons were probably of somewhat shorter duration than now. For such a conjecture our only guides are mathematics and physics, and both tend to support these inferences.

73. At a path near an old quarry N.E. of Prior's Frome Farm there is an exposure of yellowish rubbly shale; through these layers of shale there is a seam of dark brown Sandstone 6-12 inches thick. This Sandstone consists of rather coarse rounded and half-rounded grains of variously tinted quartz, associated with grains of other materials, the combination of which give it the dark colour. All the grains are loosely bound together so that the rock, although hard, is porous and readily absorbs water; it is also light in weight compared with other sandstones such as No.74. It was probably part of a sandy shore below tide influence, and produced during a time when the site was raised between periods of deeper water suitable for the production of shales immediately below and above it. From the identification of the contained substances, their place of origin and method of transport, with their formation into this Sandstone, an interesting story of old time Nature could be revealed.

74. At an old quarry of S. of Prior's Court Farm the strata is highly inclined from S.W. up to N.E., and among such there is a seam of hard and heavy medium-grained brownish Sandstone. This has a mottled appearance owing to the distribution of the coloured substances. The bulk of this rock consists of rounded and angular Quartz grains with a small proportion of other minerals. These substances are closely bound together with siliceous matter, and the brownish colour is due to ferric oxide. The sprinkling of black is probably volcanic dust.

75. By the side of this old lane S.E. of Dormington, and overlooking Shucknall Hill, there is a small exposure of yellowish, sandy shale without lime. Some layers of this rock contain numerous fossil

organisms, chiefly Brachiopods. Many of these remains are but casts of the creatures that lived within the shells; others exhibit remains of the shells while in some this is in perfect condition. A little further N.E. we leave this interesting lane for the main road to Stoke Edith, and various places along this road afford the naturalist pleasing and instructive views.

76-81. At Shucknall Hill, 5 miles E. x N. from Hereford, an old quarry, W. of the chapel, is reached by a rough lane from the main road opposite a water trough and telephone station. The strata are inclined about 29 º from S.W. up to N.E. as a result of the raising of the Hill; and are clearly showing it is not the result of soft strata having been denuded away while the harder remained. The exposed rock of this higher ground is Upper Silurian, while the Hill is surrounded by the Lower Old Red Sandstone of the subsequent Devonian Epoch. On the eastern side of the lane the strata are lower than the opposite side, they also differ in material and are less fossiliferous.

76. This is a very fine-grained, slightly micaceous drab Sandstone with brownish tinges and rather hard.

77. A semi-crystalline and partly siliceous grey Limestone, hard, tough and heavy; occurring in thin seams. Associated with Nos. 76 and 77 are numerous zones of softer rock of similar appearance, but which weathers more readily; while coral lime is evident in the upper series.

From such we may conclude that the hillsides were shallow areas of the ancient tropical ocean before being raised, and long before the Old Red Sandstone was deposited about them. Strata similar to the above mentioned may be seen at the side of the main road farther to the east.

78-81 The following specimens (Nos. 78-81) are from the western side of this quarry where much of this strata resembles Nos. 76 and 77, while other and higher zones are much more fossiliferous, some being crowded with organic remains, especially shells of Brachiopods. Another large quarry at the eastern side of the Hill will be mentioned under Nos. 90-95.

78. A fine-grained drab rock intermediate in structure between Nos. 76 and 77. This mixture of Sandstone with Limestone indicates changes in either the current or the source of supply; possibly the estuary of a river was not far distant, and gave its seasonal changes. Both the rock and its fossils indicate that the ocean was not of great depth at this area. The narrow dark strip at one side of the specimen represents a side view of the face between two layers of strata, and has been stained by the penetration of water containing such minerals as ferric-oxide etc. in solution.

79. A fine-grained drab, slightly micaceous Sandstone in thin flags, frequently with numerous fossil shells of Brachiopods etc.

80. A similar rock to No. 79 showing some of the fossils.

81. A rock similar to No. 77, but in thicker seams and crowded with remains of brachiopods.

82-89. About Kingston and Gladestry, 18 to 20 miles N.W. from Hereford, a large area of Silurian strata appears at the surface from below the Old Red Sandstone. With small areas of other strata, associated at the surface with it, this Silurian continues N. to the sea on the Denbigh coast, and N.E. towards Coalbrookdale and Shrewsbury. On the S.W. it extends to beyond Builth, from which a long narrow area reaches to within a few miles E. of Carmarthen. At, and W. of, Church Stretton, S. of Shrewsbury, there is a considerable area at the surface consisting of the Longmyndian series of early Pre-Cambrian rocks that crop up from deep below the Silurian. These consist largely of red and grey grits and conglomerates some of which are possibly coeval with the remarkable Torridonian Sandstones etc., of N.W. Sutherland, with noble reddish cliffs beautifully displayed around Lock Torridon, and known to be among the earliest sedimentary strata of the world. From these early strata in nearby districts to the Jurassic at the S. of the Malvern Hills, and the Glacial deposits of the Wye valley an observer residing in Hereford has within reach samples of a wide range of the world's history to examine and meditate upon.

Small areas of Igneous rocks such as Greenstone, Syenite etc. are at the surface of a little N.E. of Gladestry and may have been the source of some of the Igneous stones in the Glacial material of Herefordshire.

For Tilestones and Downton Sandstone about Kington see pamphlets Nos. 28, and 550-552 in the City Library. [now in the local collection]. These give positions of quarries etc.

The specimens (Nos. 82-89) are all from the Ludlow series of the Upper Silurian and not far below the base of the Old Red Sandstone (see also Nos. 68-69 above).

82. A Sandstone of rather fine grain, consisting of drab and colourless quartz granules of both rounded and angular shape. When held at a certain angle to the incident light this rock appears to be in narrow horizontal zones due to somewhat different grains that tend to run in lines. This was probably caused by a seasonal change of current bringing a new material to the usual deposit. The rock has no lime or mica and the layers vary in thickness from two to several inches. The black specks may be volcanic dust from a distant volcano. This stratum was probably laid down in rather deep water below tide influence.

83. A very fine-grained grey Sandstone, slightly micaceous and with traces of lime; the latter probably came from the numerous fossil shells of Brachiopods contained in the rock; these creatures, of course, secured the lime for their shells by absorbing it from the sea-water that, like most natural water, held it in solution. The brownish zone on one side is due to weathering, an influence to which that surface has been exposed for a long period.

84. A drab Sandstone of very fine grain without lime or mica. The chief ingredients of this rock resemble those of No. 82, but the grains are smaller: the materials having been derived from a similar source, but subjected to more attrition, and deposited in deeper water as the fine grains could be carried further from land before coming to rest on the sea bottom. This rock occurs in thin shaly seams of varying thickness; the thinner are used as tiles, and the thicker for walls and low buildings.

85. A fine-grained Sandstone occurring in thin seams. It is intermediate in grain and general structure between Nos. 82 and 84 and shows the narrow zones more clearly than 82. It has no fossils.

86. A variety of No.85, but occurring in very thin shaly seams, and is very micaceous. Evidently deposited in rather deep water.

87. A variety of No. 86, but occurs in thicker shaly seams, which tend, however, to split into thin layers.

88. A dark grey, very fined-grained micaceous Sandstone, without lime or fossils, and deposited in fairly deep water as thin shaly layers. The minerals are microscopic grey quartz grains mostly quite angular, and bound together with siliceous matter. Associated with them are black and grey particles that are probably volcanic dust, and the minute mica grains.

89. A very fine-grained greyish-drab Sandstone without mica, lime or fossils, and occurring in thin seams. The minerals consist of a grey quartz dust, quite microscopic, associated with a copious drab material of even finer grains, all bound together with silica. Nos. 88 and 89 are among the finest-grained siliceous rocks that are not of igneous origin.

90-95. At the large quarry E. of the chapel by Shucknall Hill, 5 miles E. x N. from Hereford the strata are highly inclined from S.E. to N.W. in layers of variable thickness. The rubble at the surface is from one to three feet thick; below this is a yellowish brown rock that is frequently drab, and under this are zones of a bluish-grey tint. Both series being similar to and doubtless continuous with those at Perton, Old Sufton, Mordiford and other places to the S. See specimens No. 45 from Perton, 54 from Old Sufton, and 22 from Littlehope where the drab and grey are united as they frequently are at Shucknall. At this quarry there is also a zone of conglomerate more or less between the brown and grey strata; see No. 55 from Old Sufton. With the upper zones of bluish-grey rock there is an abundance of Mudstone of a similar but paler colour, see No. 46 from Perton. The Aymestry Limestone, No. 47 is also plentiful about Shucknall Hill. For Mudstone see No. 93.

The strata of this quarry have been upraised a few hundred feet from their original site as shown by the steep inclination up to the N.W. As a result of this uplift the rocks are much cracked, and these splits, as at other places, have in the past been filled by the gradual infiltration and subsequent evaporation of water containing in solution calcium, quartz, iron-oxide and other minerals. The recrystallisation of such substance has filled many of the cracks with forms of calcite and quartz; often coloured by the iron. Such minerals occur here in larger masses than usual on account of the larger cracks; very conspicuous are the large lumps of pink calcite, often several cubic inches in size and quite ornamental.

From Shucknall Hill, which rises to about 400 feet above sea, to Ethelbert's Camp, 738 feet, the distance is 2½ miles. The valley between, through which runs the River Frome, is about 180 feet above the sea. The colour of the fluids, and most of the alluvium from the River indicate Old Red Sandstone for the valley, while the Hills on each side are highly inclined Upper Silurian Strata. An interesting view is thus presented, as the Silurian is continuous below the O.R.S. deposited upon it and subsequently partially denuded away, while more recently the River has brought more O.R.S. from other districts N. and E.

90. A very fine-grained, pale grey siliceous rock with traces of lime here and there. The grey quartz grains are of microscopic size, mostly angular, and bound together with a siliceous substance, the rock is frequently hard, tough and heavy. Evidently laid down in rather deep water, the grains not having undergone much attrition either by air, as in deserts, or by water at sea-shores.

91. Similar to No. 90 but darker in tint, and of slightly coarser grain, it also has traces of lime and other minerals. These silicified fine-grain Sandstones, being hard and tough, make excellent road metal, and it is chiefly for these rocks that the quarry is now worked.

92. Rounded stones from the conglomerate mentioned above. These pebbles are of various sizes from one inch to several inches in diameter, and consist mostly of rock similar to Nos. 90 and 91, while other are more distinctly sandstones and limestones. These pebbles are loosely cemented together by a rather soft bluish-grey material resembling mudstone (No.93). Compare with No. 55 and the description of same. The yellowish stain on the exterior of many of these stones is due to ferric-oxide in water, iron being the most abundant mineral in Nature. The conglomerate was probably a portion of a former beach.

93. Specimen of the Mudstone mentioned above. This is a form of clay, but is quite untenaceous when either wet or dry, and is readily cut with a sharp knife. It consists of exceedingly small grains of greyish and clear quartz associated with similar size grains of other minerals, and just visible under a magnifying power of 27 diameters. With such grains there is a larger quantity of still finer materials that require a greater magnification even to see the separate grains. It contains the merest trace of lime. The origin of this Mudstone is not entirely clear, but probably it is very fine material deposited below wave influence, when the conglomerate was being formed by waves breaking up rocks similar to Nos. 90 and 91, and rounding the pieces. There was probably a submerged beach that became the conglomerate. See No. 46 and the description. The Mudstone is also known as 'Soapstone', and 'Walker's Soap' is another name. When wet it is apt to let the rock above slide down and thus cause a landslip in a quarry or other exposure forming a cliff.

94. Specimen of pink Calcite associated with quartz, from the cracks in the brownish Sandstone of the quarry. The large piece at the side of the case weighed 2¾lbs before a part was broken off to expose the interior. This mineral is a form of lime that becomes crystallized in various colours, and even in translucent crystals like Iceland Spar, an allied mineral. It also assumes various types of crystallization.

95. Specimen of an impure pinkish quartz from a crack in the brownish Sandstone of this Quarry.

96-100. At Hagley near Bartestree 3½ miles E. from Hereford and about half a miles N.W. from the lava-like mass near the R.C. Convent (See Nos. 154-162), the Upper Silurian strata of the Ludlow series has been thrust up to 25ft. or so higher than the present surrounding Old Red Sandstone. To estimate from these surroundings it seems probable that the O.R.S. originally covered these Silurian rocks; but was subsequently denuded from them so that they now occupy the top of the mound. This Silurian strata is termed Downton Sandstone, after that village in N.Herefordshire, 6 miles W. from Ludlow, where it is more abundant at the surface. At the side of the mound the seams are inclined about 10º upwards, but near the top they are almost horizontal. At the uppermost part of this rising ground a large overturned tree had a variety of stones about its roots. Some of such pieces were angular pieces of the local Sandstone, but the majority were rounded pebbles of many kinds including white quartz rock. Such items may indicate former drift material from the Rivers Frome or Lugg, but a vertical exposure and classification of the stones would be necessary to prove it, as the pebbles may have been placed there by a human agency.

This Downton Sandstone consists of small and minute rounded and angular grains of drab and colourless quartz as the dominant mineral, with which there are several others that need a microscope for their identification, but conspicuous to the unaided eye are the innumerable tiny flakes of mica that sparkle in the light. There are also numerous black grains of irregular shape and size which may be carbonised remains of organisms, such as scraps of the firmer parts of seaweeds washed from an adjacent shore, but they exhibit no trace of structure and may be volcanic dust. All these substances are cemented together by a microscopically fine-grained, pale yellowish material. This binding matter is probably the result of the wearing down of other ingredients by the action of waves and currents, combined with material brought into the ancient sea by streams. Such natural agents for attrition and sedimentation began with the first water upon the Earth's surface, and still continues.

At this place the Sandstone is in thin seams, mostly from half an inch to three inches wide, while some are thinner and others are up to six inches thick. The colour is chiefly yellowish-drab, and nearly all the seams are more or less micaceous, such as the mica-schist, now so abundant in Scotland N. of a line from Helensburgh on the Clyde, to Stonehaven in Kincardine. Many of the seams of this Sandstone exhibit alternating zones of lighter and darker tint, 18 to 20, more or less zones to an inch. This structure is best seen when the light from a certain direction falls upon a newly broken surface vertical to the plane of stratification; a weathered face being useless for these observations. Such zones are probably due to seasonal changes altering materials carried by currents. Between some of the seams of this Sandstone there are one or more very thin layers about $^{1}/_{8}$ of an inch or less thick. Such shaly layers (No. 100) consist of about 25 parts of mica flakes and 75 parts of fine-grained sand, and binding material already mentioned. These thin layers are very brittle, and break readily when handled; the abundant mica flakes, sparkling in the light, give them a beauty of their own. Such from [?], as may have resulted from a river washing to the Sea the mica from rock that had fallen across its course. If for example, the cliffs of Meall Garbh (pro. Myall Garo = lump or hill; rugged or hard, alt. 3,661ft) fell into the Tay the mica would reach the sea bottom beyond Tayport after a journey of 70 miles.

One thin seam of this Sandstone, (No. 99) is abundantly marked on both upper and lower surfaces, with oval or rounded knobs and depressions. These consist of matter of a grey tint extremely fine in grain, while the exterior is often dotted or coated with a structureless black film as if derived from carbon. In many of these depressions the grey matter has mostly disappeared, while about some of the knobs scraps of silicified shell may be seen, or even lines that are casts of the markings of the shell. These items are probably the remains of Brachiopods, the shells of which became filled with Mudstone as the animal within decomposed, while the black film may be carbonised remnants of the animal matter; and remaining parts of the shells became silicified. Some of the black specks in the rock may be volcanic dust from vents not far distant, and not known by their surroundings, to have been active in those days.

Formerly it may have been possible to observe deeper layers of strata at this site, which is now being overspread with rubbish, weeds and brambles. The upper layers belong to the Tilestone, or Temeside Flags (Nos. 101-103), and have been denuded from this spot, but are probably below the O.R.S. not far away. Temeside because such rocks are abundant, at the surface, about the R. Teme in N.W. Herefordshire.

An old roadside wall near the beginning of the road from Hagley to Prior's Frome has been built with slabs of the nearby Downton Sandstone, and the thin, slabs stand together without cement sufficiently well for such a purpose, forming what country-folk in Scotland call – "A dry-stone dike" i.e. a wall without cement. The stones of this wall have become weathered, and do not exhibit the features of fresh specimens. About Hereford City old walls of the same material may be observed, both with and without cement. Similar looking stones used for walls are obtained from certain layers of somewhat earlier origin than the Downton Sandstone, and in below it, a series of shales etc. intervening. These layers used for walls lie above the blue-grey Aymestry Limestone (No. 47) and occur among thick masses of worthless shale and rubble. This rock and its associates can be seen around Old Sufton Farm ¾ mile N. from Mordiford Church, and at various places along the Lane from Dormington from that farm. Many dry walls of this district illustrate how readily this stone weathers to dust; but it is easily obtained, needs no labour for trimming and the slabs hold together without binding material during the life of the person who paid for the erection.

96-100 are from Hagley and are described more fully above.

96. Samples of Downton Sandstone of medium thickness, and with abundant mica. The back piece shows a vertical sectional view having the narrow layers of deposit described above.

97. Specimen from a thinner seam having less mica, and showing the black carbonaceous grains mentioned.

98. Vertical sectional view of a rather thicker seam to show the alternating light and dark zones referred to.

99. Specimen illustrating the oval and rounded knobs and depressions described as remains of Brachio-pods.

100. Examples of the very thin layers having a superabundance of mica as described above.

101-103 With remarks on the Downton Sandstone (Nos. 96-100), reference was made to Tilestone otherwise called Temeside Flags. This deposit consists of a variety of shales, grits, marls, sandstones etc. of various tints that lie above the Downton Sandstone series, i.e. they are of a more recent formation, and are next below the Old Red Sandstone in Herefordshire.
The Tilestone is a very fine-grained sandstone, usually micaceous and formed in thin shaly layers or flags from which roofing tiles were made formerly. Modern changes in conveyance, wages, invention, and industry have caused such roofing material to become obsolete, but it still can be seen on some rural buildings. Like the Downton Sandstone the layers of Tilestone are in thin seams, which also consist of thinner alternating zones of lighter and darker tint, 20 or so of such zones to an inch; mica flakes also abound. This rock is of a similar structure to Downton Sandstone but materials darker than the usual quartz, being generally more abundant, give it a duller tint.

101. The tile from a roof, shown at the back of the case, came from the Nash Scar district, N. of Kington, on the N.W. border of Herefordshire. The shining specks are flakes of mica, still bright after long exposure on the roof of a house, but many have doubtless been denuded away. The hole in the tile is for the purpose of fixing it. Compare with No. 103.

102. A broken piece from another tile to show the narrow alternating zones as seen in a vertical sectional view.

103. Specimen of fresh Tilestone showing surface parallel to the Plane of stratification, also vertical sectional view. The mica is more abundant here than on the surface of the old and worn tile, No. 101.

From the table of strata [Not provided with manuscript but see Appendix 2] it will be seen that the next series of Rocks above the Silurian are the Devonian Proper, but such strata do not occur at the surface of Herefordshire, although perhaps below. Consequently the next series for our consideration comprises the various rocks of the Old Red Sandstone which were formed during the latter part of the Devonian Epoch, and before the Carboniferous became dominant. Keep in mind that all the various Epochs overlapped one another by perhaps millions of years so that while one Epoch was slowly nearing its end in one district another was gradually making a beginning elsewhere.

104-115.

The soil at the surface of the greater part of Herefordshire is of a reddish tint, due to the colour of the strata below, and these are a portion of the great series of rocks known as the Devonian System. This System is more recent than the Silurian System which lies directly below it, and older than the Carboniferous System (the coal series) immediately above it. The Devonian is so named because it is well displayed at the surface in several parts of N. and S. Devonshire. These older and typical Devonian rocks are not usually red. They consist of sandstones, grits, limestones, slates and the clay-slates which often have shining particles of mica. In Devonshire there are also other kinds of older and younger formations such as schist, quartzites, granite, volcanic rocks etc. all of which, including the Devonian are of other colours, often greyish, and usually quite different in appearance from the red and reddish strata of Herefordshire, but the last mentioned do occur in some parts of N. and S. Devon; while other reddish rocks of later periods are at the S. and E. sides of that county. The red rocks of Herefordshire are known as the Old Red Sandstone and were deposited during the latter portion of the Devonian Epoch. This series of rocks must not be confounded with other red strata which colour the land with similar tints. Of these the principal are the Torridon Sandstones which redden the sea-cliffs of N.W. Scotland in many places from Scrishaven [?] Hill in N.Sutherland to the beautiful Loch Torridon in Ross, where it occupies a large area. It also occurs at Rum and Islay in Argyll, about Stornoway in Lewis, and less abundantly at a few other places in Britain. These rocks are far more ancient than the Devonian and are among the earliest sedimentary rocks of the world unaltered by heat. Then more recent than the Devonian Old Red Sandstone are certain strata of the Permian and Triassic Periods which were subsequent to the Carboniferous. These are often of red or reddish brown colours, and being more recent than the O.R.S. are frequently called the New Red Sandstones. Such strata occur in many parts of Britain from S. and E. Devon to small areas in Scotland, but are most abundantly displayed in the West Central counties of England, and enter the Herefordshire border W. of Worcester, and S. of Malvern Hills.

Returning to the Old Red sandstone their structure is not as simple as the name might suggest, and they exhibit great differences of mineral structure in the various districts from S.W. England to the Orkney and Shetland Islands, S. Wales and Ireland. These rocks, with their peculiar features, were perhaps formed in seas more or less isolated from the main oceans, and appear to have been slowly built up by sand and other substances mostly ejected from volcanoes, which were doubtless very numerous in those early days of the world's history. Such an origin will account for the general lack of fossils representing plant and animal life, which is a common feature of many of these. They dominate the surface of Herefordshire, control most of its scenery, and exert subtle influences into the lives of plant, animals and men that exist thereon. Other geological formations act in a corresponding yet variable manner: compare for instance the living things of Herefordshire with those of the coal producing districts not far away.

The frequent reddish or brownish colour of the O.R.S. is evidently due to an oxide of iron, such, for example a iron rust (Fe_2O_3), associated with other mineral and earthy matters which often colour the exterior of the grains of sand, chiefly particles of quartz and bind them together; while on other examples of this rock the quartz grains are also interiorly stained reddish. Exactly how this occurred, and the source of so much iron-oxide and quartz grains has not yet been definitely discovered, but both are possibly connected with volcanic discharges which were probably frequent in those early days of the world's history. All rocks coloured thus are usually poor in fossil remains of once living things, or quite devoid of them; the colouring substance or other matters in the water being inimical to all forms of life. In some districts, however fossils occur, and may even be abundant as in the yellowish strata of the Den of Dura, Fifeshire, mentioned below. In certain places fossil plants abound, and occasionally form thin seams of coal thus initiating the Carboniferous Period. Beautifully preserved plants occur near Rhynie, 30 miles N.W. from the city of Aberdeen. These are in a narrow strip of

O.R.S. surrounded by, and overlying an area dominated by igneous rocks such as granite, gneiss, schist etc., the main portion of the softer O.R.S. having been denuded away. Some of these Rhynie fossil plants were probably washed from the ancient land and quickly covered with the preserving sediment, while others doubtless grew in pools and bogs where they were fossilised. They are often so well preserved that thin sections of them are almost as good for microscopical study as those from modern plants, with certain of the lower forms of which their structure is quite comparable. Some of the largest relatives of such plants now existing in Britain are Marsh Horse-tails *(Equisetum)* that grow from 3 to 5 feet in height about shallow water of marshes, rivers and ponds, and the Club-moss *(Lycopodium)* growing from 6 to 15 inches long on wild, damp moors. This plant is much higher in the scale of life than a moss, and received that common name because its small leaves are moss-like. In ancient times, long before the advent of flowering plants, the various forerunners of *Equisetum* and *Lycopodium* grew to the stature of small or even large trees, and much of the coal is the result of their growth.

The Devonian, including the O.R.S. deposits occupied a vast period of time between the low form of living things in the Silurian Epoch, and much more advanced forms of the Carboniferous Period. With all these matters it is well to bear in mind that if we divide the present surface of the Earth into 40 equal parts, only 11 of them will be land while 29 will be water. There is no doubt that much of the past geological history is now under the waves, and the records thus hidden from us.

In a general way the Old Red Sandstone rocks are composed chiefly of reddish, brownish, yellowish, purple and grey sandstones, occasional cornstones (i.e. sand or siliceous limestones), nodular limestones, plain limestones and conglomerate, which vary from fine to coarse. In addition to these are also grey flagstones as at Turin in Forfarshire, which are known as Arbroath flags. About Stonehaven this Lower O.R.S. rests conformably (i.e. as it should in the order of succession) on strata of the Upper Silurian, but elsewhere in Scotland where its base has been traced, it lies unconformably on the other and much older strata. This means that the Upper Silurian has not been deposited at such places, or if deposited has been entirely denuded away, or uplifted and changed from its original position before the O.R.S. was laid down on it. Vast accumulations of igneous rocks (i.e. materials now rock thrust up from the molten matter in the Earth) occur in several areas of the O.R.S. as about Oban, Arran Island, S. Campbeltown, the Ochil, Sidlaw and Pentland Hills, and in Ayrshire. In some districts, as near Abergavenny, W. Monmouth, there are greenish fossiliferous beds of this Lower series. Such colour is due to the presence of green Chlorite associated with yellow Epidote, minerals resulting partly from the decomposition of plant and animal matter.

The supposed Middle O.R.S. occurs chiefly N. of the Grampian Hills in areas about Aberdeenshire, the Moray and Dornoch Firths, Caithness, Orkney and Shetland Islands. It consists partly of reddish sandstones, cornstones and conglomerates, but to a greater extent of greyish and blue-grey calcareous and bituminous flagstones, such as the well-known Caithness flagstones which form the pavements of many towns in Britain. This series has not so far been found superimposed on the Lower, nor connected above with the Upper O.R.S., but the few contained fossils prove it is intermediate in age between those deposits. This means that the fossils of organisms are intermediate in phases of evolution between those of the other series, and indicate a considerable interval of time, with alteration of environment, for such changes to occur. The igneous rocks are much less abundant than in the Lower series.

The Herefordshire O.R.S. consists mostly of reddish and brownish sandstones, while grey, yellow and white are less abundant. There are also similarly coloured cornstones, clays, marls, conglomerates, breccias (see Nos. 120-123) etc. The grains of these sandstones are sometimes more rounded than they commonly are by water; this is possibly due to wind action rounding the grains, like those of deserts and to coastal areas of blown sand. Such may have accumulated under aerial conditions, and were subsequently submerged by the land sinking. At the base of the Herefordshire series there is usually an unconformity as it rests on previously disturbed Silurian strata, as about the districts of Mordiford and Woolhope, or even on the earlier Cambrian and Pre-Cambrian rocks as near the south of the Malvern Hills. This is because the intermediate series of strata have not been deposited at such places, or if deposited were denuded away before the Old Red Sandstone began to be laid down. The O.R.S. rocks, however, are often in conformity with the succeeding Carboniferous strata which overlie them, as in parts of South Herefordshire, Central Fife, and other districts. In a few places about S.W. England, and in S. Wales, small areas of the O.R.S. occur, as well as in parts of Shropshire. Doubtless all such deposits have been much reduced by denudation in the subsequent Epochs. Similar series of strata are also well developed in various districts across Central Scotland, from Ayrshire to Berwickshire, Roxburghshire and Central Fife, as well as farther north in less abundance. A narrow zone of O.R.S. passes through Central Fifeshire from S.W. to N.E., parts of which are of yellowish sandstone. It lies between the volcanic series of N. Fife, and the Carboniferous rocks with coal in the S. of that county. In this O.R.S., about 2 miles E. from Cupar, there is a narrow wooded valley in the yellowish sandstone called the Den of Dura, through which flows the Ceres Burn. This valley is very remarkable for the abundance of its well preserved fossil fish. These were probably part of a shoal destroyed suddenly by a volcanic heat, or by vibrations in the water due to volcanic explosion, and quickly buried by sediment disturbed by the outburst. Or a sudden change in the nature of the water may have destroyed them; thus fresh water quickly kills marine fish, and those of fresh water are readily destroyed by a overflow from the sea. The igneous rocks in this series of the O.R.S. are rather scarce, but occur plainly in some districts as about Hoy in the S.W. Orkney Islands, and on a small scale close to the R.C. Convent near Bartestree, Herefordshire, where it has been exposed by an old quarry; and the Sandstone has been fused and altered by the molten matter (see Nos. 154-162). Most of such volcanic intrusions in this series are considered to have been thrown up during the succeeding Carboniferous Epoch.

The whole of the Devonian rocks, deposited in succession and now existing, are probably more than 35,000 feet in vertical thickness; while possibly half as much again, or more, has been denuded away for the construction of subsequent series of strata, and this process still continues with all strata at Earth's Surface. The nearby River Lugg, for example, has brought down from higher land sufficient mud, gravel and stones to form the flat ground between Tupsley and Lugwardine. This process still continues without a halt; and in wet seasons the River covers the flats and drops more mud and sand, while the gravel seldom leaves its bed, but is carried down the stream into the Wye, and some of it finally to the Severn and the sea. Banks of sand, gravel and stones are thus formed; and in future ages, when the slowly rising sea bottom has exposed them on the surface, geologists, if they exist, will endeavour to trace them to their original strata. The O.R.S. is partly the result of the wearing away of previously formed strata, as many of its granules clearly prove; while in the conglomerate are stones rounded by the action of water or ice. Such stones and granules can be recognised as the fragments of older Strata the remains of which can be traced; then other parts of the O.R.S. have been formed by vast ejections such as molten matter, sand, ash, dust etc. All the strata of the Earth have been produced from the Earth itself. Even in the case of Chalk, Coral-reef, Radiolarian and Diatomaceous rocks, all formed by the action of living organisms, the materials they employed, and still continue to employ, are the calcium and silica of the Earth dissolved in water. These minerals are found in nearly all natural waters, and the organisms extract them from the water to make their shells, or other habitations of which these rocks consist.

An excellent example of the remains of denudation occurs on the hills about 4 miles N.W. from Dawlish, S. Devon. Chalk flints are scattered about the moor, while the nearest remnant of Chalk is E. of Sidmouth, 16 miles distant. By searching to the westward one can find the Upper Green Sand – a rock which lies next below the Chalk. These facts imply that Chalk once covered the moor, but has disappeared leaving only its weather resisting flints.

The Devonian (including O.R.S.) and Carboniferous Epochs may be considered as the Third great period of the Earth's history. The vertical thickness of the remains of their strata at present above water, and consequently open to investigation, amounts to about 62,000 feet. This is probably about half the original thickness that was deposited, because from 50 to 60 per cent or more would have been denuded away and gone to form strata of subsequent periods, while the same process still continues with all strata exposed to air and water. From the assumed rate of deposit for the original consolidated rock of that long period – from the beginning of the Devonian to the end of the Carboniferous – we may estimate about 275 millions of years were occupied. It must be kept in mind that no Epoch through which the Earth has passed began and ended suddenly, but rather that the various Epochs overlapped one another. This is illustrated by the history of mankind. Primitive types allied to those of 250,000 years or more [ago] still remain in remote regions, while between them and the so-called civilised there exist many grades. Then in future time the present civilisation, with its ignorance and vice, will be regarded as savagery.

To some persons the figures mentioned about may appear "tall"; yet a little acquaintance with the facts and calculations of astronomical affairs make them seem probably less than they should be.

For example – the most remote stars we are able to recognise made visible by means of modern apparatus, are considered to be $32x10^{40}$ miles distant from Earth. Light from them travelling at 186,283 miles a second, the same as light from the Sun occupies $5,442x10^{25}$ years in reaching Earth. These figures means after 32 add 40 0s, and after 5,442 add 25 0s. The first can be read as 320,000 trillions of trillions and the second as 54,420 millions of trillions. A trillion is a million million million. [The author gives no further explanation of his calculations or their relevance]

From the foregoing pages the reader will gather clear notions of the O.R.S. Epoch that covers the major portion of Herefordshire, while numbers 104-162 will become more profitable to mind, and help it to reason upon the facts.

The strata of the O.R.S. series differs from other series of rocks, and is more difficult to account for. In the usual course of formation of strata portions of the rocks of previous epochs are slowly worn away by aerial and aqueous denudation; and such remains are deposited as coarse-grained material in shallow water while the finer grains are carried into deeper water. In reference to this it must ever be kept in mind that the surface of the Earth is usually in a state of rise or fall. This is commonly carried out with great slowness – say an inch or two in 100 years. Occasionally however the movement is rapid, as for example, a few years ago the bottom of the Sea of Japan. Then in all parts of the ocean bottom, telegraph cables are frequently broken by similar means. In the Silurian and Devonian Epochs, on which the O.R.S. has usually been deposited, we fail to find strata of a reddish colour from which the O.R.S. could have been derived, while the red rocks of the far older Torridonian could scarcely have been available to all the areas of the O.R.S., which appears to have been deposited in various districts of no great extent. It therefore seems probable that such areas of water were sites of great volcanic activity; and that the reddish strata of sand, grit, gravel, conglomerate etc. so frequently associated with ferric oxide, and usually without fossil remains, were ejected from volcanic vents that have disappeared. The reddish sandstone of some more recent Epochs may have been partly derived from denudations of the O.R.S. and partly from volcanic outbursts.

On entering Ross from Hereford via Much Birch there is an extensive roadside exposure of the lower part of the Old Red Sandstone. This overlays the Upper Silurian outcrop, seen about 5 miles to the East, which is an extension of the Silurian from the Woolhope district; while it underlies the Carboniferous beds about 3 miles to the South, into which the River Wye makes an eastward bend.

This exposure of the O.R.S. is not quite typical of the general rock of this formation, although similar strata occur in other districts of Britain. Attention is arrested by the various alternating zones of reddish brown, mottled brown and grey, pale-grey, greenish white and almost white rock. All these layers of stratification have been contorted from the original horizontal position by subsequent movements of the Earth's surface, due to internal heat or surface contraction. A few zones only of this exposure of varied strata are hard, and difficult to break with the hammer. These have resisted weathering and are of a reddish grey tint, or mottled by these colours; they are also finer in grain than the other varieties. This would make a handsome and lasting stone for buildings, although more costly to work than the softer kinds (see specimen 104). The numerous pale grey or whitish layers vary in thickness from a fraction of an inch to several inches, while the reddish brown layers are usually several inches thick. Most of these grey and reddish layers are comparatively soft so that the hammer and chisel will quickly remove a sample. In some places the greyish rock contains irregular patches of a reddish hue, while less commonly the reddish has grey, patches; consequently in both such instances the rock has a mottled appearance. Some of the reddish layers differ conspicuously from the normal in having an abundant mixture of rounded and half-rounded pebbles of various sizes, thus forming a fine, or in other places a rather coarse conglomerate. These stones come from the rocks of previous geological periods, reduced and rounded by the action of weather, water or ice etc. Such pebbles can be referred to the remains of the strata from which they came. In several parts of this exposure the rocks of reddish and greyish tint have weathered deeply so that the side of the hammer could scrape it away as sand for a depth of 3 or 4 inches below the surface (see Nos.113 and 114).

We must conclude that during the formation of the strata here exposed there were various more or less alternating conditions of climate, and surface movement of the Earth, that brought the different materials from various districts of previously formed strata, besides altering the flow of current and depth of water on several occasions. No fossils were observed in any part of this exposure, and as previously remarked fossils are usually absent or scarce in the O.R.S. and other strata tinted by iron-oxides.

104. This consists of small and minute angular and rounded quartz grains of a reddish brown hue associated with an extremely finely granular material of similar colour which is probably dust of the quartz and other siliceous substances coloured by the iron-oxide and binding the grains together. With this there are angular and rounded white and grey quartz grains of similar sizes found together with white quartz dust, these also being frequently in isolated patches which give the rock a mottled appearance. Mingled with the granules of the tints mentioned are numerous grains of a pale green mineral which is probably glauconite. Scattered through the rock are angular and rounded scraps and smaller particles of several other kinds of rock, each sort is probably composed of various minerals. This rock is very hard and difficult to break, it resists weathering and would make a durable and handsome building material. From a series of thin sections of this and other rocks, the various minerals and scraps of stone could be identified by aid of a suitable polarising microscope. Most of the grains could then be traced to their former source in strata more ancient than this O.R.S., save that some of the grains were probably blown from volcanoes, nearby or far distant. Volcanic material in modern times is sometimes carried thousands of miles by air currents. This was shown well after the outburst in 1883 from Krakatoa Island, W. Java; the dust from which surrounded the Earth from 10 to 20 miles high, and was the cause of remarkable sunsets in Britain and elsewhere. Thus after the Earth had been cooling for probably about three or four thousand millions of years its molten matter had, and still has, enormous power.

105. The general structure of this rock is somewhat similar to that of No. 104, but contains rounded and somewhat angular shingle and stones, but not usually enough of them to make it completely a conglomerate. The included stones are of various formations preceding the O.R.S. and indicate this rock was deposited in water of no great depth as the larger stones could not, in the general way, be washed into deep water, (see No. 107).

106. This is similar to No. 105 but in this seam the larger stones are of one kind – a peculiar clay-stone which is quite soft when wet. They may originally have been harder, but became disintegrated during the long ages of entombment; or they may have been original scraps of clay broken from a deposit and carried into the sea or lake by currents. The falling bank of a river may have been the source of their supply, or perhaps the Silurian mud rock (see No. 93) and the following No. 107).

107. Several varieties of water rounded stones from [or ? form] parts of No. 105, and similar seams where the stones were sufficient to form a conglomerate. Many others could be gathered by giving a few hours to the job. About walls at Pontshill and Lea, 3 and 4 miles S.E. from Ross, there is a dark conglomerate rock crowded with rounded white opal pebbles which give it a handsome appearance. The different varieties of opal are forms of silica, of which quartz is another and flint another. The varieties of stones of these conglomerates are too numerous to exhibit here; they are mainly siliceous, including some igneous such as gneiss.

108. A pale grey almost white sandstone. This consists of rounded and somewhat angular white quartz grains of various small sizes, mixed with grains of similar shapes and sizes but darker colours – grey, drab, brown etc. – with other varieties of rock, some being green glauconite. All are bound together by whitish fine-grained siliceous cement.

On portions exposed to air a greenish encrusting lichen of the *Verrucaria* Type grow on this rock, and on No. 111, chiefly because these rocks withstand rapid weathering, and partly because of their light colour and freedom from iron oxide. The lichen collects calcium i.e. lime, and exhibits a marked reaction for this substance. There appears to be no lime in any of the rocks of this exposure, and it probably results from the rain gathering carbon dioxide from the atmosphere. By the aid of this CO_2 the water can slowly dissolve the calcium substances of other plant and animal remains in the surface soil above, and trickling down the cliff a little is retained by the lichen, and the calcium deposited. This deposition of the calcium is partly due to evaporation of the water, and also to the greenish Algal cells of the lichen absorbing CO_2 from the water so that it can no longer hold the calcium in solution. The lime is of very considerable use to the life functions of the lichen by neutralizing some of the waste acidity produced by those functions. There are in Britain many species and forms of lichens, in fact about 2,000 kinds, and each consists of a combination of two quite different plants, one being a microscopic often greenish Alga, and the other a filamentous Fungus which is never of a green tint. The Fungus only, produces its fructifications, the Alga being a subordinate partner. The various species of Algae thus concerned are microscopic forms of the lowest class, and usually yellowish-green but some lichens utilise the higher pure green Algae as partners.

109. The materials of this seam resemble those of 108, but the grains are all smaller and more even in size, while the glauconite granules are more abundant, and, mixed with other minerals give the rock its greyish hue. A whitish siliceous cement as in No. 108 binds the grains together. This rock differs again in having been deposited in thin layers similar to flagstone. These differences from the foregoing indicate deeper water during the time the layers were deposited; probably the sea bottom had sunk as a result of volcanic disturbances. The small specimen behind shows a vertical face.

110. This represents a thick seam of rock following a seam tending to the conglomerate type, and indicates a change to somewhat deeper water, by the sinking of the sea bottom, as the stones of the conglomerate must have been deposited within the influence of waves or strong currents. The present specimen also indicates, by its mixture of greyish and reddish colours; occasional changes in the material deposited, although the reddish was the most predominant. Possibly the supply was due to a river which normally carried the reddish, material to the sea, but occasionally, as during flood, brought some of the grey substance. The latter resembles specimen No. 109, while the reddish is allied to that of No. 105, but somewhat coarser in grain. The shining particles, seen when the Sun shines on the specimen, are not mica but scraps of quartz.

111. The grey of this closely resembles No. 108, but there are more of the larger grains. It also contains isolated patches of the fine-grained reddish brown material resembling that of No. 115, but with more of the reddish dust. The rock is thus mottled.

112. This differs from No. 111 chiefly in having very little of the reddish brown material, and by containing numerous patches of a grey fine-grained clay-like substance, which was quite soft when the specimen was broken from its seam. For this clay see remarks under specimen No. 106, as it agrees with that save in colour and possibly in microscopic structure.

113. Sand from a reddish seam of this O.R.S. which had weathered so much that 3 or 4 inches of it could be scraped away with the side of the hammer. It consists of angular and rounded grains of minerals, and scraps similar to those mentioned for specimen No. 104, but with this there is far more of the reddish dust-like earthy matter and no siliceous bonding material. The rapid weathering of the rock is probably due to this earthy material separating from the larger particles under the action of the varied atmospheric conditions. A salt-spoon full of this sand could be graded into several sizes by shaking it in a small bottle of benzole, and samples of the grades mounted for the microscope in benzole-balsam. By such means most of the different ingredients could be identified.

114. Sand from a grey seam of the O.R.S. about 10 inches thick, which had weathered in the same manner as No. 113. This consists of substances, including green glauconite, similar to, those of No. 109, but all are somewhat finer in grain; and the white siliceous cement is replaced by a pale greyish dust-like substance, apparently of the same materials as those of the various grains. This material replacing the siliceous cement, is doubtless the cause of the deep weathering. Samples similar to this and No. 113 may be seen in old walls and buildings about Hereford City, the stones of which probably came from places nearer than Ross. This sand can be prepared for the microscope in the way suggested for No. 113. The finer materials of seams that supplied these sands were probably deposited in deeper water than Nos. 105 and 108, caused by the sinking of the sea bottom.

115. Thick seams of this rock indicate alternating conditions in the supply of materials similar to those of the greys in Nos. 108 and 109, and the reddish in No. 110. In No. 115, the fineness of the grains in

both colours, save some of the grey, together with a few scraps of mica suggest fairly deep water for the deposits while the difference in materials may be due to changes of current induced by alterations of level elsewhere. In those early days levels were changing at intervals of a few tens or hundreds of years, while remains of such are still seen in the undulating land in most districts of Herefordshire. Such changes still continue, fast or slow, in all parts of our unstable world.

116. Specimen of Old Red Sandstone from near the base of that formation where it is a little above the upper strata of the Silurian. In consists chiefly of rather small colourless quartz grains both rounded and angular associated with other minerals of a darker tint that gives the rock a drab colour, while those of reddish shades are relatively few. This came from a bank S. of Dodmarsh, 5 miles E x N, from Hereford situated at the margin of the wood covering the W. extension of Shucknall Hill, altitude for this bank about 250 feet. Exposures by the public road S. of the wood, are of Upper Silurian strata with abundant fossils. Farther S. about the base of a quarry close to Bartestree Convent a similar non-red, but micaceous sandstone occurs. The lower lying country N. and S. of Shucknall Hill is consequently early O.R.S. belonging to the upper division of this series of rocks and resting upon the Upper Silurian. Some of the Silurian of this Hill is tilted upwards very considerably as a result of the uplifting of the strata, while the Hill was doubtless considerably higher, at a former period before denudation.

117-123 From Bromyard 13 miles N.E. of Hereford. The fields, roadsides and other places show that the general rock of this district is of the Old Red Sandstone period, and mostly reddish; yet in some parts much of the rock is not of that colour, but greyish and pale brownish. The local walls indicate that seams of a hard fine-grained sandstone of the tints just mentioned, and from 1 to about 4 inches thick are abundant in the neighbourhood. These are illustrated by specimens Nos. 117 to 118, but the most interesting rocks observed are four varieties of Breccia (Nos. 120-123). A Breccia consists of large or small, more or less angular fragments of other rocks, united by binding material so as to form a new stratum of rock. A Conglomerate, on the other hand, is composed of broken pieces that are more or less rounded; which implies that the fragments, previous to being united, were subjected to considerable movement as by wind, water or ice. All this series of specimens are from the north of the town, altitude about 400 feet, and belong to the O.R.S. period.

117. A fine-grained greyish-brown, or drab flaggy Sandstone, consisting of partially rounded and angular grains, most of which are greyish, and associated with other minerals all bound together with a minimum of siliceous cement. There are traces of Lime, but not sufficient to allow the rock being termed a cornstone. The other minerals are tinted brown, ochre-yellow, black and white, some of which are evidently quartz. These minerals, additional to the quartz, resemble those in the Breccia mentioned below, but cannot be identified in either without adequate means and time. This rock was probably deposited in deeper water than the Breccias, and did not receive the coarser fragments they contain. In the early times the land and sea-bottom underwent many changes of level by the rise of volcanic matter, and shrinking of the Earth's surface; phenomena that still continue, although commonly on a slower scale.

118. A fine-grained brownish-grey or drab Sandstone composed chiefly of angular and half-rounded quartz grains, some of which are translucent, but most are pale-grey and light brown. This much resembles No. 117, including traces of lime, but the grains are somewhat coarser, and the layers of strata are thicker. In this specimen a narrow crack has been filled with clear quartz crystals in a manner described on previous pages.

119. A grey shale in thin layers and brittle. It consists of minute and microscopic grains of angular and half rounded grey and translucent quartz, associated with a small quantity of other minerals, including a little mica, all held together by a slightly siliceous earthy substance. Scattered through it are scraps of other items, the most conspicuous being patches of black matter, probably carbon, and a whitish calcareous substance, most of which materials are likely to be disintegrated organic matter; otherwise the rock has no lime. The materials for this shale were doubtless derived chiefly from the destruction of Silurian strata by river or sea, and deposited in fairly deep water. By the way, the word sea throughout these pages dealing with O.R.S. include both salt and fresh expanses of water, as absence of fossil remains affords no proof of either.[2]

120. A greyish crystalline Breccia containing innumerable specks of yellowish and brownish minerals which may be forms of dolomite from Silurian strata. With such are numerous minute grains of other tints, some being white, as well as an abundance of greyish quartz grains. All these are non-calcareous although the rock contains traces of lime which may have originated from scraps of broken shell, from various organisms, that are observed in some parts of the seams of rock. Here and there are partly denuded small stones that seem to be of Silurian rock, like the scraps of shell just mentioned. These varied enclosures are bound together by an earthy siliceous substance which makes the rock a very hard and fine-grained Breccia. The strata resist weathering fairly well because the items liable to such change are minute and scattered in thin layers between more resistant substance, so that a weathered surface appears as numerous thin seams that stand out from the harder material. This rock was doubtless formed near a shore in water too deep for active wave influence. The identification of the various minerals herein require careful chemical and microscopic analysis.

121. The basic substance of this rock resembles those of No. 120, and the larger pieces of minerals are similar except for their size, the mixture thus forms a somewhat larger-grained Breccia. When

exposed to the atmosphere many of the enclosed stones have weathered away, and left cavities that give the surface a very irregular appearance. The specimen behind shows a vertical aspect.

122. This is similar in general structure to No. 121, but more grey granular material is associated with the siliceous binding substance, and most of the enclosed stones of this Breccia are greyish rather than yellowish. This rock also contains more evidence of lime with the other ingredients. Local changes had brought to the basic material different substances for enclosure. It was probably laid down in shallower water than No. 120.

123. Specimen from another seam of Breccia having a similar but rather darker grey basic substance and more lime than either of the foregoing. Another change of surroundings had sent for enclosure more numerous and larger pieces of this yellowish rock resembling dolomite previously mentioned for No. 120, along with the grey of No. 122. The varied enclosures of these Breccias probably resulted from movement of the Earth's crust breaking up previously formed strata, altering currents of the sea, changing the course of rivers etc., and also to volcanic outbursts scattering earthy materials and volcanic matter over the entire district where the Breccia was being deposited. The results of volcanic heat are still very evident about the Malvern Hills, and in other places in Herefordshire and Wales. Igneous rocks brought by ice from Wales are scattered over the valley of the River Wye, as well as pieces of siliceous sinter. This sinter[3] is deposited from the water of hot springs, or eruptive geysers, and at present is abundantly produced in Iceland and other places. The chief materials of the Breccia were doubtless derived from the aqueous destruction of Silurian, Cambrian, and older strata then exposed at the surrounding district, but now mostly overlaid by more recent strata such as those of the Carboniferous, Permian and Triassic Epochs. Subsequent to the redeposition to form the Breccias the basic material has partly crystallised by chemical changes, probably resulting from the infiltration of calcite and silica in aqueous solution.

124-137.

At Lugwardine, 2 miles E. of Hereford there is an old quarry on the W. side of the village, it is of little depth, and has long been used as a rubbish dump. The varied strata are slightly inclined and belong to the Old Red Sandstone. The nature of the various layers of rock cannot be recognised without breaking, because all are weathered and overgrown with Algae, Lichens, Moss, etc. The general exterior tone being brownish suggests O.R.S. but no typical form of that rock, such as No. 115, occurs at this place. The upper strata are mostly of broken shale in thin layers, and much of it has become disintegrated and associated with the surface subsoil. Below the upper shaly portion the layers of strata are usually somewhat thicker, and appear more solid, but consist of varied forms of rather soft sandstone. The hardest is the lowest and thickest seam which appears only here and there above the rubbish. The rock obtainable here has no value beyond use for low walls and paths; yet the different forms are interesting when their structure is associated with thoughts regarding the conditions of their formation, which began probably more than eight hundred million years ago.

The various layers of coarse and fine grain rock indicate respectively shallower and deeper water for their precipitation. The surface movement of the Earth's crust that produced the raising and lowering of the sea floor were doubtless continued on the adjacent land, thus bringing different series of the former Silurian strata within the destructive power of the waves, and producing thereby variations in the new deposits. Of such deposits the finer would be carried to deeper water, farther from the shore than the coarser and heavier. From those movements we gain notions regarding the levels of the present surface of the land, plainly indicated by the undulating nature of Herefordshire and its surrounding districts where the levels above sea range from about 65 to over 2,000 feet. These extremes, however, occupy small areas and we may consider the major part of the County lies between 150 and 400 feet above sea, all of which has been sea floor probably several times. Such changes of level whether slow or fast would change direction of currents in seas and rivers that would carry new materials to be deposited on previous sediments, and the same phenomena still continue. With these matters we must keep in mind the various observations which indicate that probably the great oceanic depressions, to a depth of about 6 miles below sea-level, and existing igneous mountains of continents to about 5½ miles above sea level, have perhaps occupied an approximately similar position since oceans formed upon the cool and solid surface of the world. This implies that around existing land areas, beyond a depth of perhaps three to four miles, or less, the present bottom of the deep oceans has probably never been dry land. The lowest existing land below sea-level is the shore of the Dead Sea, about 1,300 feet down, but it varies considerably with wet and dry seasons. The river Jordan, besides about 60 small streams, flow in to it, but there is no outlet save evaporation by the semi-tropical sunshine, and dry atmosphere; on that account the water is gradually becoming more saline, because these salts are being added to continuously and evaporation leaves them behind. Material dredged from the floor of the deepest part of the oceans consists chiefly of exceedingly fine-grained reddish or brownish clay, and does not correspond with substances that constitute the rock of any geological age; while in somewhat shallower parts, but still many thousands of feet deep, deposits similar to some rocks e.g. Chalk, Radiolarian Chert, Diatom-ooze etc. are still being produced. These substances consist mostly of the calcareous and siliceous microscopic shells of organisms living in the water above, while after death their cases sink to the bottom and form rock.

The materials of the various strata of this quarry indicate their origin was chiefly by the wearing action of water in motion upon previously formed strata. At the time when these seams were deposited the outlying portions of the Malvern Hills, now 12 miles to the E. probably extended their more ancient series of rocks farther westward. These were denuded by the local position of the Old Red Sandstone sea; while intermittent volcanic materials such as reddish quartz grains, from both aerial and sub-aqueous vents became associated with the remains of denudation forming mixtures, patches or separate layers of strata. It would be of interest to know what rocks underlie the O.R.S. between Lugwardine and the Malverns – whether Silurian, Ordovician, Cambrian, or a mixture of them.

This shallow quarry is surrounded by trees, and in several places these well illustrate the manner by which their roots penetrate between the layers of rock, and into their cracks, often splitting and crushing them in various directions, especially when swayed by the wind. Roots that would have a diameter of 3 or 4 inches in soil are compressed in the cracks to a thickness of ½ to ¾ of an inch, and 8 to 10 inches wide. A bunch of fibrous roots given off from a main flattened root is exhibited. This was found in a vertical cleft 10 feet below the surface, and was surrounded by a small amount of fine dark soil, due partly to the action of the rootlets on the rock by their normal chemical process, and partly due to surface soil being gradually carried by rainwater through the crack. Such splits also admit air and small animals so that in the course of time these, and other agents, such as the never ceasing chemical changes, slowly synthesise portions of the living, dead, and mineral substances to a complex subsoil. The quarry is worth a visit for the study of such matters, for they are natural forces that serve a geological purpose as well as their own. No fossil organic remains were found here, and lime was exceeding scanty, occurring chiefly in very thin layers of a form of mudstone that here and there is intervened between the sandstones as in No. 126.

The specimens exhibited from this quarry are placed in order of succession from the earliest, exposed at the base, upwards to the more recent.

124. Emerging from the rubbish at the bottom are thick seams of rather soft, pale brownish, slightly micaceous sandstone, the grains of which are of medium size and mostly rounded. About half of them consist of colourless quartz, while the remainder are of various other materials which give the rock its colour, the most abundant being a yellowish brown quartz; a few green grains are probably glauconite, while the blackish minute particles may be magnetite or augite. It is impossible to distinguish such small items with a pocket lens, their identification requires specialised microscopical and chemical methods not at present available. The grains are loosely united by a trace of siliceous matter, and not by an iron oxide as in typical hard Old Red Sandstone. For this reason the rock is readily broken by the hammer, and crumbles readily by weathering as may be observed at garden walls of the neighbourhood. With some forms of quartz-sand rock, as previously mentioned, the siliceous cementing material is abundant, and such rock is hard and usually difficult to break.

125. A very fine-grained, micaceous, brown Sandstone formed in thin shaly seams. In consists chiefly of brownish quartz grains, with numerous black particles of magnetite or augite, traces of greenish glauconite, and an extremely fine-grained dark material which is probably volcanic dust. The narrow, straight and horizontal layers of different thicknesses, with alternating lighter and darker zones of colour (shown in vertical view by the back specimen), together with the minute grains of minerals,

indicate deposit in rather deep water with very little current or change in supply of substance, save for the very narrow dark zones which are probably volcanic dust from aerial or sub-aqueous vents.

126. A very fine-grained, light, grey, slightly micaceous Sandstone formed in thin shaly seams. It consists chiefly of colourless and grey quartz grains with a small quantity of other minerals, of these the most abundant are green glauconite and black dust-like particles probably of magnetite and augite. About this shale are small patches of fine-grained material of a brownish tint similar in substance to the lighter zones of No. 125. These patches appear as if sub-aqueous eruptions had prevented the material from forming a continuous stratum while portions of it fell often into the forming layers of this No. 126. The fine grain of this shale indicates deposit in fairly deep water. As alluded to above one side of the shaly seam of sandstone is united with an extremely thin layer of a variety of mudstone containing some lime, along with a few spread out patches of the brownish material. It seems probable that a change of current, combined with other alterations had deposited the mudstone on the recently formed sandstone, while into it fell scraps of the brownish material from similar sub aqueous volcanic outbursts.

127. This rock consists of brownish and greyish layers of very fine-grained micaceous Sandstone, altogether about 30 inches thick. It is best seen about 6 feet above the deepest corner of the quarry. The zones of colour resemble in material the foregoing Nos. 125 and 126, and probably came from the same original sources of supply. But after these rocks had been laid down there were changes in the features governing the direction of the currents, yet the flow of these must have remained slow in order to deposit such fine materials, the new currents were in different directions without regularity in periods of change. This resulted in the deposits being laid down in various thicknesses and overlapping one another, without the regular order of precipitation shown by No. 125. This is a small example of irregular stratification termed current-bedding or false-bedding when on a larger scale. In some examples many times the present thickness of strata may be involved, and it occurs in the geological formations of most Epochs. Gigantic examples are seen among the earliest of the world's sedimentary rocks on the W. coast of Ross-shire; the red and brown sandstone of these cliffs is known as the Torridon Sandstone, and is of the Pre-Cambrian Epoch. The disorderly arrangement of these Lugwardine deposits indicate that the variations of the currents were not seasonal changes, but were more probably the result of altering levels of portions of the sea-floor that would divert the direction of flow. A present long-standing example of reversed flow on a large scale is at Portland Island, Dorset, which reverses the local littoral portion of the general current in the English Channel, which is from W. to E. On this account stones from the coastal areas of the W. brought by the general current along the sea-bottom, and washed against the Island, are returned N.W. along the great beach called the Chesil Bank. On this journey rounded and often flattened stones, broken as angular fragments from the Devon sea cliffs, and one to four inches in diameter near Portland, are by wave action reduced to fine sand near Bridport 16 miles distant.

No. 127A shows a vertical view to illustrate the irregular thin layers mentioned above, compare with No. 125.

128. This rock is a mixture of dark brown and pale grey sandstone, the grains of which vary from a medium size to rather coarse. The two colours are interstratified after the manner of Nos. 126 and 127, and the layers of strata are one or two inches thick. The grains being loosely held together with a mere trace of siliceous binding matter make the rock brittle. The grey portions consist of half-rounded grains of colourless quartz associated with grains of yellow and yellow-brown quartz, with a sprinkling of mica, glauconite and other minerals. The dark layers are composed of less rounded and more angular quartz grains, chiefly of a smaller size and of various dark colours, with a sprinkling of other minerals; among those items there is a small quantity of fine dark matter without perceptible grain, and helping to hold the main items together. The quartz grains of the dark layers appear corroded as if burnt, while their angularity also proves they have not been subjected to reductive wear by either wind or water. These dark layers are probably volcanic sand and dust blown from a vent possibly hundreds of miles distant, but probably from the area about Builth, or from the district now called Devonshire. Such material falling to the bottom of comparatively shallow water

became interstratified with the normal lighter coloured deposit. With regard to the Devonshire area, that, and probably much now under the sea, was the site of considerable volcanic activity from about the middle of the Silurian, and through the Devonian to the earlier portion of the Carboniferous period; known by the igneous matter included in the strata of the three Epochs.

129. A sample from a shaly layer similar in composition to No. 128, but with less material of the dark seams. This stratum, moreover is associated on the upper side with a very thin deposit of a fine-grained micaceous sandstone, united with it after the manner of the mudstone with No. 126. The finer-grained material again indicating a change of depth or current, or as a combination of both.

130. This layer of shale laid down subsequent to Nos. 128 and 129 closely resembles them, but the grains of the grey quartz are of rather larger size and were thus probably deposited in rather shallower water due to the sea-bottom rising. Another difference is that it has less of the dark material in seams and patches, although more of it is scattered through the whole rock giving it a somewhat darker tone. These features seem to imply that the volcanic discharges were more continuous as time advanced.

131. This is subsequent to No. 130, and is very similar to it, but has rather less of the dark material.

132. A sample deposited subsequent to No. 130 and of the same nature as it, but containing less of the dark material which is diffused through its substance. From this we glean that the volcanic action was languishing for a period and merely scattering its sand and dust in small occasional showers. Similar varieties of strata represented by Nos. 128 to 132, occur at other places in this area. Such are readily seen at the cutting where the road from Tupsley to Lugwardine dips down to the plain of the River Lugg. These strata, also being weathered, must be broken to reveal their structure.

133. A very fine-grained grey, micaceous Sandstone in thin shaly seams. The general structure resembles the above No. 126, but has more mica. It also exhibits, although faintly, the straight, thin, horizontal layers of stratification and traces of the brown material of No. 125. Such matters, along with the fineness of the grain, indicate a change to deeper water than that in which Nos. 128 to 132 were deposited under, and probably due to the floor of the sea sinking in response to surface movements of the Earth, while the materials suggest a change of current. At that early period of the world's history the results of internal heat must have been more widely-spaced at its surface than at the present time since it has been gradually cooling during the past 800 million, or so, of years; a period about the middle of the time between the first formation of oceans, and the present Epoch. During the next period of a similar number of years from the present time, how terrible will be the wars for living space and food between the nations, if they continue to increase at a rate similar to that of the past 200 years. With a continuation of such conditions the only alternative to blood-letting will be something in the nature of wholesale poison gas administered periodically by the most successful tribes. Certainly a repetition of the Axis plan every thirty years, or so, will not be popular among peaceful, thinking folk.[4]

134. A pale brownish, slightly micaceous Sandstone with medium sized rounded and angular grains of colourless quartz, and found in thin shaly seams. About half its bulk is of yellow and yellow-brown quartz grains with other darker minerals, and it is to those its colour is due. The volcanic matter of No. 128 is absent. Compared with No. 133 below it the difference in grain and material leads us to infer another change of depth and current.

135. A fine-grained, brown, micaceous sandstone formed in shaly layers. The general material of this rock resembles that of No. 125 but in addition to the grains being somewhat coarser there is more mica. The layers are also rather thicker, and do not exhibit the horizontal seams of stratification, nor the dust-like material. The present rock is also associated with an upper thin layer of fine-grained light-grey sandstone similar to that of No. 129 below it. Compared with the coarser-grained No. 134, this rock indicates another change to deeper waters and of current bringing different materials. These substances were probably from the sources that supplied the essentials for Nos. 125 and 127, or

perhaps by rocks undergoing destruction caused by alterations of land level, or to land slides, the latter still being frequently occurring on existing coasts, especially during wet seasons.

136. This closely resembles the brown of No. 135 occurring below it, but is rather finer in grain and less micaceous. It was probably derived from the same source as No. 135 after an interval of time, and was deposited as thin shaly layers in fairly deep water. Above this rock lies broken shales, rubble, and surface soil.

137. Example of the roots mentioned on p.75. This is placed at the back of the show case. [this no longer exists, having presumably decayed].

This quarry is an excellent place for a beginner to study; it is easily worked over, and supplies numerous objects of geological value. A beginner is advised to do a little at a time, and think about his job; even an expert cannot profitably rush at geology.

138-142.

Mansell Hill, near Byford, 7 miles W x N from Hereford has an altitude of about 450 feet; it is covered with trees, below which a luxuriant growth of brambles with other bushy plants and bracken encumber the ground. The abundance of large fruited blackberries (about 50 wild species or varieties in Britain) indicate a supply of lime for their roots. This undergrowth, with its decaying remains covering the ground, renders impossible the gathering of an adequate set of rock specimens, and their proper sequence, without tools and sufficient time. The same growth makes inaccessible small quarries situated about the Hill. Judging from what could be observed the foundation rock of this Hill is Old Red Sandstone that differs from the normal colour of that deposit in being of purple and grey tints. The grey appears to occupy the higher part of the surface, but whether above or below the purple in sequence of stratification could not be determined, nor could other types of rock be seen; but from observations in other parts the purple is below the grey. Towards Farley on the N.E. of Mansell Hill the ground rises again to about 450 feet, and the arable land near that place has the distinct reddish tint of the normal O.R.S., while from near the base of Mansell Hill, and half a mile onwards the fields have a much lighter colour such as the grey rocks might afford. Southwards is the River Wye, the banks of which consist of alluvium and rounded stones of various kinds and sizes, mostly of Welsh origin, while a few are O.R.S. The arable fields also have similar rounded stones which also occur on the adjoining Mansell Hill. Such stones are doubtless remains of the last Glacial Epoch. They do not occur abundantly about the arable ground, because in former times the land owners and farmers gradually removed them in order to improve the ground and provide road metal, etc. and many heaps of such stones still remain in reserve. On Mansell Hill such rounded stones also occur especially among the roots of fallen trees. A few of the same kind were seen in Offa's Dike [in?] places where the undergrowth of plants did not inhibit observation. This Dike – a date about 770 A.D. – runs over the Hill from S.E. to N.W. and is merely a trench 3 or 4 feet wide and deep, the material from which forms a rampart on the lower side, while on the upper side of the trench a stout wall of uncemented stones offers another impediment to an upward advancing enemy, the defenders behind it could shoot their arrows in comparative safety. Across the Hill oblique to the Dike are the remains of another wall that formerly divided Wales from England. These walls are formed chiefly with stones from the local O.R.S. rocks, and probably obtained from the small quarries previously mentioned; while rounded glacial stones that were perhaps gathered about the Hill, occur among them. Some of the rocks hereabout contain a small amount of lime, and such stones gradually weathering on the soil liberate portions of lime that renders the ground advantageous for grain and other crops; consequently such rock is often termed Cornstone. No evidence of former living organisms was found in any rock of this district.

138. A very fine-grained purplish-grey Sandstone destitute of lime, or in some parts with mere traces of that mineral, and without, or scarcely any mica. It occurs both in thick solid layers and as thinner shale-like seams. The minute, partly rounded, and angular quartz grains of which it mainly consists, are of various tints – grey, bluish-grey, blackish-grey, brownish and colourless, while scraps of glauconite and augite occur here and there. The whole being bound together with a greyish siliceous

cement results in the rock being hard and tough. It appears to be but slightly affected by weathering, and this, with its other features, make it a good building stone for public erections, but too costly to work for the speculative builder.

139. A grey Sandstone composed of small and medium size colourless, grey and brownish quartz grains both rounded and angular, with scraps of other minerals, scattered grains of mica and traces of lime; these items being bound together with a pale-greyish siliceous cement. This rock occurs in shaly layers an inch or so thick, and was doubtless laid down in shallower water than No. 138.

140. A medium to fine-grained purplish grey Sandstone composed of minute rounded and semi-angular quartz grains of various tints, along with a few other minerals, the combination of which give the rocks it purplish-grey colour. Grains of mica are scattered throughout it, while lime is absent. Here and there are small patches of reddish-brown mudstone, minute scraps of the same being mixed with the greyish siliceous matter that binds the whole together and forms a hard rock. It occurs in rather thin shaly layers, as well as other a few inches thick. The grains are somewhat coarser than those of No. 138. It was doubtless deposited in rather deep water, and a careful chemical and microscopical analysis would probably reveal the presence of volcanic matter in it.

141. A rock similar in general features to No. 138, but it is a little coarser in grain, has a greater abundance of the greyish quartz grains and binding material, while there is a little more mica; and these slightly modify the general colour. It is probably a forerunner or continuation of the same deposit as No. 138, and occurs in thin shaly seams as well as in thicker layers.

142. This is a variety of [the same] rock as No. 141 with somewhat more of the reddish quartz grains.

143-146.

Specimens from a railway cutting a little past Hereford College on the road to Holmer. The strata here are Old Red Sandstone of grey and purple-grey tints rather than browns and reds. Their fineness of grain, mixture of different colours, and abundant micaceous dust, especially of the thinner layers, give these strata an appearance quite discrepant with that of the normal O.R.S., while similar deposits extend at or near the surface of many districts in the County. Below the upper clayey soil these strata are inclined upward to the N.E. in seams of varied thickness. Some are a foot or more thick alternating with others only a few inches or less than one inch. Between the thicker seams are numerous layers of shale each from $^{1}/_{8}$ to ½ an inch thick. These shaly layers have weathered to dust for a few inches inwards, so that the thicker seams remain as narrow shelves. These rocks are all brittle and worthless for building purposes; they contain no fossils and are destitute of lime.

143. This is a rather fine-grained Sandstone, one portion of the layers being coloured purplish-grey, while a smaller portion is plain light grey. These colours indicate alteration of current, or materials it carried to the place of deposit. The purplish part is composed of rounded and angular grains of quartz in various sizes but mostly rather small, many are colourless, a lesser number being reddish, brownish, or grey. In addition there are several other minerals of various sizes and colours. That assortment is loosely held together by very minute grains of quartz mixed with a non-granular siliceous matter in small quantity, which accounts for the rock being readily broken. Most of the material of these strata has been derived from the denudation of older rocks, while other minerals are of volcanic origin, and the combination results in the general colours. An analysis of the rock would be of interest, and probably indicate where some of the minerals came from, that is if the composition of the other rocks was known. The light-grey portion is of similar minerals with a much greater number of colourless and whitish quartz grains. Scattered through both forms of the rocks are grains of mica. In some of the seams the two main colours alternate with one another.

144. Similar to No. 143, but from a seam lacking the light-grey layer, and with more abundant mica.

145. Similar in materials to No. 143 but the general colour is of a darker purplish tint, the grains are smaller and more uniform in size, and the rock is formed in thin shaly layers, some being entirely of either purple or grey, while other layers are composed of both colours.

146. In materials this is similar to the foregoing samples, but the grains are rather coarser in size, and the rock also occurs in thin flaggy or shaly seams but is not so brittle.

Such strata which are deposited in this and variable layers, have, doubtless been laid down at a much faster rate than rocks in layers of considerable thickness without much variation of materials. The thin layers having been formed within the influence of shore currents, or those from rivers, while the more solid rock has been deposited in deeper water beyond the immediate influence of the agents mentioned. An advanced student would find much of interest in working out the minerals of these rocks and comparing them with those of the Silurian strata and the still older rocks remaining in the Malvern Hills.

147-153.

Specimens from a small quarry, altitude about 300ft. above sea, ¼ mile E. x S. from Pipe and Lyde Church which is 3 miles N. from Hereford. This quarry in the Old Red Sandstone series has not been worked for about 50 years, and is now overgrown with trees, brambles and weeds. The durable grey and brownish rocks, used for some of the buildings of the district, were mostly obtained from a tunnel in the quarry, but this is now inaccessible. Much of the upper rock is of brownish or reddish shades, some layers of which have dark and almost black seams running through them. These upper layers are mostly in flags from ½ an inch to 2 or more inches thick. Some of the lower seams are much thicker, and of both brown and pale-grey colours, while others are mottled by a mixture of the two shades. Some of these mottled layers are very micaceous.

147. A very fine-grained greyish-brown sandstone formed from flags from ½ an inch to 2 inches thick. It consists chiefly of minute half-rounded and angular brownish quartz grains associated with a similar quantity of grey and translucent grains of the same mineral. A considerable number of smaller specks are blackish, with a sprinkling of equally minute green and yellow particles and flakes of mica; all the mineral grains being held together by a scarcely visible siliceous cement. The front specimen shows the mica grains on the plain of stratification while the piece behind shows a face vertical to that plane.

148. This is also a fine-grained Sandstone and closely resembles No. 147. Differences are that the colour is rather lighter, and the grains more variable in size, the largest being just visible to the unaided eye, while the mica is more abundant. The grey material runs through the rock in very thin seams, so that a surface which has been broken uneven to the plane of stratification shows the grey as patches like the specimen in front. This rock was doubtlessly derived from the same original material source as No. 147, but laid down in somewhat shallow water.

149. A rather coarse-grained mottled Sandstone, the two main colours being reddish-brown and pale-grey, while irregular streaks of very dark grey, or almost black, pass through it. The last-named is dark because the normal grains are associated with roughened, dark quartz which appears to have been burnt, but not fused, by volcanic heat, and thrown out from a vent intermittently. The main portion of the rock consists of half-rounded quartz grains of the colours mentioned, and a sprinkling of other minerals, all being held together by a little siliceous cement, so that the rock breaks readily. It was probably deposited in much shallower water than No. 148 from a similar source of supply for the brown and grey materials.

150. Specimen from a fine-grained, dark greyish-brown Sandstone having streaks of still darker grains than those of No. 149. The lighter coloured portion is composed of half-rounded quartz grains of various tints, the greyish-brown being predominant. The dark streaks consist of angular, roughened dark-grey quartz grains (angular and rough because they have not been subjected to much movement by water or air). Associated with those dark streaks are minute black grains and grainless matter

which appears to be a dusty volcanic-tuff, now more or less consolidated. While this rock was being deposited in rather deep water there were periodic volcanic effusions, from which the materials of the dark streaks were laid down with the more normal materials. Sections of the rock prepared for use with a microscope would enable one to identify the minerals of which it is composed. For this purpose a proper geological microscope is necessary, so that the light, when passing through each scrap of mineral can be modified by the apparatus in a way that causes it to differ from that of all other minerals.[5] The correct use of such an instrument, requires, of course, considerable skill in the identification of the substances. (Simple books for beginners on this subject are – 'Minerals and Microscope', H.G. Smith, plain illustrations; 'Modern Lithology', E.H. Adye, many coloured illustrations. Every student will improve his mind even by looking through these books.)

151. This specimen is from another layer of strata having features similar to No. 150, but, the normal mass of rock has been darkened by a more frequent small supply of the volcanic materials. These, especially the tuff, are occasionally abundant and form thin layers in the normal rock.

152. A sample of sandstone, composed of medium-size rounded and angular quartz grains, in which irregularly disposed areas of pale-grey and reddish-brown give the rock a mottled appearance, and thus, with abundant specks of mica, make it rather handsome. As a building stone, however, it would probably not withstand the weather, as the grains are held together by a scanty cementing substance. The grey portions consist of angular and rounded quartz grains of medium size and that colour, with which are mixed many that are translucent or reddish, while a few grains of other minerals occur. The reddish-brown parts are chiefly formed by similar quartz grains, but of that hue, while flakes of mica abound in each colour. Splashes of the volcanic matter, previously mentioned, also appear in many parts of the rock.

153. This Sandstone is similar in composition to the grey of No. 152, and contains very few of the brownish grains, save that occasionally these form thin layers in the grey; while the mica is far less abundant. When an obliquely broken surface is held at a certain angle with the light small areas of it shine like mica. This is due to refraction from small local groups of translucent, minute quartz grains, most of which have their angles so placed as to reflect most of the light falling on them from a particular direction. The grains of rock are firmly cemented together with a siliceous substance, consequently it would be a good and pleasing building stone if enough could be found to pay for working.

154-162.

Between Bartestree and Dormington, about 4 miles E. from Hereford, there is a large Roman Catholic Convent readily seen from the public roads both near it and from that above it. From the upper road one sees at the E. side of the Convent the ground rising a little on the hillside to form a low mound covered with trees. From this mound extends a low ridge, due to a rise of the surface, extending southward towards The Monument. Both mound and ridge owe their origin to an upthrust of lava through the Old Red Sandstone from the Earth's molten matter beneath the solid surface. This lava plug was forced up probably during the Carboniferous Epoch when a considerable amount of such activity was continuing from the Silurian Period. It is probable that the lava originally extended over the surface to some extent, if so it seems to have been denuded away save for the mound and the ridge. The surrounding ground, being private and devoted to agriculture, cannot be dug into without a certain amount of difficulty by a stranger, who wishes to examine the sub-set in order to test for lava or O.R.S. below it. From the lower road adjoining the grounds of the Convent, an elongated quarry has been excavated into the mound mentioned above, its long axis running from N. x E. to S. x W. This quarry is narrow at the entrance but widens inwards towards the rear where the lava is fully exposed. The quarry was probably excavated for obtaining the hard lava as road metal. Such work has long been discontinued and owing to the fertilizing action of the disintegrated surface of the lava, and lime it contains, the bottom of the old quarry is covered with rank vegetation, especially sting [sic] – nettles *(Urtica divica)*, which drawn up towards the light above grow from 4 to 7 feet in height. On that account a visit during winter would be more pleasant and profitable. The dip of the strata about Mordiford 2 miles southward indicates that the coral reefs of the Silurian at that District probably underlie the O.R.S. of this quarry. That would account for the lavas having brought up small quantities of lime in passing through such reefs. This lime in the lava has, of course, been fused, and much of it is contained in cavities of various sizes in the hardened rock, as well as in the cracks. During the period the quarry has remained unworked the atmosphere and rain have considerably weathered both lime and lava, with the result that the surface of the once black rock is now partly whitened by liberated lime. Distinct varieties of Old Red Sandstone are exposed in this quarry. One form is the ordinary reddish-brown of rather fine grain, and another is a drab micaceous Sandstone assuming the form of flagstone in the mode of formation of its strata. Portions of each kind of rock have been fused by the lava, or altered in less degree when somewhat more distant from the once molten matter; a series of such alterations can readily be obtained from each side of the lava plug (or dyke), see specimens Nos. 158 – 161. There is also a pale-grey micaceous Sandstone of the flagstone type. The colour being due to a greater abundance of rounded, colourless quartz grains of larger size than those of the other rocks, and containing but small proportions of the darker grains common to the strata of that Epoch. None of the last mentioned rock was found altered by heat. All these Sandstones are of the early period of the Old Red Sandstone deposits of Herefordshire. The specimens exhibited from this interesting quarry are limited in number by the space available.

154. An example of the blackish Lava that had probably crystallised between cracks. Each smooth side represents the face of a crack and shows a very fine-grained crystalline condition. Traces of quartz and ferric oxide had penetrated from the fused O.R.S., and the latter had slightly stained the lava. This lava is technically known as analcite dolerite (the first name is also called analcime), and was probably thrust up during the Carboniferous Epoch, and similar lavas in other districts are known to be of that period. Dolerite is one of several kind of rock of the lava group, and there are several varieties of it, each being characterised by certain minerals it may contain. Analcite is a glassy mineral, and was long considered as volcanic glass, from which it can be distinguished only when it exhibit its crystalline condition. Rocks of its class were formerly known under the general name of Greenstone. An example of a similar upheaval on a gigantic scale, resulting in a slightly different volcanic rock, is the whole Isle of May at the entrance to the Firth of Forth from the North Sea, and 11 miles from North Berwick. For description and illustrations see – 'Proceedings of the Royal Society of Edinburgh vol. 5 – Part II – (No. 6) 1909-1910 pp 173-177 Figs. 118-124. This and a companion contribution by the present writer may be consulted in the Hereford City Library by requesting an assistant for them. [no longer available]

155. A sample of the lava which is more grey than black, not so crystalline as No. 154, and with a patch of impure lime which it had fused and brought up from the Silurian coral reefs, or limestone below. There are also minute scraps of fused silica a strip of which is seen at one side of the white line. Traces of the fused Red Sandstone, and stains from its ferric oxide also occur.

156. Another specimen of the blackish Lava showing some of the features already mentioned.

157. An example resembling No. 156, but from another portion of the dyke.

158. A specimen of the Lava adjoining the Old Red Sandstone with which it had fused, and consequently became brownish thereby.

159. A sample of the Old Red Sandstone of fine-grain which had been burnt but not fused, by the lava, so that its grains of mica have recrystallised, while its reddish-brown patches are stains from the ferric-oxide of the O.R.S.

160. Another sample of Old Red Sandstone of fine-grain, reddish hue, and deposited in layers a few inches thick. Taken from another side of the lava plug, by which it has been burnt and much discoloured, but not completely fused.

161. A specimen of fine-grained Old Red Sandstone normally of a reddish hue and occurring in thinner layers than No. 160. Taken from nearer the lava plug, by which it has been almost completely fused and more discoloured than No. 160.

162. Another specimen of the brownish-grey Old Red Sandstone similar to No. 159. Taken from the other side of the lava plug which has also heated and discoloured it, but it has not been fused.

163-165.

Six miles S x W from Ross is the village of Symonds Yat, in the neighbourhood of which rocks of the Carboniferous Epoch occur at the surface. These are followed westward by the Old Red Sandstone as far as Abergavenny, west of which the Carboniferous again occur and cover the greater part of S. Wales. Herefordshire has therefore small claim to this important series of rocks.

163. Is a grey crystalline limestone including a few specks of other minerals, and crushed remnants of organisms.

164. Is a lighter grey crystalline limestone with a few inclusions.

165. Is a drab non-crystalline limestone.

166-175.

At the southern part of the Malvern Hills continuing to the district around Broomsbarrow, strata of the Permian and Trias Epoch; extending from Worcestershire, overlie the older rocks. What these older rocks are can be discovered only by digging or boring downwards as there is but scant evidence at the surface, and they may range from Gneiss and Pre-Cambrian to Carboniferous. The most conspicuous of the surface strata are the fragile Red Sandstones of the Trias which are evident at roadside cuttings, made to graduate the inclination. This material is also quarried for sand because the loosely compacted rock readily breaks into separate small grains, see Specimen No. 175. The older Permian rocks are not so easily recognised as they often resemble some of those of the more primitive Cambrian Epoch.

166. A fine-grained flaggy sandstone of the Lower Permian from the S. side of Coal Hill. This has been deposited in alternating lighter and darker layers, which are visible when [the] specimen is seen at a certain angle with the incident light. Such layers are probably the result of seasonal changes bringing slightly different materials for deposition. This rock is without lime, and consists of brownish, reddish and colourless grains chiefly of quartz. Some that glisten in the light may be scraps of mica. Here and there are greenish-grey spots or granules, probably composed of quartz and glauconate grains. The colour does not change much by weathering.

167. A variety of No. 166 from another part of Coal Hill. This is also without lime, and has but few of the greenish-grey spots, but is associated with a narrow seam of the same colour and probably of the same minerals. This narrow layer is a fine-grained sandstone, and indicates a change of current bringing different materials for deposition. There are also numerous minute black spots which may be volcanic dust.

Coal Hill is so named because the rocks were mistaken for those of the Carboniferous Epoch, and that error led to fruitless excavations for coal. Possibly the owner did not first consult a geologist!

168. A fine-grained sandstone paler in colour than the foregoing, and with grains slightly coarser. These consist chiefly of brownish, greyish and colourless quartz mixed with other minerals, which together give the flags a yellowish-brown tint. This is also Lower Permian although it resembles some of the Llandovery sandstones of the Silurian. It came from the S. side of Coal Hill towards Broomsberrow Palace.

169. A greyish-brown sandstone consisting of medium size quartz grains of various colours and shining micaceous specks, there are also black spots similar to those of No. 167. This is also a Lower Permian rock, and came from a little more to the South than No. 168.

170. A brownish sandstone similar in minerals to No. 169, but without mica. Parts of it have more of the brownish and reddish earthy materials which are often in larger granules than those that form the bulk of the rock. It has no lime, and the larger granules seem to indicate a tendency towards Permian Breccia, see No. 173. This was gathered somewhat farther South than No. 169.

171. A reddish-brown sandstone without lime, and showing the alternating lighter and darker layers similar to No. 166. With reddish brown grains, most of which are quartz, there are particles of angular fragments resembling those of No. 170 but larger. It came from an exposure somewhat nearer Broomsberrow Palace.

172. A greyish purple sandstone without lime and occurring in flags. The grains vary from fine to coarse, and include small pieces of quartz and other rock. At some parts of this strata many of the granules are quite coarse and angular thus making the rock resemble Breccia. This again belongs to the Lower Permian series, and is inclined to become blackish on the outside by weathering.

173. This reddish-brown sandstone rock, being composed of varied fragments, corresponds with a Permian Breccia. It comes from the S.W. side of Chase End Hill.

Fossil remains of plants and animals are scanty in most Permian strata of Britain, and none were seen in the district above-mentioned. During this Epoch the conditions appear to have been unfavourable for living things in most of what is now Europe. Possibly arctic conditions prevailed for a long period, and for this there is evidence shown by the extensive areas of ice-scratched stones and rocks that occur in many places that were then above sea-level.

174. This friable red sandstone rock belongs to the Bunter section of the Lower Trias Epoch, which is in the period next after the Permian. It occurs at the surface about Broomsberrow Heath, where there is a quarry, and other exposures may be seen at roadside cuttings made to equalise the gradient of the roads. These exposures consist of seams of bright red sandstone that are variously inclined, because they have been uplifted by surface movement of the Earth; such movement may have been due to more recent action of the Gneiss which raised the Malvern Hills. The "stone" is merely slightly compacted sand, the grains of which are mostly red quartz of various small size and rounded. With these are associated a small quantity of minute white and colourless quartz grains; these cause the "rock" to exhibit a pale greyish streak on the face where a chisel splits it. There is very little siliceous or other material binding the rock together, hence the rocks readily crumble to sand, and is excavated at the quarry for sale as sand. The specimens shown in small blocks have been soaked in gum water to bind the grains together, and the gum slightly dulls the bright red exhibited by the strata *in situ*. Larger pieces were originally gathered, but the writer, when returning to Hereford slipped on some oil scattered over the road, and falling on his collecting bag, broke the specimens. Then it was too late to go back for more.

175. This is simply the above mentioned stone reduced to sand. These grains much resemble those from a desert where they have been reduced and rounded by the action of wind, instead of by water as more normally the case. Then the quartz grains are red throughout, and not merely stained on the exterior, or with reddish streaks like much of the Old Red Sandstone. Difficulty therefore arises in tracing them to an original source; possibly they are of volcanic origin blown from vents as dust, and reduced by desert conditions.

NOTES ON GLACIAL SPECIMENS BEGIN WITH NO. 176

176. White siliceous Sinter with numerous spots on the broken face. These appear to be due to ferric oxide, and on the rounded exterior this has disintegrated and left holes. Found at the Swainshill glacial

moraine. It probably originated in springs of hot-water about the volcanic district N. of Builth in Radnorshire. Such springs hold silica, calcium and other minerals in solution and the water becoming super-saturated the minerals are deposited. This probably happened there about a thousand millions of years ago, and the process still occurs in many active volcanic districts, as for example in Iceland.

177. Of similar nature to No. 176, but there has been more general staining by the ferric-oxide. From the same district as No. 176.

178. A rounded pebble of siliceous Sinter from the terminal glacial moraine at Portway. The rounded little holes appear to be sites from which ferric-oxide, perhaps mixed with other substances, has decomposed. It probably originated in the same manner and place as No. 176.

179. Volcanic Scoria[3] (a variety of dross or ash remaining from molten substances.) The white material is calcareous. Found in the same moraine as No. 178, and probably originated in the same ancient volcanic district.

180. This is a fine-grained Gneiss (compare with No. 5A from the Malvern Hills and No. 181 from Eardisley). The various specimens – Nos. 180, 182, 183 and 185 were all gathered at the Swainshill glacial moraine; their original site was probably the ancient volcanic area N. of Builth in Radnorshire. There the Silurian strata overlaps the older Ordovician, and during the formation of these strata volcanic activity seems to have been frequent. Volcanic dust is of common occurrence in the adjacent rocks of these Epochs, and with a lens some are seen as minute blackish specks singly or in small groups, and may be scraps of biotite. Such dust can be carried great distances by air currents. That from Krakatoa (between Java and Sumatra) in 1883, was carried around the world three times.

181. A Gneiss of medium grain with white quartz granules. Compare with Nos. 180 and 1 to 5A, and this variety will be found intermediate in grain. Gathered in the fields between Eardisley and Staunton, but it originated probably from the ancient volcanic area about Builth in Radnorshire.

182. A form of black volcanic lava that has burnt carbonaceous matter, and this produced a species of Anthracitic shale.

183. Another variety of No. 182.

184. Another variety of volcanic lava of a dull black colour. This is one of the numerous species of Rhyolite. Compare this with the large specimen, too big for [the] case, which was found in boulder clay that forms part of the River bank at Castle Green, Hereford. That large specimen was obtained when the water was very low through drought. Boulder clay is a form of that substance deposited by glaciers, and containing stones of various sizes. This black rock probably originated in the volcanic area N. of Builth.

185. Another species of Rhyolite, dark grey in colour and slightly coarser in grain than No. 184. When in the molten state this had fused with a siliceous rock, remains of which adhere to it notwithstanding the distanced it has travelled under rough treatment.

186. A fine-grained dark reddish Sandstone having an abundance of lime, and seams and patches of Calcite, which is a crystalline form of lime. Found at the Swainshill moraine, but it probably originated from strata about the Welsh borderland where detritus from Old Red Sandstone, or a more ancient reddish strata was mixed with that from a Silurian limestone deposit.

187. A fine-grained reddish-brown Limestone formed in concentric layers, and with grains of mica. This is apparently a section broken from a stalactite. Such formations are often seen hanging from railway, and other arches, in limestone and chalky districts. In the present example the lime is probably from Silurian rocks and the reddish stain from over lying Old Red Sandstone. This specimen was broken

from a larger piece found at the Swainshill moraine, and it probably originated about the Welsh borderland. For stalactites consult article – 'Caves' – in Chamber's Encyclopaedia, Volume 3, also on p 38 herein.

188. A rounded stone of coarse-grained yellow Sandstone from the Portway terminal moraine. The various sizes of quartz grains are held together by an elderly substance stained with a form of ferric-oxide, as is frequently the case with Old Red Sandstone rock. This example probably originated from the Ordovician strata of Wales.

189. A coarse-grained grey sandstone devoid of lime. It has numerous dark patches of various sizes which usually contain larger angular and rounded grains, even to the size of small stones, giving the rocks the semblance of Breccia. Found in the Portway moraine, but probably originated in the Ordovician rocks of Wales.

190. A fine-grained greyish Sandstone destitute of lime and having purple areas of various sizes. It contains other minerals besides quartz. The shining spots are due to the incident light reflected from the faces of broken quartz grains. Its original site was probably the Ordovician strata of Wales, but ice brought it to the Portway moraine.

191. This is perhaps a greenish-grey Chert (a siliceous rock without perceptible grain), or it may be a variety of siliceous Sinter. It is rather heavy and hard enough to scratch glass, but lacks toughness. Lime is absent save for a trace here and there. Rounded stones of this rock in various sizes are common in the Portway glacial deposit, and it is probably from the Ordovician strata of Wales. Isolated bits of rock of this nature are impossible to identify without analysis. Another possibility is that it was formed from siliceous mud associated with glauconite on a sea floor below deep water, and hardened by precipitation of aqueous solution of silica. Such processes still continue on the floor of deep seas.

192. A very fine-grained dark red Sandstone with seams and patches of an equally fine-grained light grey Sandstone. Both are without lime, but have minute specks of mica as if the flakes of that mineral had been broken. Found at the Swainshill moraine, but probably originated about the Welsh Borderland in a similar manner to Nos. 186 and 221.

193. A medium-grained drab Sandstone with numerous grains of mica. This rounded stone was found at the Portway moraine, but its site of origin was probably the Silurian strata of Wales.

194. A rather fine-grained purplish-brown Sandstone with minute grey areas, very micaceous and destitute of lime. Probably from Ordovician strata of Wales but found at the Portway moraine.

195. A medium-grained drabbish-grey Sandstone without lime, the quartz grains are more or less colourless, and are surrounded with a drab earthy material containing siliceous matter that binds the grains together. There are numerous dark spots where the grains are brownish and more or less rounded. Numerous larger pieces of white quartz and other minerals are included with the finer grains. Gathered at the Portway moraine, but probably an Ordovician rock from Wales.

196. A medium-grained brownish-grey Sandstone without lime. It consists of quartz grains of various tints associated with an assortment of other minerals. It has faint lighter and darker horizontal streaks like many other rocks, and these may represent seasonal additions to the thickness. It was found at the Portway moraine and probably came from Wales.

197. A brownish and yellowish very coarse grained Sandstone consisting of various minerals but chiefly quartz. The particles are mostly rounded as by moving water. From such data we may conclude that the specimen is a portion of a former beach that was raised and consolidated. Fathered at the Swainshill moraine, but probably originated in the Ordovician strata of Wales.

198. A rather fine-grained greyish-red Sandstone, very micaceous. This is a variety of Old Red Sandstone from further N. of the County, brought down by the former glacier of the R. Lugg. Gathered from the low fields between that River and Sutton Walls.

199. A rather fine-grained light grey Sandstone with various inclusions. The quartz grains are both rounded and angular. Lime is absent, and the numerous whitish particles appear to be siliceous sinter from a volcanic spring. Gathered in fields between Eardisley and Staunton, but it probably originated in Ordovician strata N. of Builth in Radnorshire.

200. A medium-grained darkish-grey Sandstone without lime or mica. It has faint lighter and darker horizontal streaks as in No. 196. Most of the quartz grains are more or less rounded, indicating it may have been deposited off the embouchure of a stream. It probably originated in Wales, but was found at the Portway moraine.

201. A brown Felsite, a grainless siliceous volcanic lava rock allied to Rhyolite. Found in low fields about Ruxton and Hoarwithy, but probably originated in the volcanic area N. of Builth in Radnorshire.

202. A very fine-grained Sandstone without lime, the quartz grains are both rounded and angular, the general colour is greyish-purple. The majority of the quartz grains are reddish, while a smaller quantity are colourless, white, grey and a few specks are black or almost so and may be volcanic dust. All are bound together by inconspicuous siliceous matter. This occurs in low fields between Eardisley and Staunton on Wye, about 23 miles W x N from Hereford but it was probably formed about the Borderland in deep water of the Silurian Epoch. It appears to be a mixture of the detritus from a greyish Ordovician or Silurian Sandstone, with a larger quantity from a reddish Sandstone such as the Torridonian, not now exposed at the surface of Wales or Herefordshire, but remains of allied strata occur W., N., and S. of Church Stretton in Shropshire, and reach within 10 miles of N.W. Herefordshire.

203. A medium-grained reddish and greyish Sandstone, the colours tending to be grouped in lines. Included in it are pieces of a very fine-grained rock of a reddish hue. This is probably a variety of Old Red Sandstone from the northern part of the County, but was found on low fields about the River near Hereford where other glacial stones occur.

204. A medium-grained pale grey Sandstone with traces of lime. It includes several other minerals besides the rounded grains of quartz, and many minute dark specks some of which are black, such spots may be volcanic dust. All are held together by a greyish earthy siliceous substance. Found at the Portway moraine, but it is probably a rock from Wales.

205. A fine-grained purplish-grey Sandstone with numerous larger inclusions of other rocks that make it resemble a Breccia. There are also veins and spots of white calcite resembling quartz crystals. Gathered at the Portway moraine, but is probably from the Ordovician rocks of Wales.

206. A greyish-black Rhyolite (a form of lava) associated with a paler seam of the same, and still lighter coloured remains of a siliceous rock that had been fused by it. Found in the fields between Eardisley and Staunton on Wye but its place of origin is probably the ancient volcanic area N. of Builth in Radnorshire.

207. A grey semi-crystalline Sandstone without lime. The angular grains are mostly quartz of various sizes and tints. Quartz crystals have developed in former cracks of the rock and often exhibit their prismatic structure. Many spots of ferric-oxide may be of volcanic origin introduced when the rock was being deposited. Gathered in fields about Hoarwithy and Ruxton, but probably originated from Ordovician strata of Wales.

208. A brownish-grey fine-grained Sandstone without lime. The grains, both rounded and angular, are of various minerals, the reddish-brown quartz grains being very abundant. Found in fields between Eardisley and Staunton on Wye and perhaps [originated] as Silurian rock from about the Borderland.

209. A rather fine-grained pale grey micaceous Sandstone without lime. The grey quartz grains are mostly rounded, and associated with others of brownish and other tints. There are numerous minute black spots which may have been from volcanic dust. It is probably a rock of Wales, but was found in the Portway moraine.

210. This much resembles No. 207, and is probably a variety of rock from the same original strata, and was also gathered in the same district.

211. A pinkish-grey rather coarse-grained Sandstone. The Quartz grains are both rounded and angular, white, colourless or drab, and associated with a pinkish non-crystalline siliceous substance. There are also larger quartz grains and other inclusions, some of a grey colour appear to be of volcanic origin. Probably from the Ordovician strata of Wales but gathered from the moraine at Sutton Walls.

212. A purplish-grey Sandstone, slightly micaceous and destitute of lime. The quartz grains, which are mostly angular, are a mixture of various tints chiefly greyish, while a few that are reddish-brown give the rock a purple tinge; scattered black grains also occur. Several lighter spots are of colourless and white quartz grains among which are a few that are green and perhaps glauconite. These light spots may be due to excreta of small animals that had taken in such mineral grains with their food. Found in fields between Eardisley and Staunton on Wye, but probably came from Silurian strata about the Borderland.

213. A very fine-grained greenish-drab micaceous Sandstone without lime. It was doubtless deposited in deep water, and is probably from the Ordovician strata of Wales, but was found in the Portway moraine.

214. A pale-grey rather coarse-gained Sandstone. The grains are mostly rounded and of various sizes which indicate formation of the rock near a coast. These grains consist chiefly of white and grey quartz, but several other minerals occur; while some of the units are small pebbles of drab quartz. Several pieces of this rock were found in fields about Nunnington, 2½ miles N.E. from Hereford, and may have originated from Silurian strata of N.W. Herefordshire.

215. A fine-grained yellowish-drab Sandstone without lime. This sample shows a zone of weathering penetrating from the exterior. It is a Silurian rock from farther N. of the County, and was found in a field between the River Lugg and Sutton Walls.

216. A fine-grained Sandstone without lime, and irregularly variegated with reddish and grey patches. This is a variety of Old Red Sandstone occurring in many parts of Herefordshire, and was brought down by the ice stream to the flats about Hoarwithy and Ruxton.

217. At the corner of the road leading to Stretton Sugwas from the W. end of King's Acre, about 2 miles W. from Hereford, there is a glacial drift rock opposite Mr H. J. Powell's petrol supply station. This block is about 5½ft. long and 3ft. in width and height. It is but slightly rounded and lacks striations. It was found a little below the surface in the garden of a nearby cottage and was removed to its present site by Mr Powell who kindly gave me a sample of it. It is an extremely fine-grained Sandstone of a dark grey colour. There is not a trace of lime and very little additional matter save a little glauconite and mica, with silica binding the minute grains together. It is hard and readily scratches glass, but is rather brittle. The altitude of the place where found is about 244ft. above sea, while that of the R. Wye about a mile S. is about 180ft. It probably originated from the Silurian strata of N.W. Herefordshire.

218. A greenish-drab rather coarse-grained semi-crystalline in Sandstone without lime. It consists chiefly of quartz grains of varied tints and a few other minerals. The grains are of various sizes from minute

to as large as a small bean. Among the grains is a quantity of earthy material stained yellowish brown. This was evidently formed near a coast, and the yellowish stain may be due to ferric-oxide. It is probably an Ordovician rock from Wales, but was gathered on the alluvial flats about the River near Hereford.

219. A fine-grained purplish-grey sandstone without lime or mica. Associated with the white and colourless quartz grains are various other minerals of different colours, and the combination of these give the rock its general tone. There are also minute black specks which are probably volcanic dust. Such items are all bound together by a structureless siliceous matter. Gathered at the Portway moraine, but probably from the Ordovician strata of Wales.

220. A light-grey semi-crystalline Limestone. The brownish stain is due to ferric-oxide entering a crack. Gathered from low fields near Eardisley, but probably it originated in Silurian strata about the Borderland.

221. A very fine-grained dark red Sandstone rock without lime, having numerous grey semi-crystalline seams that are distinctly calcareous, both colours being slightly micaceous. Gathered at the Swainshill moraine, but it possibly originated about the Welsh Borderland, and produced under conditions similar to those mentioned for No. 186.

222. A light grey Sandstone of medium grain. In consists chiefly of partly rounded grey, colourless, white and brown quartz grains, with a mixture of other minerals. Found in the field S. of Eardisley, but is probably from Silurian strata west of the Old Red Sandstone.

223. A light brown very fine-grained micaceous Sandstone without lime. The fine grain indicates it was deposited in deep water. Found in fields between Eardisley and Staunton on Wye, but it probably originated in Silurian strata about the Borderland.

224. A purplish-grey fine-grained Sandstone with traces of lime. It consists of pinkish, grey, and colourless, rounded and angular quartz grains, associated with numerous black specks that are probably volcanic dust. It has shining areas similar to those of No. 234, and such must not be mistaken for specks of mica. Found in the Burghill moraine, but probably originated in Silurian strata about the Borderland.

225. A fine-grained, grey, micaceous Sandstone Shale, with very thin layers of a different tint which may indicate seasonal variations of the deposit. Found in abundance at the Swainshill moraine, but is probably originated in the Silurian strata of W. Herefordshire.

226. A fine-grained purplish Sandstone with light grey areas of various sizes, it has no lime and is slightly micaceous. The purple consists chiefly of more or less rounded grains of quartz of that tint, and the grey is of similar material. With each colour other minerals occur scantily, as well as in minute black specks that may be biotite from volcanic dust. This much resembles certain Old Red Sandstone rocks, and is perhaps from E. Wales, but was gathered at the Portway moraine. Biotite is one of the many varieties of mica.

227. A medium-grained Sandstone of a greyish-drab colour. It consists mainly of partly rounded grey, colourless, and reddish-brown quartz with scattered grains of other minerals. The dark streaks and patches giving it a variegated appearance may be due to volcanic dust from which ferric-oxide is liberated during weathering, hence the brownish exterior. It is devoid of lime and is perhaps a rock from the Ordovician strata N.W. of Builth in Radnor, but was gathered in fields between Eardisley and Staunton on Wye.

228. A brownish-grey crystalline Sandstone with lime. The quartz grains of the bulk of the rock are very small; but there are many inclusions about the size of a pea or bean which consist of a fine-grained

brown limestone. Probably from the Ordovician strata of Wales, but gathered at the Sutton Walls moraine.

229. An almost black Rhyolite tending towards a fine-grained Gneiss, and showing the greyish exterior caused by weathering. Found in fields about Hoarwithy and Ruxton, but it probably originated in the volcanic area N. of Builth, Radnorshire.

230. A greyish Sandstone of medium grain, without lime. The rounded and angular grains are of grey, colourless and drab quartz. There are also traces of mica, as well as minute groups and isolated grains of black material which are perhaps volcanic dust. A Silurian rock probably from N.W. Herefordshire, but found in the Burghill moraine.

231. A medium-grained dark reddish Sandstone with mica, and destitute of lime. Found in fields between Eardisley and Staunton on Wye and probably a form of Old Red Sandstone from the W. of the County.

232. A dark grey semi-crystalline Sandstone without Lime. The quartz grains are small, and both rounded and angular; the bulk of them are dark grey, while a small number are white and colourless. There are narrow veins of white quartz. The small specks of ferric-oxide may be of volcanic origin. Found in fields between Hoarwithy and Ruxton, but it originated from Silurian strata about the Borderland.

233. A fine-grained purplish Sandstone with ill-defined streaks, and small areas of a greyish hue. It consists to a great extent of rounded and partly rounded quartz grains of the colours mentioned and associated with other minerals, but lime is absent. It was found in the Portway moraine and probably originated in the Ordovician strata of Wales.

234. A grey Sandstone of medium grain, the grains are mostly angular, and consist of grey and colourless quartz with a few other minerals including traces of lime. At certain angles with the incident light shining areas are seen, such as reflections from crystals facing one direction. A Silurian rock from the N.W. of the County, but found in the Burghill terminal moraine.

235. A fine-grained semi-crystalline Limestone mottled with purplish and light grey areas, with these are small streaks and patches of white calcite, some crystals of which reflect light from their split faces. The general colours, however, are dull. This is probably from Ordovician strata of Wales and was found at the Portway moraine.

236. A very fine-grained grey Sandstone with traces of lime at places. One side there has been a crack into which a calcareous solution entered and crystallised. Another side has been stained by ferric-oxide. Both these additions to the rock may have been since it left the original strata, which is probably a Silurian rock about the Welsh Borderland, but it was found at the Sutton Walls terminal moraine.

237. A rather fine-grained yellowish Sandstone. The rounded and angular quartz grains are mostly colourless and yellow. There are spots of black and ferric-oxide both of which may be volcanic dust. Found in fields about Hoarwithy and Ruxton, but probably originated from Ordovician strata of Wales

238. A greyish-drab Sandstone the grains of which are of medium size with some larger ones among them. Such colourless and pale grey quartz grains are both angular and rounded. Other minerals are associated with them, but a thin section for the microscope is required for their identification. This is probably a Silurian rock from the Welsh Borderland but was gathered on the terminal moraine at Sutton Walls.

239. A drabbish-grey Sandstone without lime. It consists chiefly of medium-size grains of colourless, drab and pinkish quartz mixed with a variety of other minerals, and numerous inclusions of larger sizes and different kinds, which give the rock the appearance of a small glacial conglomerate. It was

found in the Burghill terminal moraine, but probably originated in Silurian strata about the Welsh Borderland.

240. A dark grey Sandstone of rather fine grain. The grains are rounded and angular of various tints from colourless and white to almost black. The lighter colours are mostly quartz with other minerals, while the darker are probably fragments from disintegrated volcanic rock, whence also came the grains of mica and traces of ferric-oxide. Found in fields between Eardisley and Staunton, but originated probably in Ordovician strata N. of Builth in Radnor.

241. A medium-grained pale grey crystalline Sandstone having pale pink areas of a finer grain. Such pink areas are without definite shape or position. Some parts of the grey exhibit traces of lime. Both colours consist of angular and rounded quartz grains associated with a few other minerals. The grey areas have patches that reflect the light from the broken quartz grains. Found at the Portway moraine, but probably originated in Ordovician strata of Wales.

242. A pale yellowish Sandstone of medium size grains without lime. The colourless and white quartz grains are associated with many particles of a yellow non-crystalline substance which gives that tint to the rock. It came from the moraine at Sutton Walls, and is perhaps a Silurian rock from the N.W. Borderland.

243. A coarse-grained medium crystalline sandstone with shapeless dark areas due to greyish-brown grains of quartz. With both colours most of the grains are rounded, of various sizes, and mixed with other minerals, all being rounded together with an earthy substance. The coarser parts have traces of lime. The general structure indicates formation near a creek. Found at the Portway moraine and probably an Ordovician rock of Wales.

244. A very fine-grained yellowish-drab Sandstone without lime or other inclusions. Found at the Swainshill moraine but probably originated in an Ordovician strata of Wales.

245. A fine-grained crystalline Limestone irregularly mottled with medium-grey and purplish-grey tints, much of this rock, especially of the darker colour, exhibits no grain. It probably originated in the Ordovician strata of Wales, but was gathered at the Portway moraine.

246. A sample from conglomerate now forming in the sand and gravel at the Portway moraine. Some of the blocks are several feet in diameter, and are well on the way towards the production of firm rock. The consolidation of the fragments is due to calcium, silica, ferric-oxide, etc. being carried down in solution, from deposits above, by the rain water that falls on the surface. The water undergoes faster evaporation in the coarser material below, consequently the substances in solution are deposited upon the fragments. This process is similar to the formation of stalactites (No. 187 above). While here there is also the constant pressure exerted by the mass of material above.

247. A greyish Sandstone without lime. It consists of colourless, white and drab quartz grains of small and medium size, both rounded and angular. There are also a small quantity of black grains that are probably volcanic dust, and numerous inclusions of larger sizes, chiefly rounded scraps of greyish quartz. This appears to be a Silurian rock from about the Welsh Borderland, but it was found in the terminal moraine at Burghill.

248. A medium-grained grey Sandstone composed chiefly of grey and colourless quartz grains among which few are brownish. Most of the grains are partly rounded like those on a sheltered sandy shore; there are also a few inclusions of darker granules. There is scanty binding material for the grains so that the rock is brittle though hard. This sample is from a block measuring about 5x3x1½ feet, but not much rounded. It was found in the Swainhill terminal moraine, and probably originated in Silurian strata about the Welsh Borderland.

249. A lump of impure lime from the zone of sand at the glacial moraine of Sutton Walls. Similar lumps of lime occur in the zone of sand at the other terminal moraines mentioned in these notes, viz. – Portway, Burghill and Swainshill. This specimen has been soaked in gum water to hold it together and that slightly darkens the colour. Rainwater contains among other items gathered from the atmosphere, a small amount of carbon dioxide. In the presence of this the rainwater readily dissolves the lime in the upper layers of sand etc. as it slowly percolates downwards. Upon evaporation of the water in the lower zones of sand the lime is redeposited as calcium carbonate, while mutual attraction of the elements produce the lumps as exhibited. This is a simple example of the slow, never ceasing action of the Natural Laws. These moraines are now being quarried for sand and gravel.

250. Yellowish-brown sand of medium grain from the zone of that substance at Sutton Walls Terminal moraine. For comparison with specimens from other places.

251. Very fine reddish-brown sand without appreciable lime, reduced by glacial action grinding down chiefly the Old Red Sandstone rock of this County. Gathered from the terminal moraine at Burghill. The moss – *Funaria hygrometrica* grows luxuriantly on the vertical face of this and other moraines mentioned, where the quarrying operations have exposed such a face of the sand. This is due to the rainwater and soluble matters keeping the sand continuously damp.

252. Sand of coarser grain than No. 251, but still fine and of the same origin. From the Burghill moraine.

253. A sample from the zone of reddish sand gradually consolidating into rock, and with streaks of lime here and there. This zone is from two to three feet in vertical thickness, and the moss mentioned in No. 251 grows abundantly on this deposit.

[6]This moss has a peculiar method for the liberation of its spores which are reproductive bodies that correspond indirectly to seeds of flowering plants but contain no formal embryo, or young plant, as seeds do. The minute spores are liberated only in dry weather so that distribution by air currents is not checked by their being made wet and heavier. The spore-case is found at the top of a slender, twisted, thread-like stalk, and when young it is covered by a protecting conical hood which is subsequently shed. At the apex of the case which curves downwards, there is a small saucer shaped lid which falls off when the spores are ripe, yet they cannot then escape for below the lid there are two sets of narrow pointed teeth, with sixteen for each set. When [the] weather is damp the teeth of each set twist together so that no spores can escape, although they are less than $^{1}/_{1,000}$ inch in diameter. With dry conditions the teeth become straight, thus forming an opening through which the spores are liberated. The word *Funaria* is derived from Latin – funis = a cord, because the stalk of the spore case is twisted somewhat like one of the threads of a cord; while *hygrometric* = movement under damp conditions, is in reference to the teeth of [the] spore-case. By a study of several other species of moss spore-cases, by aid of the microscope, the process of evolution leading to the complications mentioned may be followed.

As mentioned above the spores correspond indirectly to seeds. Indirectly implies, among other things, that when the spores germinate they do not produce a new moss plant, but give origin to a small branched, greenish, thread-like plant without leaves termed the protonema, and entirely unlike moss. This branched thread sends delicate hair-like rootlets into the ground for nutrition; while after many weeks the aerial thread gives origin to minute buds. From these buds the real leafy moss plant grows, and in due season produces again the spores in their spore-case on the stalk. These last mentioned structures are produced by sex organs that grow on the leafy moss plant among the leaves, chiefly at or near the apical portions. When the female organ has been fertilised by the male sperm it begins to grow, and soon produces a minute root-like suctorial organ at its base. This grows into the leafy moss plant to absorb nutrient substances for the production of the stalk, spore-case and spores which together constitute the Sporogonium (i.e. spore producer). This structure is often regarded as a new dwarf plant growing as a semi-parasite on the leafy sexual plant. Consequently this, with the threadlike protonema, and the leafy moss plant, comprise three individuals concerned with the sexual reproduction of a moss. In the case of a common fern the spores are produced in great abundance, without an intermediate sex process, in spore-cases growing on the underside of the leaves. After falling on the damp ground, the spore produces a small, more or less heart shaped, green leaf-like body termed the prothallus. In due course this gives origin to sex organs much resembling those of a moss. After fertilisation by a sperm the female organ or germ produces a young fern plant which soon sends a tiny root into the ground, and releases itself from the prothallus. In time it grows to a mature fern plant giving origin to spores encased on the underside of the leaves as first mentioned. Therefore with a fern two plants only are concerned in its life cycle. The prothallus corresponds with the leafy moss plant, but its fertilised female organ produces directly a spore-bearing leafy fern plant instead of a leafless semi-parasitic Sporogonium; while the moss-like protonema is not represented in the life-cycle of a fern, and the fern spores originate without a direct sex process. These peculiar phenomena in the reproduction of mosses, ferns and many other plants are termed Alternation of Generations. There is of course, method in this seeming madness which is concerned with the exceedingly microscopic elements, termed nuclei necessary in reproduction, but space forbids description here.

Nearly all plants, from the simple Red and Brown sea-weeds up the scale of plant life until flowering plants are reached reproduce themselves by methods that include some form of the several varieties of Alternation of Generations. The largest living plants thus reproduced are the tree ferns of warm climates various species of which grow from 20 to 60 feet high. Most of them have straight, tall stems marked by scars of former leaf bases, while at the apex there is a large tuft of leaves. In Carboniferous times flowering plants producing seed had not evolved, and the trees that produced the coal were of the Fern-like orders such as Lepidodendron, Calamites, Sigillaria, Sigmaria, Stauropteris, Cordaites, and scores of other genera that flourished in the damp, hot climate, and reproduced themselves by varieties of Alternation of Generations. It is the same reduced and small existing species such as Horse-tails, or *Equisetum*, Club Mosses (not really mosses) or *Lycopodium* and other genera that now represent the extinct and relatively giant ancestral species of the Carboniferous Epoch. Towards the end of that Epoch, however, the Pteridosperms, which are considered to have been the primitive fore runners of existing seed-bearing plants, began to appear more abundantly. Beginners in Geology should give attention to these interesting matters, helpful to them in many ways.

In the evolution of plants the mosses appear to be a lateral group which failed to give origin to more advanced plant-life, and their [?] fossil remains have not been discovered previous to the Late Cretaceous Epoch. On the other hand an order somewhat allied to mosses termed Hepaticae have fossil remains as early as the Carboniferous Epoch, while their general structure and life-cycle afford reasons for considering them as probable originators of more advanced plants. The Hepaticae include plants of two distinctive forms, the most primitive being a flat, variously lobed green structure growing in groups on the ground in damp places where they are quite common. The far more numerous advanced forms flourish on rocks, tree-trunks, banks etc. often in exposed damp conditions as on mountains. These possess a main stem with a row of lateral leaves on each side that often have curved back lobes, also a single row of back leaves that more or less overlap one another. None of the leaves possess a midrib or other veins. These characteristics at once distinguish them from mosses which have leaves, often with a vein, all of the same shape, and growing equally all round the stem, or more rarely in two rows. Then the spore-cases of Hepatics are quite different and less complicated than those of mosses. The Hepaticae or Hepatics, as they are familiarly called, are also known as Liverworts, because the lobed form of the more simple species, first mentioned was supposed to resemble the liver, so that on the ancient hypothesis that "like cures like" concoctions of these plants were used as a medicine for that organ.

Notes

1. p.54 Petalocrinus is a primitive crinoid (sea-lily) belonging to the Echinodermata, which also include starfish and sea-urchins. It belongs to the Silurian Era between 409 and 439 million years ago.

2. p.72 Old Red Sandstone (referred to throughout the text) properly applies to the non-marine and freshwater deposits of the latest Silurian and the Devonian Eras.

3. p.73 A cinder-like deposit which forms an encrustation on rocks by precipitation from mineral rich water e.g. volcanic fumaroles.

4. p.78 This is obviously a reference to what has become known as Hitler’s ‘Final Solution’, although the manner in which it is expressed would not be found acceptable today.

5. p.102 Refers to the need for a polarising microscope.

6. p.98 This concluding essay on the reproductive strategies of mosses and other non-flowering plants, although quite irrelevant to the rest of the text has been retained as an example of West’s real love and academic specialism, botany.

APPENDIX 1

GEOLOGICAL TIME CHART

EON	ERA	PERIOD		EPOCH	START millions of years ago
PHANEROZOIC	CENOZOIC	QUATERNARY		RECENT	0.01
				PLEISTOCENE	1.8
		TERTIARY	NEOGENE	PLIOCENE	5.3
				MIOCENE	23.0
			PALAEOGENE	OLIGOCENE	34.0
				EOCENE	56.0
				PALAEOCENE	65.5
	MESOZOIC	CRETACEOUS		146	
		JURASSIC		208	
		TRIASSIC		245	
	PALAEOZOIC	PERMIAN		290	
		CARBONIFEROUS		363	
		DEVONIAN		409	
		SILURIAN		439	
		ORDOVICIAN		510	
		CAMBRIAN		544	
PRE–CAMBRIAN (CRYPTOZOIC)		EDIACARAN		600	
	PROTEROZOIC	2500			
	ARCHAEAN	4000			
	HADEAN	4500			

New scientific techniques, especially radiometric dating, mean that the describing and defining of periods of geological time has reached a precision almost unimaginable in West's day. The above chart indicates the currently accepted time scale (2006) but is still continually being refined and modified.

APPENDIX 2

STAGES AND STRATA OF CAMBRIAN, SILURIAN AND DEVONIAN SYSTEMS RELEVANT TO HEREFORDSHIRE

CAMBRIAN	
Series	Examples of strata
Merioneth	Dolgelly Beds, White-leaved Oak Shales, Lingula Flags, Festiniog Beds
St David's	Clogau Shale, Solva Group, Upper Comley Group
Caerfai (Comley)	Purley Shales, Lower Comley Group, Llanbedr Shales, Lickey Quartzite, Hollybush Sandstone

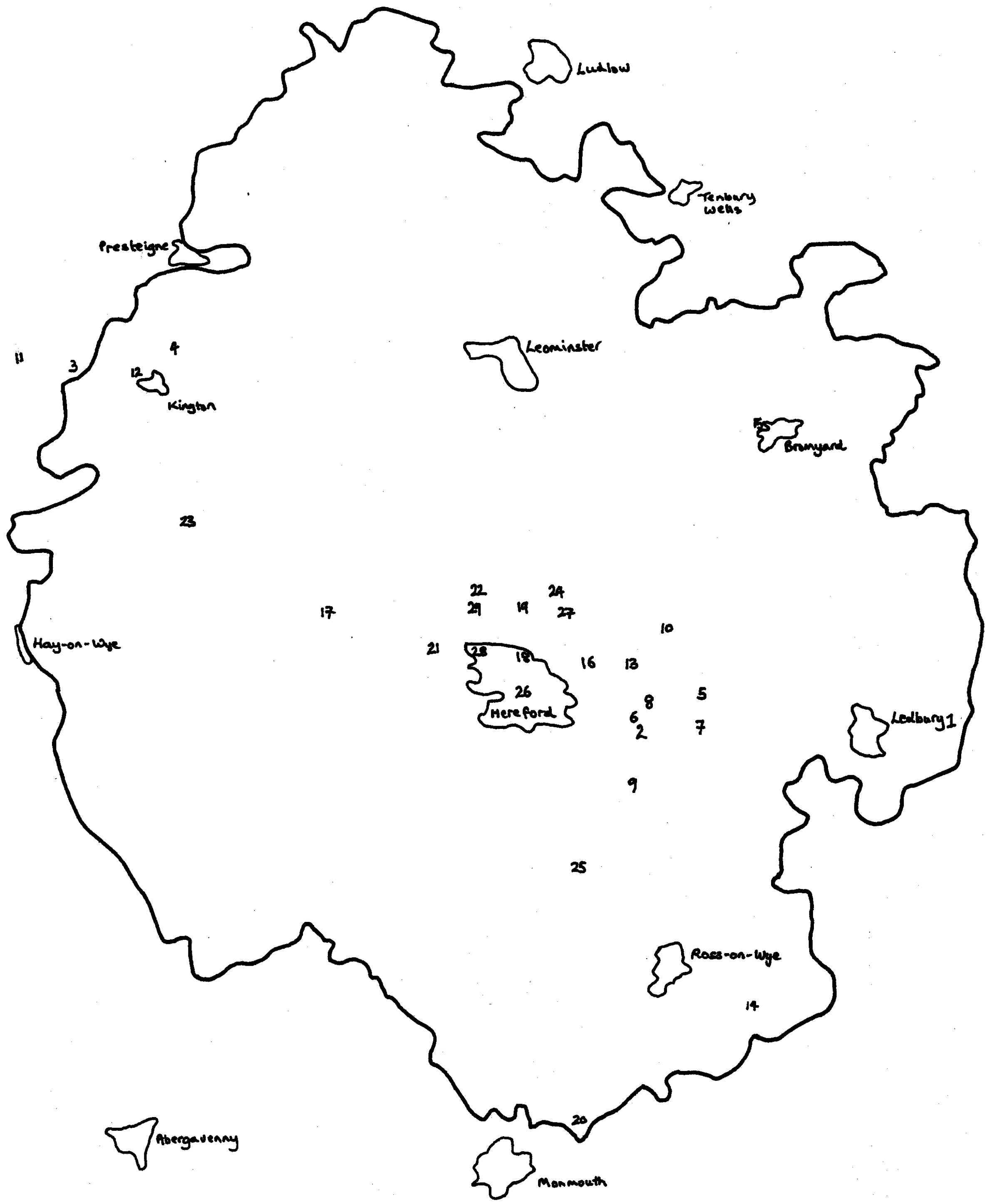
	SILURIAN	
Series	Stage	British Strata
Pridóli (Downton)	ORS ORS	Downton Group,(includes Ludlow Bone Bed) Downton Castle Sandstone
Ludlow	Whitcliffian	Whitcliffe Beds, Upper Ludlow Shale
	Leintwardinian	Leintwardine Beds
	Bringewoodian	Bringewood Beds, Aymestry Limestone
	Eltonian	Elton Beds, Lower Ludlow Shales
Wenlock	Homerian	Much Wenlock Limestone Dudley Limestone
	Sheinwoodian	Coalbrookdale Beds, Wenlock Shale Group, Buildwas beds, Woolhope Limestone
Llandovery	Telychian	Purple Shale, Mayhill Sandstone, Penkill Formation, Pentamarus Beds
	Fronian	Llandovery Beds
	Idwian	Llandovery Beds, Gasworks Sandstone
	Rhuddanian	Mullock Hill Sandstone, Llandovery Beds, Haverford Mudstones

DEVONIAN			
Series	Stage		British Non-Marine Strata
Upper	Fammenian	Old Red Sandstone	Farlow Sandstone Series, Portishead Beds, Dura Den Fish Beds, Elgin Beds, Nairn Beds
	Frasnian		Orcadian Series, Caithness Flags
Middle	Givetian		Moray Fish Beds
	Eifelian		Brecon Group, Senni Beds, Cosheston Beds
Lower	Emsian		Ridgeway Conglomerate, Clee Group
	Siegenian		Abdon Limestone, Ditton Group, Stonehaven Beds, Hendre Limestone, Psammosteus Limestone
	Gedinnian		St Maughan's Group

There is very little CARBONIFEROUS in the county, although there is an igneous outcrop near Ledbury, and Carboniferous limestone and Coal Measures are to be found on the Gloucestershire borders near Symonds Yat and in the Forest of Dean.

APPENDIX 3

HEREFORDSHIRE LOCALITIES REFERRED TO BY WEST



	Specimen Numbers
1. South Malvern Hills including White-leaved Oak, Chase End Hill Bromsberrow	1-18
2. Mordiford including Lower and Upper Littlehope, New Cemetery, Coal Hill, Haugh Wood, Scutterdine, Pentaloe Brook	19 – 29, 31-34, 166-175
3. Nash Scar Hill	30, 101-103
4. Flintsham	35 - 39
5. Perton	40 - 46
6. Ethelbert's camp	47 - 51
7. Old Sufton, Cockshoot	52 - 61, 70 - 75
8. Priors Frome	62 - 63
9. Fownhope	64 - 66
10. Shucknall Hill	67, 76 – 81, 90 – 95
11. Gladestry } 12. Kington }	68 – 69, 82 - 89
13. Bartestree/Hagley	96 – 100, 154 - 162
14. Pontshill/Lea	107
15. Bromyard	117 -123
16. Lugwardine	124 - 137
17. Mansell Hill	138 – 142
18. Hereford College	143 – 146
19. Pype and Lyde	147 - 153
20. Symond's Yat	163

21. Swainshill	176 – 177, 186 – 187, 192, 197, 221, 225, 244, 248
22. Portway	178 – 179, 180, 182-183, 185, 188 – 191, 193 -196, 200, 204 – 205, 209 – 210, 213, 219, 226, 233, 235, 241, 243
23. Between Eardisley and Staunton	181, 199, 202, 206, 208, 212, 220, 222-223, 227, 231, 241, 245-246
24. Sutton Walls	198, 211, 215, 228, 236, 238, 242, 249-250
25. Between Ruxton and Hoarwithy	201, 207, 216, 229, 232, 237
26. Hereford	184, 203, 218
27. Nunnington	214
28. King's Acre/Stretton Sugwas	217
29. Burghill	224, 230, 234, 239, 247, 251-253

N.B. A number of Old Red Sandstone specimens between numbers 104 – 116 have no specific localities given

APPENDIX 4

Sources and References used by West

West claims to have written several unspecified works including donations to Hereford Library of two books on the Lochs of Scotland and one on photomicrography. Apart from the last item, these works have not been identified but are probably offprints of his papers on the Scottish Lochs, details of which are given below. In a number of cases West makes only passing reference to source or author without giving any further details.

ADYE, E.H.: Modern Lithology, 1907

ARISTOTLE (384-322 BC): Greek philosopher who was revered as a "beacon of scholasticism" throughout the Middle Ages and beyond. His works, particularly the "Ethics" and "Poetics" have remained key texts in the education of any scholar.

BANKS, R.W.: On the Tilestones or Downton Sandstones, in the Neighbourhood of Kington, and their Contents. (Quarterly Journal of the Geographical Society of London May 1856. (Communicated to the Society by Sir Roderick Murchison)

BRITANNICA, Encyclopaedia: general work of reference

BROWNING, Robert (1812-1889) Prince Hohenstäl-Schwangau, Saviour of Souls 1871

CHAMBERS Encyclopaedia: General work of reference. No edition specified.

CONFUCIUS (551-489 BC): Influential Chinese philosopher most widely known in the west through his "Conversations" which were published in English in 1890

DARWIN, Charles: (1809-1882) 1. On the Origin of Species 1859. 2. The Descent of Man 1871

GEIKIE, Sir Archibald : Textbook of GeologyIVth revised edition 1903 (2 vols.)

INTERNATIONAL LIBRARY OF FAMOUS LITERATURE: Pliny's account of the Vesuvius eruption.Vol. III p.1039. No publication details given

LOCKE, John (1632-1704) : British philosopher best known for his "An Essay Concerning Human Understanding" 1696

LONGFELLOW, H.W. (1807-1842) The Spanish Student

LUCRETIUS Titus Carus c94-c55 BC Roman poet and philosopher: De Rerum Naturae (on the Nature of Things) is an exposition of the atomist physics of the Epicureans

LYELL, Sir Charles: (1797-1875) Principles of Geology10th revised edition Vols. I and II, 1867-8

MURRAY, Sir John et al. The Depths of the Ocean 1902

RUSKIN, John (1819-1900): Very influential Art and Social critic

SHAKESPEARE, William: 1. Cymbeline 2. Troilus and Cressida

SMITH, H.G. Minerals and the Microscope 1919

THALES (6th century BC): Greek philosopher held by Aristotle to be the father of physical science. Credited with founding the study of geometry.

WEST, George : 1. Bathymetrical Survey of the Scottish Fresh-Water Lochs. Directed by Sir John Murray and Mr Laurence Pullar Vol. 1 pp.156-260 + 9 plates. Edinburgh 19102.
2. An Epitome of a Comparative Study of the Dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Seven Loch Areas of Scotland (with 9 plates). Proceedings of the Royal Society of Edinburgh c.19053.
3. A Comparative Study of the Dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Three Lake Areas of Scotland (with 55

plates). Proceedings of the Royal Society of Edinburgh Session 1904-5, Vol. XXV pp. 967-1023 19054.

4. Notes on the Aquatic Flora of the Ness Area Geographical Journal Vol. pp. 67-72 Jan. 1908

5. A further Contribution of a Comparative Study of the Dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Scottish Lakes (with 62 plates) Proceedings of the Royal Society of Edinburgh Session 1908-9.6.

6. The Practical Principles of Plain Photo-micrography Dundee 1916 (privately printed)

APPENDIX 5

Further Reading

An extensive collection of papers and pamphlets is held at the Hereford Museum Learning and Resource Centre. The following selection provides an introduction to the geology of the area.

British Geological Survey 1:50000 Geological Maps	Sheet 198 and Memoir: Brandon, A 1989 Sheet 197 and Notes: Wilby, P. 2004
Earp, J.R. and Haims, B.A.:	The Welsh Borderland. British Regional Geology 3rd ed. HMSO 1971
Miller, Hugh:	The Old Red Sandstone 1842 Recently reprinted (2006)
Richardson, L.:	An Outline of the Geology of Herefordshire. Transactions of the Woolhope Naturalists Field Club 1905. Published as a separate pamphlet
Symonds, Rev. W.S.:	Notes on the Geology of Herefordshire. Transactions of the Woolhope Naturalists Field Club 1867
Toghill, Peter :	The Geology of Britain. Swan Hill Press 2000

Herefordshire Council's Cultural Services providing opportunities in Arts, Museums and Heritage, Libraries, Tourism and Sports Development to residents and visitors.