GEOLOGISTS' ASSOCIATION

SOUTH WALES GROUP

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THE GEOLOGISTS' ASSOCIATION: SOUTH WALES GROUP. The Group was formed in 1959 as a direct result of the interest shown by the teachers of geology from Welsh schools attending refresher courses at the University Colleges at Aberystwyth, Cardiff and Swansea. It is designed to further the study of geology, with particular reference to Wales, and to provide a link between the amateur, the student, the teacher and the professional geologist. At present all four groups are strongly represented in the membership of 160 or so. The members are drawn from a catchment area extending from Pembrokeshire to Gloucester.

The Group's session coincides with the academic year. Ordinary Meetings are held monthly from September to March, the Annual General Meeting in March or April, and up to six Field Meetings – including one week-end excursion – between April and September. The Ordinary Meetings take place alternately at Cardiff and Swansea in the Geology Departments of the University Colleges. They are held at 11.00 a.m. on Saturday – usually the third of the month.

The annual subscription is £1 (which includes the cost of *The Welsh Geological Quarterly*). Student membership is 2 shillings. Further details available from: The Secretary, c/o Department of Geology, National Museum of Wales, Cardiff.

Geologists' Association - South Wales Group

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Cardiff : February, 1970.

EDITORIAL

The current number of the Quarterly attempts to reflect two very different aspects of the geological interest of the year 1969. On the one hand, the celebration of the bicentenary of the birth of two of the formative figures in the development of the subject; and, on the other, the spectacular achievements of collecting samples of rock from the Moon.

The first of the bicentenaries, that of William Smith, the Father of English Geology and Stratigraphy, is celebrated in the reprint of the article by Mrs. Joan Eyles in the journal Science in Action. Mrs. Eyles (née Biggs), who studied geology at University College, Cardiff, is currently compiling a biography of Smith. The second bicentenary, that of the illustrious French palaeontologist Georges Cuvier, is celebrated by reprinting part of one of the biographical articles in H. Alleyne Nicholson's delightful, albeit dated, review of the growth of the study of Natural History in this country.

An attempt to capture some of the excitement created by the Moon venture has been made by selecting a series of extracts from copies of The Times issued during the month of July.

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THE DISCOVERERS : WILLIAM SMITH

Joan M. Eyles

All over the world, on land and at sea, rapidly rotating drills are ceaselessly biting their way deep into the Earth's crust, in search of oil, gas and minerals. Many of these bores have a direct economic purpose. Others, sponsored by governments or scientific foundations, are probing in chosen spots to add to the sum of geological knowledge.

The rock chips or solid cores brought to the surface by these drilling rigs are scrutinized by geologists. The interpretation they provide is based on the knowledge that there is a definite succession in the sedimentary strata of the Earth's crust, ranging in age from the million years of the clays and soft sediments of the last Ice Age (Pleistocene) to the 300 million years of the Coal Measures in Britain (Carboniferous), and the several thousand million years of the oldest rocks of all, the Pre-Cambrian. All but the very oldest sedimentary rocks have characteristic fossils, so that the discovery of such fossils in a bore gives essential information concerning the formation that has been reached.

Towards the end of the 18th century, little was known of the rock succession or the relative ages of different strata, although some attempt had been made, particularly by German mining geologists, to draw up short successions in particular areas. No attention had been paid to fossils as a mark of age, although they were collected and studied. After much controversy it had been agreed that they were indeed true remains of once-living creatures, even though they were petrified.

It is to an Englishman, William Smith, that we owe the discovery, made in 1795, that different strata carry different assemblages of fossils. Some are characteristic of the Chalk and are found in Chalk quarries from Dorset to Yorkshire; others are characteristic of the older range of oolitic limestones prominent around Bath and in the Cotswolds; and still others are restricted to the softer clay beds of the vales between them. By drawing up in 1799 a list of strata near Bath, where he was then employed, and by adding to each group the names of the fossils he had found in it, William Smith had achieved undying fame as the founder of stratigraphical geology. Even during his lifetime he was awarded the title of 'father of English geology'.

William Smith was born on 23 March 1769. Next month [March 1969] British geologists will celebrate the bicentenary of his birth by holding an 'International Field Symposium on the British Jurassic'. Smith has received particular credit for his subdivision of the rocks now called Jurassic. Many foreign geologists have been invited to attend the symposium, and will be able to visit the little Cotswold village of Churchill, in north Oxfordshire, William Smith's birthplace.

He was the eldest of five children, three boys and two girls. His grandfather and great-grandfather were yeoman farmers, but his father was a blacksmith in Churchill. This was a trade which called for a knowledge of all sorts of machinery, from clocks to watermills. John Smith was evidently a clever man, an 'ingenious mechanic' as his son later called him, and was ambitious for his children. Unfortunately he died from a chill, caught while erecting some machinery, when William was only seven years old. Nevertheless he may have unconsciously already have influenced the future of the little boy, by giving him a small hammer - 'my digging hammer', he called it - with which he played in the rough stony places around the village.

The cottage in which the Smith family lived now became the property of the blacksmith's brother. William's mother, after a year or two, made a second marriage, to the landlord of the nearby Chequers Inn. William saw more of his uncle than his new stepfather, and also spent much time with his great-uncle, the elderly William Cook, who showed the boy how marshy fields were drained of their unwanted water. In the ploughed fields he often found fossils, the flat sea-urchins (Clypeus sinuatus) which his aunt used as weights for butter, and the little round ones (Terebratulae) which could be used as marbles.

In 1781, when he was 12, he was sent to London with a neighbour's boy to work in a shop. He was not happy there, and returned to his native fields a little over a year later. On the journey there and back - no doubt by the slow horse-drawn stage wagon, far cheaper than the coach - he noticed with great interest the chalk hills, rising sharply above the flat clay vales near Oxford. As a new road was being cut, he was able to see that the chalk was very different from the rocks he had seen in the Cotswolds.

Back in Churchill, he lived with his unmarried uncle, who was persuaded to buy him some books, for him to continue his studies. At the village school he had already learned to read, to spell and to write well in a copperplate hand, but only simple arithmetic was taught and no grammar. He later deeply regretted his lack of grammatical knowledge, when he found it difficult to set down his thoughts on geological matters.

Many of the Churchill farms belonged to a local landlord, who also had estates in Devon. In 1787 he decided to sell his Oxfordshire properties and called in a surveyor from Stow-on-the-Wold, six miles away, to make a map and a valuation. At the same time it was decided to enclose the common land, a step which improved the value of the large farms, though the small farmer was placed at a disadvantage.

Edward Webb, the surveyor, was looking for an assistant, and took on young William Smith, whose first task was to carry the measuring chain. He was an apt pupil, and was invited to enter Webb's office in Stow. He lived with the Webb family for nearly five years, learning a surveyor's duties. One year

he went with his master to Hampshire, and while there observed the gravels of the New Forest. In 1789, aged 20, he was sent to make a survey of a farm near Evesham, and was impressed by the red soils he saw, so different from the stony Cotswold fields or the wet clayey valleys near his home.

In the autumn of 1791 Webb had to make a valuation of an estate in north Somerset, and William Smith, now fully trained, went off on foot to carry it out. He walked first to Burford to receive his instructions, and then by Cirencester, Tetbury and Bath to his destination some ten miles further on. Here he was in country which was then busy with working coalpits, though they are now all closed. Descending mines as part of his surveying duties, he learnt that the beds of rock were not flat, but dipped or sloped, sometimes gently, sometimes steeply, and that faults, or slips in the rocks, often nearly vertical, could affect the succession seen on the surface.

This was a time when there were many new projects for the building of canals to reduce transport costs. These were often so speculative that it has been called the 'period of canal mania'. Smith, lodging near the village of High Littleton, at Rugborne Farm (now known as the 'birthplace of English geology'), was asked to take levels for a canal which would carry coal from the pits to the proposed Kennet and Avon Canal (between Newbury and Bath). Smith was already intensely interested in the rocks around him, and the survey proved what he already suspected - that there was a regular easterly dip in the beds of limestone which were prominent in the hills around. From this he argued to himself, quite correctly, that since each bed dipped under the one above it, as one moved eastward, the outcrop of each higher bed would be crossed in turn.

An Act of Parliament was necessary before the canal could be constructed, and Smith accompanied members of the Coal Canal Committee to London, to give evidence before the Members of Parliament. While in London, he looked around in bookshops to find some written account of what he had discovered. If he had been able to read German, he might have found something relevant, but fortunately he could not and so he was not confused by the preconceived ideas of others but went boldly on his way, working out geological laws for himself.

A tour to north-east England in a chaise, with two members of the Committee, to see other canals and coalpits, allowed him to see the variety and extent of the strata. At the same time he recognized that there was indeed a regularity such as he had guessed. The chalk wolds of east Yorkshire were recognized from afar by their contours and in the hills north of them he saw the typical features of his familiar Cotswolds. He observed too the red marls he knew in Somerset, and beneath them the coals.

A year later, in 1795, excavation of the canal began, and Smith as the appointed surveyor had splendid opportunities to collect fossils. As the canal advanced, starting from near the collieries, crossing the unfossiliferous

red beds, and then arriving at the beds of clay, shale and limestone that we now call (as did William Smith) the Lias, he got every chance to see the succession. Some notes he wrote in January 1796 show that he was by that time well aware that the successive beds of strata held different fossils by which they could be recognized - a scientific discovery of outstanding importance.

He continued to observe, to compare and to collect, and he regularly wrote down his observations. Had he published them in one of the journals of the time, his scientific priority would have had wide recognition, but his contacts with knowledgeable men were few. Two local clergymen, collectors of fossils and minerals, made his acquaintance, and in the summer of 1799, soon after ceasing to be employed by the Canal Company, he dictated to these two men, Benjamin Richardson and Joseph Townsend, his now famous list of the strata near Bath and the associated fossils. His friends made other copies and passed them to interested persons and so, almost unknown to Smith himself, his carefully collected knowledge became common property.

Years later, in the doggerel verse which came easily to his pen, he wrote of showing his fossil collection in Bath, in 1805, to a visitor who:

> Ere I could run my system through
> Presented much to my surprize,
> My own design before my eyes.
> 'It is no secret' he replies,
> 'For I, from certain knowledge tell thee,
> 'East and west it's gone, to Indie.'
> Judge my surprize! I had in view
> And hoped to publish, something new.
> But hundreds thus might have the clue.

His hopes 'to publish something new' were to be deferred for at least ten years more. All this time he was fully occupied as a land drainer, a mineral surveyor, and in supervising the building of embankments to keep back the sea, particularly in Norfolk. Great landowners such as the famous Thomas Coke of Holkham, the Duke of Bedford at Woburn, Lord Sefton and the Earl of Egremont employed him to improve their properties, by irrigation or by discovering coal. As he went around the country he took every opportunity of examining the rocks and collecting fossils. First on the floor of an office in Bath, and then on sloping shelves in a large house which he rented near the Strand in London, he laid out his fossils in the order in which they were found in the strata.

His professional training had taught him to make maps, and he did not neglect to make geological ones. In this field, too, he was a pioneer. In 1799 he coloured a map of the country five miles round Bath, showing how the outcrop or edge of each hard rock could be followed around the hillsides. Next he showed the principal outcrops on maps of England and Wales; three of these manuscript maps, coloured about 1801, still exist. His friends urged him to publish a geological map of England and Wales, but the initial

financial cost promised to be considerable, and years passed before he found a map publisher who would take the risk. At last, in 1812, John Cary in London agreed to do it, but three more years went by before it was on sale. In 1815 the first copy was exhibited and received an award of 50 guineas from the Society of Arts. On a scale of five miles to the inch, it was the first detailed geological map of a country to be published. It included all England and Wales and the southern part of Scotland, measured 8½ feet by 6 feet, and was beautifully coloured.

During the next few years Smith brought out more publications. One, Strata Identified by Organized Fossils, was illustrated by plates of fossils characteristic of particular strata - such as the Chalk, the Greensand, Portland Stone - and each plate was on paper tinted to represent the colour of the strata where the fossils were found. He also published geological maps of 21 different English counties, as well as several horizontal geological sections across parts of southern England. In 1816, his collection of nearly 3000 fossils, arranged stratigraphically, was bought by the Treasury for the British Museum. It is still preserved in South Kensington, at the Natural History Museum.

From 1820 Smith lived in the north of England, mostly in Yorkshire, and improved his knowledge of the older rocks. His nephew John Phillips, whom he had brought up, lived with him. Phillips was later to become Professor of Geology at Oxford. William Smith was never a member of the Geological Society of London, established first as a dining club in 1807, but in 1831 the Society recognized his eminence as a 'great original discoverer in English geology' by awarding him the first Wollaston Medal, now the premier geological award. The following year he was granted a Civil List pension of £100 a year. This recognition by the Government of scientific worth and financial need was given to John Dalton in 1833 and Michael Faraday in 1835.

William Smith died on 28 August 1839, on his way to a meeting of the British Association in Birmingham - still actively pursuing field geology, in whose beginnings he had played so notable a part.

Welsh Geological Quarterly, vol.4, no.4, pp.3-7

NATURE-TIMES NEWS SERVICE

[April to June 1969]

Life-making gases in space clouds. The Times, 3rd April.

An important clue to how life may begin has been found at the National Radio Astronomy Observatory in the United States, where astronomers have discovered traces of formaldehyde in the clouds of dust and gas in space which are believed to be the birthplace of stars and planets.

This brings to four the number of different molecules that have been found in the dust and gas clouds. The others are water, ammonia and a molecule made up of one oxygen and one hydrogen atom. Hydrogen atoms are the chief constituents of the gas clouds.

Like the other three molecules, formaldehyde was detected by the characteristic wavelength of the radio signals which it emits under certain conditions. Evidence for formaldehyde has been found in 15 regions of space.

Part of the importance of the formaldehyde discovery is that it is indirect evidence for the presence in space of methane, a chemically related molecule. Methane is held to be one of the essential components from which primitive forms of life could develop.

Unfortunately, however, methane is not expected to be detectable with radio telescope.

Physical Review Letters, March 31st, 1969.

Is space dust made of sand. The Times, 7th April.

Evidence that the dust which is known to be present in space has a composition very much like ordinary sand has come from a team of astronomers at the Universities of Minnesota and California. Several series of infrared astronomy are the basis of the announcement. This is the first time sand has been put forward as the material of the dust in space.

Astrophysical Journal Letters, March 1969.

Origin of two groups of mountains. The Times, 12th April.

A theory to explain the origin of the Appalachian range of North America and the Caledonian mountains of central England and Scotland has been put forward by J.F. Dewey, a geologist at Cambridge University. It seems that the two groups of mountains, once part of a single system, were formed some 500 million years ago as part of the process in which a great ocean, the predecessor of the present North Atlantic, was gradually destroyed by the convergence of two continents.

The basis of the idea is the theory of continental drift, according to which the land masses of the world have been continually moving over the surface of the globe so as to form new continents and break up old ones.

The forces that power the movement are conveyor belts of molten material driven up by convection from the mantle of the earth. Surfacing at the underwater ridges in the centre of the major oceans, the material solidifies and spreads across the sea floor at speeds of a few centimetres a year before plunging back into the mantle.

Nature, v.222, p.124, 12th April, 1969.

Queensland rock yields old algae. The Times, 17th April.

The fossil remains of algae that probably lived some 1,600 million years ago have been found in rocks in Queensland, Australia. In appearance they resemble a still living species of algae.

The fossils visible only under a microscope, were discovered by Preston E. Cloud, of California University. They occur in rock formed from hardened layers of sediment which accumulated on the shore of an ancient sea. The sedimentary rock is sandwiched between two layers formed by volcanic eruptions, which can be dated by measuring the extent of radioactive decay in certain isotopes they contain.

The Queensland fossils are pairs of cup-shaped objects which resemble cells in the process of division. The pairs are stacked up to form regular cubes, a feature in which they resemble colonies of the present-day alga known as Eucapsis. Eucapsis, however, is a freshwater species, whereas the Queensland algae lived in salt water, probably in the intertidal zone.

The fossils do not appear to possess the well defined nucleus characteristic of all but the most primitive plant cells. This confirms an earlier suggestion of Dr. Cloud that conditions on earth would have been barely suitable for the evolution of cells with complex apparatus such as a nucleus until at the earliest some 2,000 million years ago.

Proceedings of the National Academy of Sciences, v.62, p.56, 1969.

A million tons of sand in the sky. The Times, 22nd April.

The shower of red rain that fell on July 1 last deposited about a million tons of Saharan sand over England and Wales, according to a report by Catherine Stevenson of the Meteorological Office. Previous dust-falls of this size have occurred only twice in the past 200 years.

The weather prevailing at the time and the appearance of the sand suggest that it originated from the Sahara around the Ahaggar mountains of southern Algeria. Freshwater algae found in one sample of dust may have come from the flood plains of the Niger and its tributaries, which border the southern edge of the desert.

Weather, v.24, p.126, April 1969.

Stability of rock magnetism. The Times, 23rd April.

The study of the magnetism trapped in ancient rocks has in the past few years helped to turn geophysics upside down. The discovery of alternating bands of magnetism along the length of the mid-Atlantic ridge and similar features in other oceans, for example, has forced most people to the uncomfortable conclusion that the continents have been drifting about in the surface of the earth in the past thousand million years or so.

Similar studies have shown more directly how the direction of the north magnetic pole of the earth seems to have changed in the course of geological time - the permanent magnetism of ancient rocks may frequently point in a direction quite different from that of the current magnetic poles.

By now the conclusions of these studies hang together so well that it is frequently forgotten how, even a few years ago, there were vigorous arguments about the rights and wrongs of using the magnetization of ancient rocks as a guide to the direction of the earth's magnetism in the recent past.

Such doubt as may persist on this score has now, however, been laid to rest by the appearance of a careful study of the subject carried out by Professor T. Nagata and two of his colleagues at Tokyo University, working in collaboration with E. Larson and D. Strangeway of the Massachusetts Institute of Technology.

Geophysical Journal of the Royal Astronomical Society, v.17, p.263, April 1969.

Australia fitted to Antarctica. The Times, 25th April.

The continents of Australia and Antarctica fit together almost exactly when their margins are taken at the 1,000-fathom level. The good fit is eloquent support for the belief that the two continents were once joined together in a single land mass.

The positioning of the continents has been carried out with the aid of a computer program by Walter P. Sproll and Robert S. Dietz at the Atlantic Oceanographic Laboratories, Miami. Dr. Dietz with H.H. Hess proposed 10 years ago that the sea floor is gradually spreading out on either side of the underwater mountain ranges that divide the world's major oceans. Moving at a few centimetres a year the sea floor eventually plunges back into the mantle from which it came, thus constituting a conveyor belt strong enough to move and break up continents.

The conveyor belt hypothesis, which has since been confirmed by magnetic studies of the sea floor, provided the essential piece that had hitherto been missing from the theory of continental drift, an idea put forward to explain the similarities of geology and species distribution on the opposite sides of several oceans, as well as the nicety with which, for example, the east coast of South America fits into the west coast of Africa.

Nature, v.222, p.345, 26th April, 1969.

Result of continental drift. The Times, 26th April.

Even as recently as 10 years ago there was great controversy about the theory of continental drift. Although there are still a few geophysicists who consider that this doctrine is inapplicable to the real world, their conspicuous isolation is a proof of how complete has been the triumph of those who have been arguing that the recognizable features of the surface of the earth have appeared only in the past two or three hundred million years.

Why has all this happened so suddenly? In the half century and more since Wegener pointed to the correspondence between the coast lines of West Africa and South America as one piece of evidence to suggest that the South Atlantic was once nonexistent, the theory of continental drift has had several ups and downs.

Only with the development in the 1950's of techniques for measuring the amounts of magnetism trapped in ancient rocks, first volcanic rocks and then sediments, did the theory command serious attention. For the magnetization of an ancient rock is a guide to the position of the magnetic poles at the time the rock was formed. This means, for example, that the studies of different rocks laid down at more or less the same period provide some evidence of how the two strata have moved relative to each other.

By themselves, however, the magnetic measurements would not have been enough to swing opinion behind the theory of continental drift and the elaborations of it which are now fashionable. Clinching support came not from studies of the continents but, paradoxically, from studies of the great mountain ridges that run along the seabed in the deepest parts of the Atlantic, Pacific and Indian oceans. The best known of these is the Mid-Atlantic Ridge, which runs southwards from Iceland through the Azores and St. Helena until it turns eastwards south of the Cape of Good Hope to join up with a similar ridge in the Indian Ocean east of Madagascar.

These ridges are huge constructions even by the standards of mountain ridges on land. The Mid-Atlantic Ridge rises more than a mile above the surface of the surrounding seabed which has long been recognized to be exceedingly featureless. But the ridges are often centres of volcanic activity, which explains the presence of strings of islands along their length. The problem in the late 1950's was to find some explanation of them.

The first telling suggestion was that of Hess and Dietz, who argued that the ridges were places where material was welling up from the interior of the earth and then spreading out over the surface of the oceans. This fitted well with other arguments, such as that of Professor S.K. Runcorn, who argued that the drifting of the continents could be driven by forces of thermal convection such as those which make hot air move upwards in a closed room. But how to discover that this theory is correct? The answer came in the early 1960s, when Vine and Matthews pointed out that if the sea floor is really spreading outwards from the ocean ridges it should be possible to tell how fast by studying the magnetism of the rocks on the seabed on each side of the ridge.

Oceanographers and geophysicists have splendidly confirmed this in the past few years. It turns out that the spreading of the sea floor is surprisingly rapid - a few centimetres a year in many places. In some

places the continents are being pushed apart by the spreading of the sea floor - this explains the opening up of the South Atlantic which is a mere 150 million years old or roughly as old as the Coal Measures in Britain.

But the theory of continental drift is only a beginning of the transformation of geophysics which seems to be under way. In the past few months two radical developments of the theory have taken place. First, it has been recognized that the ocean ridges cannot keep on spewing out matter from the interior of the Earth and yet retain exactly the same geometry. Instead the ridges are broken up into segments and consecutive blocks slide against each other so as to give the surface of the seabed some kind of structure and causing earthquakes in the process.

The second more recent development is the recognition of how the processes responsible for the activity of the mid-Atlantic ridges may also affect processes in the great continental land masses. One step in this direction came a year ago, when McKenzie and Parker argued that the geological history of the Earth in the past 100 million years or so could be explained by supposing that rather fewer than a dozen pieces were being moved across the surface of the globe, carrying mountains, pieces of continents, and even ocean ridges, with them.

Nature-Times News Service.

Did meteorite seed earth with life? The Times, 28th April.

The analysis of a meteorite that fell in Mexico on February 8 last has cast a long shadow over hopes that meteorites might provide positive proof of extraterrestrial life. The Mexican meteorite contains chemicals which could only have been produced by living organisms, but which were almost certainly acquired during the brief period between the meteorite's fall and the time it was taken to a laboratory seven days later.

Scientists have looked for signs of extraterrestrial life in meteorites ever since it was realized that meteorites originate from outside the earth. Pasteur searched for bacteria in the meteorite that fell at Orgeuil in 1864 and organic molecules, probably of biological origin, have been detected in the Orgeuil and other meteorites.

The discovery last year of fossil organisms that are some 3,200 million years old has added new zest to the analysis of meteorites. The earth is thought to be only some 4,800 million years old and it is somewhat surprising that living cells apparently evolved so soon after its formation. From this uneasiness has grown the speculation that the primitive earth was fertilized by the fall of a meteorite carrying biological molecules.

In analysing a meteorite, however, it is always hard to prove that it has not been contaminated during its stay on the ground or even by its passage through the air. Many meteorites are fairly porous, so that even material taken from the centre may be suspect. Occasionally meteorites are removed to the safety of the laboratory fairly soon after their fall, but it now seems that even in these circumstances the possibility of contamination cannot be excluded.

Nature, v.222, p.364, 26th April, 1969.

Protein key to primate evolution. The Times, 29th April.

A branching point on the evolutionary tree of man and monkeys has been identified by an analysis of protein molecules in living species. The analysis, which shows how the composition of a particular molecule differs from one species to another, identifies one of the genetic changes by which the common ancestors of man and apes diverged from those of the Old World monkeys.

Journal of Molecular Biology, v.41, p.83, 14th April, 1969.

Mascons and orbit of Apollo 10. The Times, 2nd May.

Space scientists have discovered six concentrations of dense material below the surface of the moon which may have to be allowed for in calculating the orbits of Apollo spacecraft. This brings to 12 the number of mass concentrations, or mascons, that have been detected in the moon.

Mascons are found by the gravitational pull they exert on the orbits of unmanned spacecraft circling the moon. Mascons affected the orbit of the three-man Apollo 8 spacecraft which circled the moon last Christmas.

A clue to the origin of the mascons is that they are centred beneath roughly circular plains surrounded by a ring of mountains, called "ringed maria" in astronomical terminology. One theory is that the ringed maria were excavated by large meteorites and that the mascons are the buried remains of the meteorites.

Nature-Times News Service.

An inland sea of 150m years ago. The Times, 8th May.

The existence of a vast inland sea, whose southern borders covered much of western Europe some 150m. years ago, has been inferred from a study of the fossil remains of the period. The sea has been named the Boreal Inland Sea by its discoverer, Dr. A. Hallam, of Oxford University.

In the Jurassic period, which lasted from about 185m. to 140m. years ago, the land masses of the world were in part the same as exist now but were in a quite different configuration.

According to the theory of continental drift, the details of which are still being worked out, it seems that North America and Greenland abutted on to the European land mass at this time, and Africa was swivelled clockwise and downwards from its present position so that the Mediterranean was merely the western extremity of a great sea, the Tethys Ocean, which stretched across the present lands of the Middle East as far as Indonesia.

Palaeontologists have grouped the worldwide marine fossil remains of the period into two main groups known as the Tethyan and the Boreal. But it has not been clear what physical agency, such as temperature differences or a land barrier, for example, underlay the evolution of the two fairly separate groups of sea animals.

Dr. Hallam's suggestion is that it was a difference in the salt content of the water that divided the Boreal and Tethyan groups of animals. Marine animals, whose blood is as salty as the ocean waters in which they evolved, find it hard to colonize waters of a lesser salt content, which as a result often contain a smaller number of different species.

Palaeontology, v.12, p.1, 1st April, 1969.

Fault on sea bed reaches the shore. The Times, 20th May.

One of the most remarkable developments so far in the history of sea-floor spreading, itself the explanation of how the continents seem to drift apart, is the discovery, now reported in Nature, of how zones of disturbance on the floor of the Atlantic seem to be linked with zones of seismic disturbance on the coast of West Africa around the Volta Delta. This is more proof that the continents are not merely being moved about on the surface of the Earth but also, in some places, being torn apart.

Dr. Kevin Burke, of the Department of Geology at the University of Ibadan, has now pointed out that the two conspicuous faults in the Mid-Atlantic Ridge at, or just south of, the equator can be projected eastwards so as to reach the coast of Africa in regions which are also seismically disturbed. For example, the so-called chain fracture zone, the more southerly of the two fracture zones, appears to reach the coast of Africa near Accra and then to run north-east, separating the young geological structure known as the Dahomey Basin from the older rocks of the African mainland.

Nature, v.222, p.655, 17th May, 1969.

Unknown elements in meteorites. The Times, 23rd May.

Chemical elements heavier than any discovered or created may once have been in meteorites. The clue to their existence lies in a pattern of abundance in stone meteorites of the various isotopes of xenon.

Xenon, a noble gas element, exists in several forms, known as isotopes, which differ in the number of neutrons contained in the nucleus of each atom. Some of its isotopes are created in the radioactive decay of heavier elements, such as plutonium, and from the abundance of the various isotopes in a lump of material it is often possible to work out the parent elements from which they must be derived.

The relative abundance in stony meteorites of one of these isotopes, xenon-136, has been studied by Edward Anders, of Chicago University, and Dieter Heymann, of Rice University. They say that although the isotope is the product of radioactive decay, none of the known chemical elements could produce it in the proportions in which it is found.

Science, v.164, p.821, 16th May, 1969.

Old sea reefs in Midlands may hold oil. The Times, 27th May.

A belt of oil-laden rocks may underlie the Manchester area and parts of the Midlands if a theory about geological events of about 330m. years ago is correct.

It seems that the shallow sea which inundated England at this time built up an extensive belt of limestone reefs that could be reservoirs of oil, including the oil of unknown origin that has been discovered at Formby, near the Lancashire coast.

The theory is proposed by W.H.C. Ramsbottom, of the Institute of Geological Sciences, Leeds, who has recognized a pattern in the occurrence of two types of limestone rocks. The rocks were deposited as limestone reefs, one type as long as 350m. years ago and the other possibly about 30m. years later.

Nature, v.222, p.765, 24th May, 1969.

The progress of the Irish meteorite. The Times, 27th May.

The path of the meteorite that passed over the British Isles on the evening of April 25 last has been plotted by astronomers at the Armagh and Dunsink observatories. The fragments recovered have been sent to the Atomic Energy Research Establishment, Harwell, for measurements of their radioactivity.

From observers' accounts it appears that the meteorite took a north-westerly course over southern England, Wales and the Irish Sea, breaking up into three parts as it passed over the co. Down coast and then into further fragments. The meteorite's 360-mile flight over the British Isles lasted for only 20 sec. From Dublin the meteorite, as it burnt up in the atmosphere, was seen as a fireball slightly brighter than the full moon.

Nature, v.222, p.727, 24th May, 1969.

Scars left when earth caught moon. The Times, 30th May.

Geological features that may be the scars left from when the earth captured the moon have been identified by Dr. Norman Herz, of the United States Geological Service. The features are outcrops of a certain kind of rock which, when the continents are rearranged in the positions they occupied 200 million years ago, are seen to run across the world in two great belts, one in each hemisphere.

The belts are the result of some cataclysm that overtook the earth 1,300 million years ago, an event that Dr. Herz suggests was the capture of the moon by the earth.

The rocks, known as anorthosites, occur mostly as massifs of material several miles across, which were probably squeezed up through the crust of the earth from the hotter regions underneath. There are more than 50 anorthosite massifs in Canada and the United States and as many others in the rest of the world.

Dr. Herz is apparently the first to notice that the anorthosite massifs scattered across the present face of the world lie on two almost unbroken belts when the continents are replaced in the positions they occupied before the present phase of continental drift began.

Science, v.164, p.944, 23rd May, 1969.

Evidence of continental drift. The Times, 6th June.

The way in which the various species of earwig are distributed throughout the world suggests that the continents must once have laid in positions very different from those they occupy today. This confirms independently the theory of continental drift, proposed chiefly on geological grounds.

Dr. E.J. Popham, of Salford University, has studied the geographical relationships between the thousand or so species of earwig that now exist. The earwigs belong to three family groups, and by noting the number of species in each family that various areas of the world have in common it is possible to infer the general routes by which the earwigs spread out across the globe from their place of evolution.

Together with Dr. B.F.J. Manly, Dr. Popham has shown that the present distribution of earwigs can be accounted for only if the continents once occupied the positions that are implied by the theory of continental drift.

Nature, v.222, p.981, 7th June, 1969.

Silicon on the earth and moon. The Times, 3rd June.

Two independent lines of argument have led American scientists to the view that the element silicon is deficient on the earth and over-abundant on the moon, and that this distribution of the element may account for certain features in the evolution of the solar system. The arguments, due respectively to Dr. David E. Fisher and Professor E. Orowan, appear in the current issue of Nature.

Nature, v.222, pp.866,867, 31st May, 1969.

Disturbing consequences of mascons. The Times, 12th June.

The reports at the weekend that the Apollo 10 astronauts were at one point four miles off course because of the irregularities of the moon's gravitational field, known as mascons, have been followed by a detailed report in which mathematical analysis shows that the anomalies are exceedingly confusing.

In the current issue of Science, Dr. William M. Boyce, of the Bell Telephone Laboratories, says the irregularities have invalidated the methods of analysis previously used "at several space centres in the United States."

Science, v.164, p.1189, 6th June, 1969.

Did moon spin off from earth? The Times, 13th June.

An old and largely discredited theory about the origin of the moon has been revived by John O'Keefe of the Goddard Space Flight Centre in Maryland. He argues that the parent body of the present moon was spun off from the earth, an event that according to certain geological evidence could have occurred some 3,500 million years ago.

On present evidence, such as it is, it seems that the moon was either a wandering planet that was captured by the earth or else was formed from a cloud of matter at the same time as the earth and quite close to it. One theory that can fairly definitely be excluded, at least in its simple form, is that the earth and the moon were once a single rotating mass which because of some instability divided into two.

For reasons of dynamics it turns out that one of the two fragments created in this kind of fusion has to be about 10 times as heavy as the other whereas in fact the mass of the earth is 81 times greater than that of the moon. Even if the two fragments did separate, the smaller would either be spun off to infinity or crash back to the parent body.

Dr. O'Keefe has sought to circumvent these objections by arguing that when the moon was spun off the earth it was as heavy as the dynamical theory requires and had a mass at least one-tenth of the earth's.

Journal of Geophysical Research, v.74, p.2758, 1969.

Fossil man in British Museum. The Times, 14th June.

A fragment of jawbone in the collection at the British Museum (Natural History) has been identified as belonging to an ape-like creature that may have been a direct ancestor of man.

Dr. David Pilbeam of Yale University believes that the fossil bone, hitherto unidentified, is the jaw of Ramapithecus punjabicus. Remains of this species are of particular interest to students of man's evolution because it lived at the crucial time, some 12 million years ago, when the ancestors of man and apes were diverging from each other.

Ramapithecus is only known by jaw fragments but these are enough to suggest that the animal had certain man-like features such as a foreshortened face.

Nature, v.222, p.1093, 14th June, 1969.

Spread of sea floor explains topography. The Times, 17th June.

The theory of how new crust is continually being created beneath the deep oceans is now well on the way to explaining the important features of the geological history of the earth in the past 300m. years. It also seems extraordinarily successful in accounting for some of the features of the topography of the oceans recently uncovered by deep sounding.

In the current issue of Nature, H.W. Menard and Tanya Atwater, of the Scripps Institution of Oceanography in California, have been able to show how the theory of the malleable ocean floor now in fashion is able to explain the appearance of what are called the moonless mountains in the north-east Pacific.

Nature, v.222, 14th June, 1969.

How the land grew up from the sea. The Times, 19th June.

A remarkable synthesis of geological data gathered over many years has been made the basis of an ambitious attempt to describe how the land masses of the world evolved. In outline the theory suggests that the bulk of what land there is was thrust up from beneath the ocean and accreted round two ancient nuclei until a single supercontinent had been formed.

The supercontinent began to break apart 200 million years ago into fragments that exist today which were carried to their present positions by the process of continental drift.

The chief conclusion of the new study is that the piling up of the land above the water probably began 3,800 million years ago, about 1,000 million years after the formation of the earth, and proceeded at a steadily increasing rate until the supercontinent began to disintegrate. The present phase of continental drift seems to be unique in the earth's history.

A synthesis of this nature is bound to be tentative but it rests on the dating by radioactive decay of thousands of rock samples throughout the world. Patrick M. Hurley, of the Massachusetts Institute of Technology, and his colleague John R. Rand, have plotted the dates on a map of the continents in their pre-drift positions. From the pattern of dates that emerged they have recognized clues as to how the continents may have evolved.

Science, v.164, p.1229, 13th June, 1969.

When the first arachnids came on land. The Times, 20th June.

Fossils of the oldest land-dwelling arachnid, the group that includes scorpions, spiders and mites, have been found in a quarry near Alken an der Mosel, west Germany. It seems that the earliest arachnids had established themselves on land some 390 million years ago and developed at the same time as the first land plants.

The quarry is a rich source of fossils from the Lower Devonian, the geological period that lasted from 400 to 385 million years ago. Embedded in the petrified clay are Devonian algae, molluscs and eurypterids, the scorpion-like aquatic animals that grew up to 6 ft. in length. The fossil arachnids, found by Leif Størmer of Oslo University, are about $\frac{1}{2}$in. long and covered in numerous small knobs. The chief feature of interest is the structure of their legs, which were clearly adapted for walking on land. As such, the fossils are the earliest known terrestrial arachnids, although some Scottish arachnids may be nearly as old.

Science, v.164, p.1276, 13th June, 1969.

Light on the origin of modern man. The Times, 21st June.

An expedition to the Omo River valley in south-west Ethiopia has discovered three fossil skulls which may place a new perspective on the origins of modern man. The skulls are those of Homo sapiens but unexpectedly primitive features in one of them are reminiscent of Homo erectus, the species from which modern man is usually assumed to have evolved.

The Omo fossils were found in 1967 by the Kenya contingent of the International Palaeontological Research Expedition, led by Mr. Richard Leakey. The skulls are described in this week's Nature, by Dr. M.H. Day of the Middlesex Hospital Medical School, a member of the expedition.

The importance of the skulls is that they probably date back to the crucial period when Homo sapiens had recently evolved as a distinct species. Only three fossil skulls of this age have been discovered but neither they nor the many more recent Homo sapiens skulls do much to clarify the evolutionary relationships between Homo sapiens and the extinct fossil species such as Homo erectus and the even more ancient Homo habilis.

Nature, v.222, p.1132, 21st June 1969.

Openings of the Kattegat. The Times, 25th June.

One of the most detailed studies made of the melting of the ice with the disappearance of the glaciers has been carried out by Dr. Nils-Axel Morner, of Stockholm University.

The study is more detailed than any previously available, although it is essentially in agreement with what is known of the melting of the ice from studies of the coastlines in widely separate places - North America and New Zealand, for example. This monumental piece of work is published in the current issue of Sverigs Geologiska Undersökning.

The interest of Dr. Morner's work to scientists will be that it will provide a series of landmarks in the melting of the ice against which measurements obtained from other parts of the world may be measured. It provides also a fascinating account of how the sea level in the Baltic advanced and retreated under the influence of several forces - the gradual rising of the land relieved of the weight of glaciers, the gradual rise of sea level accompanying the world-wide melting of ice, and the climatic fluctuations, which may on occasions have been local.

It is well known that the last ice age reached its maximum intensity about 54,000 years ago. For practical purposes, however, the disappearance of the ice age began between 12,000 and 13,000 years ago and Dr. Morner has been able to document the processes that followed 10,000 B.C. with unprecedented thoroughness.

This has been done by collecting samples from the floor of the Baltic so as to study the pollen which they contain, the ages of the organic materials in them and the nature of the sediments that may have been carried there by glaciers.

Sverigs Geologiska Undersökning, v.63, p.1, 1969.

GEORGES CUVIER (1769-1832): THE FOUNDER OF VERTEBRATE PALAEONTOLOGY

An extract from H. Alleyne Nicholson's Natural History: its rise and progress in Britain as developed in the life and labours of leading naturalists (W. & R. Chambers, London and Edinburgh, 1886) to commemorate the bicentary of the birth of Baron Georges Léopold Chrétien Fréderic Dagobert Cuvier, who was the first man to work extensively and really systematically on the palaeontology of fossil vertebrates and whose writings formed the scientific Bible of Catastrophism.

"Cuvier effected the most important advances as regards the natural history of former periods of the development of the earth. Indeed, it is not too much to say that Cuvier may fairly claim to have been the chief founder of the modern science of 'Palæontology;' a science which has enormously expanded during the last fifty years, and which, when fully mature, will obtain the recognition to which it is justly entitled, of being from all points of view one of the most important branches of scientific zoology. It is true that palæontology is often spoken of - in some cases even by scientific writers - as a branch of geology. It has even been termed 'the handmaid of geology.' A more erroneous conception of the entire aim and scope of palæontology could not well be formed; and it is one which will certainly not be accepted by any one who is himself a palæontologist in the proper sense of the term. It may be freely admitted that many of the earlier palæontologists dealt with fossils to a large extent from the geological point of view rather than in their zoological aspect. It is also true that some so-called palæontologists have been little more than 'collectors,' and have had no real grasp of the scientific side of palæontology. This is, however, equally true of zoology in its earlier days; and, even now, 'collectors' are by no means extinct, nor are their labours by any means to be despised. Recent zoology, also, has as one of its departments the 'Geographical Distribution of Animals;' but no one for this reason would think of asserting that zoology was only a branch of geography. The sole relations between the subjects of geology and palæontology arise from the fact that fossils occur in rocks. Geology is to palæontology almost precisely what geography is to zoology. In its essence, however, palæontology is concerned

entirely with the study of the remains of animals and plants; and in its two divisions of palæozoology and palæobotany, it is a branch of zoology on the one hand, or of botany on the other hand. The very use of the separate term 'palæontology' is a misfortune and a cause of error. The truth is, that all that part of palæontology which is concerned with animals is a branch of zoology; and just as a man cannot be a good palæontologist unless he is first a good zoologist, so it may be safely stated that a man cannot be a good zoologist, unless he has at least a good general knowledge of palæontology.

Cuvier's palæontological researches were mostly carried out in connection with the numerous remains of animals, chiefly Vertebrates, which had been met with in the strata of the neighbourhood of Paris. With his usual love of thoroughness in all he did, Cuvier undertook, in conjunction with Alexander Brongniart, an investigation into the arrangement of the Tertiary strata round Paris, in which these fossil remains abounded, and the results of this investigation were published in 1808, in the famous joint memoir, entitled 'Essai sur la Géographie minéralogique des Environs de Paris.' This work may be looked upon as the most important contribution which had been made up to that time to the study of the Tertiary series of rocks. It was principally, however, by the study of the organic remains contained in these strata that Cuvier has made himself famous.

Long controversies had been carried out among the earlier naturalists as to whether 'fossils' were really the remains of animals at all - many holding that they were merely peculiar mineral structures, formed by a kind of 'plastic virtue' in the earth itself. The notion, however, that fossils were merely lusus naturæ had been given up before Cuvier's time by most of the leaders of science; though it was still generally held that fossils were the remains of the animals and plants now in existence upon the globe. It had, of course, often been pointed out - as early as the time of Hooke and Ray, in fact - that many fossil shells were quite unlike any similar shells now existing; but it had been common to meet this by the argument that our knowledge of living animals was still very imperfect, and that very probably further investigations would show that the fossil forms which were supposed to be extinct, were really still living in some hitherto unexplored region. This last argument was,

however, rendered quite untenable by the discovery of the remains of numerous unknown quadrupeds, often of large size, in the Tertiary beds round Paris; since, even in the beginning of this century, it was certain that no noteworthy discovery of large living Mammals was likely to be made in any of the less known portions of the earth's surface.

Cuvier, however, went further than this. He showed, by a close comparative examination of the fossil bones of these Mammals with the bones of their nearest living allies, with which they had previously been confounded, that such differences existed between them as to render it certain that the fossil forms belonged to 'extinct' species. The one grand point in which Cuvier's views fell short of those of modern palæontology, was that he failed to recognise any direct connection, by modification or descent, between the extinct species of animals and those now alive. On the contrary, Cuvier, like all the geologists of his time, was a 'catastrophist.' In other words, he believed that the present period was separated from preceding periods - as these were supposed to be separated from each other - by sharp lines of demarcation, due to great 'catastrophes' or natural convulsions, by which the animals and plants of each period were destroyed, a new series of organic forms coming into existince at the commencement of each fresh period.

On the question, also, of the nature and origin of 'species,' Cuvier was entirely in agreement with most of the naturalists of his day, being a firm believer in their fixity and immutability. His great predecessor and contemporary, Lamarck, ... had attacked this complex problem from its zoological side; and had arrived at the conclusion that the existing species of animals and plants had been produced by the modification of pre-existing species. In this conclusion, however, Lamarck had run counter to the most cherished beliefs of zoologists generally; and the prejudices which he had to confront were not lessened by the fantastic theories which had been put forward upon this subject by some of his own countrymen.

Thus, Benedict de Maillet, who wrote theoretically, and without any special knowledge of zoological science, had published a curious work entitled

'Telliamed,* or a Discourse between an Indian Philosopher and a French Missionary on the Diminution of the Sea,' of which an English translation was published in 1749. The fundamental proposition of this work was that the sea had at one time covered the whole of the dry land, and that therefore all the primitive forms of animal life must have been marine and aquatic in their habits. Hence, he supposed that the inhabitants of this hypothetical universal ocean had become changed into new forms, when the sea had retired, and the land had come into existence. In this way, all our present diversified forms of animal life had been produced, some of those animals which lived near the surface of the sea (such as Flying-fishes) becoming developed into birds; while some of those which lived at the bottom of the sea became converted into the terrestrial quadrupeds.

Again, Robinet, another theorist, had likewise published, in 1768, a work entitled 'Considerations philosophiques sur la Gradation naturelle des Formes de l'être,' in which he endeavoured to establish the proposition that the lower animals were merely the unsuccessful attempts which Nature had made in the production of Man.

In his views as to the fixity of species, Cuvier, on the other hand, was strictly orthodox. He recognised the existence of numerous varieties, especially among the domesticated animals; but he regarded the peculiarities of these as purely superficial. He believed that these varietal differences were the result solely of differences in the external conditions to which different individuals of the same species were exposed. He regarded these differences, therefore, as evanescent, and he would certainly have rejected entirely the idea that 'varieties' are 'incipient species.'

In dealing with the views which had been put forth by Lamarck, it seemed to Cuvier a sufficient argument that we find in the Catacombs of Egypt the mummies of cats, dogs, monkeys, and other animals, in a state of excellent preservation;

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* Telliamed is an anagram of the author's own name.

and that we can therefore be certain that these particular species have remained essentially unchanged during the long period, from a human point of view, which separates the formation of the Catacombs from the present day. This argument, however, was sufficiently met by Lamarck himself. Lamarck saw no difficulty in accepting the fact that the species of animals preserved in the Egyptian catacombs are in all essential respects precisely similar to forms now in existence. On the contrary, 'it would assuredly be singular,' says he, 'if this was otherwise; since the position and climate of Egypt remain at the present day almost precisely what they were in the epoch of the catacombs.' Hence the animals which now live in Egypt find themselves under exactly the same conditions as they were then, and have therefore retained the habitudes which they at that time possessed. Besides, he adds, there is nothing in the observation in question to prove that these animals have existed from the beginning in their present form. It merely means that they have remained unchanged for the last two or three thousand years; but every one who has been in the position to appreciate the antiquity of Nature, will readily give the proper value to such a period, as compared with the age of the world.

Apart from his views as to 'species,' it is to Cuvier that we owe the establishment of a really scientific basis to palæontology. Cuvier showed that the only method by which the remains of fossil animals could be scientifically investigated, was by comparing them morphologically with the known living forms. In other words, he applied to palæontology those principles of comparative anatomy which he had used with such brilliant results in his purely zoological investigations. There is, however, an obvious difficulty in the way of the application of the laws of comparative anatomy to fossils in the same way as they can be applied to animals now in existence. In the case of the latter, we have the entire organism before us; we have not only its skeleton, but also its muscles, nerves, blood-vessels, and internal organs generally. Moreover, in systematic zoology, it is from the soft parts, rather than from the skeleton, that we in many cases draw our most weighty conclusions. In fossil animals on the other hand, with very few exceptions, only the hard parts are preserved for our inspection and examination. If we are to draw any conclusions at all as to the relationships and systematic position of extinct animals, we must do so from the characters and structure of the skeleton alone.

Besides, in the case of a great many fossil animals, it is not usual that even the entire skeleton is preserved. In the case of all the Vertebrate animals, at any rate, the palæontologist is usually called upon to frame his conclusions on a fragmentary specimen. He may have only a single bone or tooth; or he may have a number of detached bones. Only rarely does he find a complete skeleton, or meet with the bones still in their proper places and connections.

This inherent difficulty in all palæontological investigation was solved by the establishment by Cuvier of the famous law of 'the correlation of organs.' Cuvier showed that certain organs or structures in animals are only found in association with one another; so that if one of these correlated organs be found to be present, then we may be sure that the others will also be there. In some cases, this correlation or association of particular organs is based upon an obvious physiological connection. Thus, thin-walled hollow bones are associated with a peculiar form of lung, in which the greater air-passages (bronchi) do not end within the lung itself, but become connected at the surface of the lung with membranous receptacles or air-sacs distributed in different parts of the body. Again, the peculiar form of toe-bone which is adapted for the carrying of a hoof is correlated with such other modifications of the bones of the limb as are needed to secure the absence of rotation in the bones, and to insure the fitness of the leg for its special function of supporting the weight of the body. In very many cases, however, no physiological explanation can be given as to the association or correlation of particular organs. Thus, all animals in which the skull is jointed to the backbone by a double articulation, and in which the two halves of the lower jaw are composed each of a single piece, have at the same time the glands by which they are enabled to suckle their young. All animals possessing these two structures also possess (or may possess) the special integumentary appendages known as hairs. Similarly, all those animals which have the stomach adapted for chewing the cud, or ruminating, have as a correlation with this, no more than two functionally useful toes, the third and fourth toes. All such animals, moreover, have an incomplete development of the incisor teeth in the upper jaw. They are also the only living quadrupeds which have horns developed upon the frontal bones.

The few examples given above may suffice to illustrate the general nature of the 'law of the correlation of organs.' Stated in its most general form, this law asserts that all the parts of the organism stand in some relation to each other, the form and characters of each being in direct connection with the form and character of all the rest. The nature of this connection is in many cases hidden from us; but it is certain that if, by an arbitrary exercise of will, we could suddenly change the form of any one organ in any given animal, we should find ourselves compelled to make changes in all the other organs of the same animal. In many cases, perhaps, the changes necessitated by the modification of some particular organ might be slight; in most cases we should be unable to see why any changes should be needed at all, beyond the one with which we had started; in all cases the fact would remain, that the living organism is an aggregate of parts so put together that any modification of any one part necessitates a modification of all the rest.

The application of this law to palæontology is easy to understand. It is found from the study of living animals, where all the parts of the organism can be investigated as a whole, that certain organs or structures are found associated with one another, or, at any rate, are never found apart. In the case of fossil animals, we never have more than certain parts of the organism preserved. We never, save in such exceptional instances as the preservation of the bodies of animals in the frozen soil of Siberia, have the opportunity of examining the whole organism. By the help, however, of the law of 'the correlation of organs,' we can 'reconstruct' the animal from its fragments. If we find certain structures preserved in the fossil, we can infer that certain other correlated parts must have been present. Thus, from a single molar tooth it may be possible to infer the form of the jaw, the structure of the limbs, and, in fact, the general features of the organisation. Those who wish to learn with what precision and certainty an extinct animal may in this way be 'reconstructed' from its fragmentary remains, can easily satisfy their curiosity by reference to the pages of the 'Ossemens fossiles'* of Cuvier, or to the works of his illustrious disciple, Sir Richard Owen.

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*[Recherches sur les ossements fossiles de quadrupèdes (4 volumes), 1812; translated into English and published in 1834-35.]

It should be pointed out, however, as indeed was recognised by both Cuvier and Owen, that the law of correlation of organs can only be applied in practice with certain reservations, of which the following are the most important: In the first place, the law is a purely empirical one, and is based wholly upon the results of observation and experience. Having, therefore, no rational basis, it is always liable to be overthrown in particular instances by more extensive observation, though its validity as a general law remains unaffected .....

In the second place, when we have to deal with fossil organisms, we may easily assume that a particular structure was absent in an animal, whereas it might have been present, and yet might not have been preserved, owing to its only having been present in a condition incapable of preservation in the fossil condition. Thus Marsupial quadrupeds (kangaroos, opossums, &c.) may be stated, as a general rule, to have the lower jaw of a characteristic form, the part of the jaw known as the 'angle' being bent inwards or 'inflected.' Correlated with this peculiar structure of the jaw, but having no recognisable connection with it, are two little bony splints, which are attached to the brim of the pelvis, and which are known as the 'marsupial bones.' No exceptions were known in the time of Cuvier to this rule; hence Cuvier was entitled to regard this as a constant correlation. Thus he met with a fossil skeleton of a quadruped, like all such fossils, only preserved in parts, which showed the lower jaw; and finding that the angle of the jaw was 'inflected,' he came to the conclusion that it was a Marsupial. Moreover, from the structure of its teeth he inferred that the skeleton belonged to one of the opossums, such as now inhabit the American continent, and he named it the Didelphys gypsorum.

As all living Marsupials are found in Australia, New Guinea, certain of the islands of the Pacific, and in North and South America, the alleged discovery of an opossum in the Tertiary strata near Paris, naturally excited some incredulity in the scientific world. In order to dissipate this incredulity, Cuvier invited his scientific colleagues to meet him, and proceeded in their presence to cut away with a chisel the stone enveloping the bones, so as to bring into view the front part of the pelvis, which lay deeply buried in the matrix. On accomplishing this, he was able to demonstrate at

once that the pelvic bones carried the 'marsupial bones,' which are so characteristic of the opossums and of Marsupial quadrupeds in general. It is needless to add that this demonstration of the value of the law of the correlation of organs in palæontological researches excited the greatest admiration, and was regarded as absolutely conclusive. In one important point it was indeed conclusive; since no known animal outside of the order of the Marsupials is known to have both an inflected angle to the lower jaw, and also marsupial bones on the brim of the pelvis.

The conclusiveness arose, however, from the fact that Cuvier found both these structures together; and we now know that the presence of the one would not necessarily prove the presence of the other. Cuvier knew this himself so far as the presence of 'marsupial bones' is concerned, because he knew that these bones occur in the duck-mole and spiny ant-eater, in which the angle of the jaw is nevertheless not inflected. He did not know that he might have found the inflected angle of the lower jaw, and that he might have been quite right in his conclusion that the animal was a Marsupial; and yet, on laying bare the **pelvis**, he might have found no 'marsupial bones.' It is known, namely, that in certain living Marsupials (the Thylacinus of Tasmania) the 'marsupial bones' do not become converted into bone, but remain permanently in the condition of cartilage. These structures would therefore be absent in any fossil specimen of such a Marsupial, since cartilages are not preserved in the fossil state. Hence, it is possible, though not probable, that we might some day meet with the skeleton of some extinct Marsupial, in which we should find the angle of the lower jaw to be inflected, but which would nevertheless show no traces of 'marsupial bones.'

In the third place, in any two correlated organs it is not usual that each is correlated with the other, but that one of the two is correlated with the other. That is to say, of any two correlated organs, A and B, it may be true that A is never found without B, but it does not follow that B may not occur without A. Thus, the presence of a stomach adapted for 'rumination' is invariably associated with an imperfect development of the incisors of the upper jaw, the central upper incisors being always wanting; but it is not the case that an

incomplete condition of the upper incisors, or the absence of the central ones, is necessarily correlated with the habit of chewing the cud. The proper way of putting the case is to assert that certain structures (A) are never found apart from other structures (B), though the latter may be present without the former. When, therefore, we find a lower jaw having its angle 'inflected,' we may, with our present knowledge, assert that the animal to which that jaw belonged must have possessed 'marsupial bones' or 'marsupial cartilages' upon the brim of the pelvis. If, however, we were to find a pelvis with marsupial bones, we should not be justified in asserting that the owner of the same must have possessed an inflected angle to the lower jaw. On the contrary, we know that such an assertion would be erroneous, since the 'marsupial bones' are present in the duck-mole and spiny ant-eater, in which the angle of the jaw has its usual form."

Editor's Note

Much more modern and extremely lively sketches of Cuvier and his work are given in the section entitled Cuvier: the magician of the Charnel House, in Loren Eiseley's Darwin's Century: evolution and the men who discovered it (Gollancz, London, 1959); and in the chapter headed Cuvier: monsters and revolutions in Ruth Moore's The earth we live on: the story of geological discovery (Jonathan Cape, 1957).

The latter starts as follows:-

"Paris was shocked, interested, incredulous, fascinated. In the fashionable salons, at the university, in the streets, everyone was talking about the fantastic elephant bones that M. Cuvier was digging from the very soil of the capital. Elephants, M. Cuvier had told the Institut National, had once lived in France and roamed the Paris countryside itself. It was almost too much, and yet it was an irresistible prospect. Everyone rushed out to see.

And the elephants were only a beginning. Soon the amazing M. Cuvier was unearthing even stranger denizens of a past that no one, or certainly very few, had suspected or even imagined. There were lizards as big as

whales, lizards that could fly almost like birds, mammoths covered with long hair, hippopotamuses, rhinoceroses, bears, wolves, and other odd and often huge creatures that bore only a slight resemblance to living animals.

Cuvier, almost like a sorcerer, reconstructed them from their bones, often from only a few fragments of fossilized bone. His magic was almost as astounding as the singular, unnatural creatures themselves and the incalculably ancient worlds to which Cuvier said they had belonged. For Cuvier was telling his already staggered contemporaries that some of these ancient animals had lived in a time when the seas washed over the Paris basin, some in eras that were warm and tropical, and some in the years that had elapsed since the Flood, which Cuvier called the last great revolution that the world had undergone.

'Is Cuvier not the greatest poet of our century?' exclaimed Balzac with admiration and enthusiasm. 'Our immortal naturalist has reconstructed worlds from blanched bones. He picks up a piece of gypsum and says to us "See!" Suddenly stone turns into animals, the dead come to life, and another world unrolls before our eyes.'"

> Genius and science have burst the limits of space ... Would it not also be glorious for man to burst the limits of time and .. ascertain the history of this world, and the series of events which preceded the birth of the human race?
>
> (Georges Cuvier: The Animal Kingdom. 1817.)

Welsh Geological Quarterly, vol.4, no.4, pp.20-30.

THE DRAINAGE OF CENTRAL MONMOUTHSHIRE

Miss E.J. Searle

An extract from the book Rivers of Monmouthshire shortly to be published by Messrs. Christopher Davies (Publishers) Ltd., Llandebie.

In Central Monmouthshire, in the neighbourhood of the village of Raglan (415077)* there is an area of lowland about 10 miles from east to west and 5 miles from north to south, nearly all under 300 feet. This lowland, which will be referred to as the Raglan Lowland, is surrounded by hills everywhere except immediately south of Raglan itself. Low-lying land of this size might confidently be expected to attract the drainage but instead it appears to repel it.

The River Usk flows in a south-south-easterly direction to the western margin of the lowland and then turns abruptly, just east of Clytha Park, to flow south-south-west. Not far away the Nant y Wilcae stream rises near Trostrey Hill Farm (375054), and flows north-west for about 2 miles as if making for the Raglan Lowland, but it turns first eastwards for about 2 miles and then due south to join the Olway Brook near Llandenny. Where the brook turns to flow eastwards, the alignment of the valley can be traced in a north-easterly direction over a low col (395078), and beyond the col by a little valley about half a mile long. The Nant y Wilcae is only flowing about 25 feet below the level of the col. A small tributary of the brook flows parallel to its upper course, also in a north-easterly direction, and about a mile further east.

On the north side of the Raglan Lowland, the Troddi flows in a southerly direction until it is about half a mile east of Llanvapley (372141), where the stream turns round in a semi-circular course and flows north-east in a little gorge with sides about 100 feet high, as far as the village of Llantilio Croesenny. A low-lying area, below 200 feet, can be followed southwards to reach the Lowland just east of Llanarth (376109). The Troddi then flows eastwards through a hilly region where it cuts through four north to south ridges, varying in height from 300 to 500 feet. About a mile beyond Llanvihangel Ystern-Llewern, the brook again turns south (4413), and reaches the Raglan Lowland near Dingestow. Again it turns away and flows through a narrow gap at Mitchel Troy, reaching the Wye near Monmouth.

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* The Grid References refer to Ordnance Survey Sheets 142 (Hereford) and 155 (Bristol and Newport).
In the book the text is illustrated by a diagrammatic map.

A tributary of the Troddi, the Nant y Wechan, rises about a mile north of the village of Penrhos and flows southwards. South-east of the village church (415115), the brook turns to flow north-east through a deep, wooded gorge about a mile long. The old valley can be traced southwards, near Tregare, and so to the Raglan Lowland.

Even more unusual is the course of the Pont y Rhedan stream, which rising at about 300 feet, south-east of Tregare, flows through the Raglan Lowland and then its valley is cut into the 300 to 400 foot plateau formed of St. Maughan's Beds, in a straight, deep trough, to join the Olway Brook near Llanishen Court. East of Kingcoed (428055), the valley is 200 feet deep.

It is therefore interesting to note that the Usk, the Nant y Wilcae, the Nant y Wechan and the Pont y Rhedan all turn away from the Raglan Lowland and the Troddi turns away twice. The abandoned sections of the valleys are very slightly, and often, not at all, above the level of the new courses, which suggests that, geologically speaking, the diversions are recent.

A satisfactory explanation is that, for a prolonged period, the Lowland was filled with dead or stagnant ice. It is a common feature of glacial retreat that a mass of ice at the end of a glacier can be separated from the main tongue and, if insulated by a thick covering of moraine, could melt extremely slowly. The Usk Glacier in the Newer Drift period was fed by ice from the Brecknock Beacons, the Mynydd Epynt, the Black Mountains and the Clydach Glacier from the Coalfield Plateau. On reaching the country east of Abergavenny it divided into three arms of which the arm in the Raglan Lowland was the central. The glacier would almost certainly have a large amount of englacial and surface moraine. If this dead ice were covered with thick blankets of drift, it could take thousands of years to melt. The climate would be improving and water would be flowing freely round the ice mass. The damming of old valleys would result in a number of lakes of the "marjelen" type forming near the margin of the ice. Three of these are indicated on the geological map, where there are flats of stoneless clay on the northern side of the Raglan Lowland. Two of these are referred to as Lakes Llanvapley and Llantilio after the villages in their neighbourhood. The third has no official name but can be called Lake Nantyderi after a farm which is near a former outlet of the lake. An interesting feature of Lake Llantilio is that its old cutlet to the south is now a broad dry valley, just east of Llantilio Croesenny church, which is a fine example of a spillway.

The geological map also shows a considerable amount of morainic drift, which actually reaches a height of 400 feet near White Castle (380168). Professor Charlesworth mentions several characteristics by which a former mass of dead

ice may be recognised. These are: indeterminate drainage, many tiny alluvial filled hollows, tiny ponds or "kettles", often with no outlet, no clear drainage pattern, tunnel valleys, eskers and no clearly marked terminal moraine.

In the Raglan Lowland the drainage is certainly indeterminate, and kettles and alluvial filled hollows abound. Many of the streams are doubtful about which way they are flowing. Just south of Cwrt Robert Farm (4009), there is a little square-shaped hollow. In wet weather, streams from this hollow drain eastwards to a tributary of the Olway Brook, westwards to another tributary of the Olway, and northwards to a tributary of the Usk by a roundabout route.

Near Raglan Castle is a narrow, trough-like hollow which looks very like a tunnel valley (one excavated by a stream flowing under the ice), but its nearness to Raglan Castle may mean that it is not a natural feature. Twyn y Tregan (363097) is a small esker-like ridge to the north of Clytha Park. In all the huge area of glacial drift there is no sign of a terminal moraine. There is a mass of moundy, coarse gravel near Tregare, but it is not a true terminal moraine. This gravel mass can be seen clearly from Penrhos church and is obviously the cause of the diversion of the Nant y Wechan.

Near Llanarth there is an alluvial flat (377109), with small gravel terraces along its northern edge, which suggests that this was the site of a little lake formed in the middle of the drift while the ice was wasting away.

This small area of country therefore, shows many interesting features which appear to be caused by the slow wasting of a mass of dead or stagnant ice.

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MOON ROCKS

A selection of items from The Times describing the collection and study of the moon samples.

MOON SAMPLES FOR BRITAIN

When a part of the moon comes down to earth 15 privileged teams of scientists in Britain will be waiting to scrape, slice, heat, probe, crush, dissolve, bombard, irradiate and measure it.

By grain, lump and spoonful it will go under microscope, X-ray and spectrometer, into radioactive chamber and magnetic vacuum. One geochemist said yesterday it would become the most studied material ever.

"Nothing has ever had this battery of techniques unloaded on to it in such a short space of time", he observed.

Britain expects to receive the greatest quantity outside America of the precious rock and soil the Apollo 11 astronauts bring back from the moon. It is going to scientists of international repute, accepted by the United States National Aeronautics and Space Administration (Nasa) as "investigators" of lunar material.

The Apollo men have been asked now to bring back about 100lb. of the surface, twice as much as originally planned, from which pieces are to be distributed to some 150 laboratories throughout the world. Germany, Canada and Japan are among the chosen countries.

Many of the scientists will have to be content with no more than a saltspoonful. Only 20 or 30 per cent of the samples the astronauts pick up are expected to be available. When the investigators have finished with the lunar material the Americans want it back, whatever its condition.

Numerous experiments on the samples are planned. Professor Samuel Tolansky of the Royal Holloway College hopes he may receive diamonds. He believes these may lie around the rims of the moon craters, created by shock-waves from meteorites crashing on to the surface and turning carbon into diamonds.

The Professor thinks the moon may also be littered with tektites, like glass marbles. These are from splashes of glass caused by meteoric collision with rock. On earth they are usually button shaped because of the atmosphere.

If lunar tektites are spherical Professor Tolansky says it would be unlikely that the moon had an atmosphere when they were formed.

If the professor receives any diamonds he says he would not expect them to be gems. "They would probably be like dirty black powder", he said.

Three of the British investigators will receive grants from the Science Research Council, totalling £17,890, and two will be granted a total of £4,268 by the Natural Environment Research Council.

Professor Stanley Runcorn, head of the School of Physics at Newcastle-upon-Tyne University, is acting as coordinator for the moon-sample teams in Britain. He is chairman of the Science Research Council's working group on the moon, planets and interplanetary matter and is now in the United States.

Dr. David Collinson, senior research officer at the University, who will work as part of the Newcastle team, said yesterday they would be measuring the magnetic properties of the samples they received. "We hope to get some solid pieces of rock", he said. "We shall be looking for signs of permanent magnetization like rocks on earth".

Magnetization on earth is known to arise from its molten core. Dr. Collinson said the Newcastle tests might determine whether the moon had originally been a molten body, or help to resolve the currently favoured theory that all the planets were formed by an accretion of small particles.

Dr. Geoffrey Eglinton, who will head a team from the Organic Geochemistry Unit at Bristol University, said their experiments could show whether life had existed on the moon. He had a completely open mind on the question.

In a report published in the current edition of Chemistry in Britain, journal of the Royal Institute of Chemistry and the Chemical Society, Dr. Eglinton and his colleagues say one of their main problems will be contamination of the samples. Dust, organic vapours and fingerprints could affect them and, since they would come from the immediate vicinity of the spacecraft, exhaust from the rocket engines.

How the samples will be brought to Britain has not yet been decided. They must first be examined in the isolated confines of the Lunar Receiving Laboratory, at Houston. British scientists will probably then have to cross the Atlantic to collect them.

..... The Times, 8th July, 1969.

MOONWORDS

ARMSTRONG: I'm at the foot of the ladder. The L.M. footpads are only depressed in the surface about one or two inches. Although the surface appears to be very finely grained as you get close to it, it's almost like a powder. Now and then it's very fine. I'm going to step off the L.M. now. That's one small step for man, one giant leap for mankind. As the - the surface is fine and powdery, I can - I can pick it up loosely with my toe. It does adhere in fine layers like powdered charcoal to the sole and sides of my boots. I can only go in a small fraction of an inch. Maybe an eighth of an inch, but I can see the footprints of my boots and the treads in the fine sandy particles.

.....

ARMSTRONG: Right. That's good. Okay, the contingency sample is down and it's (garbled). Looks like it's a little difficult to dig through..... This is very interesting. It's a very soft surface, but here and there where I plug with the contingency sample collector, I run into a very hard surface, but it appears to be very cohesive material of the same sort. I'll try to get a rock in here. Here's a couple.

ALDRIN: That looks beautiful from here, Neil.

ARMSTRONG: It has a stark beauty all its own. It's like much of the high desert of the United States. It's different but its very pretty out here. Be advised that a lot of the rock samples out here, the hard rock samples, have what appear to be vesicles in the surface. Also, I am looking at one now that appears to have some sort of phenocryst.

.....

ALDRIN: Got to be careful that you are leaning in the direction you want to go otherwise (garble). In other words, you have to cross your foot over to stay underneath where your centre of mass is. And Neil, didn't I say we might see some purple rocks?

ARMSTRONG: Find the purple rocks?

ALDRIN: Yes, they are small, sparkly (garbled) ... are the box. I would take a guess, some sort of biotite. We'll leave that to the lunar analysis.

ARMSTRONG: Bio compacts underneath (fade) completely (fade). No, I'd say you don't sink down more than a quarter of an inch.

PAO: Biotite is a brown mica substance.

.....

The Times, 22nd July, 1969.

MOON DUST WILL BE STRICTLY GUARDED

Houston, July 24. - Some scientists here expect an instant black market in fake moon dust. As one of them said: "Unscrupulous promoters and dangerour nuts will claim they have lunar samples and offer them for sale."

But the real stuff will be better safeguarded than anything in the vaults of Fort Knox, where the United States gold reserve is kept. The man who will see to this is Mr. Elbert King, who soon will have one of the world's great new jobs - keeper of all authentic moon dust on the earth.

Mr. King's official title is "Curator of the Lunar Receiving Laboratory", the specially constructed quarantine facility here designed to keep what is outside out and what is inside in. It is in the laboratory that the lunar explorers and lunar rocks will stay for several weeks to prevent contamination.

A great many people would like a piece of the moon. A 12-year-old boy wrote to the laboratory here recently: "I have no scientific reasons but I'd just like a piece of the moon because I think I deserve it." A Young Men's Christian Association in New Zealand would like to incorporate a moon rock in a "feature wall" of a new youth centre. A museum employee in New Jersey has made the plea: "I will never have the pleasure or chance to prospect for minerals on the moon ... is there a possibility of getting a specimen when you are finished with them?"

The answer to all such queries is "No". The first moon material will be and will remain the property of the United States Government.

The Times, 25th July, 1969.

MOON ROCKS ARRIVE AT HOUSTON

On board the U.S.S. Hornet, July 25. - The Apollo 11 astronauts today underwent their first physical examinations since returning from the moon and showed no signs of having picked up germs on the lunar surface. Dr. William Carpentier, of the National Aeronautics and Space Administration, said Mr. Neil Armstrong, Colonel Edwin Aldrin and Lietenant-Colonel Michael Collins were in "very good shape".

Dr. Carpentier added that Mr. Armstrong had a slight infection of his left ear, apparently contracted on reentry to earth. The three astronauts suffered less strain of their hearts and blood vessels from the journey than did several other previous space explorers.

None of the astronauts had had time for sleep since splashing down in the Pacific yesterday. They had been undergoing tests and unloading the spaceship's command module of moon samples and film.

The Times, 26th July, 1969.

ROCKS OF MOON A PUZZLE

Thirteen scientists who are examining the first rock specimens from the moon are embarrassed because they are able to describe them with less accuracy than Mr. Neil Armstrong and Colonel Edwin Aldrin, who gathered them from the moon's surface.

When the test box of moon rock was opened in a special cabinet under a vacuum, using remote control equipment, the preliminary examination revealed little. All the lumps were covered in a film of fine black dust which prevented an accurate identification of colour and shape of the crystal structure of the minerals present.

At this early stage of the analysis, which will take several weeks to complete, the investigators were unable to clean the material to separate the fine powder from the surface of the lumps.

Dr. Elbert King, curator of the laboratory, said: "Here we have been waiting for years to get the lunar samples in our clutches. We somehow felt that the first look would solve a lot of questions. But I find there is not a single mineral that I could identify. Being a mineralogist, I found that somewhat embarrassing".

The Times, 28th July, 1969.

NEWS AND NOTES

DOVEY ESTUARY NATIONAL NATURE RESERVE, CARDIGANSHIRE AND MERIONETHSHIRE.

The estuary of the Dovey (Dyfi), with its mudflats, saltmarshes and sand-dunes, is one of the finest examples of its type in western Britain. The new National Nature Reserve, which comprises 3525 acres of unspoilt foreshore and saltmarsh, has been leased from the Crown Estate Commissioners together with the shooting rights over a further 327 acres near the mouth.

Universities and colleges have used the estuary for many years for research and teaching. Important pioneer studies into the development of saltmarsh were made here by the late Professor R.H. Yapp and other workers in 1916, and the University College of Wales, Aberystwyth, is carrying out several scientific projects at the present time.

Extract from the Nature Conservancy Press Notice, 30th May, 1969.

TEMPORARY SECTIONS, INCLUDING ROAD SCHEMES AND PIPELINES.

The Director of the Institute of Geological Sciences would like to bring to the attention of all those who record such sections the special obligations laid on the Institute to advise on, record and collate the appropriate geological information as part of the public service maintained since its inception by the Geological Survey of Great Britain. Observations and researches outside the work of the Institute are greatly to be welcomed and conversely the records obtained by the Institute are available for public reference unless they carry confidential cover.

The quantity of the Institute's observations of extensive temporary sections in the field has to be limited; it is necessarily concentrated into those areas currently under six-inch survey. Brief notification or description of important new sections will therefore be most gratefully acknowledged if communicated to the relevant offices in London, Exeter, Leeds, Edinburgh and Belfast. The Survey geologist in exercising his duties and right of access will be very glad to reciprocate and to co-operate with other research workers according to their special line of inquiry.

Geological Section of the Nature Conservancy, Information Circular 3, May 1969, p.7.

SLATE QUARRY CLOSES.

Dinorwic slate quarry at Llanberis, Caernarvon, the largest open mine quarry in the world, is closing down. At one time more than 3,000 worked there but the present labour staff of 350 were told by the owners yesterday that the quarry, due to reopen this week after the summer holidays, will not now reopen.

Three hundred men were laid off early last month because of a lack of orders, but some of them were kept on. A statement issued yesterday by Dinorwic Slate Quarries Ltd. said: "Owing to the continued lack of demand for roofing slates, both in the home market and abroad, with consequent build-up of stocks, the directors of the company have had no alternative other than to recommend the appointment of a receiver by the debenture holders, one of whom is the Board of Trade."

The statement adds: "Those employees who have been laid off will be declared redundant."

Edward Oliver, secretary of the quarry section of the Transport and General Workers' Union, at Caernarvon, said he had been informed of the position and would be meeting Goronwy Roberts, Labour M.P. for Caernarvon to discuss the future of the quarry. It was from Dinorwic that the royal dais for the investiture of the Prince of Wales at Caernarvon was quarried.

The Times, 21st August, 1969.

IRISH SEA DRILLING STARTS NEXT WEEK.

Drilling is expected to start next week in the joint Gulf Oil-National Coal Board search for oil or gas in the Irish Sea. Costing £10,000 a day the search will be made from the drilling platform Gulftide, an 8,500-ton barge.

The first bore will be made in one of five adjoining concessions held jointly by the two concerns and will be followed by two others over a three month period down to a depth of 10,000 feet. Gulf Oil have a 60 per cent. interest in the project, and the National Coal Board 40 per cent.

South Wales Echo, 31st July, 1969.

DISCUSSING THE IRISH SEA.

One hundred and fifty scientists attended a Royal Society Discussion Meeting on the Irish Sea held at the society's rooms in London on January 14-15. For the purposes of the meeting the area under discussion was taken to be a line drawn between St. David's Head and Cawnsore Point in the south, and Stranraer and Larne in the north. The papers presented ranged in scale and diversity of subject from considerations of the general circulation of the region to the distribution of foraminifera in part of Cardigan Bay. They were concerned chiefly with research projects recently completed but not yet fully reported, or with proposed programmes of work for the immediate future.

Most of the first day was taken up with the physical and chemical oceanography of the region. A feature of these sessions was the extent to which new measuring techniques are likely to make good in the short term the lack of detailed data that has held back our understanding of the dynamics of not only the Irish Sea, but of all seas and oceans. Thus there was a report of the first results obtained in this region with networks of moored recording current meters and of an instrument which gives a continuous measure of salinity and temperature according to depth when lowered from a ship. But a report of changes in the distribution of two zoo-plankton "indicators" of water movement suggested that progress in understanding fully the week by week changes in the physical state of this relatively small sea area might be very gradual.

The second day of the discussion was devoted to the geology and sediment distribution of the region and to papers dealing with various biological problems and programmes. One of the speakers described the Irish Sea as "a great natural laboratory", an idea which was echoed by others. The relatively small geographical extent and proximity of this sea to Britain has meant that such topics as moving fields of sand waves and the plaice population, for example, associated with a particular spawning ground could be studied with only some of the normal inconveniences that marine scientists have to contend with.

Another theme running through the papers and the discussions following them was the need for cooperation, not only between the various disciplines but also between the different types of organization engaged in this sort of research. Scientists at the many universities with research projects in the Irish Sea were urged to note that relatively small scale studies in the bays and shallows, for example, might yield important information about the food chains of fish which would be of national economic importance. Government research laboratories, on the other hand, were asked to make their collections of detailed data generally available as soon as possible. All, it was suggested, ought to face together the prospect of growing pollution problems associated with the cities, towns and industries found on the coasts of this region.

Nature, Lond., Vol.221, no.5179,
February 1st, p.415.

WREN'S NEST, WORCESTERSHIRE.

The booklet describing this Reserve was published last Autumn; 2,500 copies have been sold in the first year and the edition is now approaching exhaustion. The high level of demand shows the need for self-guiding nature trails and also the spread of interest in geological field work taken by members of the lay public.

During Easter 1968, the Conservation Corps cleared a section at the south end of the hill to expose the main fault. It is now possible to see Nodular Beds faulted against Lower Quarried Limestone and crushed and deeply weathered Wenlock Shale with a clear difference in dip. Minor disturbances in the Lower Quarried Limestone add further interest. Though the Reserve is ideal for demonstration of the topographic expression of faults, no actual exposure of a fault has been available in recent years. Time did not permit the completion of this large scale project and it is hoped to improve the exposures further next Easter.

All underground workings on the Reserve have had to be closed, even for research purposes, owing to their highly unstable condition. As assessment of the problems involved is being made by Dudley Borough Council, the owners of the Reserve.

Geological Section of the Nature Conservancy, Information Circular 2, October 1968, p.2.

EXPLOSIVE STUDY OF BRITAIN.

Seismic waves generated by 70 depth charges will be used in September in experiments to discover how the earth's crust varies beneath Britain. The department of geology at Birmingham University will coordinate the experiments.

The 300 lb. depth charges will be fired from the survey ship H.M.S. Hecla, on a line westward from Pembrokeshire and south of Ireland, across the continental shelf as far as its western margin.

The Times, 31st July, 1969.

SURVEY MAY DISCREDIT WELSH GOLD LEGEND.

Ironically against the background of the gold crisis, the first comprehensive archaeological survey has been launched into what was one of the richest gold mines in the Roman Empire, at Dolaucothi, Carmarthenshire.

It is a further irony that the coming of the archaeologists seems to spell an end to local legends of the bonanza under the hills. Thirty years ago the Ogofau mine was hailed by geologists and press as that marvel, a profitable British gold mine.

The late Inspector of Mines of the Transvaal wrote in 1933: "I have never known an exploration company to start with better evidence of the value of the ground it is floated to explore."

By 1936 The Times was declaring that "gold prosperity in Wales is a commercial proposition". But by 1939 it was all over. In response to their geologists the mining company had dug deeper and deeper, their shaft reaching 480ft. But capital had run out, the war had started and returns were not sufficient to meet costs.

The mine lapsed back into the local legend from which, with its pit shaft and 200 employees, it had so dramatically emerged. But the operations had revealed one thing. At a depth of 150ft. the shaft had broken into old workings, and part of a Roman drainage wheel was found.

The Roman origin of the mine had been suspected from occasional finds, the signs of a Roman settlement near by, and the presence of a seven-mile aqueduct.

But the tradition of mining there seemed to have passed with the Romans.

The archaeological survey is the result of a joint enterprise between the University of Wales and the National Museum at Cardiff. A Caio goldfield exploration committee has been set up which expects to start work this year on an undertaking lasting from five to 10 years.

The survey, Mr. George Boon, of the National Museum, said, will be taken underground, as the Romans had followed the seams down to a depth of over 100ft. The gold, he emphasized, had all been cleaned out.

William Lewis (Printers) Ltd, Cardiff