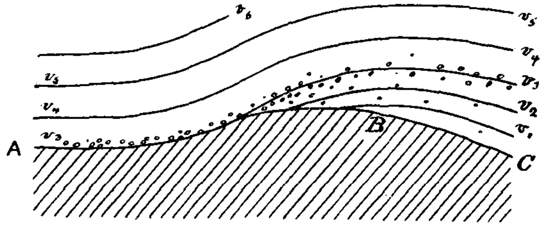
A and B the velocity of sliding is v_3, whereas between B and C it is *nil.* The stream lines v_1 to v_6 show roughly the velocities along various planes in the glacier. It is clear that the ice before reaching B must be greatly compressed in the line of motion, and must eventually spread over the adherent portions, carrying the boulders, etc., up into the mass of ice as shown in the Figure.



That the ice may freeze firmly to the floor upon which it rests and drag up and carry along with it the rocky masses thus displaced, I have shown is a reasonable deduction on theoretical grounds, and it is interesting to find that the adhesion of the glacier to its floor in places will also account for the incorporation, in its lower portions, of boulders, etc.

NOTICES OF MEMOIRS.

I.—The Comparative Value of Different Kinds of Fossils in determining Geological Age.[1] By Professor O. C. Marsh, Ph.D., LL.D.

MORE than twenty years ago, my attention was called to the subject of the difference between the value of fossil Plants, Invertebrates, and Vertebrates, as evidence of the geological age of the strata in which they were preserved. On the comparative value of these different groups of fossils then depended the solution of some grave problems in the geology of the Rocky Mountains. I therefore began a systematic investigation of the subject, and gave the results in an address before the American Association for the Advancement of Science in 1877.[2] I stated the case as follows:—

"The boundary-line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially whether the great Lignite series of the West is uppermost Cretaceous or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favour of the former view.

[1] *Abstract of communication made to Section C, British Association for the* Advancement of Science, Bristol Meeting, September 9, 1898.

[2] American Journal of Science, vol. xiv (November, 1877), pp. 338–378.

"This brings up an important point in Palæontology, one to which my attention was drawn several years since; namely, the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy reptiles or birds, and the higher mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves."

In the statement I have quoted, I had no intention of reflecting in the slightest degree on the work of the conscientious palæobotanists who had endeavoured to solve the problem with the best means at their command. I merely meant to suggest that the means then at their command were not adequate to the solution.

It so happened that one of the most renowned of European botanists, Sir Joseph Hooker, was then in America, and to him I personally submitted the question as to the value of fossil plants as witnesses in determining the geological age of formations. The answer he made fully confirmed the conclusions I had stated in my address. Quoting from that, in his next annual address as President of the Royal Society, he added his own views on the same question.[1] His words of caution should be borne in mind by all who use fossil plants in determining questions of geological age.

The scientific investigation of fossil plants is an important branch of botany, however fragmentary the specimens may be. To attempt to make out the age of formations by the use of such material alone is too often labour lost, and must necessarily be so. As a faithful pupil of Goeppert, one of the fathers of fossil botany, I may perhaps be allowed to say this, especially as it was from his instruction that I first learned to doubt the value of fossil plants as indices of the past history of the world. Such specimens may indeed aid in marking the continuity of a particular stratum or horizon, but without the reinforcement of higher forms of life can do little to determine the age.

The evidence of detached fossil leaves and other fragments of foliage that may have been carried hundreds of miles by wind or stream, or swept down to the sea-level from the lofty mountains where they grew, should have but little weight in determining the age of the special strata in which they are imbedded, and failure to recognize this fact has led to many erroneous opinions in regard to geological time. There are, however, fossil plants that are more reliable witnesses as to the period in which they lived. Those found

[1] Proceedings of the Royal Society of London, vol. xxvi (1887), pp. 441–3.

on the spot where they grew, with their most characteristic parts preserved, may furnish important evidence as to their own nature and geological age. Characteristic examples are found among the plants of the Coal-measures, in the Cycads of Mesozoic strata, and in the fossil forests of Tertiary and more recent deposits.

The value of all fossils as evidence of geological age depends mainly upon their degree of *specialization*. In the Invertebrates, for instance, a Linguloid shell from the Cambrian has reached a definite point of development from some earlier ancestor. One from the Silurian or the Devonian, or even later formations, however, shows little advance. Even the recent forms of the same group have no distinctive characters sufficiently important to mark geological horizons.

If we take the Ammonites as another example from the invertebrates, the case is totally different. From the earliest appearance of this family, the members have been constantly changing, developing new genera and species, each admirably adapted to mark definite zones or horizons, and already used extensively for that purpose.

The Trilobites offer another example of a group of invertebrates ever subject to modification, from the earliest known forms in the Cambrian to the last survivors in the Permian. They, too, are thus especially fitted to aid the geologist, as each has distinctive features, and an abiding place of its own in geological time.

The above examples are all marine forms, and from their abundance, wide distribution both in time and space, are among the best of all witnesses in marking the succession and duration of changes in geological history.

If we turn now to the fresh-water Mollusca, we find among them little evidence of change from the Palæozoic forms to those still living, and can therefore expect little assistance from them in noting the succeeding periods during their life-history.

Among the fossil Vertebrates the same law as to specialization holds good. The value of particular groups as witnesses of geological changes depends largely on their own susceptibility to change, and this is equally true of single genera and species. There are, indeed, some primitive vertebrates, especially among the Fishes, that appear to have changed little during their geological life. The genus *Lepidosteus* is a good illustration, and hence it is of limited value as evidence of what has taken place during its known geological history. Other fishes, however, are much better witnesses of the past.

The Reptiles as a class offer still better evidence of geological changes, and in many instances may be used to advantage in marking horizons. The great subclass of Dinosaurs, from their beginning in the Triassic, show marked changes of development throughout the whole of Mesozoic time. During the Cretaceous, highly specialized forms made their appearance, and at the close of this period, when all became extinct, the last survivors were the strangest of all, reminding one, in their bizarre forms, of the last

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stages of the Ammonites, their cotemporaries. The Crocodiles, too, show great changes during Mesozoic time, and are thus of much value in determining geological horizons. So, also, are the Pterodactyles and many other extinct reptiles, each according to the degree of specialization attained.

The Mammals, however, are by far the most important class for marking geological time, as their changes and the high degree of their specialization furnish the particular characters that are most useful to the geologist in distinguishing definite zones, and the more limited divisions of the strata containing their remains. The few mammals known from the Trias are so peculiar that they can only give us hints of what mammalian life then was, but in the Jurassic the many forms now known offer important testimony as to the different horizons in which their remains are found. This is true also of the known mammals from the Cretaceous; all are of special value as witnesses of the past.

During Tertiary time, however, the enormous development of the class of mammals, their rapid variations, and, most important of all, the highly specialized characters they develop, offer by far the best evidence of even the smaller changes of climate and environment that mark their life-history throughout. The ungulates alone will answer the present purpose as an illustration, and even one group, the horses, will make clear the point I wish to bring before you.

Near the base of the Eocene the genus *Eohippus* is found, representing the oldest known member of the horse tribe. Higher up in the Eocene *Orohippus* occurs, and still higher comes *Epihippus*, near the top of the Eocene. Again, through the Miocene more genera of horses, *Mesohippus*, *Miohippus*, and others, follow in succession; and the line still continues in the Pliocene, when the modern genus *Equus* makes it appearance. Throughout this entire series definite horizons may be marked by the genera, and even by the species of these equine mammals, as there is a change from one stage to the other, both in the teeth and feet, so that every experienced palæontologist can distinguish even fragments of these remains, and thus identify the zones in which they occur.

This is true of every group of mammals, although not to an equal extent, so that in this class we have beyond question the best means of identifying the age of Tertiary strata by their fossil remains.

I have thus briefly pointed out some of the evidence on which a decision may be reached as to the value of the different kinds of fossils, Plants, Invertebrates, and Vertebrates, in determining the relative age of strata. All evidence of this kind is of value, but it is the comparative value of each group that is the important point I wish to emphasize, and I have brought the matter before this Section of the Association in the hope that a better understanding on this question may be reached among geologists in the interest of the science to which we are all devoted.

II.—Further Exploration of the Ty Newydd Cave, Tremeirchion, North Wales. By Rev. G. C. H. Pollen, S.J., F.G.S.

In a paper read before the Geological Society on December 15, 1897,[1] the author gave the results of an exploration of 60 feet from the old quarry. The work has now been extended to 150 feet in this direction. In the upper portion a stalagmite floor has been found *in situ*, completely sealing up the local gravels. Over this were found five feet of clay with broken limestone, which is all that is left to represent the strata in which the former roof of the cave was situated. The whole is now overlain with boulder-clay, containing many specimens of northern and western drift, with striated stones of more local origin. No trace of erratics or of glaciated stones have been found in the lower cave materials.

The cave has also been traced for 55 feet across the floor of the quarry where it re-enters the rock, running in the direction of the gully which separates it from the Ffynnon Beuno and Cae Gwyn caves. In the lowest gravel of this part a water-worn fragment of the molar of *Equus* was found. The following succession seems to be established for the contents of the cave:—

(*a*) Cave nearly filled by torrents with local gravel containing water-worn fragments of mammalian teeth.

(*b*) Formation of stalagmite floor.

(*c*) Last few yards of floor broken up and redeposited further down the cave by floods, which completely filled lower portion with sand and clay.

(*d*) Denudation of rock above, destroying roof of upper portion and depositing limestone débris on floor.

(*e*) Introduction of striated stones and northern and western erratics, which are deposited as one bed over the hillside.

III.—On the Exploration of Two Caves at Uphill, Weston-super-Mare, containing Remains of Pleistocene Mammalia. By the late Edward Wilson, F.G.S.[2]

(Communicated by Herbert Bolton, F.R.S.E.)

Quarrying operations now proceeding in the Carboniferous Limestone near the old parish church of Uphill have led to the discovery of two caves.

The caves are about half-way up the face of the quarry, which is 100 feet in height. The floor of each cave is covered with a deposit which varies from one to two feet in thickness.

A typical section of the upper cave deposits is as follows:—

	ft.	in.
1. Deep purplish-red, soft, sandy Marl, containing blocks of Limestone	4	0
2. Greenish-yellow, soft, sandy Marl	1	2
3. Greenish-drab argillaceous Sandstone	5	6
4. Limestone floor.		

[1] Quart. Journ. Geol. Soc., February, 1898, pp. 119–134, pl. viii.

[2] Read before Section C (Geology), British Association, Bristol Meeting, September, 1898.

The Green Marl (No. 3) for a varying thickness in different parts of the cave becomes brecciated and occasionally tufaceous.

The animal remains are contained in this bed, and consist chiefly of the teeth and jaws of hyæna, with gnawed and ungnawed bones of horse, mammoth, cave bear, fox, etc.

The lower of the two caves is partly filled with a deposit of coarse rubble, and has yielded remains of hyæna, rhinoceros, and the teeth and jaws of small carnivora and rodents, together with worked flints, and a number of rounded stones supposed to have been used as pot-boilers. The rubble deposit has evidently undergone a certain amount of displacement, so that it is by no means certain if the remains contained in it are contemporaneous.

IV.—Further Exploration of the Fermanagh Caves.[1] By Thomas Plunkett, Enniskillen.

THE original report was read by me at Dublin in 1878, and I then stated that after the exploration of F cave the work would be suspended, as it seemed probable that none of the caves in this district would yield bones of extinct mammalia.

I spent three summers exploring the caverns which penetrate the Carboniferous Limestone hills in Fermanagh, in which I found flint implements, bone, bronze, and iron pins, a large cinerary urn inverted over burnt human bones, human skulls, ancient hearths, etc., also quantities of the bones of the wild horse, red deer, long-snouted pig, ox, and remains of other animals not extinct. Having explored a number of caves in this county previous to my reading the report referred to above, I came to the conclusion that remains of extinct mammalia were not likely to be found in this locality. Now, on the contrary, I am glad to be in a position to report that I have been fortunate in finding an entire cranium of what I believe to be the great cave bear (*Ursus spelæus*) in one of the Knockmore caverns, which penetrates a cliff not far from the caverns I formerly explored, and is a narrow cleft with vertical sides. The height of the cave is about 40 feet and length 90 feet. When standing at the extreme end of this cleft-cavern one may observe near the top of one of the sides an opening which is evidently the end of a horizontal cave which runs at right angles into the cave in question; a good deal of débris has been during heavy rains washed out of the higher cave down into the lower one; in this débris, the cave bear's head was found, and I have no doubt that, when explored, the higher cave will yield more remains of the skeleton of the bear and possibly other extinct animals.

I have commenced excavations on the top of the rock, and hope to find the upper or horizontal cavern (which cannot be reached from the narrow cave below), which formerly must have had an opening out to the surface of the ground, and probably has been filled up level with the surface for the protection of cattle.

[1] Read before Section C (Geology), British Association, Bristol Meeting, September, 1898. See also earlier Report, 1878, pp. 183–185.

I thought it well to place this find in Fermanagh upon record in the proceedings of the British Association, and I shall be happy to report to the Association next year the results of the cave-digging which I am carrying on here at present.

REVIEWS.

I.—A TEXT-BOOK OF MINERALOGY, WITH AN EXTENDED TREATISE ON CRYSTALLOGRAPHY AND PHYSICAL MINERALOGY. By EDWARD SALISBURY DANA. New Edition, entirely rewritten and enlarged. 8vo; pp. 593, with nearly 1,000 Figures and a Coloured Plate. (New York: John Wiley & Sons, 1898.)

BY the irony of Fate the author of this treatise, Mr. E. S. Dana, though an experienced mineralogist, is a University Professor, not of Mineralogy, but of Physics; those who have been his pupils report him to be an ideal teacher of that branch of knowledge: further, Mr. Dana prepared for press the last edition (1892) of his father's well-known "System of Mineralogy," a book which is in constant use by mineralogists throughout the world. An excellent teacher and closely associated with Mineralogy as a living science, Mr. Dana was thus particularly qualified to furnish the Students of Minerals with a good text-book of their subject, and he has done so.

The work was first issued twenty-one years ago: the author has now rewritten it with the results of recent researches in mind. Part I (144 pages) deals with Crystallography in a practical way, demanding from the student only the elements of mathematical science. The subject is treated from the point of view of Symmetry, and the thirty-two classes of symmetry are briefly but clearly explained; the name assigned to each of the prominent classes being taken from some mineral species, of which the crystals present good illustrations of the class of symmetry. The facial symbols are those of Miller, and stereographic projection is made extensive use of. Part II (94 pages) treats of Physical Mineralogy in a similarly elementary way, and necessarily deals for the most part with the characters which depend upon Light, and with the modes of their determination. "Axes of optical elasticity" are dropped, and the "Indicatrix" is explained and made use of in the discussion of doubly-refracting crystals. Part III, Chemical Mineralogy, is compressed into 30 pages, and is limited to the explanation of the general principles of Chemistry and of the modes of chemical determination of minerals. The last Part, Descriptive Mineralogy, extending to 225 pages, is not susceptible of much variation of treatment, but is accurate and brought up well to date. The book is plentifully illustrated throughout.

We may assume that so completely changed an Edition is evidence of the recovery of the author from the shattered health to which he had been brought by the years of toil required by the preparation of the last edition of the "System of Mineralogy";