ADEQUACY OF THE PALEONTOLOGIC RECORD

By R. S. BASSLER
U. S. NATIONAL MUSEUM

THE imperfection or inadequacy, instead of the adequacy of the paleontologic record, has long been a favorite subject of discussion, and it is only within recent years that this heresy of an imperfect record is being abandoned by paleontologists in general. However, as many of our biologic, and even a few of our paleontologic, friends still have doubts regarding the matter, the present conference upon this and allied subjects is very opportune.

I have a vivid recollection of the joy experienced in my school days, when, during an examination in geology, the subject of an impromptu essay was announced as "The Imperfection of the Paleontologic Record." Here was a subject in which I was well grounded from textbook reading, and I remember distinctly the telling points made. The lack of hard parts causing the absence of many classes of animals; the great amount of unrepresented time in the geologic column; the metamorphism and consequent disappearance of fossils, and, when present, the frequent imperfectness of the specimens themselves, were dwelt on in great detail. Since that time, my experience in invertebrate paleontology has compelled me to unlearn every one of these supposed facts, and to come to the conclusion that, considered both biologically and stratigraphically, the paleontologic record is sufficiently adequate for all reasonable purposes.

Professor Calvin's paper tells us (1) of the detailed perfection of the record, (2) of the profusion of the material, and (3) of the broad view as to trend and tendency of biologic characters which the study of paleontology gives. His presentation of the subject is such that we must all agree with him. It therefore seems best for me to confine my remarks to the reasons usually advocated for the imperfection, namely, the lack of hard parts in many animals, metamorphism, the frequent imperfect preservation of fossils, and the unrepresented time in the geologic column.

The lack of hard parts in many animals is a serious, although not fatal, objection to their preservation as fossils. For the best results as

fossils, a stony framework of some kind is desirable, as we all know, but horny, or even the most perishable materials may be preserved under favorable conditions. Mr. Walcott's work on the Medusæ, and the researches of Ruedemann on the graptolites, as well as the work of others whom we can call to mind, are examples of excellent results from material of the latter nature, not to mention the hairs of the worm so carefully described by the Cincinnati paleontologist!

The metamorphism and apparently complete obliteration of all fossil remains in the rocks of certain large areas is likewise an apparently serious objection to the adequacy of the record, but here careful searching with the structural relations in mind will reveal the fossils, if present at all. The greatly folded and cleaved slates, schists and volcanic tuffs of the Piedmont area have long been the despair of both paleontologist and geologist, but at this meeting of the Geological Society of America, the State Geologist of Virginia will tell of Cincinnatian fossils in the so-called Algonkian and other schists and volcanics of the easternmost Piedmont of that state. In this case the discovery of well-preserved fossils was quite simple. It consisted merely in finding a place where the cleavage and stratification coincided, and then working hard.

Professor Calvin has spoken of the richness and beautiful preservation of certain Paleozoic faunas. While the beauty and occasional richness of such faunas is not to be gainsaid, we must not forget the many horizons and localities affording, in comparison, specimens so poorly preserved that they might readily furnish an argument for the inadequacy of the record. Nor must we forget that in quite a portion of the geologic column organic remains are not only poorly preserved, but are, as known at present, very rare. However, these lean spots can be made most productive of paleontologic results by careful search and by methods of preparation. Several years ago the number of lower Paleozoic fossils found in the Ozarks could almost be counted on one's fingers, but we now have in the National Museum, from this formerly almost barren spot, several hundred drawers of beautiful material.

Fortunately the preparation and methods of study of paleontologic material has progressed to such a point that a poor fossil is no longer a bugbear. A specimen may be considered inadequate for study because it is covered with refractory clay. The application of caustic potash solves this difficulty. Certain limestone bands in the New York Niagaran and Cayugan are crowded with fossils, although often few of the species can be determined because of a hard, clayey covering. In preparing some specimens for exhibition, the treatment with caustic of a single slab, about three inches wide and five inches long, enabled me to bring out over a hundred species on one surface alone, not including the ostracods and other microscopic organisms. How often will the present sea bottom furnish such results?

Nature is very kind in preparing fossils for us. The Onondaga limestone, at the Falls of the Ohio, although only a few feet in thickness, has yielded seven hundred or more species of exquisitely preserved fossils. Examine the freshly quarried limestone and you may be able to crack out perhaps two dozen species of poorly preserved material, but go to the neighboring field where solution of the limestone and silicification of its contained fossils has occurred, and a host of beautiful forms awaits you. Strata, which under ordinary circumstances would yield very poor fossils, can, if silicification has commenced, be made to afford excellent specimens. By exposure to the weather for a year or so, the silicification can be advanced to such a stage that etching with acid will free the fossils. The beautiful etched material from the New Scotland of New York is a familiar example of this style of preparatory work. Most of the Cambrian and Ordovician formations of the Appalachian Valley yield shells which, as they occur in the limestone, are almost impossible as subjects for study, but as silicified pseudomorphs, all the beauty and detail of the original shell are reproduced.

Thin sections are a valuable aid in identifying the merest fragment of certain classes of organisms, and their use here is indispensable. A thin section of an otherwise undeterminable fragment of a Cambrian protremate brachiopod will distinguish the horizon. Other methods of preparation and study might be mentioned, but time forbids, although I can not refrain from speaking of the several whitening processes. The use of a coating of ammonium chloride or anilin chloride on fossils for photographic purposes is well known, but the excellent results obtained from the use of the same process in the study of poor material may not be so apparent to all. A trilobite indistinctly outlined in the rock under ordinary circumstances, flashes into bold relief when covered with the ivory white film of ammonium chloride. Casts and molds of fossils too indistinct to show any structure ordinarily, will reveal many characters when so whitened. Recently occasion arose to study a species of Cambrian phyllopod which had already been described and figured. The specimen was practically nothing but a film upon the rock, and apparently the last word had been said upon it. It was suggested that the specimen be whitened and then photographed with the sun's rays nearly parallel to its surface. The result was most gratifying as structures which could not be proved to exist by the aid of the eye alone, came into plain view in the negative. All these various methods of preparation and study make available a vast amount of material which formerly was thought too imperfect to be fully considered in determining the adequacy of the record, hence the great value of such methods to the paleontologist is obvious.

The real adequacy of the record, if it might be so called, lies in the

imperfections or gaps in the stratigraphic column. Measured according to the sections of twenty-five years ago, the number of these gaps is growing greater and greater, yet with the discovery and intercalation of new formations, the aggregate of which at the present day has almost doubled the thickness of Paleozoic rocks in the last decade, manifestly the great breaks are being reduced. It was not so many years ago that the Potsdam sandstone was supposed to be the oldest fossiliferous sedimentary rock, yet now we know that many thousands of feet of much more highly fossiliferous strata intervene between this formation and the Azoic, and that other thousands occur above the Potsdam and below the Ordovician as then recognized.

With the intercalation of new formations and the consequent diminution in the size of the stratigraphic gaps, it is then probably only a matter of time before the complete faunal succession can be established. The break in stratigraphy at one point will be bridged over in another area, and it is possible that in only a few regions, such as on the borders of the continent, will permanent gaps exist. Faunas are and will be traced from one area to another until in time we shall know their complete geologic history. With these data in hand, the study of their correlation will not only be greatly simplified, but also will not be hampered by time breaks in the record. While imperfect, or possibly irretrievably lost at the dawn, the faunas of succeeding times are ample for all purposes.