CERTAIN ASPECTS OF GEOLOGIC CLASSIFICATIONS AND CORRELATIONS.[1] II

By Professor ROLLIN T. CHAMBERLIN
THE UNIVERSITY OF CHICAGO

In the tripartite division of the old Carboniferous into the Mississippian, Pennsylvanian and Permian systems the first division between the Mississippian and Pennsylvanian is seemingly based on sound grounds; but the present separation of the Permian from the Pennsylvanian has no such good basis. If we look to diastrophism as the ultimate basis for classification we naturally turn to the Asturian phase of the Hercynian revolution. Diastrophically this was the most pronounced of the several important manifestations of earth unrest during Pennsylvanian and Permian times. Was it also the most significant from the standpoint of its consequences—stratigraphic, climatic and biologic? This is the vital question, but one which, owing to its complexity and the lack of sufficient data, we are perhaps not yet ready to answer satisfactorily.

The Asturian orogeny broke out between the Westphalian and Stephanian of Western Europe or the Moscovian and Uralian of Eastern Europe. A marked stratigraphic break characterizes much of Europe. Where the corresponding formations are well displayed in Eastern Asia, a similar important gap in the stratigraphic column is likewise manifest. In China, the equivalent of the Uralian, separated from the underlying Middle Carboniferous by a pronounced unconformity, possesses a very different fauna which, however, is closely linked with the overlying Artinskian, classified as Permian. In India and South Africa, the Talchir and Dwyka tillites at the base of the Permo-Carboniferous sequence both rest upon very much older rocks, so that the time gaps in these regions are very much longer and definite knowledge of whatever diastrophic manifestations may have preceded the glaciation is wanting. More certain dating of these tillites is greatly needed, but the long time represented by the unconformities beneath is in itself of some significance. On the other hand, the history of Texas and adjoining region has been different. A relatively complete record of the Pennsylvanian and Permian is here the notable feature. No dominating conspicuous break is found within the existing Pennsylvanian-Permian stratigraphic column where those formations are best represented, though Hercynian deformation strongly affected other belts. Consequently, reasons have been advanced in this country for combining the Pennsylvanian and Permian into a single system. But European, Asiatic and Southern Hemisphere history was seemingly more significant at this time than North American.

As means of classification and correlation we have the orogenic movements, the regressions of the sea, the glaciation and the faunas and floras. The practical question arises: How closely synchronous were the orogenic movements and the regression of the seas in the most typical regions of the globe? Our chief method of determination is by the use of fossils. We rely principally upon them for dating formations and events. Where diastrophic episodes do not match closely in distant lands, according to fossil testimony, we are prone to assume that these physical events were somewhat scattered in time. Is this conclusion, however, necessarily true? May not the other alternative perhaps be true in many cases? May not the diastrophism have been relatively short-lived and more or less synchronous in the broader sense, while the seeming discrepancy in time lies principally in the fossil interpretations? Are the fossils *always* a better means of age determination and correlation than major diastrophic movements?

Let us consider fossil criteria for a moment. Age determination and correlations can be based upon the first appearance of certain forms of life which are taken to be of diagnostic significance, or they can be based upon the last stand of old forms, or upon the presence of certain short-lived, highly characteristic types or assemblages. If we utilize the first appearance of new forms, we face the problem of their migration from distant regions. So far as present information may be trusted, slowness of migration has apparently often been the case. This may have been a matter of slow travel, or of delay until the removal of barriers allowed the necessary spreading into the areas considered, or until slow physical changes in a given region made it a fit habitat for invasion by the forms of life in question. In many cases, the time required for the accomplishment of these things may have been very considerable, and the initial appearance of critical forms in two distant regions may have been at very different times. Furthermore, in addition to the true time difference, the discrepancy may appear still greater because of the well-known imperfections of our very fragmentary fossil records. The

[1] Address of the vice-president and chairman of the section on Geology and Geography, American Association for the Advancement of Science, Pittsburgh, December 31, 1934.

earliest of fossil finds may not represent the first invaders.

Favorable or unfavorable environmental conditions are very important in determining whether a given life assemblage will, or will not, inhabit two different areas at the same time. So also, hostile conditions have often caused the disappearance of certain types from some areas, while they linger long after in other areas of more genial climate, fewer enemies or other advantages.

When these important factors shall have been more fully worked out and better understood, and when our present patchy information shall have been greatly extended, as it will be in time, our paleontologic correlations will be much more reliable than they are today. Every little while the known range of a species or genus is extended rather surprisingly. Not infrequently two species, supposed to exist only in beds separated by many hundreds of feet of strata, are found together in the same hand specimen.

This is not an attempt to disparage paleontologic correlations, for their great value is universally recognized, but we must face the facts and maintain a proper open-minded reserve. It may well be that the major diastrophic movements were more nearly synchronous in different portions of the earth than some present fossil correlations would lead us to believe. That possibility must be kept in mind while awaiting fuller knowledge.

Likewise of importance in our problem is a more certain timing than we now have of the onset and main stages of the glaciation in Australia, South Africa, India and South America. The thicknesses of late Paleozoic glacial drift in these widely separated regions were so much greater than those of the Pleistocene glacial drift of Europe and North America, and the glaciers reached such incredibly low latitudes, that it seems reasonable to infer a general refrigeration of the earth's climate during the several stages of glaciation. The only alternative now apparent is to assume that the strongly glaciated areas were at those times located in the South Polar region—a view not favored for various reasons, not the least of which is the difficulty of explaining, on this hypothesis, the warm interglacial times between the glacial stages. If we believe in an underlying general cooling of the earth's surface and atmosphere, with special conditions of precipitation, atmospheric and ocean currents, etc., determining the loci of glacier development, the climatic factors must not only have been of great importance in leading to radical biologic changes, but the times of glaciation, ordinarily relatively short in duration, should have been roughly correlative in the different continents.

If we accept this view, another question confronts us. How closely was the glaciation related in time to the diastrophism, particularly the Asturian disturbance? It seems now that the first of these late Paleozoic glacial stages appeared approximately at the close of the Mississippian, which was characterized by the Culmide diastrophism. David and Süssmilch locate the second glacial stage of New South Wales high up in the thick Kuttung series, which they call Middle Carboniferous, and the third or Lochinvar glaciation at the base of the Kamilaroi (Permo-Carboniferous) system. According to their sections, the deposits of the second glaciation lie directly below those of the third (Lochinvar, Bacchus Marsh, Inman Valley) glaciation, though there is a break in the sequence and a marked floral change between them. At some time within this interval was the Asturian orogeny. The fourth and fifth Australian glacial stages occurred much later, in the Permian.

In India, the Talchir tillite has usually been placed after the Middle Carboniferous. In harmony with this, Grabau held in 1933 that the Talchir glacial beds of the Salt Range belong to the time of the Asturian folding and succeeding erosion. Du Toit believes that the Dwyka glaciation of South Africa, whose deposits he regards as unmistakably equivalent to the Sierra de la Ventana tillite of Argentina, began at the end of the Lower Carboniferous and terminated not later than the close of the Upper Carboniferous. His 1933 view was that the main Gondwana glaciation reached its maximum during the middle of the Upper Carboniferous (Westphalian-Moscovian) and that the only true Permian occurrences seem to be the minor ones of New South Wales and probably Bolivia.

From the writings of these authorities one would judge that an important Culmide glaciation occurred at the close of the Mississippian and another and more pronounced glaciation about the time of the Asturian orogeny. Schuchert, on the other hand, while in agreement on the Culmide glaciation, is strongly of the opinion that the Dwyka-Talchir-Lochinvar glaciation occurred long after the Asturian orogeny, in early Artinskian or early Middle Permian according to his classification. In this difference of opinion, we see the present status of the Permo-Carboniferous glacial problem.

Whether the Asturian phase of the Hercynian revolution should properly be raised to the importance of a division marker between geologic periods is therefore less a question for immediate decision than a working proposition to be tested with each new acquisition of relevant facts. Nevertheless, a movement toward utilizing this Asturian break between the Westphalian and Stephanian, or Moscovian and Uralian, as the division between the Pennsylvanian and the Permian is already apparent. As a result of

his recent wide studies in China, Grabau now definitely ends the Pennsylvanian with the Moscovian and starts the Permian with the Uralian. Schuchert, in his latest writing on the Permian, does likewise, though maintaining that the pronounced glaciation followed long after the beginning of the Permian.

If we entertain tentatively the proposition to begin the Permian with the Uralian, following the Asturian orogeny, the close of the Permian likewise merits consideration in rounding out the problem of that period. Lack of time, however, will allow only brief consideration of one possibility. The Saalian orogeny, after deposition of the Lower Rothliegende, caused an important break in the European stratigraphic succession and was followed by a flora of more Mesozoic aspect. As the authorities participating in the symposium before the British Association have considered this a more significant break than that between the present Permian and the Triassic, it may be that the most logical termination of a redefined Permian period is at the Saalian deformative episode. In the Eastern United States, the Appalachian revolution occurred after the Dunkard (Lower Rothliegende), though it is not yet certain just how soon after the Dunkard it actually took place. Should the Appalachian revolution prove to be equivalent to the Saalian deformation in Europe, this would be strong additional reason for placing a division between periods at that time. Therefore, as a working hypothesis to be given careful testing, we have the proposition that the Pennsylvanian end with the Asturian orogeny, that the Permian comprise the time from that deformation to the close of the Saalian disturbance (or Appalachian revolution), and that what remains of the present Permian after that be included in the Triassic, to which it is closely related.

This proposition, so briefly and inadequately treated here, leads to the final, still larger question: Where is the boundary between the Paleozoic and the Mesozoic, between ancient life and medieval life, most appropriately placed? Drawing it at the Saalian break is one alternative. In this case the Permian, between the Asturian and Saalian beats of the geologic rhythm, would constitute a transitional period completing the Paleozoic. General conservatism may militate against any more radical departure from our present classification than this. But, when everything has been considered, does such a step go far enough?

One of the principles of the general philosophy here followed is to go back to causes and beginnings. If we are correct in seeking the initiation of the newer order in the Asturian phase of the Hercynian revolution, that should seemingly have strongest claim as the natural starting point of the new era. On this basis, the Permian, with the beginning and early stages of the newer order of things, would belong to the Mesozoic.

The Mesozoic is the "Age of Reptiles." Outstanding in importance in that era, this great class overshadows all other animal groups. Already in the Permian the reptiles were strongly developed and considerably deployed. From the Pennsylvanian, however, they have not been reported in any great abundance. Very recently Professor Romer has been exploring the Upper Cisco beds of Texas with confident expectation of finding significant reptiles in those strata which have ordinarily been classed as Pennsylvanian. As the Upper Cisco, however, is correlated with the Uralian, these beds according to the classification here under consideration would belong to the early Permian. So far as we can judge at present, the first rise of the reptiles to power was not far removed in time from the Asturian orogeny, following which came their relatively rapid and very great development. Including, therefore, the post-Asturian Permian in the Mesozoic would make that era, in the truest sense of the expression, the "Age of Reptiles."

The keynote of this address may be taken to be an encouragement of efforts to bring greater harmony into our general picture of earth history. There is nothing new in the motive, nor is it taking a new tack to urge the cosmopolitan point of view against the provincial point of view. What has been presented merely reemphasizes some of the underlying philosophical considerations whose application is believed to be broader and of more general import than regional peculiarities and local details. Even so, perhaps too much uniformity is expected of so large a sphere as our earth; perhaps we shall find that there has been too much local variation in the behavior of different portions of its surface to allow completely satisfactory coordination of all into a single standard history. Possibly practical considerations will force us to recognize that a given geologic period, as best delimited in a certain area, actually began there earlier than it did in some other particular area, according to the most useful classification in that area. This address ends in the year 1934; Australia and Eastern Asia are already in the year 1935. We must take nature as it is. In any case, however, it is best to assume the attitude that geologic history can be treated satisfactorily on a world basis, and to proceed on that assumption until it shall be definitely and finally proved that Mother Earth has not shown sufficient system and order in her doings to give us a basis for a good universal classification.