ART. LIV.—*The Lower Cretaceous of the Southwest and its relation to the underlying and overlying formations*; by CHARLES A. WHITE.

[Published by permission of the Director of the U. S. Geological Survey.]

THE Cretaceous strata which constitute what has become known as the Texas section are referable to two natural divisions which, in North American geology, may be properly designated as Upper and Lower Cretaceous respectively, although not implying thereby that they are respectively the equivalents of the Upper and Lower Cretaceous of Europe.* The fossil contents of each division indicates that each represents an unbroken portion of Cretaceous time; and the paleontological contrast between the two divisions indicates that there is a time hiatus between them.

The Upper Missouri river section of Meek & Hayden, from, and including, the Dakota Group upward, may be taken as representing the upper division, while the lower division, which I have heretofore designated as the Comanche series, has been often omitted by geologists from their sections of the North American Cretaceous, or its relation to other formations has been imperfectly understood, or stated. Strata of the lower division have not been discovered to the eastward of the 95th meridian, and, with the probable exception of a locality in

* In my future writings upon the North American Cretaceous I propose to make its division into Upper and Lower Cretaceous still more general.

central Kansas, none have been discovered farther north than the southern part of Indian Territory and the southwestern part of Arkansas.

The results of observations made by myself during the past season indicate that they do not extend so far northward in New Mexico as the central part of that territory, although they are known to exist in the extreme southern part. Several years ago M. Remond obtained a collection of fossils containing characteristic species of the Lower Cretaceous from "the Sierra de las Conchas, near Arivechi, Sonora," which were described and figured by Mr. Gabb in volume ii, *Paleontology of California*. This is the most westerly locality at which the Lower Cretaceous strata discussed in this article are known to exist, the Lower Cretaceous of California, which contains a totally different fauna, not being now referred to. Important exposures of the Lower Cretaceous strata which are discussed herein are known in the Mexican states of Chihuahua and Coahuila, and I have obtained some indirect indication of their presence in the States of Nuevo Leon and Zacatecas also. They are believed to extend still farther southward in the Republic of Mexico, but I have yet no definite information of it.

The greatest known development of these Lower Cretaceous strata, as regards thickness, is reached in northern Mexico, but more abundant collections of the fossil fauna which characterizes them have been obtained within the limits of the State of Texas than elsewhere. This latter fact is probably due not more to the originally greater prevalence of the fauna there than to the greater consolidation which the strata have undergone in their westward extension and the consequent obscuration and inaccessibility of most of the fossils which the rocks there really contain.

The contrast between the Lower Cretaceous of the Southwest and the Upper Cretaceous which overlies it there, and which also prevails in the Atlantic, Gulf and Interior regions, is very great. The former, wherever it has been found, is shown by its fossils to have been an open sea deposit. The strata are either limestones or strongly calcareous rocks, sandstones and argillaceous shales having never been found to enter largely into their composition; and, except locally, it has not yet been found practicable to divide them into separate formations upon paleontological grounds. On the contrary the Upper Cretaceous is largely composed of sand and other detrital material, plant remains are frequently found in its strata and, in the great interior region, portions of all the formations are coal-bearing. Furthermore, it is divisible into several separate formations which are recognizable over large geographical areas.

The paleontological contrast between the Upper and Lower Cretaceous is also great, as has just been intimated. With the exception of the Laramie formation at the top of the Upper Cretaceous series, and the Dakota at its base, all the formations of that series are characterized by marine fossils, and the southern equivalent of the Dakota formation is also of marine origin, as is shown by the character of its fossils. But while the marine faunas of the respective formations which compose the Upper Cretaceous are so related to one another by identity of a portion of their specific and generic forms as to indicate that no complete chronological break occurred between any of them, such faunal relationship between the Upper and Lower Cretaceous, so far as is now known, does not exist. That is, not only are no known species common to both divisions, but many of the genera and some of the families of mollusks found in the lower, are not known in the upper, division. Besides the lithological and paleontological contrast between the two divisions, which has just been noticed as indicating their separateness, they have been found in some places to be plainly unconformable.

The extent of the chronological hiatus between the Upper and Lower Cretaceous we have at present no satisfactory means of determining, because the Cretaceous record for our continent, so far as it is now known, is much broken below the horizon of the Dakota Group; because most of the known subdivisions below that horizon are geographically widely separated from one another and all of them have not yet been thoroughly studied; and also because the European record is not an adequate standard in this case. For the latter cause, we cannot say with confidence that the Comanche series really represents any one of the divisions of the European Cretaceous from the Gault to the Lower Neocomian inclusive. Furthermore, while it is not at present improbable that this series is equivalent with the Queen Charlotte Island and Kootanie formations, as has been suggested by Dr. G. M. Dawson,* we have yet no direct evidence of it; that is, there is no known stratigraphical continuity between those northwestern formations and the Comanche series, and no fossils have been found common to both. The presumptive evidence of their equivalency is therefore apparently confined to the position which each is known to hold beneath acknowledged Upper Cretaceous strata and to certain probably contemporaneous displacements of the lower series which have occurred in both regions.

The unconformity between the Lower and Upper Cretaceous of the Southwest, together with the faunal break between them, which have already been mentioned, make it evident

* This Journal, vol. xxxviii, p. 122.

that the latest strata of the Comanche series are considerably older than the earliest ones of the Dakota Group, but we yet know of no formation, either upon this continent or elsewhere, which can be confidently assigned to a place between them. Between the Lower Cretaceous of the Southwest and the underlying formations there is a distinct hiatus which will presently be further mentioned.

In Texas, east of the Pecos river, and in Arkansas and the Indian Territory, the Comanche or Lower Cretaceous strata, while they are frequently in the condition of ordinary firm limestones, often consist of friable, more or less concretionary calcareous layers, the prevailing color of the whole being light gray. All the strata are usually fossiliferous, often abundantly so, and it is from the less compacted layers that most of the collections of fossils have been made. Even where these eastern Comanche strata are most displaced, they rarely consist of densely compacted layers.

East of Pecos river they are found on the east, south and west sides of the Texas Paleozoic area, where the series ranges in thickness from one hundred to eight hundred feet, with a considerable thickening above this in the neighborhood of Austin. Upon the western side of that area the whole series disappears from view by a westerly dip; and when it is brought up again west of the Pecos in Texas, and south of the Rio Grande in Mexico, by the mountain uplifts which are presently to be further mentioned, it is found to have become greatly thickened and its strata all changed to compact bluish limestone closely resembling those of Paleozoic age, especially those of the Carboniferous of the great interior region. In these respects they are in strong contrast with all other known strata of the North American Cretaceous.

Within the region that includes the portion of Western Texas which lies west of Pecos river, together with the adjacent parts of the Mexican states of Chihuahua and Coahuila, there are numerous clusters and short ranges of mountains, a part of which are composed of erupted rocks, but many of which are true orogenic uplifts of stratified formations. It is the latter that have just been briefly referred to. These uplifts have brought to view strata of various ages including Lower Cretaceous, Carboniferous, Silurian and apparently still older strata. The Upper Cretaceous, including the Laramie, was also involved in the same displacements. Besides these stratified rocks, a crystalline granitic rock is sometimes observable beneath them, in the mountain ranges, which has sometimes the appearance of having been intruded, but it is not thought to have any relation to the erupted rocks which have been mentioned as composing a part of the mountain ranges of this region.

One of these short ranges lying in the Mexican state of Chihuahua, 75 miles southeastward from Presidio del Norte, and known as the Sierra San Carlos, was observed by Dr. Newberry several years ago, and lately by myself, to consist mainly of the hard bluish limestones which, from bottom to top carry fossil forms which are characteristic of the Comanche series. These strata which are there strongly upturned and flexed, have a thickness of fully 4,000 feet, to which should probably be added 500 feet of similar and conformable strata at the base of the former, the only doubt as to their being a part of the Lower Cretaceous series there arising from the obliteration or obscuration of the contained fossils. These latter strata which, it may be incidently mentioned, contain deposits of argentiferous galena, rest with apparent conformity upon others which are mostly siliceous, highly metamorphosed, and probably of pre-Silurian age. The latter in turn rest upon the crystalline granitic rock which has already been referred to, and which seems to form the core of the mountain range.

At the eastern base of the range about 700 feet in thickness of strata occur which bear *Inoceramus problematicus* and other Upper Cretaceous fossils. The lowermost of these Upper Cretaceous strata are there almost vertical, and they are apparently conformable with the almost vertical Lower Cretaceous strata with which they are in contact; so that it is evident that both the Upper and Lower Cretaceous were involved in one and the same displacement. Because of this apparent conformity the stratigraphical hiatus which is understood to exist between the Upper and Lower Cretaceous is not distinctly shown here.

There is no apparent reason for supposing that the much altered strata which underlie the Lower Cretaceous in the San Carlos Mountains are of Mesozoic age, and therefore it is assumed that both the Jura and Trias, perhaps also the Carboniferous, Devonian and Silurian are absent there. It is such evidence as this of a great hiatus beneath the Lower Cretaceous that has been referred to.

The only other uplift of Lower Cretaceous strata that will be specially mentioned in this article occurs in the Chinate Mountains, in Texas, about 25 miles north of Presidio del Norte. At the eastern end of this range, near the Shafter silver mines, the Lower Cretaceous* strata are found resting directly and conformably upon the Carboniferous limestones; both formations being composed of limestones which are so similar in color and lithological character that their difference in age would hardly be suspected by casual observation, and is only demonstrable by the discovery of characteristic fossils in

* These Cretaceous strata also bear silver ores.

each. Omitting mention of the Permian, or uppermost portion of the Carboniferous system, which seems to be absent here, the hiatus between the Lower Cretaceous, and the Carboniferous strata of the Chinate Mountains amounts to at least the whole of the Jura and Trias.

This hiatus is no greater than is exhibited in others of the mountain uplifts in the region under discussion, and not so great as it is in some cases. Indeed, so far as I am now aware, the hiatus between the Lower Cretaceous and the next underlying rocks is nowhere in all that region less than it is at the locality in the Chinate Mountains just mentioned. That is, both the Jura and Trias are believed to be absent there. That neither the Jura, Trias, or Lower Cretaceous occur between the Upper Cretaceous and Carboniferous in central New Mexico, accords with observations that I made there during the past season. So far as both the Jura and Trias are concerned, I have not yet been able to obtain any satisfactory proof that either of these geological divisions are represented by any North American strata south of the 34th parallel of latitude.*