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ALTERNATION OF FOSSIL FAUNAS.

BY CHARLES R. KEYES.

Several years ago while studying the coal measures of Iowa and the neighboring states, it was suggested in a general way that the so-called Lower Coal Measures and the so-called Upper Coal Measures eventually might prove to be essentially contemporaneous.

In commenting upon the great erosion plane at the base of the Coal Measures it was stated that in the Iowa region at least for a very considerable period during the Kaskaskia epoch erosive agencies were actively at work on the land surface which extended southward about as far as the present city of Saint Louis. Shore deposits, sands and clays, were laid down immediately beyond the place just mentioned, while farther southward marine beds continued to be formed one above another conformably.

When a new period of depression set in, coal marshes were formed along the landward creeping shore-line. The more strictly marine deposits began to slowly extend farther and farther northward resting on the older calcareous beds as well as the earlier formed marginal areas of sands, clays, and accumulated vegetation. This process with many brief interruptions continued until the old shore-line had again gained its former place near the present Iowa-Minnesota boundary. The coal, or marginal, beds were formed at the same time as certain limy layers farther outward; and that all formations along any given horizontal line (nearly horizontal, but having a slight inclination to the southwest) were deposited contemporaneously. On a sinking coast the marginal sediments would have continually the later open sea deposits laid down upon them. The covering of the coal-bearing strata by the calcareous beds would constantly take place as long as the depression of the shore continued.

The "Lower" Coal Measures are not then a series of beds laid down previous to the deposition of the "Upper" Coal Measures. Each particular part of the former was deposited at the same time as portions of the latter farther seaward; the lines of contemporaneous deposition being nearly horizontal, yet having a common though slight seaward tilt. As a whole the "Lower" Coal Measures do actually lie beneath the "Upper" Coal Measures; but the line of separation is not a line drawn parallel, but obliquely to the planes of sedimentation.

More recently some instructive facts bearing upon the question have been brought to light regarding the faunas contained in the Kansas section. Previous results of very similar character were obtained in Iowa and Missouri a decade previous, and incidental mention made of them,

The results of the late Kansas work by Girty\* and White are presented in tables giving the range of the fossil species. The vertical distribution is extended upward beyond the highest rocks of Iowa and Missouri.

Altogether, from the base of the productive coal measures in these states, from the bottom of the Des Moines series, through the Missourian series and the Oklahoman series, or to the top of the Marion formation in central Kansas, there are some 2,000 feet of strata. There are alternating limestone and shale formations which number about fifty. These 25 limestones and 25 shales have received distinctive names.

It is a well known fact that organic remains are abundant from the bottom to the top of the section. The remarkable feature of the Girty tables is that with few exceptions the fossils were obtained from only the limestone beds—the shales yielding few or no forms. In other words the fossils are practically in alternating formations. This alternation of limestones and shales is shown in the following list of formations beginning at the top of the section.

MID. CARBONIFEROUS.	Oklahoman S.	Marion formation Winfield formation Doyle shale Fort Riley limestone Florence flint Matfield shale Wreford limestone Garrison formation Cottonwood limestone
	Missourian Series	Eskridge shale Neva limestone Elmdale formation Americus limestone Admire shale Emporia limestone Olpe shale Barclay limestone Burlingame shale Howard limestone Severy shale Hartford limestone Calhoun shale Deer Creek limestone Tecumseh shale Lecompton limestone Kanwaka shale Oread limestone Le Roy shale Stanton limestone Lane shale Iola limestone Vilas shale Earlton limestone Chanute shale Drum limestone Cherryvale shale Dennis limestone Galesburg shale Hertha limestone
	Des Moines S.	Dudley shale Parsons limestone Bandera shale Pawnee limestone Labette shale Fort Scott limestone Cherokee shale

\*Bull. U. S. Geol. Sur., No. 211, p. 77, 1903.

While some of the species from the limestones also occur in the shales, they are represented usually by so few individuals that they may be considered in the latter as purely accidental occurrences.

To the eastward the conditions of sedimentation are reversed. Shales predominate, with limestones intercalated. The shales are quite fossiliferous. Forms from the shales only sparingly occur in the limestones. The faunas of the limestones are very distinct from those of the shales, but among themselves are practically the same. Moreover, they are essentially identical with those from the limestones higher up in the Missourian series of Kansas.

Kansas shales have not been exhaustively examined for fossils. Those shale formations of the Missourian series which have been carefully examined carry the typical forms of the shales of the lower Des Moines and Arkansan series rather than the types of the Missourian faunas as generally known, which is the limestone fauna.

There is, then, in the Coal Measures of Iowa, Missouri, and Kansas an alternation of faunas corresponding to the alternation of lithologic units. There is a characteristic fauna of the limestone formations; and there is a characteristic fauna and a flora of the shale formations. The main reasons why the two faunas have not been differentiated are these: Little attention has been paid to the formational range of the organic remains. Comparative abundance of the invertebrates in each formation has not been noted. The tendency to list simply species has done nothing towards distinguishing faunas. As a result faunas which are really distinct and which should be kept entirely separate are merged. Critical examination of the biologic features as given in the literature of the subject indicate quite clearly that the faunas as usually recognized are composite faunas. Inquiry in the field shows that such faunas are in reality made up of distinct elements. These are not continuous through any considerable range, but alternate, much the same way as do the general lithologic characters.

Similar conditions of alternations of faunas have also led to very erroneous conclusions regarding the age of the different parts of the Cretaceous section in the southern Rocky Mountain region, to which attention has been recently called.