Art. XII.—*The Dakotan Series of Northern New Mexico;* by Charles R. Keyes.

Strata that have been referred to the Dakota division of the Cretaceous age have been long known in the Southwest, around the southern end of the Rocky Mountains in northern New Mexico. The section there exposed has been generally regarded as exactly representing the "Dakota Group" as first defined by Meek and Hayden* for the upper Missouri region. Late observations in the New Mexican region indicate clearly that the formation called the Dakota sandstone has never been carefully delimited, that it has been given quite different limits by different authors, and that the section usually so called actually belongs to several geological ages.

As recently made out, the general Mesozoic section of northeastern New Mexico presents the following elements:

General Mesozoic Section of Northeastern New Mexico.

Age.		Series.	Thickness.
Cretacic	Late	7. Laramian sandstones	2500
		6. Montanan shales	1600
	Mid	5. Coloradan shales	1000
		4. Dakotan sandstones	500
	Early	3. Comanchan shales	100
Jurassic		2. Morrisonian sandstones	250
Triassic		1. Red Beds (upper part)	1000

As usually considered in the literature of the subject, the Dakota sandstone has been made to cover of the above section not only No. 4, but No. 2 and No. 3, and not infrequently part of No. 1. The reasons for these long standing errors of interpretation recalls one of the unpleasant chapters in the history of American geology. It goes back to the very beginning, to the early sixties, when there was a concerted attempt to thoroughly discredit the work of Jules Marcou in this country. The proofs of the conclusions which the Swiss geologist submitted may have been insufficient at the time, or they may have been happy guesses, but the fact yet remains that the latest work in the region has, in the main, substantiated his observations and there are too many of his statements that are correct to assert at this day that they were anything less than a display of geological acumen such as none of his critics possessed. Newberry, Hayden, Meek and others appear to have become so absorbed in their side of the controversy that they all but lost sight of the facts, and they not infrequently went

* Proc. Acad. Nat. Sci., Phila., vol. xiii, pp. 410–420, 1862.

so far as to discuss in the most positive manner sections which they had never been near. Instead of clearing up the points under discussion, this long drawn out controversy only served to make the entire question more obscure.

When I was first suddenly made acquainted with the Cretaceous formations of the region, it was in the field, before it was possible to consult carefully very much of the literature on the subject. In mapping and in local descriptions in the northern New Mexican province I assumed the Dakota sandstone to be the great massive plate of yellow sandstone about 500 feet in maximum thickness. Above it were the Colorado shales and beneath in many places a peculiar succession of sandy shales, shaly sandstones and clay shales. Several papers were even published on New Mexican geology in which this idea of the Dakota formation of the region was expressed. The chief reasons for considering this great plate as a formation by itself and as representing the Dakota sandstone were (1) that it immediately underlay the Colorado shales, which were well identified by numerous fossils, and (2) that the sandstone rested in marked unconformity upon the formations beneath. When, later, the literature was gone over carefully in order to compare the published observations of others with my own, it was with much surprise that I found that prevailing opinions included in the Dakota section a much greater sequence than I had done. This led immediately to a detailed examination of many of the more critical of the described sections; and the location of the real difficulties of former interpretations.

The use of the term Dakotan series for the sequence of massive yellow sandstones which form the bottom of the Cretaceous section over the greater part of New Mexico is based upon the accepted terminology of the general Mesozoic section of the Rocky Mountain region. As a definite geologic title the name Dakota was first applied by Meek and Hayden,* in 1862, to the basal member of the Cretaceous of the Upper Missouri River district. Although included in their "Earlier Cretaceous" division, this is not the Early Cretaceous division as at present understood, but is the base of what has long been known as the "Upper Cretaceous." In the general geological section the formation belongs properly to the Mid Cretaceous period.

As the entire succession of the Mid Cretaceous and Late Cretaceous formations is upturned along the eastern flank of the Rocky Mountains, the Dakotan division is readily traced from the original locality southward into central New Mexico, and the title given to the series in the north appears to be

*Proc. Acad. Nat. Sci., Phila., vol. xiii, pp. 510–520, 1862.

fully applicable to certain sandstones widely distributed in the south.

Many different titles have been given to the sandstones belonging to the Dakotan series; and the term itself has been used in many different senses by the various writers who have passed through the New Mexican field. Among the first to call attention to the formation in question was Jules Marcou,* who, as early as the year 1853, traversed this region in connection with an expedition sent out by the Federal government to survey a railroad route to the Pacific coast along the thirty-fifth parallel of latitude.

Capping Pyramid Mountain, Cerro Tucumcari and the cliffs of the Canadian river near the eastern border of New Mexico, Marcou noted about 50 feet of massive yellow sandstones which, with other underlying beds, he regarded as Jurassic in age. The massive yellow sandstone of these sections subsequently proved to be the attenuated eastern edge of what is now denominated the Dakotan series; while lately the age of the beds beneath was finally adjudged in accordance with Marcou's original designation.

During the year 1858 Newberry† crossed northern New Mexico and recognized an extensive development of rocks which he regarded as of Cretaceous age and which he divided into a lower group and an upper group. These divisions are not regarded as representing the similarly named subdivisions of the general Cretaceous section. In the "Lower" division, as thus understood, the Dakotan sandstones were included; and the terms so far as they apply to northeastern New Mexico may be considered as practically co-extensive. In northwestern New Mexico he embraced in this Lower division also the Jurassic Zunian beds. His "Lower Cretaceous" does not, as has been widely believed, correspond to Meek and Hayden's subdivision of the "Early Cretaceous." This is very clearly shown in his descriptions of the region around Las Vegas.‡ In the year following Newberry's return from the Colorado River of the West, and two years before the publication of his official report just referred to, this author published a criticism§ on Marcou's Jurassic system of New Mexico, in which he attempted to show that all of the so-called Jurassic rocks are really Cretaceous in age, and correspond to Meek and Hayden's Fort Benton and Niobrara groups, or the Coloradan series of present nomenclature. This, however, is not strictly correct. The larger part of Marcou's Jurassic system of rocks

* Exp. and Sur. Pacific R. R. Route. vol. iii, p. 137, 1856.
† Ives Rept. Colorado River of West, pt. iii, p. 107, 1861.
‡ Loc. cit., p. 106.
§ This Journal (2), vol. xxviii, pp. 298–299, 1859.

of the New Mexican region belongs to the Dakotan series, or below. The discussion is quite remarkable and, in the light of recent investigations, is strangely incongruent. Marcou and Newberry traversed very different routes; that of the first named explorer being up the Canadian river valley a hundred miles south of the old Santa Fe trail which the last mentioned observer followed. While Newberry was discrediting Marcou's recognition of Jurassic rocks, he himself passed over country where they were not present except at one point—at the Cimarron crossing; and years afterward,* with no reference whatever to his former contention, he assigned certain beds in this vicinity to a Jurassic age. Recently Stanton† finds that these and the Tucumcari beds of Marcou are continuous and form part of the Morrisonian series.

Newberry‡ in his later report subdivided the Cretaceous into three sections, the "Lower" division embracing only the Dakota sandstone.

Although Hayden,§ who with Meek originally defined the Dakota division of the Cretaceous, recognized his formation within the limits of New Mexico in traveling from Raton to Santa Fe, it is not possible to determine from his meager descriptions just how much of the general section of the region he intended to include under the title. However, it is known from the route which he followed that he had at no time any other than the main massive sandstone in view. At no point which he visited are any of the lower, or Morrisonian, beds exposed.

As originally described, the "Lower Cretaceous" of Stevenson,‖ of northeastern New Mexico, appears to embrace only what is now called the Dakotan series. In a later publication¶ this writer uses the terms "Dakota Group" to cover not only the Dakotan series, as at present understood, but also the Jurassic section, and a part of the underlying Triassic beds of previous writers. This group was subdivided by him into three sections called the Lower Dakota, the Middle Dakota and the Upper Dakota. The last mentioned alone can now be considered as the equivalent of Meek and Hayden's original Dakotan series. This author** says: "The grouping to be proposed is merely provisional; dependence has been placed

* Macomb's Expl. Exp. Junc. Grand and Green Rivers, p. 28, 1876.
† Journal of Geology, vol. xiii, pp. 657-669, 1905.
‡ Macomb's Expl. Exp. Geol. Rept., 121, 1877.
§ U. S. Geol. Surv. Terr., Third Ann. Rept., 2d ed., p. 162, 1873.
¶ Ibid., Supp., p. 90, 1881.
‖ U. S. Geol. Surv. W. 100 Merid., vol. iii, p. 400, 1975.
** Loc. cit., p. 88.

solely upon lithological characters and stratigraphy, since testimony of fossils is either unattainable or indecisive. When the work shall have been prosecuted in detail and carried systematically toward the south and west to localities already well determined by evidence of fossils, this classification may prove to be somewhat arbitrary. For the present, however, it seems desirable to include under one group the Dakota of Meek and Hayden and the greater part of the Triassic of authors found in New Mexico. The whole series may be Triassic or it may be wholly Cretaceous. It is included under the Dakota here merely for convenience of description."

It is quite clear from a consideration of the various localities mentioned that the author had somewhat mixed his stratigraphy, a fact not to be wondered at when the limited time he had for examination is taken into account. His "Upper Dakota" of one locality is the "Lower Dakota" of another. Elsewhere the latter is of undoubted Early Cretaceous age, and not Mid Cretaceous (Upper Cretaceous) at all.

So far as is known, it is largely due to this report that the confusion regarding the delimitation of the Dakotan series arose in this region. Although the Hayden reports make scant reference to the New Mexican region, the various allusions are of similar tone. And the way was paved by Newberry's denunciations of Marcou based upon very incomplete observations.

In northwestern New Mexico, Holmes* ascribes about 1,200 feet of strata to the Dakota group, which he divides into "Lower" and "Upper" portions. Only the massive Upper division is now regarded as properly representing the Dakotan series. The so-called "Lower Dakota" formation is quite different lithologically from the "Upper" portion, and Dutton† more recently gave it the name of Zuñi sandstones. It is now regarded as Jurassic in age, as already noted.

In later years Cummins‡ has proposed to put the attenuated Dakota sandstone, as exposed in the Cerro Tucumcari in eastern New Mexico, with the Early Cretaceous and Jurassic formations of that section, and to call the whole the Tucumcari beds, or formation.

The unity of the great sandstone plate as a distinct and easily recognizable stratigraphic formation seems to be now fully demonstrated, and also finds corroboration in the recent observations of Stanton in southeastern Colorado. The name Dakotan series is properly restricted to it.

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* U. S. Geol. and Geog. Sur. Terr., 9th Ann. Rept., p. 224, 1877.
† U. S. Geol. Sur., 6th Ann Rept., p. 140, 1886.
‡ Texas Geol. Sur., Third Ann. Rept., p. 201, 1892.