

1907

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Recommended Citation

Keyes, Charles R. (1907) "Tertiary Terranes of New Mexico," *Proceedings of the Iowa Academy of Science*, 14(1), 223-228.

Available at: <https://scholarworks.uni.edu/pias/vol14/iss1/18>

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TERTIARY TERRANES OF NEW MEXICO.

BY CHARLES R. KEYES.

Deposits of Tertiary age are extensively developed in New Mexico. The greatest thicknesses are found in the northwestern and central parts of the state, where their maximum measurements reach no less than 3,000 feet. Many minor areas are also known. These deposits recline usually in marked unconformity upon the beveled edges of the Cretaceous and older strata. They are geologically among the most important deposits of the region.

Tertiary deposits in New Mexico indicate a marked change in the physical conditions of the region as compared with those conditions which prevailed during former geologic periods. In place of open-sea depositions, as was generally the case among all earlier formations, varied conditions existed. In some localities maritime conditions prevailed; in other places another set of conditions occurred, and some of these deposits have been regarded as having originated in large lakes. In still other localities extensive continental deposits were formed and were of fluviatile and eolian origins. The last mentioned class of deposits have a special interest at this time since it is being discovered that many so-called lake beds are not of lacustrine origin but are river formations. The first mentioned classes need no particular description at this time but the conditions under which fluviatile deposits are laid find exceptionally favorable expression. This consideration applies particularly to the Llano Estacado formations and many other deposits having as yet no special geographic designations. This phase of the subject also refers particularly to most of the Quaternary deposits which cover the bolson plains spreading out from the piedmont areas.

The general geologic section of the New Mexican Tertiary deposits may be considered as follows:

Age	Series	Formations	Thickness
Pliocene	Pecosian	Llano Estacado sands	200
Miocene	Arriban	Santa Fe marls	500
Eocene	Chaman	Chaco marls	1,000
		Canyon Largo sandstones	700
	Nacimientan	Torreon sands	300
		Puerto marls	500

Of the four parts into which the Tertiary time is subdivided the Oligocene has not been as yet recognized by sediments anywhere within the limits of New Mexico. The Eocene, or Early Tertiary, period is represented by at least four important formations and it is quite likely that further differentiation will be found advantageous.

It is proposed to call the basal portion of the Early Tertiary section of New Mexico the Nacimientan series. The term is particularly appropriate as it means, in the Spanish language, birth. The title is taken from the great land grant known as San Joaquin del Nacimiento which lies in Rio Arriba and Bernalillo counties. Nearly the entire section of the New Mexican Eocene deposits occurs within the limits of this grant. The formation also stretches away to the northwestward from the foot of the Nacimiento range of mountains; and the village of Nacimiento is built upon the rocks of this series.

The Nacimientan series has a maximum thickness of not less than 1,000 feet, divisible into at least two well-defined terranes; (1) Puerco marls, about 500 feet in thickness; and (2) the Torrejon sandstones about 200 feet thick. This series is believed to represent a period that is earlier in point of time than any other Eocene deposits. The uppermost member of the Torrejon formation may belong to the earliest or Midwayan stage but it is thought to be somewhat earlier. Its corresponding European stage is the Cernaysian. In a general way the Nacimientan series covers the better known subdivision of the Puerco beds of Cope, but it includes a considerably greater section.

The Chaman series embraces two important formations and some of less vertical extent. It includes the major portion of the New Mexican section generally that has gone under the title of the Wasatch beds.

To the lower part of the series Newberry early* gave the name of Canyon Largo beds. "Long Canyon" drains the interior of the great Eocene plateau of northwestern New Mexico. The canadas of its headwaters reach to the very crest of the high, eastward facing escarpment overlooking the valley of the Rio Gallinas, in Sandoval county. From the top of the facade a vast mesa or inclined plain stretches away a hundred and fifty miles to the northwestward to beyond the Arizona line. This tilted plain is worn out on the beveled edges of Tertiary, Cretaceous, and Triassic strata which have a

* Macomb's Exp. Green River, Geol. Rept., p. 1, 1876.

combined thickness of 10,000 feet. Where the Long arroyo traverses the median sandstone it cuts a deep canyon into this indurated formation giving to the entire waterway its title.

To the lower part of this sandstone terrane Holmes* gave the title of the Pinon Mesa group. The sandstones together with other beds above and below have been also termed Wasatch beds.

Below, the Canyon Largo formation is sharply demarcated. Its massive basal sandstone of bright yellow hue contrasts greatly with the somber colored marls of the Puerco terrane. This basal member of the formation is a conspicuous topographic feature wherever exposed, and rises over the more yielding marls beneath as a pronounced escarpment or perpendicular facade. These characteristics everywhere in the field serve to locate the bottom of the formation.

Above, the Canyon Largo section is not so readily defined as the base. The transition from prevailing sandstones to prevailing marls is not so abrupt as it is from the latter to the marls at the base. The sandstones are prominent beds for a distance of about 700 feet from the bottom of the formation. The vertebrate remains appear to be the most important feature in drawing the exact line of separation between the Canyon Largo and the Chaco terranes. Cope's reference to the shark bed near the top of the formation also seems important in this connection.

The Chaco marls, or uppermost member of the Chaman series, is a formation that is quite distinct from the other parts of the Eocene section, and is easily recognizable in the field. These marls cover the broad Chaco mesa. The southern escarpment of the Chaco mesa is a prominent feature of the landscape of the region and is composed of the sandstones of the Canyon Largo formation.

These marls constitute a part of the section which has been called the upper Wasatch group; and also the Green River shales.

The Chaco marls occupy the central part of the great Eocene plateau of northwestern New Mexico. The geologic structure of the plain being that of a broad, shallow basin the youngest deposits of which are preserved in the middle. All around general planation has removed these beds and older and older and older strata appear as the distance from the center of the basin increases.

The area occupied by the marls of the Chaco formation lies chiefly in northwestern Sandoval county, the southwestern part

*U. S. Geol. Sur. Terr., Ninth Ann. Rept., p. 249, 1877.

of Rio Arriba county, and the extreme eastern part of San Juan county. The present areal extent of the marls is only a small portion of the formation as originally deposited. The existing remnant has been preserved only on account of its position in the bottom of a syncline, the general erosion of the region not yet having reached a level that is beneath the bottom of the terrane in the central part of the trough. No other areas or exact equivalents of the Chaco formation are known elsewhere within the boundaries of New Mexico.

The fact that there are marked unconformable relationships between the beds of the Nacimientan and Chaman series already indicates that a considerable section of Eocene sedimentation is missing in the region. This may mean that all of the Chickasawan stage of the standard American section is represented by an erosion interval and that the beds in question belong to a later stage of the Eocene than has been supposed, corresponding perhaps to the Claibornian stage. Of the European analogues the latest Suessonian or earliest Parisian may be considered the nearest equivalents.

No strata of Oligocene age have been as yet identified within the boundaries of New Mexico. The Eocene and Miocene deposits of the region appear to be separated by an important erosion interval.

The Arriban series of marls is one of great thickness. Its best known member is the Santa Fe marl, although the formation never has been carefully delimited.

The title of Santa Fe marls was first used as a geological term by Hayden* in 1869. He applied the name to certain marls, clays and sands which he found in the Rio Grande valley north and south of the city of Santa Fe. Cope† subsequently studied the vertebrate fossils of these marls and referred the formation to the Loup Fork Tertiary. A few years later Stevenson‡ noted these beds, but, as recently shown by Johnson,§ his name Galesteo group covers the same section as Hayden's title. In a later publication of the geology of the Cerrillos hills, Johnson|| has extended Hayden's title so as to include also the Quaternary wash-deposits. The upper limit of the Santa Fe marls should probably be regarded as properly located at the base of the vast basaltic flows of the region.

* U. S. Geol. Sur. Terr., Prelim. Field Rept., p. 66, 1869.

† Proc. Acad. Nat. Sci. Phila., Vol. 26, pp. 147-152, 1874.

‡ U. S. Geol. Sur., W. 100 Merid., Vol. III, Supp., pp. 159-163, 1881.

§ Sch. Mines Quart., Vol. XXIV, p. 316, 1903.

|| Loc. cit.

The beds of this formation consist chiefly of sands, marls, and soft marly sandstones. There are some argillaceous layers present, and frequently some coarse materials. For the most part the beds are yellowish or reddish in color. Some of the sand beds are slightly cemented by calcareous material. At the base of the section and resting on the beveled edges of the older strata is frequently a coarse conglomerate bed which is extremely hard and firmly cemented. These "cement beds" may not be confined to the Santa Fe formation alone and probably are not.

The Santa Fe formation has a thickness of over 500 feet. Hayden reports a measurement of 1,500 feet. The base of this terrane is clearly defined. A marked plane of unconformity exists at the bottom of the formation. Wherever this base is observable the beds of this terrane are found to rest on the tilted strata of the older formations.

The upper limit of the Santa Fe formation is not as clearly marked as the bottom. Over a considerable portion of the area which is occupied by the marls the upper layers are mingled with the wash-deposits of nearby mountains. In many cases it may be difficult to distinguish between the Tertiary and Quarternary beds. Inability to separate the formations of the two ages has led Johnson* to extend Hayden's title so as to cover both sections. The facts do not appear to warrant this method of solving a difficult problem. Instead of clearing up the obscure points it causes only more confusion.

A critical examination of the Santa Fe marl sections along the Rio Grande seems very plainly to show that they terminate with the great outpourings of basalt throughout this region. These basaltic flows may then be taken as the upper boundary horizon of the marls. Since that time the Rio Grande has cut its canyon 1,500 to 2,000 feet deep, entirely through the surface eruptive sheets, the marls beneath, into the indurated formations. This has all taken time and is comparable in length to the time consumed in carrying down the thick wash-deposits which now cover the marls and often the lava flows.

The age of the series is no doubt Miocene, corresponding in the main to the Helvetian of Europe.

The Pecosian series appears to be late Pliocene in age corresponding to the Astian of Europe. The principal deposits cover the Llano Estacado of western Texas and eastern New Mexico along the Rio Pecos.

* Sch. Mines Quart., Vol. XXIV, p. 313, 1893.

The title was first applied by Hill* to the Tertiary deposits which veneer the even, seaward sloping plain of western Texas and eastern New Mexico. The thickness of the formation is about 200 feet. All of the beds are to be regarded as of fluvial origin.

*Bull. Geol. Soc. America, Vol. III, p. 87, 1892.