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1960, pp. 48-54. https://doi.org/10.56577/FFC-11.48

in:

Rio Chama Country, Beaumont, E. C.; Read, C. B.; [eds.], New Mexico Geological Society 11 th Annual Fall Field Conference Guidebook, 129 p. https://doi.org/10.56577/FFC-11

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THE VERTEBRATE FAUNA OF THE NEW MEXICO PERMIAN

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The only Paleozoic vertebrate assemblage of New Mexico worthy of note is that of the early Permian Abo and Cutler formations, mainly known from two areas in the Chama River drainage in Rio Arriba County. This is a fauna of reptiles, amphibians and (rarely) fishes broadly similar to that of the Wichita group redbeds of the early Permian of North Central Texas, but differing to some degree in composition.

HISTORY

The fauna is of interest as one of the first to be noted in the history of New Mexican geology and, incidentally, as one of the factors in initiating the famous feud between Cope and Marsh, the two greatest figures in American vertebrate paleontology in the last century.

In the 1870's Marsh, then a rising (and well-to-do) young Yale paleontologist, had hired the services of David Baldwin, a prospector who roamed northwestern New Mexico with his faithful burro,[1] to search the country for vertebrate fossils. In 1877 Baldwin discovered bones in the red sediments of the Chama Valley, both near Arroyo de Agua and, farther north, at El Cobre Canyon, and shipped a considerable quantity of material to New Haven. Marsh, however, did not immediately realize its value (most of it was not even unpacked for decades), and presently becoming dissatisfied with Baldwin, dispensed with his services. This he was to regret in future years, for Baldwin was promptly hired by Marsh's alert rival, Cope of Philadelphia. Baldwin made a small Permian collection for Cope, but his major service to science was the discovery of the Paleocene beds of the San Juan basin; the description of this important fauna was a major item in Cope's rise to scientific fame.

In the spring of 1878, at a meeting in Philadelphia, Cope announced the discovery of an important series of vertebrate fossils of Permian age in Texas. Marsh was present and, remembering the unstudied Baldwin material, left the meeting early (so runs the legend), took the first train back to New Haven, unwrapped a few packages, and wrote a hasty four-page article describing several new genera and species from the New Mexican Permian. So superficial was the work that of two species which he described as belonging to a single genus, one was the pelycosaurian reptile **Ophiacodon,** the other an amphibian of the genus **Eryops!** He rushed this paper to press in the American Journal of Science (which he controlled) and this "beat" Cope to publication on the first discovery of Permian vertebrates in North America. The latter was, quite naturally, aggrieved at this unethical conduct and (it is said) pre-dated the separates of his own paper on the Texas material in an attempt to recover priority on the discovery!

Almost no attention was paid to the New Mexican fossils for the next thirty years and so little was known of the New Mexican fauna that it is scarcely mentioned in Cases's three-volume revision of Permo-Carboniferous vertebrates published in 1907-1911. About this time, however, Williston of the University of Chicago, then the leading student of fossil reptiles, visited New Haven. The Baldwin collection was opened up, prepared, and studied by him. Its contents proved to be of remarkable interest, including, for example, the fine skeleton of a hitherto unkown large primitive reptile, **Limnoscelis,** as well as numerous remains of the carnivorous pelycosaur **Sphenacodon.** Williston determined to relocate Baldwin's sites. Few decipherable labels were found with the materials. The specimens had been shipped by narrow gauge from Durango, and for a time it was thought that part had come from the Cutler redbeds of the Animas Valley. But it seemed clear that most of the material, at any rate, came from Rio Arriba County, and one or two localities were named on the labels, although these were not to be found on maps then available. In 1911 Williston organized an exploratory trip to this region, accompanied by the veteran collector Paul Miller, Prof. Case of Michigan, and Prof. von Huene of Tubingen, then visiting in this country. They outfitted at Santa Fe and set forth up the Chama Valley. This trip has become legendary, with many stories told of it later by Miller and Case: of Williston's mixed brown and black shoes, due to exchange on the sleeper to Santa Fe; the purchase of a chicken, its pursuit through a pepper field, by big Huene and little Case and its eventual slaughter by Williston; the near-drowning of the party by a flash flood in the El Cobre arroyo; Huene's phenomonal appetite (he's a large man) and the consequent depletion of supplies and shortening of the trip. Roads were then almost non-existant and much of the travel was along the river beds. The bonebed whence much of Baldwin's material had come was identified, northwest of the village of Arroyo de Agua, and material collected along the bluff from this point down the north bank of Salitral Creek; the El Cobre Canyon site visited by Baldwin was relocated. The fossils collected were described in a 1913 volume by Williston and Case. Miller soon revisited the Arroyo de Agua region and Williston described further materials collected by him.

Later collecting in this region has mainly been by the writer, and field workers under his direction, and by University of California parties directed by C. L. Camp. I have briefly visited the region, working both the Salitral Creek exposures and El Cobre Canyon, in 1926, 1931, 1946 and 1952, and other Harvard workers went there on three other occasions. Most important, however, has been the work of the University of California parties, who discovered and worked a new series of bone pockets east and south of Arroyo de Agua in 1928, 1934 and 1935. Langston collected for the University of California on several later occasions.

Of fossil materials derived from this area, the types of Baldwin's material are in Peabody Museum, Yale University; nearly all the material collected by Williston, Case and Miller is in the Chicago Natural History Museum, as are small collections made by me; in New York is a limited amount collected by Baldwin for Cope; at Harvard most of the Baldwin finds except the types and smaller collect-

[1]In honor of which I have named one of the New Mexican Permian vertebrates **Baldwinonus trux.**

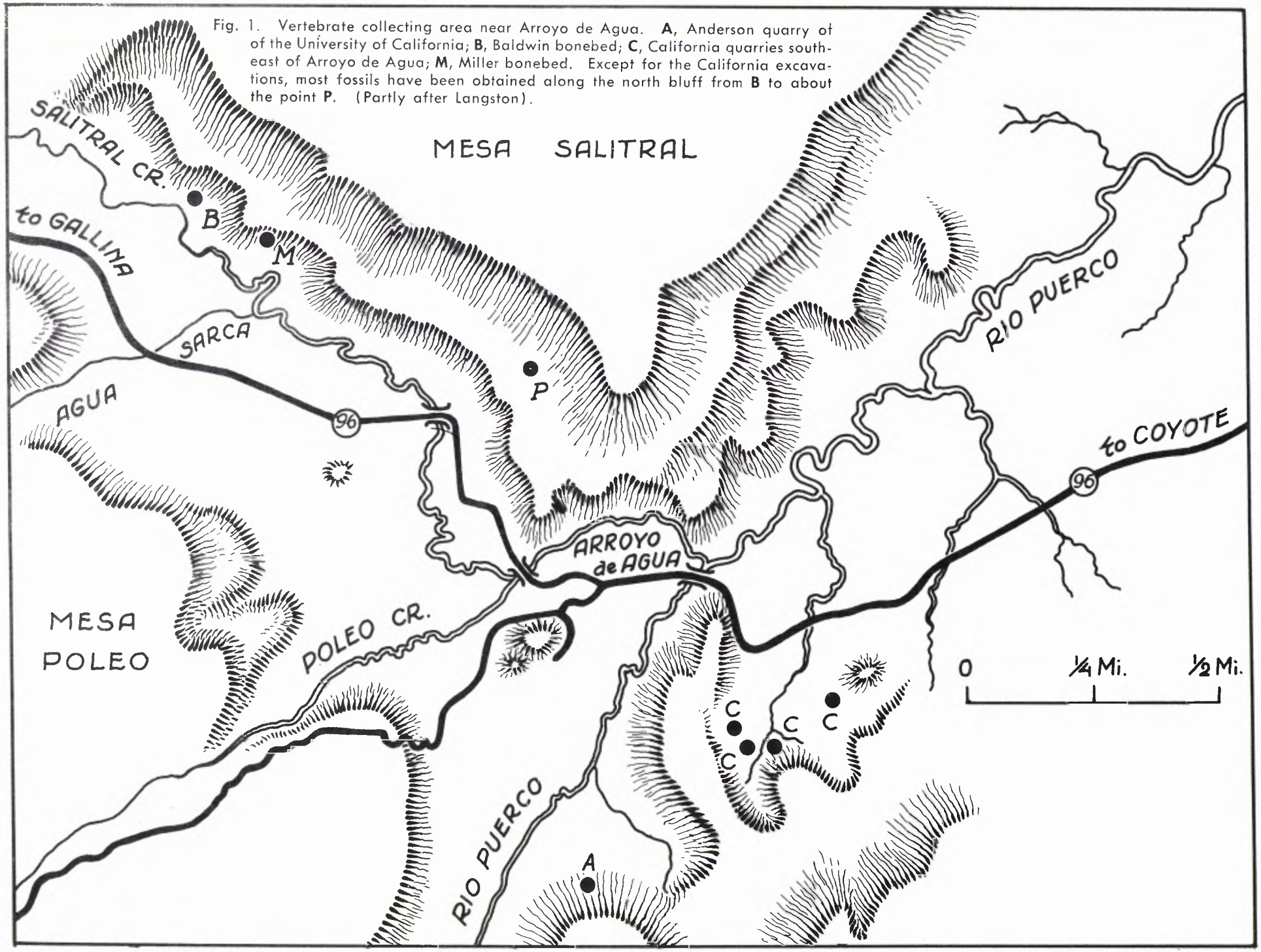

Fig. 1. Vertebrate collecting area near Arroyo de Agua. **A**, Anderson quarry of of the University of California; **B**, Baldwin bonebed; **C**, California quarries southeast of Arroyo de Agua; **M**, Miller bonebed. Except for the California excavations, most fossils have been obtained along the north bluff from **B** to about the point **P**. (Partly after Langston).

ions made by various Harvard parties; at Berkeley the valuable materials collected by the University of California parties.

THE ARROYO DE AGUA LOCALITIES

The Rio Puerco of Rio Arriba County (not to be confused with several other streams of the same name) is a small southern tributary of the Chama. Well up toward its head near the village of Arroyo de Agua there enters it from the northwest a major tributary, termed (in its upper course, at least) Salitral Creek.[2]

Excellent Permian exposures are present in the face of a bluff extending up the north side of the creek to a point about 1¼ miles northwest of the village. The Baldwin bonebed lies near the far end of these exposures; the excavation made by Baldwin and later enlarged by Miller, is readily seen in a small "pocket" at the foot of the bluff about ¼ mile above the mouth of Agua Sarca. Specimens in this bonebed are usually disarticulated but very numerous. If the horizon of the bonebed is followed to the southeast along the face of the bluff, bone fragments can be found at frequent intervals for the better part of a mile, to a prominent point opposite the mouth of Poleo Creek, where the bone horizon lies on a terrace some distance above the foot of the bluff. The matrix shows that certain of Baldwin's specimens were collected along this stretch, and except for those of the University of California, nearly all materials collected by later workers in the Arroyo de Agua region were obtained from these exposures. Beyond the prominent point mentioned, the bluff turns to the northeast, down the Valley of the Puerco. Permian exposures continue down the Puerco Valley to the Chama, but they have so far proved to be nearly barren.

A second series of fossiliferous exposures in the Arroyo de Agua region are those developed by California parties southeast and south of the village. About ⅓ mile east of the bridge over the Rio Puerco, the road to Coyote crosses a small arroyo running north in the Puerco. Four quarries upstream from this crossing were worked by California expedition. One locality lies about 300 yards SSE of the crossing, the other three, close together, about ¼ mile to the SSW. The faunas found in these quarries are similar to that of the bluff along the Salitral, and it is believed that they lie at essentially the same horizon in the Cutler. A fifth California quarry — the "Anderson quarry" — is, however distinctive. This lies about ¾ mile up the Poleo Valley SSW from the road bridge. As noted below, its fauna appears to be more advanced in character, and it is estimated to be two to three hundred feet higher in the section than the other California quarries.

Langston (1953, fig. 3) has published a map of the Arroyo de Agua region showing the location of the various quarries and the figure given here is partly derived from his.[3] For those who consult the older literature, it may be noted that the course of the road from Arroyo de Agua to Gallina (now state highway 96) has been changed since the earlier years of the century. After crossing to the north side of Salitral Creek a short distance west of the village, it formerly followed the north bank to a point above Agua Sarca; currently it recrosses the creek within 3/8 of a mile from its first crossing and continues west well up the south slopes of the creek valley.

EL COBRE CANYON

This is a long narrow box canyon, extending north, narrowing along its course, from a point about three miles northwest of Abiquiu. The arroyo draining it empties into the Chama about 1 ¾ miles west of that village. This was one of the original Baldwin localities, but has been seldom visited, for the water supply was difficult and until advent of the jeep and improved trails in recent years, it could be reached only by a difficult journey of several miles up the sandy bed of the arroyo. Williston, Case and Miller visited the canyon in 1911, and brief visits have been made by the writer and other Harvard parties on four occasions. Fossils are rare and, as far as I can learn, have nearly all been obtained from the lower part of the exposures near the southern end of the canyon. Splendid specimens of **Limnoscelis** were found by Baldwin; later visitors have found but small amounts of material. The fauna from this locality has appeared to me to be somewhat more primitive and earlier than that from the typical Arroyo de Agua localities (Romer and Price, 1940, p. 30), but Langston (1953, p. 412) questions this conclusion. None of the eight reptiles found in El Cobre Canyon are as yet surely identified in the typical Arroyo de Agua localities except **Sphenacodon ferox,** which is stated to have come from a high horizon in the canyon walls.

OTHER PERMIAN VERTEBRATE LOCALITIES

Abo-Cutler sediments are present over vast areas of New Mexico, and one would, hence, expect that finds of fossil vertebrates would be numerous and widespread. This is far from the case. I spent a month with a companion, some years ago, sampling Abo exposures up and down the state, with almost completely negative results, and I am told that similar prospecting by University of California parties met with a like lack of success. Were fossils comman, one would expect they would be reported incidental to geological work but as far as I know, this has occurred in only one instance. Only in three other areas are Permian vertebrates known.

(1) **Jemez Springs.** Darton mapped Abo deposits in Canyon San Diego, Sandoval County, from Jemez Springs southward. Since this area is not far removed from the "classic" Arroyo de Agua Area, it was not unreasonable to hope that conditions of deposition would have been similar there and that vertebrates might be present. This is the case. In 1931 I spent a short time in this area and found fairly numerous fragments of reptiles and amphibians in the canyon walls — particularly on the east side — for some four miles south of Jemez Springs, and in one instance found a small bone pocket with good remains of a new species of **Sphenacodon, S. ferocior.** Some years later a University of California party, ignorant of my work,

[2] The nomenclature of this stream is variable and confusing. In its lower course there enters it, from the slopes of Poleo Mesa to the south, Poleo Creek and, above this, Agua Sarca. Since the main creek bed is generally dry except in the rainy season, and such water as is found in its lower course is mainly that supplied by Poleo Creek and Agua Sarca, sections of the lower parts of the main channel below the mouths of each tributary are sometimes called by their names.

[3] The "Miller Bonebed," however, is incorrectly placed by Langston at the east end of the Salitral Creek bluff. This locality, from which came, among other specimens, a fine skeleton of **Ophiacodon,** lies farther to the west, above the mouth of Agua Sarca and not far downstream from the Baldwin bonebed.

prospected this same area and found a limited amount of material of **Sphenacodon**, diadectids and amphibians.

(2) **Upper Pecos Valley.** From Glorieta Pass southeastward to Doretta, the Santa Fe Railroad and U. S. Highway 85 parallel the right bank of the Pecos. For much of this distance there are good exposures of the Abo, mainly in bluffs above the railroad grade. These exposures are sparsely fossiliferous. I visited this area briefly in 1931, Harvard parties stopped equally briefly on two later occasions, and a California party also prospected in this region.[4] Finds, as fas as I know, include (a) fragmentary remains of pleuracanth shark skulls and of pelycosaurs near Glorieta Station, (b) remains of **Sphenacodon**, a diadectid and a pleuracanth shark tooth ¾ mile north of the Pecos pueblo ruins and (c) **Sphenacodon** vertebrae and pleuracanth teeth near Doretta.

(3) **Socorro County.** Case in 1916 reported fragmentary specimens of **Eryops**, **Sphenacodon**, **Ophiacodon** and a diadectid 10 miles northeast of Socorro, west of Arroyo de la Parida. I later collected **Eryops** fragments from the same area, and Camp found similarly fragmentary **Eryops** and **Sphenacodon** remains five miles further east.

THE FAUNA

In its broad aspects the Abo-Cutler fauna is comparable to the better known Texas vertebrate assemblage but, as noted below, differs in detail in relation to the zoogeographic situation and to possible climatic differences. Fish remains are rare. None were present in the older collections, but the California quarries turned up remains of the pleuracanth shark **Xenacanthus** and one specimen of a palaeoniscoid "minnow", compared to **Progyrolepis** of Texas, from the Arroyo de Agua region and pleuracanths have also been found in the Abo of the Upper Pecos.

Of amphibians, there are no remains in Rio Arriba County of embolomecous forms comparable to **Archeria** of the lower Texas beds (one such is noted for the Jemez Springs area) and no remains of microsaurs except a mandible referred with doubt to **Pantylus**. Rhachitomous amphibians are, however, not uncommon. **Eryops**, the large, sturdy-legged animal well known from Texas specimens has been found from time to time, but is not common. Of the dissorophids — small but equally sturdy forms, with armor-plating down the back — there are several skulls and partial skeletons of **Broiliellus**, and Langston refers with some doubt to **Aspidosaurus** some plates described by Cope as **"Zactrachys" apicalis.**

A fortunate find by the California parties was a quarry containing numerous remains of **Zatrachys**, a curious rhachitome with a flattened spinescent skull; the genus had been previously known only from a few rather poor specimens from both Texas and New Mexico, and this material enabled Langston (1953, pp. 383-400) to give an excellent account of the skull and certain associated postcranial materials. The genus **Platyhystrix** was founded by Williston on a few long sculptured neural spines of rhachitomous amphibians found in both New Mexico and Texas. It was long believed that these were associated with a skull similar to, if not identical with that of **Zatrachys.** Langston, however, has found that neural spines of a normal type — short and unsculptured — can be definitely associated with **Zatrachys** and hence **Platyhystrix** remains a problematical form as regards the rest of its anatomy.

Chenoprosopus is a long-snouted rhachitomous amphibian peculiar to New Mexico. Two skulls were known from the collections of Williston and Case and two further skulls and some fragments were collected by the California parties.

Of reptiles, both "stem reptiles" — the cotylosaurs — and pelycosaurs are well represented in the Rio Arriba County Permian. Of cotylosaurs, most specimens are those of diadectids — large, clumsy animals with a peculiar dentition seemingly adapted to a vegetarian diet. New Mexican specimens have been described under several names, but all are close to if not members of the typical Texas genus **Diadectes.** There is no representation of the seymouriamorphs (of interest as essentially bridging the gap between amphibians and reptiles). Of the important progressive captorhinomorphs, there are rare remains attributed to **Captorhinus** and the poorly known genus **Puercosaurus.** Important, however, is **Limnoscelis** from El Cobre, a large and archaic captorhinomorph unknown elsewhere.

In quantity, reptilian remains from New Mexico overwhelmingly pertain to the Order Pelycosauria, distant ancestors of the mammals, and of these the vast majority belong to the genus **Sphenacodon.** This form is closely related to the well-known **Dimetrodon** of Texas, but lacks the long slender spines that give the latter its spectacular appearance and has instead relatively short and flattened neural spines. In every other respect, however, the two are indistinguishable.[5] There are two described species of **Sphenacodon. S. ferox**, the commoner, is of modest size; **S. ferocior** an animal of considerable proportions, with a length (including a long tail) of about nine foot. The dentition was that appropriate to a predator, with large sharp "incisors" and powerful "canine" tusks. As in all older reptiles, the limbs were sprawled out at the sides of the body, the trackway broad and the gait a slow one. But the limbs are rather slenderly built and the animal was obviously relatively speedy and agile as compared with any of his contemporaries. **Sphenacodon** was without question the monarch of the New Mexico Permian.

Less common, but present in most localities was **Ophiacodon,** a pelycosaur whose structure suggests that it was somewhat amphibious in nature, with fish as a major article of diet. Present, although rare, was a small species of **Edaphosaurus**, of bizarre appearance with long spines bearing cross-bars; we are here dealing with a side-branch of the pelycosaurs which had (like the diadectids) taken up a herbivorous habit. Four further pelycosaurs of small size are known from sparse materials — **Baldwinonus,** possibly an aberrant ophiacodontoid; **Aerosaurus**, a primitive member of the sphenacodontoid group; **Scoliomus**, possibly

[4] Langston (1953, p. 363) says: **"Doretta.** Reports that a man named Wheeler from Chicago collected plants and a fish in Permian rocks near here have not been confirmed." This appears to be a combined rumor of my 1931 visit (I was then at Chicago) and one in 1936 by Robert V. Witter (then with me at Harvard).

[5] The late Henry Fairfield Osborn once seriously considered the possibility that **Spenacodon** and **Dimetrodon** were identical, the difference in spine development being a sex feature. When he asked me whether I had considered this possibility, I answered casually (not realizing the thought he had devoted to the matter) that this might have been responsible for the extinction of these animals, since all the males lived in Texas, the females across the sea in New Mexico!

of the same character; and **Nitosaurus**, apparantly a primitive edaphosauroid.

COMPARISON WITH TEXAS VERTEBRATES

A general resemblance is readily apparent on comparing the New Mexico fauna with those long familiar to us from the Wichita and Clear Fork groups of North Central Texas. Closer examination, however, reveals numerous differences. Almost no species appear to be common to the two areas; a number of common as well as numerous rare genera found in the one fauna are absent in the other; there are striking contrasts in the relative abundance of various groups.

Certain of these contrasts are seemingly due to differences in the climatic conditions under which deposition took place. As discussed below, the New Mexican localities appear to be correlated with the lower beds of Texas the Wichita Group, rather than the higher, Clear Fork, formations. The Abo-Cutler sediments are of the typical "redbeds" type which (despite some theoretical argument to the contrary) appear, where associated with vertebrate and plant remains, to be indicative of conditions of at least seasonal aridity. The fossiliferous Texas beds are as a whole termed "redbeds". But while the Clear Fork deposits are almost all of a typical red type, this is not true of the Wichita deposits, with the faunas of which our New Mexican material is to be compared. Some redbeds do occur in the Wichita; but these are generally barren, and the fossils occur mainly in series of variegated clays — blue, yellow, white — with occasional carbonaceous layers indicative of bog deposits. Quite surely Wichita conditions were less arid than those of the Abo-Cutler, and this is reflected in the relative composition of the fauna, the New Mexican beds being conspicuously poor in their representation of aquatic forms.

Xenacanth (pleuracanth) freshwater sharks are extremely common in many Texas Wichita localities; they are rare in New Mexico. There are a number of small palaeoniscoid fishes in the Wichita; in New Mexico only one specimen plus a few scales. The lungfish **Sagenodus** is common in the Wichita, the typical crossopterygian **Ectosteorhachis ("Megalichthys")** is known from a dozen or so localities, and the coelacanth crossopterygian **Spermatodus** is abundantly represented by scrap in several places. Not a single specimen of these three types is known from New Mexico.

Of amphibians, New Mexico is equally poorly represented among the more purely water-dwelling types. Notable is the absence of **Trimerorhachis** or any similar form. **Trimerorhachis** was a small flatheaded rhachitome with tiny limbs, which obviously was purely aquatic. It is one of the commonest of Texas vertebrates, and while its absence may be due, as Langston suggests, to geographic reasons, it is more probably attributable to climatic ones. The archaic aquatic embolomere **Archeria ("Cricotus")** is present in almost every known Wichita locality; it is unknown in the Rio Arriba County sites (Langston reports one fragmentary specimen of this general type from Jemez Springs). In the Texas Wichita there are a number of lepidospondylous amphibians which appear to have been purely aquatic, such as **Diplocaulus, Gymnarthus, and Pantylus.** Of these only the last is present in New Mexico, and it is rare there.

Apart from this dearth of purely aquatic forms in New Mexico there are many similarities in the two faunas. We have already noted that, as expected, freshwater sharks of the **Xenacanthus** type are present in both, as is one, at least, of Texas palaeoniscoids **(?Progyrolepis).** Despite the general scarcity of purely aquatic amphibians in New Mexico, **Zatrachys** is present here as well as in Texas, and so is the problematical **Platyhystrix.** Of amphibians with robust limbs, **Eryops** and **Broiliellus** are common to the two areas. **Diadectes** is the common larger cotylosaur of both areas; **Ophiacodon** and **Edaphosaurus** are two familiar pelycosaur genera present in both areas.

Generic contrasts between New Mexico, apart from those attributed above to climatic differences are, however, numerous. Characteristic New Mexican forms absent from Texas include the long-headed rhachitome **Chenoprosopus**[6] and the large primitive reptile Limnoscelis. Rare or poorly known New Mexican reptiles not known from Texas include the captorhinomorph cotylosaur **Puercosaurus** and the pelycosaur **Baldwinonus, Scoliomus, Aerosaurus** and **Nitosaurus;** the last two, however, have close Texas relatives **(Varanops, Mycterosaurus)** and **Scoliomus** is so poorly known as to be indeterminate.

The most interesting contrast between the two regions is, of course, the difference between the commonest and most dominant animal types of the two areas, the sphenacodont pelycosaurs. **Dimetrodon** is the most abundant vertebrate form in every Texas horizon; specimens of **Sphenacodon,** definitely distinct generically but indistinguishable except for spine development, make up the bulk of all collected New Mexican material.

In addition to **Dimetrodon,** the list of Wichita vertebrates includes a considerable number of forms unknown in New Mexico. The absence of a number of these, as noted above, may well be due to relative aridity in New Mexico; the absences of certain others, such as the amphibian **Edops** and the pelycosaurs **Lupeosaurus** and **Stereophallodon** may be due to the fact that their remains are mainly from the very lowest beds of the Wichita, which may well antedate the time of deposition of the typical fossiliferous Abo-Cutler. There remains, however, a considerable number of Texas Wichita forms which are not found in New Mexico. These include the amphibians **Acheloma, Parioxys** and **Alegeinosaurus; Seymouria;** the cotylosaurs **Diadectoides** and **Helodectes;** the protorosaur **Araeoscelis (Ophiodeirus);** the problematical reptile **Bolosaurus;** the pelycosaurs **Eothyris, Secodontosaurus** and **Ctenospondylus.** But although this list has an imposing appearance, its significance is not actually great. Of the eleven forms just listed, six are known from single specimens. **Seymouria,** although common in the Clear Fork has been found but once in the Wichita. **Secodontosaurus** is difficult to distinguish unless a good skull or jaw is found. As far as I am aware, the remaining four **(Acheloma, Parioxys, Araeoscelis** and **Bolosaurus)** are known from but two each of the great variety of collecting localities discovered in the Texas Wichita by a long series of workers over close to a century.

In sum, Texas Wichita and New Mexico faunas differ in part in the rarity or absence in the latter of many water-dwelling types; each has a few characteristic forms absent in the other area; both share a number of common and familiar genera, although it is probable that the species

[6] Many years ago I collected, in Texas, fragmentary remains of a long-snouted amphibian which I thought to be possibly related to Chenoprosopus. Better material, however, shows it to be a new genus of trimerorhachid.

are different; differences in the case of a number of rare types may be due to accidents of collecting. The general picture is one of two essentially contemporaneous faunas, evolving along similar lines but differing in a fashion to be expected of continental assemblages separated from one another by such a broad water barrier as is known to have been present in eastern New Mexico and western Texas in early Permian times.

AGE OF THE CUTLER-ABO VERTEBRATES

There is currently little evidence by which the age of the Cutler-Abo vertebrates can be determined through direct correlation with marine horizons. By indirection, however, they can be dated with reasonable accuracy, for Texas continental equivalents of the New Mexican faunas can be correlated with horizons in the established marine series of trans-Pecos Texas.

In the discussion above, it is assumed that it is the lower, Wichita, group of Texas formations, rather than the overlying Clear Fork group, with which the New Mexican fauna should be compared. Any worker familiar with the materials will agree without hestitation that this is the case. Typical of the Clear Fork is the prominent presence of a series of advanced forms totally absent from either the Wichita or the Abo-Cutler. These include, for example, the caseids Casea and the giant **Cotylorhynchus**; advanced captorhinomorphs such as **Labidosaurs** and **Labidosaurikos**; abundant armored dissorophids such as **Cacops** and **Dissorophus**. In addition **Ophiacodon**, common in the Wichita and in New Mexico, had become extinct. Further, the stage of evolutionary development of sphenacodonts and **Edaphosaurus** in the Clear Fork is well advanced over that of the New Mexican forms as well as (naturally) that seen in the Wichita.

But the age of the Arroyo de Agua faunas can be defined more precisely with a moderate degree of certainty. The Wichita of Texas, as originally defined by Cummins, included the sediments currently defined as composing the Pueblo, Moran, Putnam, Admiral and Belle Plains formations; to them later workers have generally added the Clyde formation. Invertebrate evidence indicates that the first three of these formations, and much, at least, of the fourth are equivalent in age to the Wolfcampian of western Texas.

It is with the Putnam formation that I believe the typical Cutler-Abo faunas can be best compared. I had reached this conclusion before the new data from the University of California collections had become available, but, as may be, seen from Langston's tabulation (1953, fig. 24, p. 411), these data tend only to reinforce my earlier conclusion. My major reasons have been based on a comparison of the evolutionary stage reached by the comparable common pelycosaurs of the two regions. In general there is a strong trend for increase in size of pelycosaurs of any given line during successive stages of the early Permian. (1) Of Texas **Ophiacodon** specimens, the one good skull from the Putnam measures 290 mm. in length; two skulls from the Belle Plains measure 458 and 485 mm.; of a still larger species from the Clyde, the skull is not adequately known, but from other skeletal elements may be estimated as having been on the order of 600 mm. in length. The one good skull from New Mexico is 311 mm. long — i. e., very close to the size of the Putnam form. (2) Again, in **Edaphosaurus**, there is a steady increase in size as we go up the sequences of Texas formations. A typical Admiral formation skull is estimated to be about 140 mm. long; the mean of two skulls from the lower Clear Fork (Arroyo formation) is 191 mm. No complete skull is known from the Putnam, but an incomplete specimen suggests a length on the order of 120 mm. — the same length as the single known New Mexico specimen. (3) The "main line" of **Dimetrodon** evolution in Texas runs through **D. milleri** of the Putnam, **D. limbatus** of the Admiral and Belle Plains and **D. grandis** of the Clear Fork. Skull lengths are as follows: **D. milleri**, 223 mm.; **D. limbatus**, mean of foux specimens 393 mm., **D. grandis**, 413-482 mm. The parallel form in the typical Arroyo de Agua localities is **Sphenacodon ferox**, of which the one described skull is 297 mm. long — i. e., intermediate in size between Putnam and Admiral-Belle Plains dimetrodons, but somewhat closer to the former.

Thus available evidence suggests comparison of the **typical** Abo-Cutler fauna with that of the Putnam formation. But it is very probable that further work may sort out the New Mexican beds into a series of successive faunal horizons. I have already pointed out that there is some slight indication that the El Cobre deposits are somewhat earlier than the typical beds of the Arroyo de Agua region. And I think that future study will demonstrate that there is a second horizon definitely above that of more typical deposits. In 1937 I described from Jemez Canyon **Sphenacodon ferocior**, of which the type skull measured 403 mm. in length — far larger than that of **S. ferox** or the Putnam **Dimetrodon** and comparable to the average **Dimetrodon** skulls from Admiral and Belle Plains. This form has been reported since from one other locality — the "Anderson Quarry" of the University of California (Langston 1953, p. 360). This is located in the Arroyo de Agua region (about ¾ mile south of the village) but appears to be stratigraphically much higher than the typical localities of the region — it is estimated by Langston to be at least 235 feet above the quarries east of Arroyo de Agua which contain the "typical" fauna. In this quarry were found, as well, remains of a "large Ophiacodon" — possibly of the dimensions of **O. retroversus** of the Admiral and Belle Plains of Texas? The estimate of 235 feet of stratigraphic difference between the typical Cutler fauna quarries and that of the Anderson quarry is on the same order of magnitude as the stratigraphic difference in Texas between the Archer City bonebed, whence much of the known Putnam fauna has been collected, and the Briar Creek-Godwin Creek localities containing the typical Admiral faunas. Very probably the **Sphenacodon ferocior** horizon will prove to be an Admiral equivalent.

To conclude: The typical Abo-Cutler fauna appears to be equivalent to that of the Putnam formation of Texas, which lies somewhat above the middle of the Wolfcamp; the higher faunal horizon containing **Sphenacodon ferocior** is not improbably to be compared with the Admiral-Belle Plains assemblage of Texas, which lies close to the Wolfcamp-Leonard boundary; the El Cobre deposits may be relatively early Wolfcampian, but the case is not proven.

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