LATE TRIASSIC VERTEBRATE LOCALITIES IN NEW MEXICO

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Abstract - Significant (and some world-class) Late Triassic vertebrate localities are present across the northern half of New Mexico. Localities reviewed here are Fort Wingate (McKinley County), Canjilon and Whitaker (Ghost Ranch) quarries (Rio Arriba County), Lamy amphibian quarry (Santa Fe County), Peacock and Sloan canyons (Union County), Bull Canyon (Guadalupe County), Mesa Redonda, Apache Canyon, Shark-Tooth Hill, Barranca Creek and Revuelto Creek (the last five in Quay County). Most of these localities are of early Norian age and represent some of the youngest Late Triassic vertebrates known from the Southwest.

INTRODUCTION

Although Upper Triassic strata were originally recognized in New Mexico by Marcou (1858), it was Cope (1875) who first reported Late Triassic vertebrate fossils from the state. Since Cope, many Late Triassic vertebrates have been collected from New Mexico. Indeed, some world-famous Late Triassic vertebrate localities are known in the state of New Mexico. Here, we review these and other scientifically significant Late Triassic vertebrate localities in New Mexico (Figs. 1, 2). The following institutional abbreviations are used: AMNH, American Museum of Natural History, New York; CM, Carnegie Museum of Natural History, Pittsburgh; CMNH, Cleveland Museum of Natural History, Cleveland; NMNH, National Museum of Natural History, Washington; NMMNH, New Mexico Museum of Natural History, Albuquerque; UCMP, University of California Museum of Paleontology, Berkeley; UMMP, University of Michigan Museum of Paleontology, Ann Arbor; UNM, University of New Mexico, Albuquerque; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D. C.; YPM, Yale Peabody Museum, New Haven.

FORT WINGATE

Geographic and Stratigraphic Context

Secs. 9 and 16 (unsurveyed), T14N, R16W, McKinley County, New Mexico; ownership Federal. The fossil vertebrate and plant localities here are in the lower part of the Petrified Forest Member of the Chinle Formation(Fig.3). We do not endorse Ash's (1978b) use of Monitor Butte Member in this area, nor do we believe his "Ciniza Lake Beds," based on a unit a couple of m thick that crops out over a few tens of acres should be recognized as a formal stratigraphic unit. Furthermore, Ash's

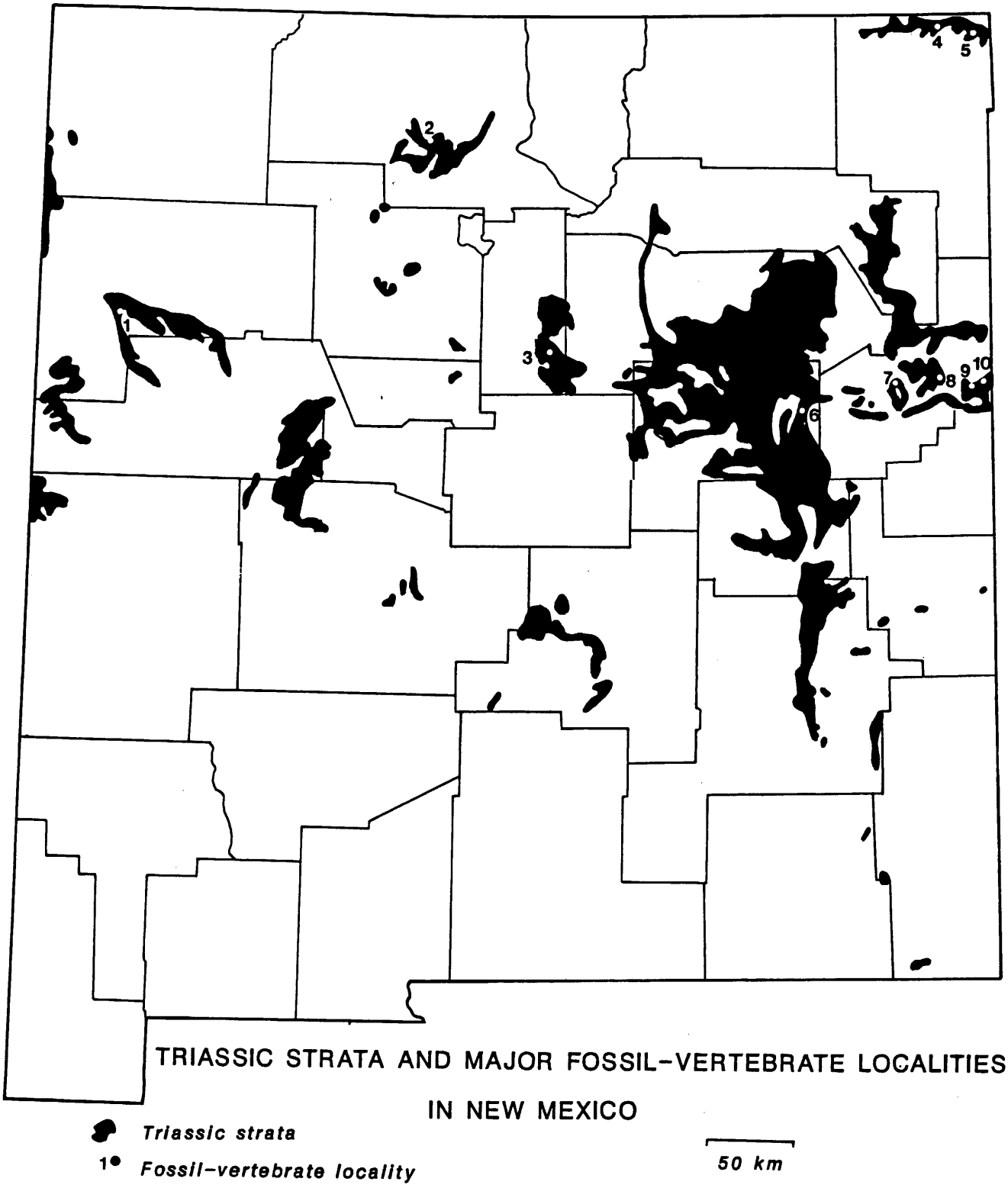

FIGURE 1. Triassic strata and major fossil-vertebrate localities in New Mexico. Localities are: 1. Fort Wingate, 2. Canjilon and Whitaker quarries, 3. Lamy amphibian quarry, 4. Peacock Canyon, 5. Sloan Canyon, 6. Bull Canyon, 7. Mesa Redonda, 8. Apache Canyon, 9. Barranca and Revuelto Creeks, 10. Shark-Tooth Hill.

	WESTERN NEW MEXICO	CENTRAL NEW MEXICO	EASTERN NEW MEXICO
EARLY NORIAN		Whitaker quarry	Mesa Redonda Apache Canyon Sloan Canyon Shark-tooth hill Peacock Canyon
		Canjilon quarry	Bull Canyon Revuelto Creek Barranca Creek
LATE CARNIAN	Fort Wingate	Lamy amphibian quarry	

FIGURE 2. Approximate temporal distribution of major Late Triassic fossil-vertebrate localities in New Mexico.

(1978b) claims for syndepositional slumping in the Chinle here cannot be upheld. The steeply dipping Chinle beds near Fort Wingate are the result of Laramide (Late Cretaceous-early Tertiary) tectonism and/or late Cenozoic slumping. No angular unconformity exists within the Chinle Formation at Fort Wingate.

Fauna and Age

Vertebrate taxa are Chinlea, cf. Metoposaurus, cf. Stagonolepis and unidentified phytosaur. An extensive megaflora as well as palynomorphs, conchostracans and coprolites from near Fort Wingate are described in Ash (1978a) and references cited therein.

The Chinlea material only consists of scales (Ash, 1978a). Amphibian fossils from Fort Wingate in the NMMNH and UCMP indicate an animal the size of Metoposaurus fraasi. Mehl et al. (1916) identified phytosaur specimens from Fort Wingate as Angistorhinus and Paleorhinus. However, we believe these specimens cannot be identified to the genus level.

The best preseved vertebrate specimen from Fort Wingate is the holotype partial skeleton of the aetosaur Acompsosaurus wingatensis Mehl, 1916. This specimen does not pertain to Typothorax as suggested by Gregory (1953) (cf. Long and Ballew, 1985). It is not the oldest Chinle aetosaur (contra Long and Ballew, 1985) simply because it is not in the Monitor Butte Member of the Chinle, and therefore not demonstrably older than other lower Petrified Forest Member aetosaurs. The type specimen

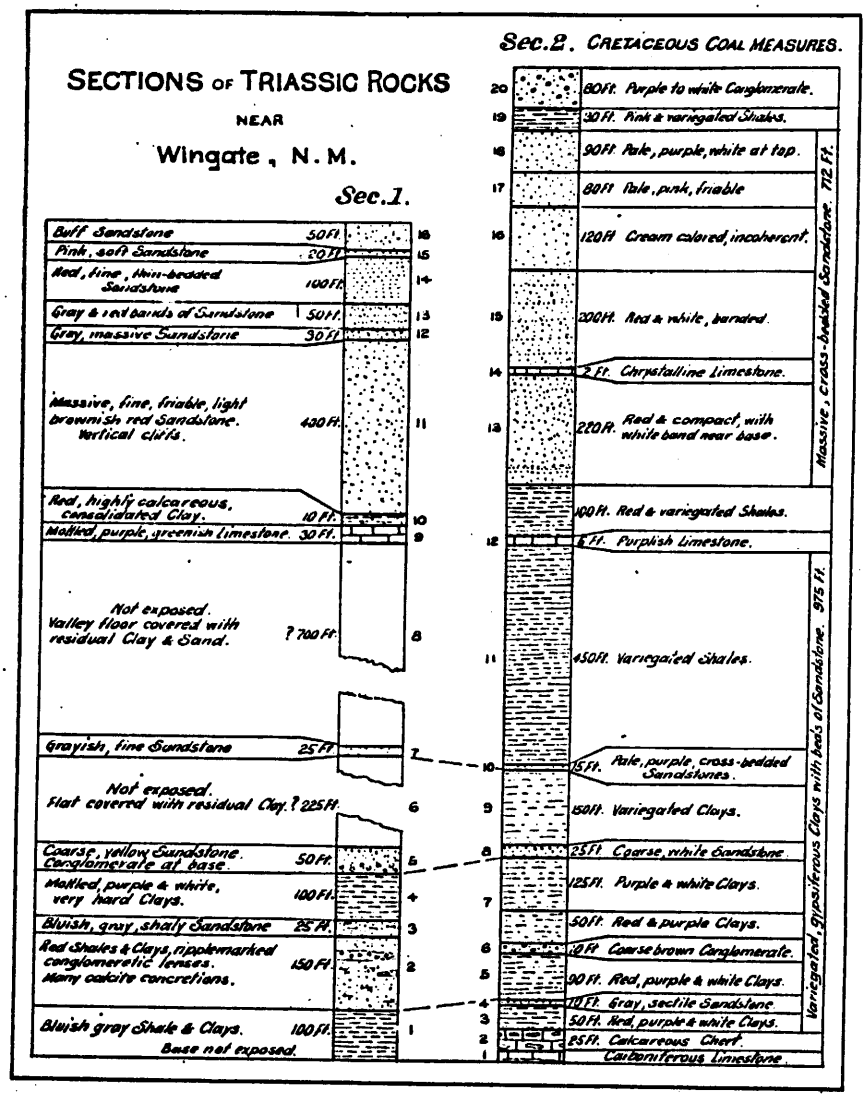

FIGURE 3. Mehl et al. (1916) stratigraphic sections at Fort Wingate. In section 1, units 11-16 are Entrada Sandstone; underlying units are Chinle; unit 5 is the Sonsela Sanstone.

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of Acompsosaurus is now lost, so it must be evaluated from published illustrations. The pelvis differs from that of Desmatosuchus in having a shorter, broader pubis and an ischium that apparently lacks a vertical supra-acetabular ridge. Instead, the pelvis of Acompsosaurus closely resembles that of Stagonolepis robertsoni (Walker, 1961, fig. 16). Therefore, we tentatively believe Acompsosaurus wingatensis is a probable species of Stagonolepis.

The probable presence of Metoposaurus and Stagonolepis and stratigraphic position (lower Petrified Forest Member) suggest a Carnian age for the Fort Wingate localities.

Sedimentology and Taphonomy

The Ciniza pond deposit is an unusual (for the Chinle)

sequence of laminated carbonaceous mudstone among typical Chinle red-bed lithologies (Ash, 1978b). These strata have been interpreted as representing a small, tropical, oligomictic lake which was chemically stratified, soft and slightly alkaline with no strong currents (Ash et al., 1978). Bottom waters were stagnant, and the pond floor was composed of organic-rich mud (Ash et al., 1978).

Surrounding beds are of fluvial origin. Mehl et al. (1916) noted that bone fragments are uncommon in mudstones near Fort Wingate. It is not clear what lithology produced the Acompsosaurus type, other than it was in a "red shale" sequence (Mehl et al., 1916). Camp noted bone fragments in fluvial strata and concretions, with the best specimens coming from red-weathering, dark blue strata. The interclavicle at NMMNH came from a massive red mudstone.

History of Collection

In 1914, M. G. Mehl, assisted by G. M. Schwartz, collected vertebrate fossils in Arizona and New Mexico (Mehl et al., 1916). Some of the fossils they collected, including the holotype of Acompsosaurus wingatensis, apparently are lost. All that remains are two specimens in the Field Museum of Natural History, FMNH UC 1252, a phytosaur ilium illustrated by Mehl et al. (1916, plate 2) and FMNH PR 1694, a poorly preserved phytosaur femur.

C. L. Camp collected from near Fort Wingate in 1924. He arrived there on 19 May and was allowed to use a small house by the commander of the fort, Captain Lewis. Camp, in his unpublished field notes for 1924 (UCMP archives) noted that "the best Triassic bad-land exposures east of Gallup surround the Fort....and prospects seem favorable for finding bones." However, he was severely disappointed, noting in his field notes the very next day that the strata here were "almost non-fossiliferous." However, on 21 May he did find several phytosaur vertebrae and part of an ilium near the McGaffey mill. The next day he left Fort Wingate for Thoreau, where he found some phytosaur fossils (Camp, 1930, map A).

From the early 1960's until the present S. Ash has collected fossil plants in the Wingate area (see Ash, 1989 for a bibliography of published work on these plants). He and others also collected and studied conchostracans, coprolites, fish scales and palynomorphs from "Lake Ciniza" (Ash, 1978a). In 1987, Hunt and Kietzke collected a fragmentary metoposaurid interclavicle, plants and microfossils for NMMNH. In 1988, Lucas and others also collected similar material for NMMNH.

CANJILON QUARRY

Geographic and Stratigraphic Context

NE1/4 SW1/4 SW1/4, sec. 3, T24N, R4E, Rio Arriba County, New Mexico (Fig. 1); ownership private. The Chinle Formation in the Ghost Ranch area (Fig. 4) consists of (in ascending order) the

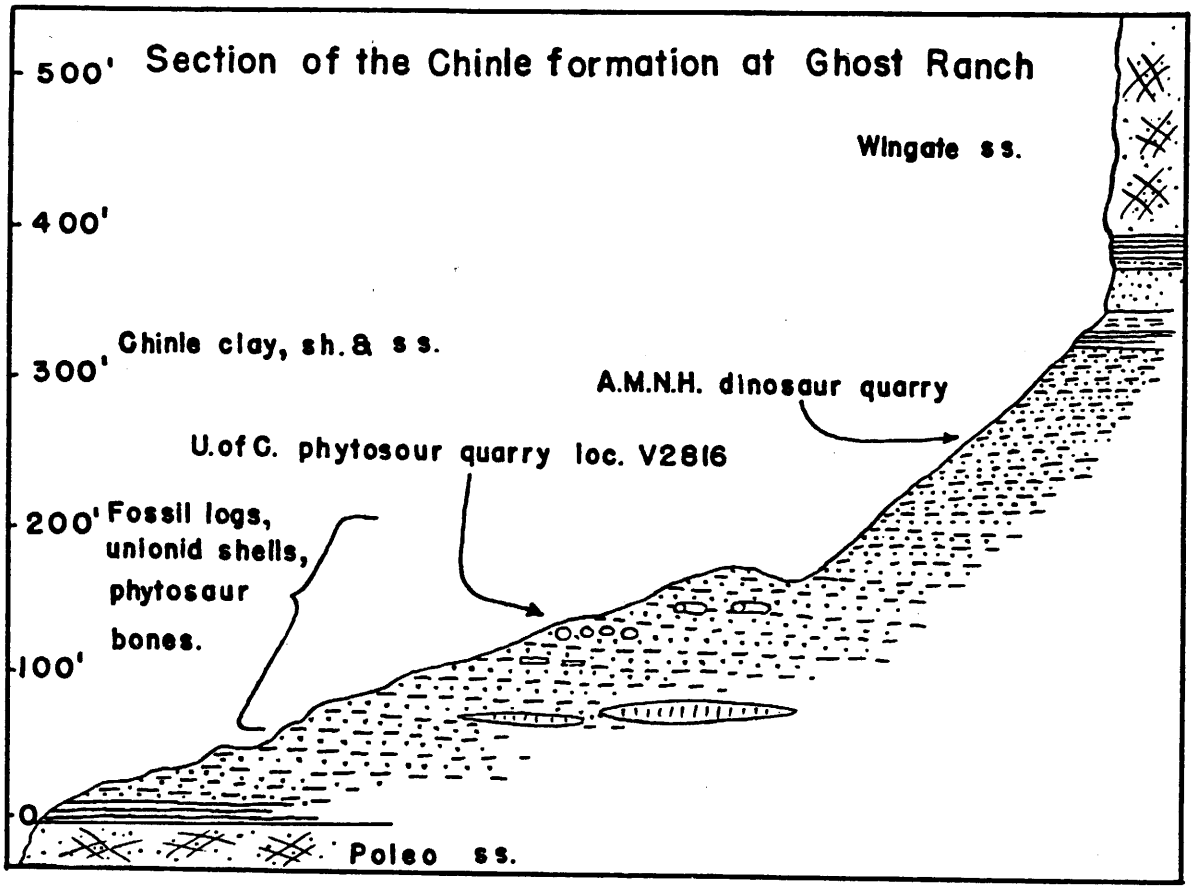

FIGURE 4. Stratigraphic section at Ghost Ranch (from Colbert, 1950) showing the Canjilon quarry ("U. of C. phytosaur quarry loc. V2816") and the Whitaker quarry ("AMNH dinosaur quarry"). Note that the unit identified as Wingate Sandstone actually is Entrada Sandstone.

Agua Zarca Sandstone Member, Salitral Shale Tongue, Poleo Sandstone Lentil, Petrified Forest Member and the siltstone member (Dubiel, in press). The Canjilon quarry is in the Petrified Forest Member (contra Litwin, 1986), 65.5 m below the Entrada Sandstone (Litwin, 1986).

Fauna and Age

The Canjilon quarry has produced abundant phytosaur material and the aetosaur Typothorax coccinarum. NMMNH has a collection from the Petrified Forest Member in the Ghost Ranch area that includes additional phytosaur specimens, Typothorax scutes, fragments of a new, small metoposaurid (see Apache Canyon below) and a partial skeleton of Coelophysis bauri. The nearby Whitaker (Coelophysis) quarry is in the siltstone member. Colbert (1974) lists Ceratodus (=Arganodus), Metoposaurus, Typothorax, "Rutiodon" and Coelophysis from the Chinle Petrified Forest Member in northern New Mexico. The phytosaur skulls from the Canjilon quarry were attributed to Rutiodon tenuis by Lawler (1976).

The phytosaur specimens from the Canjilon quarry are

important in that they represent the only reasonably size quarry sample of phytosaurs known anywhere in the world. Ballew (1986, 1989) assigned these phytosaurs to two species, Pseudopalatus (=Nicrosaurus of Murry and Long, 1989) pristinus and P. buceros. She argued that these taxa inhabited different ecological niches as indicated by their dental morphology.

Litwin (1986) collected pollen from just above the Canjilon quarry which he considered of early Norian age. The presence of a Pseudopalatus/Nicrosaurus-grade phytosaur and Typothorax suggests correlation with the upper part of the Petrified Forest Member in Petrified Forest National Park and the Bull Canyon Formation in east-central New Mexico, both of which are considered to be of Norian age.

Sedimentology and Taphonomy

The Petrified Forest Member of the Chinle Formation in the eastern San Juan Basin represents the deposits of high-sinuosity river channels (Dubiel, in press). Associated floodplain areas apparently developed thick paleosols which suggests seasonal precipitation (Dubiel, in press).

The Canjilon quarry produced a nearly complete phytosaur skeleton, three incomplete skeletons and a total of 10 skulls and numerous postcrania (Lawler, 1976). Typothorax is represented by three articulated, incomplete skeletons (Long and Ballew, 1985). However, the articulated skeletons are scattered over a broad area and mixed with diarticulated specimens (Long et al., 1989, fig. 1). Unpublished field notes of C. L. Camp and S. P. Welles indicate that the quarry matrix was reddish mudstone with calcareous nodules scattered through it, particularly at the base of the bone-producing interval (Lawler, 1976).

Although no explicit taphonomic analysis has been undertaken of the Canjilon quarry, it appears to represent a hydrodynamically sorted and/or scavenged assemblage. Lawler (1976) indicates that the field notes of the quarry workers suggest the depositional environment could have been a stream channel or pond. The former seems unlikely, given the fine-grained quarry matrix and the broad area encompassed by the quarry (Long et al., 1989, fig. 1).

History of Collection

The Canjilon quarry was excavated during 1928, 1930 and 1933 by Charles L. Camp with the assistance of R. Arriss, H. Anderson, G. Barrington and S. P. Welles (Lawler, 1976). All of the fossils excavated are in the UCMP. The collection was prepared and partially curated by WPA personnel during the 1930's, and Lawler further curated the material during the early 1970's. In the late 1930's, Harvard University collected two incomplete skeletons of Typothorax from the Canjilon quarry (Long and Ballew, 1985). This materal has not been fully prepared.

WHITAKER (GHOST RANCH) QUARRY

Geographic and Stratigraphic Context

SE 1/4 SE1/4 SW1/4, sec. 1, T24N, R4E, Rio Arriba County, New Mexico; ownership private. The Whitaker quarry is in the siltstone member of the Chinle Formation 14 m below its top (Schwartz and Gillette, 1986).

Fauna and Age

The following vertebrate taxa are known from the Whitaker quarry: aff. Sinorichthys, Chinlea sorenseni, Coelophysis bauri, Nicrosaurus/Pseudopalatus-grade phytosaur, Postosuchus kirkpatricki and several new taxa of "thecodonts."

The most spectacular elements of the quarry fauna are the articulated skeletons of Coelophysis bauri (Colbert, 1947, 1964). The taxonomic status of this dinosaur, which incidentally is New Mexico's official state fossil, was discussed at length by Padian (1986), who points out two problems. First, C. bauri was named by Cope for "the rather undistinguished remains of a primitive theropod" (Padian, 1986, p. 58). Ongoing studies by Colbert must evaluate whether the excellent quarry material represents the same taxon as the holotype. Second, C. bauri has no synapomorphies and thus is a metataxon.

Coelophysis is known only from the upper part of the Petrified Forest Member of the Chinle Formation in Arizona and the Whitaker quarry (Padian, 1986), with the possible exception of specimens collected by Case in northern New Mexico (Williston and Case, 1912). The phytosaur taxon from the Whitaker quarry also occurs in the upper Petrified Forest Member, which is of Norian age (Ash et al., 1986; Litwin, 1986). Litwin (1986) obtained palynofloral samples from above and below the Whitaker quarry that he considered of early Norian age.

Sedimentology and Taphonomy

The siltstone member was deposited in the Ghost Ranch area on lacustrine and playa mudflats (Dubiel, in press). Abundant "lungfish" burrows and many smaller burrows and other bioturbation suggest periodic fluctuation in the level of standing water and corresponding transgressions and regressions of the lakeshore (Dubiel in press).

The quarry itself is in a sequence of 11 siltstone beds, many of which are discontinuous (Schwartz and Gillette, 1986). These beds are intensively bioturbated, contain many silt rip-up clasts and have been interpreted by Schwartz and Gillette (1986) to represent a pond or shallow channel facies in a depositional low.

Coelophysis specimens abound in the lower part of the quarry and become increasingly uncommon upward through the sequence. They represent all ontogenetic stages from hatchlings to adults (Colbert, 1974). Some of the adults contain, within their rib cages, partial skeletons of juveniles, apparently indicative of

cannibalism, not viviparity (Colbert, 1974). Skeletons are articulated or semi-articulated and show a range of completeness. Some skeletons display arched vertebral columns indicating dessication and contraction of ligaments. Presumably a large group of Coelophysis individuals were killed, carcasses dessicated and a flood washed them into a depositional low (Schwartz and Gillette, 1986).

History of Collection

In 1874, E. D. Cope passed through the Ghost Ranch area on a journey from Santa Fe to Tierra Amarilla and collected fossil vertebrates near Gallina in Rio Arriba County. In 1881, David Baldwin, working for Cope, prospected Chinle outcrops around Capulin Mesa and at Ghost Ranch (Colbert, 1874). He discovered several bones that became the type specimen of C. bauri (see Padian, 1986). S. W. Williston and Paul Miller of the University of Chicago, E. C. Case of the University of Michigan and F. von Huene of Tubingen University explored the Ghost Ranch area in 1911, although their main collecting focus was on the older, Permian strata in the region (Colbert, 1974). Case found bones of Coelophysis just north of Cerro Blanco near Gallina. This locality was described as "less than one hundred feet above the basal Upper Trias sandstones" (Williston and Case, 1912, p. 11) and was thought to be the type locality of Coelophysis.

In June 1947, E. H. Colbert and G. G. Simpson lead an AMNH expedition to northern New Mexico. Colbert, assisted by George Whitaker and T. Ierardi, explored the Chinle Formation in the Ghost Ranch area (Whitaker and Myers, 1965). Colbert went to Ghost Ranch for two reasons. First, he wanted to find more specimens of Coelophysis which Cope (1887a, b, 1889) had described from fragmentary material. Indeed, he had examined the best locality data available, one of the labels with the Coelophysis specimens in Baldwin's handwriting. It read:

> Label Sack 2 Box 1 Prof. E. D. Cope. Contains Triassic or Jurassic bones all small and tender. Those marked little bones are many of them almost microscopic. All in this sack found in same place about four hundred feet below gypsum stratum 'Arroyo Seco' Rio Arriba Co., New Mexico. February 1881. No feet-no head- only one tooth. D. Baldwin - Abiquiu (Colbert, 1964, p. 3).

Second, Camp had decided to stop collecting Late Triassic vertebrates in New Mexico and had sent Colbert his locality data, including that concerning the Canjilon quarry at Ghost Ranch (Whitaker, 1965).

On 16 June 1947, George Whitaker found what was to become the Whitaker quarry. Colbert quickly recognized its significance, and contacted AMNH. Carl Sorensen came from New York to New Mexico to assist with the excavation. During 1947 and 1948, AMNH excavated the quarry with much help from Arthur Pack, the owner of Ghost Ranch at the time. Specimens from this excavation were collected in large blocks. Most went to AMNH, but others were dispersed to several institutions, including YPM, UNM and CMNH.

The Whitaker quarry was closed by AMNH in and reopened by CM

under the direction of David Berman in the mid-1980's. Blocks from the most recent excavation are at CM, NMMNH, NMNH and MNA. The quarry is currently dormant.

LAMY AMPHIBIAN QUARRY

Geographic and Stratigraphic Context

SW1/4 SW1/4 NE1/4 NE1/4, sec. 29, T12N, R11E, Santa Fe County, New Mexico; ownership private (Fig. 1). The Upper Triassic stratigraphic section in the Lamy area closely resembles that of the Tucumcari basin in east-central New Mexico (Allen and Lucas, 1988), comprising (in ascending order) the Tecolotito, Los Esteros and Tres Lagunas members of the Santa Rosa Formation, the Garita Creek Formation, the Trujillo Formation, the Bull Canyon Formation and the Redonda Formation. The quarry is within the Garita Creek Formation.

Fauna and Age

Vertebrate taxa from the quarry are Metoposaurus fraasi and unidentified phytosaur. Other material from the Garita Creek Formation in the Lamy area includes "cones" (Ratkevich and La Fon, 1978), phytosaurids and "Chatterjeea" sp.

The metoposaurs from the quarry were initially assigned to Buettneria perfecta (Romer, 1939). Subsequently they have been considered Eupelor fraasi fraasi (Colbert and Imbrie, 1956) and Metoposaurus fraasi fraasi (Roy Chowdhury, 1965). Measurements of metoposaur skulls suggested a growth series of one taxon (Colbert and Imbrie, 1956) or possibly a bimodal distribution of two taxa (Gregory, 1980). Metoposaurs in the Harvard collection tend to have larger tabular horns than those in the USNM collection because they have been reconstructed. Most skulls from the quarry have damaged posterior margins. "Chatterjeea" is represented by a proximal femoral fragment.

The underlying Los Esteros Member of the Santa Rosa Formation yields a fauna including Calyptosuchus and Desmatosuchus, indicating an age equivalent to the lower Petrified Forest Member (LPFM) of the Chinle Formation in northeastern Arizona and the "middle Dockum" (Sierrita de la Cruz, Crosby County) of Texas (Hunt and Lucas, 1988a, b). The presence of abundant amphibian skulls at the Lamy quarry also suggests a correlation with the lower part of the Chinle Petrified Forest Member (Long and Padian, 1986).

Sedimentology and Taphonomy

Romer(1939, p.339) considered that the amphibian quarry represented "the last scene in the drama of drought - a shrinking residual pool." This view has been followed by later workers (e.g., Gregory, 1980). However, the disarticulated and mixed nature of the skeletons, the alignment of many elements and the absence of small skeletal elements indicate that this is a hydrodynamic accumulation (Voorhies, 1969).

History of Collection

Mr. and Mrs. R.V. Witter discovered the amphibian quarry while prospecting for Harvard University in 1936. The site was excavated by R. V. Witter and T.E. White in 1938 for Harvard and by D.H. Dunkle, F. Pearce and G. Sternberg for USNM in 1947 (Romer, 1939; Gregory, 1972). Both Harvard and USNM collected large slabs for display purposes.

BULL CANYON

Geographic and Stratigraphic Context

Secs. 20-21, 27-29 and 32-33, T9N, R26E and sec. 10, T9N, R26E, Guadalupe County, New Mexico; ownership private. Fossil localities in Bull Canyon occur throughout the Bull Canyon Formation, at its type section (Lucas and Hunt, 1989) and further south. Two particularly productive intervals can be delimited about 25 m and about 70 m below the base of the Redonda Formation (Fig. 5).

Fauna and Age

Fossil vertebrates are unidentified osteichthyans, new small metoposaurid, "Machaeroprosopus andersoni" and other Nicrosaurus/Pseudopalatus-grade phytosaurs, Typothorax, Paratypothorax, rauisuchid, sphenosuchian, theropod, fabrosaur?, Revueltosaurus callenderi and Pseudotriconodon chatterjeei, and a ?"prosauropod". Invertebrates are Unio arizonensis, Unio (six spp.), Antediplodon dockumensis, Antediplodon sp. and Triasamnicola pilsbryi. Plants are Sanmiguelia and Neocalamites.

One of us (APH) examined the holotype of Machaeroprosopus andersoni (Mehl, 1922) and found it to be in very poor condition. It has been reconstructed extensively, lacks most diagnostic elements and can only be assigned tentatively to the Nicrosaurus/Pseudopalatus-grade phytosaurs.

In 1983, a UNM field party collected a phytosaur skull (Fig. 6) about 70 m below the Redonda Formation (Fig. 5). This skull is currently on display at the UNM Geology Museum. It has external nares above the level of the skull roof, wide postorbital-squamosal bars and elongate posterior squamosal processes. Based on these features, this skull is what Murry and Long (1989) call Nicrosaurus and what Ballew (1989) terms Pseudopalatus. The UNM skull closely resembles Pseudopalatus buceros of Ballew (1989) but lacks the apomorphous rostrum with a v-shaped cross section.

Paratypothorax occurs at the same stratigraphic level as this phytosaur skull as do many unionids (Kues, 1985; Lucas et al., 1985b). The dromatheriid Pseudotriconodon chatterjeei (Lucas and Oakes, 1988) was found at a higher level (Fig. 5). Parrish's (1989) assertions that this was published as an ictidosaur and actually is a fish are demonstrably incorrect (cf. Lucas and Oakes, 1988).

The presence of Typothorax, Nicrosaurus/Pseudopalatus-grade

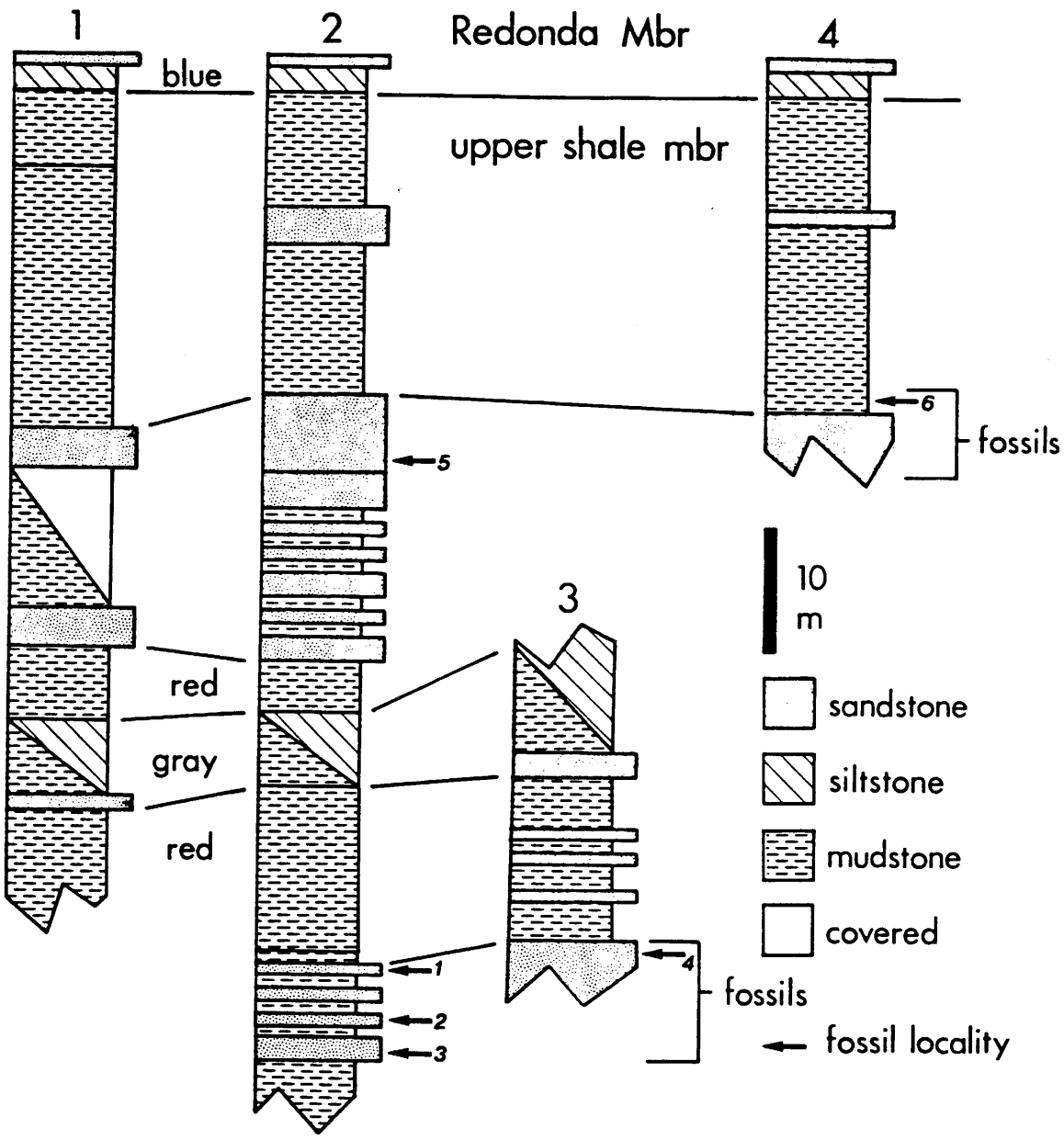

FIGURE 5. Stratigraphic distribution of fossils in the Bull Canyon Formation ("upper shale mbr" of figure) in Bull Canyon (from Lucas et al., 1985b). Localities are: Pseudopalatus buceros (Fig. 6); 2, 3, 4, Unio, Typothorax and other vertebrates; 5, phytosaurs; 6, type locality of Pseudotriconodon chatterjeei. phytosaurs and Pseudotriconodon indicate a Norian age for strata of the Bull Canyon Formation at and around its type section.

Sedimentology and Taphonomy

The Bull Canyon Formation at Bull Canyon is of fluvial origin. Fossil bone is concentrated in channel sandstone and