UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

VERTEBRATE FOSSIL ASSOCIATIONS AND TAPHONOMY IN THE MORRISON FORMATION (UPPER JURASSIC) CIMARRON COUNTY, OKLAHOMA

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTERS OF SCIENCE

BY

CARISA N. BOMBERGER
Norman, Oklahoma
2007

VERTEBRATE FOSSIL ASSOCIATIONS AND TAPHONOMY IN THE MORRISON FORMATION (UPPER JURASSIC) CIMARRON COUNTY, OKLAHOMA

A THESIS APPROVED FOR THE
CONOCOPHILLIPS SCHOOL OF GEOLOGY AND GEOPHYSICS

BY

[redacted]

Richard L. Cifelli, Ph.D., Co chair

[redacted]

Stephen R. Westrop, Ph.D., Co chair

[redacted]

Nicholas J. Czaplewski, Ph.D.

ACKNOWLEDGMENTS

I would like to thank Dr. Richard Cifelli for providing the idea for this project and his professional guidance throughout the entire process. I also thank the other members of my thesis committee for their guidance and constructive criticism as I developed and wrote this thesis.

My thanks go out to other members of the Vertebrate Paleontology Department at the OMNH especially to our Collection Manager Jeff Person and Preparator Kyle Davies. Jeff Person's help with finding individual specimens and guidance using the database to give me lists of all specimens from my quarries along with field numbers was very valuable and time saving. Kyle Davies gave up numerous hours of his time to help me with identification, verifying many elements or identifying specimens to a finer level of classification than they had previously been assigned. His help was invaluable. Without him I would still be working on identifying the first few specimens I was examining. He also let me borrow numerous items from his extensive library of dinosaur publications.

I also express my gratitude to Dr. Gary Schnell who allowed me to utilize his digitizing software for over a semester. He was always available to answer questions about the program. The IT technicians of the museum also deserve my thanks for helping to resolve problems with the digitizer board and mouse when they were malfunctioning.

I thank John Guest, an undergraduate student who gave up part of his spring break in 2007 to be my field assistant as I visited Cimarron County and the dinosaur quarries. I also thank the people of Cimarron County in the area around Kenton, Oklahoma, for allowing me to examine a few of the quarries (Quarry 5 and Quarry 6) on their private land during that visit in 2007.

I thank the Graduate College of the University of Oklahoma and the ConocoPhillips School of Geology and Geophysics for always being available to answer questions about my classes and thesis procedures. Especially helpful with answering any questions and resolving any problems I had was the school of geology's coordinator for student services, Donna Mullins. I thank the director of our school, Dr. Elmore, for finding me funding with a Teaching Assistantship when I had been told there was none. Without this funding I probably would not have been financially able to finish this degree.

I deeply appreciate the continued love and support of my parents and extended family as I have worked through the years to pursue my dreams of becoming a paleontologist and my love of geology and dinosaurs. I could never have gotten this far in accomplishing my dreams without my parents behind me encouraging me and telling me to always go for my dreams. For the times I wanted to give up or I was not sure anymore, thanks for always being there to listen and for never trying to talk me out of a career that you probably never would have chosen for me. I can never thank you enough.

ABSTRACT

The purpose of this project is to evaluate fossil distribution within three dinosaur quarries in the Morrison Formation, excavated in the 1940s, in the panhandle of Oklahoma. The sedimentology and stratigraphy of the Morrison of Cimarron County, Oklahoma, is similar to the Brushy Basin Member in the Morrison Formation of Colorado, with the varicolored jointed clays that are common within this member.

By examining the digitized versions of the original quarry maps for each of quarries 5, 6, and 8, an attempt was made to associate skeletal elements as belonging to a single individual based on their proximity to other bones of the same taxon and the skeletal elements represented. Comparisons were also made between the faunas, amount of articulated bones, and fossil preservation patterns of the three quarries.

It was possible to associate different skeletal parts as belonging to single individuals in each of the three quarries studied. The distribution of fossils within each of the quarries was in clumps, though in some quarries it was more scattered than others. The ability to associate different bones on the quarry maps led to a reevaluation of numerous fossils. These specimens were identified to a finer taxonomic level based on both their proximity to other fossils in the quarry and on a reexamination of the specimens themselves. Patterns seen on the maps affected the ease with which fossil associations could be made. These patterns are caused by the depositional environments of each quarry. These depositional environments are floodplain deposits (Quarry 5 and 6) and a pond environment (Quarry 8).

TABLE OF CONTENTS

APPENDIXES

SUPPLEMENTAL MATERIAL

CD ROM containing PDF files of the digitized quarries maps for 5, 6, and 8:

-Quarry maps showing all the bones

-Quarry maps only showing the identified bones

-Revised Quarry maps showing all the bones with
changes made to reflect the reidentified bones.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

The Upper Jurassic Morrison Formation is an extensive unit, spread over more than 1.5 million kilometers of the Western United States (Currie and Padian 1997). The Morrison extends from central New Mexico to Montana, with equivalent strata present in southwestern Canada (Turner and Peterson 2004; Figure 1). The southeastern most surface exposure lies in the westernmost portion of the Oklahoma panhandle, in Cimarron County. This is the only area in Oklahoma with outcrops of the Morrison Formation (Stovall 1932).

The Morrison Formation is known for its "variegated colors" and the "uniformly variable" nature of its secession of beds (Mook 1915). This unit contains numerous dinosaur fossils and is known in particular for its large sauropods. More than 40 different species of dinosaurs have been described from this formation (Weishampel et al. 2004), which is one of the most dinosaur-rich units in North America. It also contains many other vertebrate and invertebrate fossils, but plant fossils are less common (Osborn, 1915).

The purpose of this project is to evaluate fossil distribution within three dinosaur quarries in the Morrison of Oklahoma. Specifically, the study employs taxonomic identification, element type and side of body, and bone size in assessing possible association of skeletal parts belonging to single individuals. In a broad taphonomic context, I wished to examine the distribution of fossils in the quarries to determine if associations between skeletal elements could be identified. Because I looked at more than one quarry I also wanted to compare the faunas and the amount of articulated material found in each quarry.

History of the Morrison Formation

The Morrison Formation was named by Cross (1894) and later described by Eldridge in 1896 in Emmons et al. Over the years it has been called: "*Atlantosaurus* Beds", "Jurassic Beds", "Dakota Beds", "Variegated Beds", "Beulah Shales", "Como Beds", "La Plata Sandstone", and "McElmo Formation" as well as by many other names (Stovall 1943). In some places the name "Morrison Formation" was applied to units that included more or less strata than the present accepted definition of the Morrison Formation. Stovall (1943) wrote that Gould (1905) included the Morrison within the Dakota Formation, and Lee (1902) included the Cheyenne sandstone and the Kiowa shale (Purgatoire Formation) with the Morrison Formation of Oklahoma.

In August 1859, the first recorded vertebrate fossils from what is now attributed to the Morrison Formation were collected by John Newberry near Moab, Utah as part of an expedition lead by US Army Captain John Macomb (Barnes 1988, Gillette 1996a, 1996b). Barnes (1988) spent 12 years researching the expedition and thanks to detailed notes by Newberry, relocated the quarry. Based on the stratigraphic level of the quarry, these sauropod bones were collected from the Tidwell Member of what would later become the Morrison Formation (Barnes 1988, Gillette 1996a, 1996b), and because of Barnes' research a preliminary dig was carried out at the site in 1989 in which more of the skeleton was located. This new material has not yet been collected due to the complicated logistics of working the site (Gillette 1996a, 1996b). Named *Dystrophaeus viaemalae* Cope, 1877, this specimen is the oldest body fossil of a sauropod known from the United States, and perhaps North America (Foster et al. 2000).

The type section for the Morrison Formation is at Dinosaur Ridge near Morrison, Colorado (Stokes 1944). The original description by Eldridge contains no detailed stratigraphic section, but the upper and lower limits he chose are adequately defined in the type description (Stokes 1944). Eldridge's description of the Morrison (in Emmons et al. 1896, p. 60-62) is as follows:

> "It is a formation of fresh-water marls of an average thickness of about 200 feet. Its upper limit is sharply defined by the Dakota sandstone, while the brown and pink sandstone closing the Triassic as clearly marks its lower limit. To this formation has been assigned the name "Morrison" from the town near which it is typically developed."
>
> "The marls are green, drab, or gray, and carry in the lower two-thirds numerous lenticular bodies of limestone of a characteristic drab color and a texture compact and even throughout…The clays of the lower two-thirds of the Jura are remarkable for their reptilian remains, and from the predominating form have been designated 'Atlantosaurus Clay'."

The prevalence of dinosaur fossils in the Morrison Formations has led it to be one of the most widely studied formations in the United States. This formation figured prominently in the so called "Bone Wars" between Edward D. Cope and Othniel C. Marsh (Currie and Padian 1997). Numerous studies, reports, and books have been written on the geology and paleontology of the unit, the most recent of which is by Foster (2007) on the dinosaurs and paleoenvironment of the Morrison Formation.

Geology of the Morrison Formation

Typical exposures of the Morrison Formation generally include red, purple, gray, and green mudstone with layers of tan-brown sandstone (Foster 2003) forming benches in weathered topography (Figure 2). Limestone, dolomite, and gypsum beds can also be found in the Morrison Formation as can bentonitic clay (altered ash) beds, pure ash layers, and chert concretions (Foster 2007). Most of the color variation found in the mudstones comes from various paleosols (Demko et al. 2004) and varying amounts of iron within the layers (Stovall 1943).

Most of the sandstones have been described as representing meandering channel sands (with a western source [Currie 1998]), but braided channel deposits have also been described. The meandering stream sandstones are commonly thick and are characterized by festoon (trough) crossbedding. Many of the sandstones also include layers of pebble conglomerates. Other sandstones are thin and are laterally restricted (Derr 1974, Tyler and Ethridge 1983, Foster 2007). There are also fine-grained quartz sandstones with large, meter-scale crossbeds that are interpreted as eolian dunes (Peterson 1988, Peterson 1994).

Members of the Morrison Formation

The vastness of the Morrison Formation results in variations in appearance and characteristics from area to area. In some areas, including the majority of the Colorado Plateau, it is over 300 m (990 ft) thick and in others, such as the northernmost areas, it can be less than 30 m (98 ft) thick (Foster 1998). The various colors of mudstones that characterize the Morrison occur everywhere, but in different stratigraphic orders and in different thicknesses. Members have been assigned to the Morrison Formation on the basis of these differences (Foster 2007). The members are not the same in all areas; for present purposes, only the most common subdivisions of the Morrison Formation deserve mention. In ascending order, these are the Tidwell, Salt Wash, and Brushy Basin members (Peterson and Turner-Peterson 1987). In some regions, including the field area for this project, the Morrison has not been divided into members. In Cimarron County this is normally attributed to a lack of horizontally continuous beds within the Morrison Formation (Stovall 1943).

Tidwell Member

The Tidwell Member contains red and gray mudstone, gray and light brown sandstone, gray limestone, and gypsum. Fossils are uncommon in the Tidwell, but include trackways of pterosaurs and sauropods as well as a few body fossils (Foster, 1998). The first sauropod found in North America (*Dystrophaeus*) was from the Tidwell (Gillette 1996a).

The Tidwell is normally eight to 23 m (25 to 75 ft) thick, but can be much thicker (up to 82 m [269 ft]) where it filled paleovalleys (Foster 1998). The depositional environments represented by the Tidwall Member are varied. They include: lakes, mudflats, eolian dunes, and narrow fluvial channels (Peterson and Turner-Peterson 1987). The lower contact of the Tidwall is normally marked by a zone of chert concretions, chert pebbles, or a gypsum bed. Often this contact is an angular unconformity with the underlying formation. The upper contact with the Salt Wash Member is gradational, but is normally placed at the lowest laterally continuous tan sandstone (marking the lowest unit in the Salt Wash Member) (Peterson and Turner-Peterson 1987, Foster 2007).

Salt Wash Member

The Salt Wash Member consists of a series of irregularly alternating mudstones and sandstones. The mudstones are mostly red, but some are gray and green (Stokes 1944). They are somewhat bentonitic and are similar to those found higher up in the Morrison (Foster 2007). The sandstones, some of which contain small to medium scale trough crossbeds, are generally gray or tan with occasional yellow, white, or brown lenses (Foster 1998). The Salt Wash Member is generally interpreted as a fluvial environment with braided and meandering streams moving east across the Morrison Formation floodplain (Tyler and Ethridge 1983). Individual beds range from 0.6 to three meters (2 to 10 ft) in thickness and can be up to 3.2 km (2 miles) in length (Stokes 1944). The Salt Wash is thickest in the southwestern area of Morrison outcrops, where it ranges to 122 m (400 ft) thick; it thins to about 30 m (98 ft) toward the north and northeast (Stokes 1944, Foster 2007).

Dinosaur bones and footprints are common within the Salt Wash Member, especially the large limb bones of sauropods (Foster 1998). The Salt Wash also contains petrified wood and was mined for uranium and vanadium from the 1950s to 1970s (Carter and Gualtieri 1965, Foster 2007). This member grades upward into the Brushy Basin Member, which generally consists of finer grained rocks (Stokes 1944). The Salt Wash is also distinguishable from the Brushy Basin in most areas in that it has a higher percentage of sandstone (Foster 2007).

Brushy Basin Member

The Brushy Basin Member, sometimes called Brushy Basin shale, is the most fossiliferous member of the Morrison Formation. This is the member that most of the dinosaur skeletons and petrified wood have been found in (Foster 1998). It can be up to 165 m (540 ft) thick, though in most areas of the Colorado Plateau it is approximately 91 m (300 ft) thick (Foster 2007).

The Brushy Basin Member is commonly taken as synonymous with Morrison Formation. Terms like "variegated shale" and "jointed clays" that are used to describe the Morrison are best applied to this unit. Limestones are generally thin and lenticular and have been interpreted to represent small lakes in the Morrison floodplain. On fresh surfaces these limestones are blue or gray, but they weather to a deep yellow (Foster 2007). The sandstones (medium to coarse-grained) and shales (bentonitic clays) are varicolored; red, pink, purple, gray, green, white, and brown are present in almost any exposure (Foster 1998). Color bands within these layers are normally less than one meter (3 ft) thick, but some may reach nine to 12 m (30 to 40 ft) in thickness (Foster 2007). The sandstones represent channels (mainly meandering) or small lakes within the floodplain (mudstone) deposits (Derr 1974). Conglomerates overlying the sandstones and shales rest on eroded surfaces which exhibits marked color changes, probably due to weathering or leaching by ground water (Foster 2007). These conglomerates probably represent lag deposits within a meandering channel.

Geologic History

The geologic history of the Morrison is closely linked with the convergent plate boundary along the west coast of North America and the mountains it produced. Subduction was basically continuous under the western side of North America during the Mesozoic and Cenozoic eras (Ward 1995). This caused magmatism (volcanoes and batholiths), orogenic uplifts, and metamorphism along the western plate margin (Dilek and Moores 1995, Elison 1995, Kays 1995, Murphy et al. 1995, Thorkelson et al. 2005, Ward 1995). The new mountains provided vast amounts of fresh rock surfaces to weather and erode and the volcanoes added ash to the sediments, both of which increased sedimentation rates (Jennings and Hasiotis 2006). By the Late Jurassic the ancestral Rocky Mountains were almost if not entirely beveled down into rolling hills (Turner and Peterson 2004). One source of a significant amount of sediment to the Morrison depositional basin was elevated rift shoulders related to a magmatic arc along the western edge of the continent. Also the uplands of present day eastern Nevada and western Utah supplied sediment to the basin (Ward 1995, Turner and Peterson 2004).

The Western Interior Basin (Middle Jurassic-Early Eocene) of North America, which contains the Morrison Formation depositional basin, is an example of a retroarc foreland basin (DeCelles 2004, Roca 2007). The most widely excepted theory is that the Morrison Formation was deposited, as a part of a thick succession of sediments from the Middle Jurassic age to Early Eocene epoch, in the back-bulge depozone of the Cordilleran foreland basin (Santos and Turner-Peterson 1986, DeCelles and Currie 1996, Currie 1997, Currie 1998, Dunagan 2000) during a time of widespread deformation (from

Canada to Mexico) toward the end of a subduction cycle (Ward 1995). The large geographical extent of the Morrison Formation and its tabular geometry suggest that subduction-driven dynamic subsidence as well as flexural subsidence (crustal loading due to thrust faults) played a part in the generation of accommodation space for the large quantity of sediment flowing into the Morrison depositional basin (Lawton 1994, Currie 1997, Currie 1998, DeCelles 2004).

Age

For some time there was controversy about whether the Morrison Formation was of Jurassic or Cretaceous age, but now it is generally agreed that the Morrison is Late Jurassic in age (Osborn 1915, Rothrock 1925, Mook 1915, Stokes 1944, Demko et al. 2004, Kowallis et al. 1998, Turner and Peterson 2004, Currie and Padian 1997, etc.). The U. S. Geological Survey originally classified the Morrison as Lower Cretaceous, but later reclassified it and assigned it to the Upper Jurassic (Stovall, 1943).

This Jurassic age was originally based on correlations of the fauna with faunas in England (Osborn 1915). More recently radiometric dating techniques have obtained dates ranging from 155 to 148 million years for samples taken from the Morrison Formation (Currie and Padian 1997). Also, the most recent isotopic and micropaleontological (pollen) studies have confirmed a Late Jurassic age for at least the majority of the Morrison Formation (Kowallis et al. 1998, Litwin et al. 1998, Schudack et al. 1998, Tidwell et al. 1998, Demko et. al 2004). The age of individual exposures of Morrison may differ considerably from one locality to another. The formation is thought to have begun in early Kimmeridgian time (~156 Ma) and ended in some areas as late as early

Tithonian time (~149 Ma) (Kowallis et al. 1998, Demko et al. 2004, Turner and Peterson 2004). Some research has hinted that some of the lowest beds in the formation, in some localities, might be Oxfordian age (the earliest part of the Late Jurassic) and that the uppermost beds in the formation, in some localities, might be Early Cretaceous in age (Foster 2007).

Paleoenvironments and Climates

The Morrison Formation represents deposition in a variety of environments, almost all terrestrial, over a period of at least 7 million years (Kowallis et al. 1998, Demko et al. 2004, Turner and Peterson 2004) in an area of subsidence (West 1978). Lacustrine, fluvial, overbank, wetland, eolian erg, alkaline and saline lacustrine, and some marginal marine deposits are present in the Morrison (Derr 1974, Peterson 1988, Peterson 1994, Dunagan 2000, Demko et al. 2004, Dunagan and Turner 2004, Turner and Peterson 2004).

The Morrison Formation climate has been interpreted in many different ways. In the past some scientists, Mook (1915) and Colbert (1961) among others, chose to ignore various geologic indicators of paleoclimate due to assumptions that large herbivorous sauropod dinosaurs spent most of their time in water (e.g., Hatcher 1903) and so needed wet environments with large lakes. Because of this the Morrison was interpreted with lush vegetation around many large rivers and lakes (Mook 1915 and Colbert 1961). In the last 15 to 20 years, instead of making the environment fit what early dinosaur works assumed these large dinosaurs needed, researchers, (e.g., Dodson et al. 1980), began looking at the geology to determine the climate. The most recent interpretation is a semi-arid environment with seasonality, becoming somewhat wetter and less seasonal through time (Dodson et al. 1980).

There are many indicators for a semi-arid environment during the deposition of the Morrison Formation. Geologic evidence includes gypsum (Demko et al. 2004), halite (Peterson 1994), ergs (Peterson 1988, Parrish and Peterson 1998), and alkaline conditions (Peterson and Turner-Peterson 1987). Isotopes from carbonate nodules, dinosaur teeth, egg shells, and ostracods (Hallam 1994, Schudack 1999, Engelmann et al. 2004, Turner and Peterson 2004) also point to a semi-arid climate, as do paleosols with carbonate nodules, clay layers with slickensides, vertic fractures, and blocky ped structures (Demko et al. 2004). There was also seasonality to the climate, as indicated by growth rings in some of the bivalves (Good 2004). The red color of the paleosols as well as features such as vertic fractures and slickensides (Demko et al. 2004) results from wetting and drying of the clays, also indicative of seasonality.

During the Late Jurassic, it is generally believed that there was a subtropical high over the paleo-Pacific Ocean and that the prevailing winds were toward the east (Turner and Peterson 2004). The prevailing winds, indicated by paleocurrents in the eolian sandstones of the Morrison (Peterson 1988, Parrish and Peterson 1998), carried moisture that was "rained out" increasingly as it traveled east (northeast by present coordinates), leaving the interior of the continent and thus the area of the Morrison depositional basin dry (Demko and Parrish 1998). At this time North America was at a more southern paleolatitude, rotated clockwise, and was moving progressively north toward its current position (Parrish and Peterson 1988).

Various models conducted for Late Jurassic global climate have suggested much greater CO_2 concentrations than today, elevating the greenhouse effect. Moore et al. (1992) used a CO_2 concentration of about 1000 ppm, four times the pre-industrial concentration of atmospheric CO_2, and found the simulations they ran fit fairly well with the geologic data. Their models predicted winter temperatures for the Western Interior region of about 20 °C (68 °F) with summer temperatures of 40-45 °C (104-113 °F) (Moore et al. 1992). The more southerly latitude and enhanced greenhouse effect added to the dryness of the basin, and Moore et al. (1992) postulated that evaporation rates may have been high year-round instead of only in summer. There is some evidence from oxygen isotopes that the climate became slightly cooler through time and also that the temperature decreased from south to north across the basin. Turner and Peterson (2004) speculate that this could be because of the northward movement of North America and perhaps also a decrease in CO_2 over time. Paleosol development indicates it was drier in the western and southern portions of the basin (Demko et al. 2004).

Recently, the terrestrial Morrison ecosystem has been compared to a savannah (Parrish et al. 2004, Rees et al. 2004). This savannah expanded as the Late Jurassic Western Interior Seaway retreated northward (Turner and Peterson 2004). The ecosystem was a mixture of various environments that shifted from early Kimmeridgian time (~156 Ma) to in some areas early Tithonian time (~149 Ma), and may have become wetter and less seasonal through time (Demko et al. 2004), though the climate did not significantly change. These ages are based on isotopic (Kowallis et al. 1998) and biostratigraphic constraints (Litwin et al. 1998).

Groundwater and surface water that originated outside the basin were the main sources of water within the Morrison depositional basin. Precipitation that fell west of the basin recharged aquifers (Dunagan and Turner 2004) and fed intermittent and scarce perennial streams that originated in the higher lands to the west (Tyler and Ethridge 1983, Currie 1998) and flowed eastward across the basin, then turned south and headed toward the ancestral Gulf of Mexico. Flow direction was established from paleocurrent measurements in the fluvial sandstones in northeastern New Mexico and the westernmost parts of Oklahoma (Turner and Peterson 2004). These streams became "losing streams" in their downstream reaches and contributed to a raised water table in the eastern part of the basin (Dunagan and Turner 2004). They probably only ran above the surface for a couple months during the year and during storms. The rest of the time they would have been subsurface streams (Turner and Peterson 2004).

Riparian environments formed along these streams and were probably the areas of highest biotic diversity (Turner and Peterson 2004). The majority of the dinosaur quarries are found in fluvial sandstones and overbank mudstones associated with fluvial sandstones (Engelmann and Fiorillo 2000). The recharge of aquifers formed wetlands and lakes in the distal low-lying parts of the basin, where the floodplains intersected the water table (Dunagan and Turner 2004). The rest of the fauna (amphibians, reptiles, and mammals) are found in mudstones and carbonate deposits representing these environments (Engelmann and Fiorillo 2000). Good conditions for life around these lakes and wetlands existed when the water table was high and these environments existed. Eolian environments formed in the southern areas of the basin from sediments blown from streams that dried up at different seasons. Also alkaline and saline wetlands formed at different times from ash fall and advanced evaporation conditions in small closed basins (Turner and Peterson 2004). These last-mentioned environments were presumably inhospitable to many life forms.

Rees et al. (2004) found that during the Late Jurassic the areas of highest diversity were at the midlatitudes in "savannahs". Modern savannahs are important areas of ecological diversity. Difficult conditions favor rapid evolution and addition of new species to the surrounding areas (Rees et al. 2004). It is possible that this was also true during the deposition of the Morrison Formation, and this might, in part, explain the extraordinary diversity of ancient life known from it.

Morrison Formation Paleontology

Vertebrates, invertebrates, and plants have been found in the Morrison Formation. Dinosaurs are the most prominent vertebrate fossils in the Morrison Formation, but fish, amphibians, reptiles, and mammals are also part of the fauna. A list of vertebrates found in the Morrison Formation is given in Table 1.

Invertebrate fossils from the Morrison include crayfish and other aquatic arthropods, gastropods, freshwater mollusks (Chure et al. 1998, Hasiotis et al. 1998, Schudack et al. 1998, Good 2004), and freshwater sponges (Dunagan 1999). Trace fossils indicate the presence of beetles, termites, ants, bees, horseshoe crabs, gastropods, and crayfish (Hasiotis and Demko 1996, Hasiotis 2004). Footprints of dinosaurs, pterosaurs, and other reptiles are also present in the Morrison Formation (Hasiotis 2004, Foster 2007).

The Morrison Formation, though not as well known for its paleoflora, has one of the most diverse Mesozoic floras in the world. Fossils of plants are less common than vertebrate fossils, but are present in a number of localities and in some quarries are mixed in with the vertebrate material (Foster 2007). Plants from the Morrison Formation include algae (Schudack et. al 1999), moss, ferns, horsetails, tree ferns, cycads, seed ferns, ginkgos, and conifers (Ash and Tidwell 1998, Tidwell et al. 2000, and Engelmann and Fiorillo 2000). Seventy-seven species are known from megafloral fossils. These species come from only a few sites because macroplant fossils are not prevalent throughout the Morrison Formation (Parrish et al. 2004, Foster 2007). Pollen increases the number of plant species from the Morrison Formation to more than 200 (Litwin et al. 1998, Foster 2007).

Previous research on the Morrison Formation of Cimarron County, Oklahoma

Lee (1902) suspected the presence of the Morrison Formation along the Cimarron River in Oklahoma as early as 1901, after discovering the formation along the Purgatoire River in southeastern Colorado. Detailed studies of the geology of Cimarron County and the Morrison Formation in that area were first done by Rothrock (1925). He did not find any fossils within the Morrison of Cimarron County. After the discovery of dinosaur fossils in the area, Stovall (1943) followed up on Rothrock's study, redefining and reassigning some of the strata previously assigned to the Morrison and other formations. Stovall also created a detailed geologic map of the Cimarron River Valley from the New Mexico-Oklahoma state line eastward to where the river leaves Oklahoma.

Location

The study area is in the westernmost tip of Oklahoma in Cimarron County. It is located in the panhandle portion of Oklahoma and borders New Mexico, Texas, Colorado, and Kansas (Figure 3). The Morrison Formation (Figure 4) is present in 20 townships along this part of the Cimarron Valley (Stovall 1937), extending down the Cimarron River past Highway 38 and Boise City. Outcrops of the Morrison in western Cimarron County total an area of 160 to 168 square kilometers (99.4 to 104.4 square miles) (Stovall 1943).

History of the Kenton Dinosaurs

Dinosaur bones were discovered by a road crew in the Morrison Formation in the northwest corner of Cimarron County, Oklahoma, in 1931. The dinosaurs were found in strata that had previously been mapped as Morrison Formation (Stovall 1932). These were the first Morrison fossils to be found in Oklahoma (Stovall 1938) and the first Jurassic dinosaurs found in the state (Stovall 1932). They were also considerably farther east than any previously known occurrence of dinosaurs within the Morrison Formation.

J. Willis Stovall (Figure 5) and others visited Cimarron County, Oklahoma after he learned that some “big bones” had been uncovered along highway 64, just east of Kenton. He became aware of the discovery while he was gathering information on Pleistocene mammals in the Oklahoma Panhandle (Langston 1989). Mr. R. C. Tate, of Kenton, Oklahoma, acted as a guide to his party and pointed out the location of the bones (Stovall 1932). Stovall and Llewelyn I. Price (a Brazilian American student) did some preliminary excavation in what would become Quarry 1 in 1932 (Langston 1989). This find led Stovall to conduct a detailed study of the area to determine the actual extent of the Jurassic in that part of the state (Stovall 1938).

The discovery of the "big bones" was made by Pard Collins and Truman Tucker of Kenton, Oklahoma (Stovall 1943) as part of a road crew working on Highway 64, 16 km (10 miles) east of the New Mexico-Oklahoma state line, and 11 km (7 miles) east of Kenton, Oklahoma. The crew was approximately 91.5 m (100 yards) east of the bridge crossing South Carrizo Creek (Stovall 1932, 1937, 1938). The first element to be discovered was a sauropod rib some two meters (6.5 ft) long; it and others recovered during preliminary excavations belonged to a dinosaur later identified as *Brontosaurus* Marsh, 1879 (Stovall 1932), now *Apatosaurus* Marsh, 1877. Stovall's later (1938) account includes five additional dinosaur quarries in Cimarron County. Three more dinosaur sites (Figure 6) were discovered in the county between 1938 and Stovall's next (and final) report in 1943.

Large scale excavations in the Kenton quarries Cimarron County went on almost continuously from 1935 to March, 1942, with the help of federal aid. This federal support was in the form of a depression- relief project the University of Oklahoma received to search for, collect, and prepare fossil vertebrates in Oklahoma (Stovall 1943, Czaplewski et al. 1994). This was the first "sponsored project" in the history of the University of Oklahoma. Early funding came from the F.E.R.A. (Federal Emergency Relief Administration). This program was superseded by the Civil Works Administration (CWA) and later became the Works Progress Administration (WPA) (Langston 1989). The WPA was disbanded in 1942 when the USA became involved in World War II, and with this loss of funding, the excavations ceased. Fossils were collected from other places in Oklahoma by the WPA units as well as Cimarron County (Czaplewski et al. 1994).

WPA units were established on a county by county basis, depending on where fossils were found, and only at the request for federal relief assistance by county officials. The units were only allowed to work in their respective counties and the pay rate was based on the current wage rates in those counties. The unit in Norman, called the Headquarters or Mobile Unit, was the only unit permitted to go as needed, anywhere within the state. This unit employed up to 30 people at one time. Pay from unit to unit ranged from $55 to $95 a month. The highest rates were for those with college degrees.

WPA workers were often almost destitute. Many of them were uneducated farm hands and laborers. It was difficult to find men with the skills for paleontological work. The tools they used were primitive and heavy amounts of rock were blasted loose with black powder and then moved by hand or with a team of horses and a scraper (Langston 1989). Preparation of fossils by those without the proper previous training and experience resulted in surface damage to many of the bones (Czaplewski et al. 1994). It didn't help that many of the fossils from Quarry 1 were encased in concretions and it was difficult for the bones to be distinguished from the matrix. In many cases workers scraped away with chisels, steel files, or jackknives until they recognized bone. By this point, they had often destroyed the surface of the bones (Langston 1989). Langston (1989) indicates that, although most of the WPA workers had no idea what a fossil was when they were hired, a few developed into first-rate preparators. Some of the workers had been to college and these individuals rose quickly to supervisory positions. These included William Noel

McAnulty and Arthur (Chief) Hutchens at the Mobile Unit, and R. Crompton Tate, Stovall's field leader for the Kenton Unit (Langston 1989).

Stovall was nominally in charge of the WPA units, but the direct, *de facto* administrator was a commercial artist named Ralph B. Shead. He had no training in science and all his work was supervised by Stovall. Shead, a graduate of the University of Oklahoma (OU) when the WPA project started, returned to OU as Statewide Supervisor. He, along with others who had extensive advertising design experience, supervised the project. Shead remained officially in charge of the project until it ended in 1942. During Stovall's declining years, in the late 1940s and early 1950s, Shead assumed more and more responsibility for the little activity continuing in the area of vertebrate paleontology at OU. For several years during this time, he was the Director and only full-time employee of the Museum.

Extensive quarry operations were carried out at the site of the first discovery (Quarry 1). The field crew had to remove nearly 100 metric tons of overburden to get down to the bone layer (Foster 2007). Stovall (1938) reported that more than 3,500 individual bones, most of them from a single species, *Brontosaurus* (=*Apatosaurus*) *excelsus* Marsh, 1979, were collected from that quarry. Three other genera, *Ceratosaurus*? Marsh, 1884, *Camptosaurus*? Marsh, 1885, and *Stegosaurus* Marsh, 1877, were also identified from Quarry 1 (Stovall 1938). Stovall (1938) suggested that further study might result in the identification of more dinosaur genera (which it did) within the quarries. At the time, all bones had been identified as the remains of dinosaurs.

In 1943, Stovall wrote that a total of 6,000 bones had been removed from all of the quarries (total of 12 pits or quarries, although most were not very productive) (Langston 1989), and that they had also identified crocodiles, turtles, and fish among the bones (Stovall 1943). Stovall (1943) also reported the presence of two additional dinosaurs from Quarry 1. Of these, one was a small sauropod later found to be represented by juveniles of both *Apatosaurus* and *Camarasaurus* Cope, 1877. The other is a carnivore, almost equaling in size *Tyrannosaurus rex* Osborn, 1905. Because it is the largest carnivore known from the Morrison Formation, this form was informally called *Saurophagus maximus* by Ray (1941) in an article in a popular magazine, but later was renamed *Saurophaganax maximus* by Chure (1995). The taxon was renamed because of controversy over whether it was published according to guidelines set by the International Code of Zoological Nomenclature (Camp et al. 1953, Chure and McIntosh 1998, Czaplewski et al. 1994, Hunt and Lucas 1987). Also, Camp et al. (1953) indicated that the name *Saurophagus maximus* was preoccupied.

In some of the other quarries, WPA workers excavated bones of what Stovall (1943) identified as *Antrodemus* Leidy, 1870 (=*Allosaurus* Marsh, 1877), *Atlantosaurus* Marsh, 1878 (probably *Apatosaurus*, assuming that the fossils in question were referable to *Atlantosaurus immanis* Marsh, 1878, now considered a junior subjective synonym of *Apatosaurus ajax* Marsh, 1877), *Diplodocus* Marsh, 1878, and small unidentified carnivorous dinosaurs. Though thousands of bones (the majority of which were unidentifiable fragments) were removed from Cimarron County, nothing approaching the widely rumored "mountable skeleton" was ever found (Langston 1989). A brief and, in places, rather inaccurate account of the Kenton dinosaur project is presented by Hunt and Lucas (1987).

Quarries 5 and 6

Quarry 5 (Figure 6) was worked from December, 1939 until the middle of 1941. The Quarry was started with the discovery of seven articulated mid-caudal vertebrae belonging to *Apatosaurus*. It is unclear what happened to these bones, but a string of articulated *Apatosaurus* vertebrae from Quarry 5 was not located in the Oklahoma Museum of Natural History (OMNH) collection. Quarry 5, when closed, was 73 m (241 ft) wide and had an eight to nine meter (26 to 30 ft) tall back wall (Hunt and Lucas 1987, Langston 1989). This quarry, which will be discussed in more depth later in this report, is where the majority of the *Diplodocus* material was found (Langston 1989, Foster, 2007). Quarry 6 was discovered in 1940, a couple hundred meters to the west of Quarry 5. For a time it was worked in tandem with Quarry 5, but in 1941 it was abandoned to resume full-time work on Quarry 5. When it was abandoned, the back wall of the quarry was about two meters (6 ft) high. Both Quarry 5 and Quarry 6 were major fossil localities in Cimarron County (Langston 1989).

Quarry 8

Quarry 8 (Figure 6), one of the most productive quarries, yielded small carnivorous dinosaur teeth, two excellent crocodile skulls referable to the genus *Goniopholis* Owen, 1842 (later identified as a new species), many other crocodile bones, six chelonians from two genera, and fish elements identified as belonging to two genera of lungfish (now considered one) and one amiiform (Stovall 1943, Kirkland 1998).

Field Notes and Publications

No surviving maps for Quarry 1 have been found and as far as I could determine, no maps were kept during the first year of excavations; hence there are no quarry maps of Quarry 1 (Langston 1989, Chure 2000). This is unfortunate because it was the most productive quarry. Quarry maps were created the following years of excavation, starting with Quarry 5 (West 1978), but were later thought to be lost. West (1975) wrote that Dr. Wann Langston, Jr., told him field notes were kept by the crew leaders conducting the excavations, but these were also lost. The maps resurfaced in the late 1980s. Individual maps pertaining to the various other quarries were painstakingly fitted together and indexed by Langston (1989). Langston (1989) also compiled a map where he identified the correct locations of each of the quarries that were excavated in Cimarron County (other maps existed before this, but each had inaccuracies in the placement of at least one quarry; Figure 6).

Very little has been published on the remarkable fossils found near Kenton, Oklahoma. Stovall (1932, 1937, 1938, and 1943) published a few contemporary (and preliminary) reports. Thereafter, the vertebrate paleontology collection at what would become the Oklahoma Museum of Natural History (OMNH) fell into disrepair and became functionally inaccessible for decades. A long-term collections improvement begun by R. L. Cifelli in 1988 has resulted in full curation—and, for the first time, identification—of all the holdings, including the dinosaur material from Cimarron County. Some of the material has now been described and discussed. Accounts of the juvenile sauropod fossils from the Kenton quarries appear in Carpenter and Alf (1994) and Carpenter and McIntosh (1994). Bonnan and Wedel (2004) recorded the presence of the sauropod *Brachiosaurus* Riggs, 1903 at Kenton, based on a metacarpal (OMNH 1138) from Quarry 1, previously thought to belong to *Camarasaurus*. First mention of a large theropod at Kenton was made in a popular article by Ray (1941). A brief description and the naming the species as *Saurophaganax maximus* was published by Chure (1995), who later treated the material in more detail in 2000. In these papers, Chure put *Saurophaganax* in the family Allosauridae and points out the differences that make *Saurophaganax* its own genus, not just a very large *Allosaurus*. Mook (1964) described the crocodilian fossils from Quarry 8 as *Goniopholis stovalli*, named in honor of Dr. J. W. Stovall. Kirkland (1998) discussed the fish from Quarry 8. Most recently Larsen (2007) identified a small basal tetanuran (unranked subdivision of Theropoda) from a partial pelvic girdle (OMNH 10320 and 10321) and a hind limb (OMNH 10322, 10323, and 10324) excavated from Quarry 8. This four to five meter (13 to 16 ft) long tetanuran is unique within Oklahoma and may represent a new species of theropod dinosaur (Larsen 2007).

Geology

Within Cimarron County, Oklahoma, exposed rocks range in age from Triassic to Recent (Rothrock 1925, Stovall 1943, West 1978; Figure 7). Stovall (1937) incorrectly postulated that, in the majority of the area, the oldest rocks seen—in the bottom of the canyons—belong to the Morrison Formation.

The oldest rocks exposed in Cimarron County are a series of Upper Triassic age shale, claystone, marl, sandstone and conglomerate that belong to the Dockum Group.

These Triassic rocks lie unconformably beneath the massive, white and buff, cross-bedded Exeter Sandstone (Jurassic) (West 1978). Stovall (1943) reported that the Exeter Sandstone is overlain disconformably by the Morrison, but West (1978) never saw this unconformity and instead reported a conformable contact between the two formations in Cimarron County. The contact between the Exeter and the Morrison is a sharp line which Stovall (1943) interpreted as a complete change in the depositional conditions. Throughout most of the area the Morrison Formation forms an angular unconformity with the overlying Purgatoire Formation (Lower Cretaceous) (West 1978), but in its eastern outcrops the Purgatoire and the Cretaceous rocks above have been eroded, and the Morrison is overlain by Tertiary to Recent sediments. At some locations the bedding of the Morrison creates an angular unconformity with the overlying Purgatoire (Stovall 1943).

The Cheyenne Sandstone is the lowest member of the Purgatoire. It is a buff conglomeratic sandstone and contains many fossilized logs and wood fragments. The uppermost member, Kiowa, is a gray to black fossiliferous shale with substantial amounts of platy sandstone. The massive, cross-bedded sandstone of the Dakota Formation (Cretaceous) sits unconformably on Purgatoire. Conformably on top of the Dakota Formation sits the Graneros Formation (Cretaceous), which consists of sandstone, shale, and fossiliferous limestone (Stovall 1943 and Hattin 1986). Above the Graneros Formation is the Cretaceous age Greenhorn Formation (West 1978). The Greenhorn Formation is a pelagic, fossiliferous, marine limestone (Hattin 1986). The Greenhorn Formation is succeeded by the Tertiary sands and gravels of the Ogallala Formation

(West 1978), and Tertiary lava flows. These are followed by Quaternary fluvial and eolian sands (Stovall 1938).

Sedimentology and Stratigraphy of the Morrison Formation

The Morrison in Oklahoma is thought to be equivalent to the complete section exposed farther west in New Mexico and Colorado. The upper Morrison of Oklahoma and the upper Morrison in eastern New Mexico both contain abundant ash (Stovall 1938). In the past the Oklahoman strata was considered to be "basal Morrison", Oxfordian age, due to correlations with Europe using a chert zone that was thought to be the base of the Morrison. Based on this the Morrison Formation of Cimarron County was thought to be older than the typical Morrison of the Colorado Plateau (McKee et al. 1956). West (1978), on the other hand, argued that McKee's age assignment was unacceptable and that the Morrison Formation of Cimarron County and northeastern New Mexico should be correlation with the Kimmeridgian age Brushy Basin Member on the basis of shared reptile genera and of "jointed clays" that he indicated are typical of the Brushy Basin Member (top member of the Morrison Formation in the Colorado area). The Morrison Formation is not divided into members in Cimarron County due to the lack of horizontally persistent strata and since West's thesis in 1978 it appears no one has tried to correlate the outcrops with the Morrison Formation elsewhere.

The Morrison Formation in Oklahoma varies laterally in thickness (Stovall 1938). The lateral variations make traceable beds hard to find (Stovall 1943) and a full section is not exposed anywhere in the county (Stovall 1938). Stovall (1938) measured a composite section of exposures in Cimarron at 141.5 m (465 ft) thick. The most complete sections are Labrier (Tate) Butte and Robbers' Roost, though the lower part of the formation is exposed only in the extreme east and west ends of the area, north of Boise City, and in the vicinity of Kenton (Stovall 1943). Robbers' Roost is the best area to study the middle Morrison. Stovall (1943) also states that the rocks at Robbers' Roost are stratigraphically higher than at Labrier Butte, owing to a postulated a structural deformation that occurred post-Morrison deposition, but pre-Cheyenne (Figure 8). This deformation resulted in a northeast-southwest synclinal flexure east of Black Mesa and some smaller anticlines trending northwest-southeast (Schoff 1943, West 1978).

Most exposures of the Morrison Formation in Oklahoma are developed as slopes, and outcrops are commonly covered with alluvium and talus (Stovall 1937). They fit the description of the Morrison elsewhere in being "uniformly variable" and multicolored, with color varying both vertically and laterally (Stovall 1938). The Morrison is composed of multicolored sandstones, shales, conglomerates, limestones, some dolomites, and claystones. The dominant color is a green-gray (Stovall 1943, West 1978), though colors ranging from purple, red, brown, yellow, buff, turquoise-green, and white are also seen in the Morrison. There is an alternation between beds of coarse sandstone and layers of fine sandstone and siltstone (Stovall, 1938). Some of the beds of fine sandstone grade laterally into beds of siltstone with brown bands: the siltstone is made up of extremely fine-grained quartz grains (Stovall 1943). Limestones of the Morrison are white and contain numerous chert lenses. The beds are about 20 cm (8 inches) thick. The upper surfaces of the limestone layers are irregular and grade into sandstone (Stovall 1943, West 1978).

A large amount of the Morrison in Oklahoma is composed of shale, marl, and clay that contains varying proportions of sand, and in some places substantial amounts of calcium carbonate (West 1978). The more clay-like portions have been described as "jointed clays" because of their tendency to break off in blocky masses. These "jointed clays" are dominantly gray, but also may be purple, red, green, or mottled (Stovall 1943). These probably represent paleosols because of the jointing and the mottled color (Mack et al. 1993, Demko et al. 2004).

Paleontology

In addition to diverse vertebrate faunas fossils of the Morrison Formation of Cimarron County include invertebrates, trace fossils, and plants many of these other groups may be more common than is reported because at the time of excavations, vertebrates were the focus of the research and other fossils may have been overlooked.

Vertebrates

Dinosaurs are the dominant vertebrates in the quarries and the majority of them are sauropods. The bones are usually encrusted with carbonate concretions (Langston 1989). Stovall (1938) reported the vertebrate fauna as including dinosaurs, crocodiles, turtles, and fish; no mammals were identified, and none have been found since.

At present, ten dinosaur genera have been identified from the Morrison Formation of Oklahoma: *Apatosaurus*, *Diplodocus*, *Camarasaurus*, *Brachiosaurus*, *Barosaurus* Marsh, 1890 (Sauropoda), *Ceratosaurus*, *Saurophaganax,* an unidentified tetanuran (Theropoda), *Camptosaurus* (Ornithopoda) and *Stegosaurus* (Stegosauria) (Stovall 1938, 1943, Bonnan and Wedel 2004, Hunt and Lucas 1987, Czaplewski et al. 1994, Chure 1995, Larsen

2007). Genus is used as the highest taxonomic level for all sauropods from the Kenton Quarries.

Several aquatic or semi-aquatic taxa were recovered exclusively from Quarry 8 (where few dinosaurs, and no sauropods, are represented), which evidently represented a different depositional environment, unique among the Kenton sites (West 1978).

Sedimentology of Kenton Quarries- Most of the dinosaur quarries occur in a 2.5 m (8 ft) thick (Langston 1989) gray shale (Hunt and Lucas 1987). At Quarry 1 this shale is above a 10.5 m (34.5 ft) thick succession of purple, gray, and buff shales (Langston 1989; Figure 9 and 10). Stovall (1938) interpreted this gray shale as a floodplain deposit. It is mottled and breaks into cubical blocks (Stovall 1932), which indicates that it has been altered by soil processes (Demko et. al 2004, Martin et al. 1993, Mack et al. 1993).

Quarry 1's (Figures 9 and 10) bone layer occurs about two meters (7 ft) below a buff colored, dense ledge-forming sandstone (Stovall 1938). Stovall (1938) reported that this sandstone was undistinguishable from six other similar sandstones seen at Robbers' Roost. The lowest of these is 51 m (168 ft) below the top of the Morrison Formation at Robbers' Roost and the highest is 41.5 m (136 ft) from the top of the Morrison Formation at that location. A similar sandstone is the same distance above the bone layer at Quarry 3 and Quarry 4 (Stovall 1938; Figure 6). Stovall (1938) stated that because of lateral variations the distance of the bone layer below the top of the formation cannot be determined.

Langston (1989) noted that in quarries 5 and 6 the gray shale bone layer contained red streaks, is sandier, and is lighter in color than at the other localities and overlies thick white fluvial sandstones, 10.5 m (34 ft) thick. Stovall (1943) describes the bone layer as a limestone with shale partings and many chert lenses. This limy shale grades into a sandstone. Above the bone layer is 16 m (53 ft) of alternating green shale and brown sandstone (Langston 1989). The same limy shale layer that contained bones at Quarry 5 and Quarry 6 is exposed in several places on both the east and west walls of West Carrizo Creek Canyon north of Kenton and in this canyon the Purgatoire and Dakota overlie the Morrison (Stovall 1932).

The fossil horizon at Quarry 8 lies in a thin, gray shale on the side of a small, rocky, hill (Langston 1989; Figure 6), about 0.3 m (1 ft) above a limestone-sandstone couplet (West 1978). Other outcrops of this same thin gray shale on the side of the hill seem to indicate that the deposit was laterally extensive, though none of the other potential sites was tested for fossils to any extent (Langston, 1989).

Stovall (1938) and (1943) believed that most of the dinosaur quarries occur at a similar stratigraphic level, but West (1978) suggested that the eastern quarries (Quarries 1, 3, and 4) occur stratigraphically higher than the western quarries (Quarries 2, 5, 6, 7, and 8) (Figure 6). West (1978) correlated Quarry 5 (Figures 11 and 12) and Quarry 6 (Figure 13) using a limestone-sandstone couplet that underlies both of them. He also correlated Quarry 8 with this couplet and wrote that Quarry 8 is 0.3 m (1 ft) or less above the couplet. Stratigraphically, Quarry 8 appears to be lower than the other sites. The precise level of the quarry floors (field evidence indicates this is the bone layer) above the limestone-sandstone couplet vary, but Quarry 5, 6 and 8 are essentially at the same stratigraphic level (West 1978). West (1978) also indicates that Quarry 1 is as much as 250 ft above the limestone-sandstone couplet, though because of the lack of exposures the exact stratigraphic interval was not determined.

Taphonomy- Taphonomy is the study of events that happen between the death of an animal and its fossilization. The word comes from Greek: *taphos*, burial and *nomos*, law. The term was first coined by Efremov (1940), but scientists had been aware that changes occurred to the original animal from its death until it was fossilized long before this (Martin 1999).

Taphonomy is very important to the study of paleoecology. Biases that affect a fossil assemblage may be evaluated using various aspects of taphonomy to create a more accurate picture of the paleoecology (Behrensmeyer and Hill 1980). Biological information is lost during the taphonomic interval (Olsen 1980). Fossils assemblages can become "time averaged" and may not reflect a community of organisms living in the same place at the same time (Martin 1999). Detailed studies of the fossil localities and comparisons of the fossil assemblage with those produced by different death processes, distribution, and deposition of animal remains in modern communities can help with reconstructing what happened in the past to create a specific fossil assemblage (Shipman 1981).

With respect to the skeletal elements from the Morrison Formation of Cimarron County, Stovall (1938) reported that lateral variations in thickness and character of the Morrison Formation suggest changing conditions from one area to another, but he wrote that the unbroken condition of the bones indicates that no marked disturbances affected them. I am not sure what bones Stovall was referring to, because most of the bones in the collection at the Sam Noble Oklahoma Museum of Natural History (OMNH) are fractured or broken in some way and the huge number of bones he reported included a large number of bone scraps and fragments. Also, many of the long bones and vertebrae show rounding to their ends, although it is impossible to tell how much of the rounding is from weathering and how much of it is from poor preparation techniques. These fragments and broken bones seem to indicate that they were affected by the changing conditions within the Morrison Formation. Only a few bones were found articulated at any of the quarries excavated in Oklahoma, but there is strong support for associating certain elements within given quarries (Stovall 1938).

Most of the bones had a concretionary coating (excluding the bones of Quarry 8). The numerous bones of Quarry 1 are characterized by a light blue-gray color, sometimes with streaks of maroon (Langston 1989). Bones from some of the western quarries (excluding Quarry 8) are more heavily weathered, with surface corrosion that might have been caused by an acidic soil. They may have laid at the surface longer and thus are eroded more than the bones of Quarry 1. The bones of Quarry 5 "…are generally well preserved, but vertebrae are often distorted and limb bones are crushed, some having lost an end before burial" (Langston 1989). Bones of Quarry 8 are small and delicate, and in general scattered, although some of the crocodilian vertebrae were found articulated in groups of two or three in general the bones were scattered. The skulls of two crocodiles as well as two almost complete turtle shells were recovered from this quarry (Langston

1989). Langston (1989) also reported that the crocodile and turtle elements represented several different sized individuals.

Noting that the bones are disarticulated but undistorted, Stovall (1938) suggested disturbance by streams and, possibly, by flesh- or carrion-eating animals. He also observed that a strong current would have been required to move the larger skeletal elements. Nonetheless, based on what he considered "excellent bone preservation", together with bone bed concentration and occasional presence of articulated elements, Stovall (1938) concluded that transport distance was probably minimal.

Invertebrates and plants

Stovall (1938) wrote that invertebrates, particularly ostracods and small gastropods, and mollusks were found all over the study area. Ostracods occur in a peloidal limestone (West 1978). Stovall (1943) indicated that ostracods are present throughout the Morrison of Oklahoma though most abundant in the limestones and some of the shales. In creating a small collection of invertebrates three-fourths of a mile west of the Si Strong ranch headquarters, in the railroad cut north of Boise City, Stovall (1943) reported 60 species belonging to 25 genera. About half of the ostracod species had previously been found in Oklahoma. Most of the species do not seem to be tied to a specific stratigraphic level and so are of little stratigraphic value, while other species, particularly those belonging to the genus *Metacypris*, might be more helpful in biostratigraphy. The genera are all freshwater or brackish water varieties (Stovall 1943).

Plant fossils are scarce in the Morrison Formation of Oklahoma. Stovall (1943) listed *Chara*, charophytes (green algae), as the only identifiable plant fossils. The rest of the plant material consists of fragments of roots, stems, and a few small leaves.

Paleoclimate

Stovall (1938) used Mook's (1916) model of the overall Morrison environment to make his own interpretation of the paleoenvironment of the Morrison Formation in Oklahoma. He noted that the sandstones were from streams, the coarser layers representing flood velocities and the finer layers suggestive of floodplain deposits. The few limestones and dolomites were said to have accumulated in lacustrine environments. He stated that deposition was "consistently variable" throughout the Morrison. The area was dominated by fluvial processes and was therefore much wetter than the underlying Exeter Formation which is eolian in origin. It is also the last terrestrial environment seen in the area because the Cheyenne Member of the Purgatoire Formation represents a marine deposit (Stovall 1943). Not much is said about the climate. West (1978) identified three different paleoecologic intervals within the lower Morrison; a semi-arid period with playa lakes and fluvial deposits, a lacustrine period with a large sequence of carbonates, and another fluvial period with thick deposits of fine-grained sandstones from meandering streams. West (1978) also suggested that the sequence in depositional environments was evidence for an increase in the rainfall (or at least the availability of water) in the area through the deposition of the Morrison Formation in Cimarron County.

CHAPTER 2

MATERIALS AND METHODS

Taphonomy involves the study of many different aspects of a fossil assemblage. For the purposes of this study I considered the concentration of bones, the minimum number of individuals (MNI) represented, the relative size classes of individuals, and the elements represented in the assemblage. These can be used to determine if an assemblage was hydraulically sorted. The surface structures on the bones cannot be studied because many of them have been destroyed by preparation and others may have been caused by scraping with the preparation tools.

The central issue to be addressed—the extent to which bones of given individuals can be identified within each of the quarries—requires that field data, as recorded on the quarry charts available, be associated with catalogued specimens in the collection, and that those specimens be identified according to element, side of body, and genus. Fortuitously, the dinosaur fossils from Kenton, particularly the sauropods, had already been identified by premier authorities in the field, including but not limited to Kenneth C. Carpenter, Wann Langston, Jr., John H. McIntosh, and Mathew Wedel.

The primary means of associating field and curatorial data was field number (see Langston, 1989, for discussion of how these numbers were created and used), as indicated on both quarry charts and the fossils themselves. Unfortunately, this method is beset by difficulties. Most of the large number of specimens collected (as described above) proved to be unidentifiable fragments, and were discarded in the course of curating the collection in the 1980s. Hence many fossils on the quarry charts have no corresponding catalogued and identified specimen in the collection. Conversely, some of the catalogued and identified specimens have no field number, and consequently cannot be identified on the quarry charts. Inexplicably, some of the catalogued specimens had identical field numbers. I examined all of the specimens in the collection, measuring and drawing the problematic specimens, subsequently identifying them on the quarry charts where possible. A list of all cataloged bones that were identified on the quarry maps can be found in Appendix A.

I used a GIS type program called Didger™ to digitize the quarry maps. These maps were subsequently imported into Adobe Illustrator™ and skeletal elements were color coded by taxon. The individual charts for each quarry were than stitched together in Adobe Illustrator™ to create a composite of the entire quarry. The composite quarry maps were than saved as PDFs (see the CD). These maps were then visually examined for patterns, with reference being made to skeletal element and body side. I also calculated a MNI in the assemblage of each quarry using a database of identified elements from each quarry (Appendix B). I chose to count only elements that occur in pairs (left and right) looking for the element that is most repeated. Using that skeletal element, unless the taxon was only represented by vertebra or ribs, in which case only one individual was counted for the taxon, the number of fossils from the most common side (left or right) represented by the element was assigned as the MNI for that taxon necessary to account for all the specimens in the OMNH collection for each quarry.

Gross size categories (juvenile, subadult, or adult) were also used when differences were seen to increase the MNI for particular taxa.

The quarry maps were examined for associations between bones. Associations were established by the proximity of bones of the same genus. The bones were than cross-referenced with Appendix A to identify what skeletal element they represented. It was then decided if it was likely, based on the skeletal elements and size of elements, that these bones came from the same individual and should be associated with one another. The list of bone associations can be found in Appendix C.

While examining the maps for bone associations, some of the previous identifications of bones were questioned. It was possible by examining the placement of these bones on the quarry maps and reexamining the bones themselves to identify some of the bones to a finer taxonomic level than had been done by previous worker. Many of the Sauropoda bones were classified into one of the sauropod genera with fossils in close proximity to them in the quarries. Other bones were identified as a genus other than that to which they had originally been referred based on the bones around them in the quarry and a reexamination of the fossil itself. Reidentifications based on the fossils were done with the help of Kyle Davies (Preparator at OMNH) and numerous publications. Revised identifications of specimens are shown in bold below the original identification in Appendix A.

As noted, one of the quarries (Quarry 8) has a highly distinctive assemblage. I compared the faunas of the various quarries, and also evaluated differences (if any) in the articulation or possible association of elements. These comparisons lead to hypotheses of the depositional environment each quarry represents and how that environment affected the patterns of bones seen on the quarry maps.

I visited Cimarron County and Kenton, Oklahoma in March, 2007 to verify the observations and data record by Stovall (1938 and 1943), West (1978), and Langston (1989) about quarries 5, 6, and 8. The three quarries are on privately owned land. I received permission to visit quarries 5 and 6, but never heard from the owner of the land Quarry 8 lies on so was unable to visit it. A visit to quarries 5 and 6 revealed that because of backfilling and erosion of the quarries it was impossible to determine the level of the quarry floors during the excavations of the fossils in the 1930s and 1940s (the bone horizon according to West [1978]).

An attempt was made to measure section exposed in each quarry with a Jacob Staff, but without knowledge of the location of the original quarry floor the measurements obtained only measure the height of the current back wall to the quarry. The height of the back wall of Quarry 5 was measured at eight meters (26 ft) which is higher than Langston (1989) reported (6 m [20 ft]), but lower than Hunt and Lucas (1987) reported (9 m [29.5 ft]) from an oral report Stovall gave in 1940 about the excavations. The floor of the quarry today is not the same as the floor of the quarry during excavation. The hill has eroded and also the quarry may have been backfilled. The height of the back wall at Quarry 6 (measured at ~1.8 m [~6 ft]) seemed relatively consistent with Stovall's measurements (1.8 m [6 ft]) reported by Hunt and Lucas (1987), but there was still no absolute way to know that what was exposed as the floor of the quarry after over 40 years was the floor of the quarry during excavations.

CHAPTER 3

RESULTS

The faunas of each of the quarries are listed in Tables 2, 3 and 4. Quarries 5 and 6 have very similar faunas (Tables 2 and 3), which are very different from the fauna found in Quarry 8 (Table 4). Quarry 5 and 6 also contain immature individuals as well as adults (Tables 5 and 6). Some taxa in Quarry 5 are represented within the quarry only by immature individuals (*Camptosaurus*). Maps of each quarry can be found on the CD ROM (references to gridlines unless otherwise stated are for the x-axis). Bone associations for each quarry are listed in Appendix C.

Quarry 5

Quarry 5 (CD) has 12 different taxa. Some of these may overlap because not all the bones from this quarry were originally identified to the genus level (Table 2). Appendix B was used to calculate the MNI of each taxon for Quarry 5. These counts are listed in Table 5.

The bones in Quarry 5 (CD) appear to be in distinct patches that in many cases have bones that can be associated. Many of the clumps appear to be represented almost entirely by one individual. Though the bones seem to be clumped they do not appear to have a preferred orientation.

The skeletal elements represented in Quarry 5 vary widely. The most abundant skeletal elements are vertebrae, but there is also a large number of limb bones as well as manual and pedal bones (Figure 14). Quarry 5 includes a string of five articulated caudal vertebrae from *Camarasaurus*, though only one of these was identified in the collection (OMNH 10326; CD; located in the far eastern portion of map). Where the other four caudals went, and why this one is disarticulated in the collection, is not known. There are no other vertebrae identified as *Camarasaurus* or anything else that have the field numbers of the missing caudals. There is also another string of six articulated caudal vertebrae, from near the *Camarasaurus* vertebrae, from what was cataloged as an unidentified sauropod. Upon further examination (see revised bone identifications portion of the report and Appendix A), these also appear to be from *Camarasaurus*. There are also other bones that are not fully articulated, but are in approximately the right placement and position as they would have been in while the dinosaur was alive.

Quarry 6

Quarry 6 (CD) has eight different taxa. Some of these taxa again may overlap because not all the bones from this quarry could be identified down to genus level (Table 3). Using Appendix B, the MNI of each taxon was calculated for Quarry 6, and these are listed in Table 6. The unidentified sauropod bones from this quarry are mostly fragments or ribs, so they were not included in counts due to the fact that they most likely belong to one of the other already identified sauropod genera.

The bones of Quarry 6 seem to be more scattered than those of Quarry 5. Most of the bones are concentrated in one area of the map (CD; gridline 97-155), but there are also smaller clumps of bones in other areas of the quarry and large areas where no bones were recorded as being excavated from at all (CD; gridline 17-47 and 72-97). Not as many associations could be made in Quarry 6 as could be made in Quarry 5. Many of the

Apatosaurus elements that were associated are farther apart in this quarry than similar associations made in Quarry 5. They were still associated, though farther apart, because of what elements they represented (CD; Appendix A).

The most abundant skeletal elements in Quarry 6 are vertebrae (Figure 15). This quarry also has numerous limb bones and pelvic bones. Though the skeletal elements in Quarry 6 are widely variable there are almost no bones smaller than vertebrae present. Manual and pedal bones are absent (Figure 15; Appendix A). As in Quarry 5, there does not appear to be a preferred orientation to the bones.

Bones of Quarry 6 appear more fragmented than Quarry 5 or Quarry 8. There are many more unidentified bones on the maps of Quarry 6 than from the other 2 quarries (CD). No bones on the quarry map are articulated. The one articulated set of bones in the collection from Quarry 6 (OMNH 10383; Appendix B) could not be located on the quarry maps of Quarry 6.

Quarry 8

Quarry 8 (CD) has 13 different taxa. The taxa may have some overlap because not all the bones could be identified to genus (Table 3). Virtually all taxa are unique to Quarry 8. The only taxa Quarry 8 shares with quarries 5 and 6 are *Camptosaurus*, unidentified archosaurs, and unidentified theropods (the few theropod specimens not identified as Tetanurae by Larsen [2007]). Using Appendix B, the MNI for each taxon for Quarry 8 was calculated and is listed in Table 7. Quarry 8 contains some unidentified reptile vertebrae, but these probably belong to either the crocodiles or the turtles so they were not included in the counts.

The bones of Quarry 8 were concentrated in patches within the quarry (CD). Most of the bones were excavated on the east side of the quarry (CD; gridline 15 and east). There appears to be a preferred orientation within the quarry. A large majority of the vertebrae are oriented north-south. Also more bones can be associated in the northern areas (CD; gridline 51 and northward) of the quarry map than in the southern areas. There also appears to be more scatter to the bones excavated in the southern areas of the quarry and the bones are more fragmented than the ones toward the north.

The most abundant skeletal elements in Quarry 8 are again vertebrae (Figure 16). There is also a large amount of limb bones and many fragments of turtle shell. Quarry 8 also includes two articulated skulls of *Goniopholis stovalli* (Appendix A) and unidentified articulated vertebrae (CD). Many of the long bones are in excellent condition and many others are fragments that cannot be identified except as portions of long bones. The same is true for vertebrae with some in excellent condition and others in fragments.

Revised Bone Identifications

All of the changes in taxonomic identification are shown on revised quarry maps (CD) and in bold below the original identification in Appendix A. Some bones on the quarry maps were reclassified based on the bones around them on the maps (i.e. Sauropoda surrounded by *Diplodocus* was reclassified as *Diplodocus*). Other bones were reidentified based primarily on the fossils and not on their apparent association on the quarry maps. Here I will discuss the reasoning for their new identifications based on publications on the various dinosaurs present in the Kenton quarries (Marsh 1896, Hatcher 1901, Hatcher 1902, Hatcher 1903, Gilmore 1925, Gilmore 1936, Madsen 1976, Madsen et al. 1995, Madsen and Welles 2000, McIntosh 2005, Ikejiri et al. 2005, Bedell and Trexler 2005, Apesteguia 2005) and help from Kyle Davies.

Archosauria

All the Archosauria material was examined, but not all of the specimens could be identified to a finer level. Some archosaur material was identified as a skeletal element different than its previous identification. Some of the specimens examined (OMNH 1780, 1792, 1853) had no distinguishing characteristics and were assigned to Sauropoda or a specific sauropod genus based solely on their size and their proximity to other sauropod bones on the quarry maps. Others, such as OMNH 1090, due to their size were assigned to Dinosauria because there were no enormous crocodilians around during this time period and thus any large Archosauria material must belong to a dinosaur.

OMNH 1832, 1837, 1862, and 4024 were all previously identified as archosaur chevrons, but an examination of the bones shows that they are not chevrons but rib fragments. OMNH 1862 is, more specifically, a cervical rib fragment. It is not a dorsal rib because the second point of the rib is not at the top, but if it was present would have come out the bottom. The tubercular ramus has been sanded off in the preparation, but there is still evidence that it would have been present.

OMNH 1843 was previously identified as an archosaur vertebra fragment. Pleurocoels were present, identifying the element as a saurischian. The height of the neural arch above the neural canal indicates that it belongs to Sauropoda. The absence of a transverse process lobe and lower strutting means it is not a fragment of a cervical vertebra. The neural spine is too tall to belong to a caudal vertebra. The high strutting and the height above the neural canal led to the re-identification of this specimen as a Sauropoda dorsal? vertebra fragment. Based on what surrounds it in the quarry it is probably a *Diplodocus* dorsal vertebra fragment.

OMNH 1854 is not a zygapophysis as previously identified. It was compared to other zygapophyses and does not look resemble them. It has two articular surfaces and resembles a sacral rib. It would have to be from a young individual that had not fused the sacral ribs yet to fall out like this one. The pneumatic foramina in the bone justify classifying it as saurischian, and based on its placement on the maps, it is further classified as a Sauropoda sacral rib?.

OMNH 1856 was identified as an archosaur neural spine. The presence of well developed laminae makes it a saurischian neural spine. Its size indicates it most likely pertains to Sauropoda. Based on the size and shape (tall and narrow) of the neural spine it probably belongs to a dorsal vertebra. Cervical vertebrae are normally broader and in sauropods, have a split on top or are asymmetrical; this specimen shows none of these features. It could also belong to one of the first few caudal vertebrae. For this reason it is identified as a Sauropoda dorsal? neural spine.

OMNH 1984 was properly identified as a zygapophysis. The pneumatic development and lamina in the specimen allows it to be identified as belonging to a saurischian.

OMNH 1896 was previously identified as an archosaur skeletal element. Physical examination of the element allowed it to be tentatively identified as a parapophysis. The laminae on the specimen identify it as saurischian. The laminae and camerae of the specimen closely match that of the parapophysis of a sauropod cervical vertebra. It has been identified as a ?Sauropoda parapophysis of a cervical vertebra.

OMNH 1982 was identified as an archosaur girdle fragment. Based on the size it belongs to Dinosauria. It has two flares on the bone. This is not common in a scapula, pubis, or ischium, but is seen in an ilium. It also may show evidence of sacral rib attachments. It is therefore identified as a Dinosauria ilium? fragment.

OMNH 4023 is a chevron, as previously identified, but because it shows the start of two phalanges out of the chevron it is now taken from Archosauria and identified as belonging to a sauropod in the family Diplodocidae. This is the only family that shows this split in the chevron partway down the tail.

OMNH 10367 was previously identified as an atlas-axis complex from an archosaur. Nothing about the specimen when it was examined points toward its being and atlas-axis except for a break where two bones have been glued back together, but this break might not even be between two bones and the two bones that are glued together might not even belong together. The scraping during preparation has left this specimen with almost nothing identifiable. For this reason it is being reclassified as a “skeletal element”.

Theropoda

Theropods are represented by *Saurophaganax maximus*, *Ceratosaurus*, and a small unidentified tetanuran (most likely not a juvenile of *Saurophaganax* or *Allosaurus* [Larsen 2007]) within the Kenton quarries. There are also unidentified theropod bones and these were examined to determine if they belonged to either of these previously identified genera.

OMNH 10364 was previously identified as a theropod caudal vertebra. After examination it was reidentified as a posterior cervical vertebra based on the angle of the remnant transverse process, a lower spine, and a larger neural canal. Comparisons were made with articulated skeletal mounts of *Allosaurus* and *Saurophaganax*, but it is not consistent with any Allosauridae vertebrae. It is also not consistent with *Ceratosaurus* (Madsen and Welles, 2000) and thus represents a previously unknown genus of theropod within Quarry 5.

OMNH 1851was identified as a theropod braincase. This identification seems to be correct, though it could also be interpreted as a portion of a caudal vertebra. If it is a vertebra fragment the hole that is thought to be the foramen magnum would become the neural canal and the tuberous processes would become the fork in the top of a *Diplodocus* neural spine. Though there is no good evidence for nerve foramina as would be expected in a braincase, by comparing the specimen with drawings of *Ceratosaurus* and *Allosaurus* braincases (Madsen and Welles 2000 and Madsen 1993) as well as with an *Acrocanthosaurus* Stovall and Langston, 1950 braincase (OMNH 10146), the similarities between them and the specimen seem to point toward it being a braincase. Where portions of the braincase are missing in the specimen, breaks can be seen that match up relatively closely with Theropoda braincases. It differs from *Ceratosaurus* in the length from the foramen magnum to the tuberous processes (Madsen and Welles 2000). It is much closer to *Allosaurus* (Madsen 1993), but is still not quite the same. It would be bigger than both *Allosaurus* and *Ceratosaurus* if the entire braincase had been preserved. It is also bigger than the *Acrocanthosaurus* braincase. Based on the similarities with *Allosaurus* and the larger size it is now tentatively identified as a *Saurophaganax* braincase.

Sauropoda

Not all the sauropod material was examined because many of the specimens are rib fragments and other scraps that even upon further study would not be identifiable to genus. The metacarpals and metatarsals were examined to see if they could be assigned to *Camarasaurus*, *Apatosaurus*, or *Diplodocus*.

OMNH 10215 was identified as a right metacarpal I. Examination of pictures in various texts lead to its being assigned to *Diplodocus*. It fits the proportions of *Diplodocus* and is shown in close proximity to other bones belonging to that genus on the quarry map. However, it is not a right metacarpal, but a left.

OMNH 10217 was identified as a left metatarsal IV. Comparing it to other metatarsal IVs in the collection of *Diplodocus* from Quarry 5 (OMNH 10214 and 10216; both rights), it is a mirror image except for having more abrasion, most likely during preparation. The shaft is also the same width as the other *Diplodocus* specimens and so it has been assigned to *Diplodocus*.

OMNH 10219 and 10221 were both identified as sauropod metacarpal IVs. Though OMNH 10221 was identified as a left and OMNH 10219 as a right both are actually rights. They are about the same size, but OMNH 10219 has a much longer and narrower shaft than OMNH 10221. OMNH 10221 shows some crushing, but this does not account for all of the differences between the two bones. They are definitely not from the same animal. OMNH 10219 has the proportions of a *Camarasaurus* metacarpal and when it was put into life position with other relevant specimens (OMNH 10225, 10218, and 10228; metacarpals II, III, and V of *Camarasaurus*) it appears to fit smoothly and accurately between OMNH 10218 and 10228. Accordingly, OMNH 10219 is assigned to *Camarasaurus*. OMNH 10221 has a wider shaft and its shape is similar to metacarpals of *Diplodocus*, to which it is referred.

OMNH 10220 was identified as a right metatarsal V of a sauropod. It fits with the proportions and pictures of metatarsal V in *Diplodocus*. Metatarsal V of *Camarasaurus* is much less robust and has a more slender shaft than this specimen. It is therefore assigned to *Diplodocus*.

OMNH 10344 is a set of six articulated caudal vertebrae from a sauropod. Comparisons between *Diplodocus*, *Apatosaurus*, *Haplocanthosaurus*, and *Camarasaurus* suggest reference to *Camarasaurus*. They show portions of the transverse processes so they are somewhere between the 1st and the 13th caudal. They have a shorter length than any of the *Diplodocus* or *Apatosaurus* vertebrae from Quarry 5. They are all about the same length, which is consistent with *Camarasaurus*. The centra are oval shaped (medially constricted), a *Camarasaurus* trait, versus rounder in *Apatosaurus* and *Diplodocus*. The neural spine of the fifth in the series (marked as A4) shows the *Haplocanthosaurus* and *Camarasaurus*-type expansion at the top and does not show the notch in the front that should be present if it was from a diplodocid. The neural arch is situated more anteriorly over the centrum than in *Haplocanthosaurus*, *Apatosaurus*, or

Diplodocus. Gilmore (1925) noted that in *Camarasaurus* the anterior half of the tail (portion represented by the specimen) is higher than it is wide, as it is in this specimen. OMNH 10344 is thus assigned to *Camarasaurus* as a set of anterior caudals. The bone marked A7 in the collections is most likely A1 since it articulates correctly with A2. The size of the transverse process also should put it at the front of the series not the back; once this is done, the rest stack together nicely into a series. Put in this order, it appears that the spines were drawn onto the vertebrae backward on the quarry map (CD; the far eastern portion of map). The other set of articulated *Camarasaurus* vertebrae, if they were all still present in the collection, from near OMNH 10344 in Quarry 5, would be anterior to 10344 in the tail because OMNH 10326 has the more rounded centra and more pronounced transverse processes seen at the base of the tail in *Camarasaurus*.

Barosaurus

The *Barosaurus* material in the collection was examined and compared with *Diplodocus* material and illustrations. This examination led to the conclusion that the specimens listed as *Barosaurus* are closer to *Diplodocus* than *Barosaurus*, but there are no synapomorphies present in the specimens to make a definitive identification of *Diplodocus* over *Barosaurus*.

The material from Cimarron County identified as *Barosaurus* includes only caudal vertebrae and neural spines. According to McIntosh (2005), there are more similarities between the caudal vertebrae of *Barosaurus* and *Diplodocus* than there are between any other genera of Sauropoda. In *Diplodocus*, the pleurocoels and transverse processes persist farther back on the tail than in *Barosaurus*. Also, though both have ventral sculpting on their caudals, those of *Barosaurus* are more square shaped and gradually flatten out posteriorly. *Diplodocus*, on the other hand, has a deeper ventral pit and does not flatten out (McIntosh 2005). OMNH 10340 has a ventral pit as well as slight pleurocoels and is farther back in the tail than this should persist in *Barosaurus*. This makes it more likely that it belongs to *Diplodocus* than to *Barosaurus*. The other caudal vertebrae also have deep ventral sculpturing, but are more anterior in tail so taxonomic identification is more problematic. Nonetheless, these specimens appear to be more similar to *Diplodocus* than to *Barosaurus*. For this reason, the *Barosaurus* material was reidentified as *Diplodocus* on the revised quarry maps (CD).

Camarasaurus

The *Camarasaurus* material that was in close proximity to other genera of sauropod bones within quarries 5 and 6 was examined to determine if it truly was *Camarasaurus*. *Camarasaurus* is one of the best known genera of sauropods and so there were many good resources to compare the specimens to. It appears that all of the *Camarasaurus* material was identified correctly. The scatter of *Camarasaurus* elements within the quarries is accurate. This prompts another question, namely, why is the *Camarasaurus* material, at least in some areas, more scattered than the other sauropod material?

OMNH 10195 and 10330 are both *Camarasaurus* ischia. This was reestablished based on the lack of distal expansion, a distinct character seen in *Camarasaurus* ischia. They had both been identified as right elements, but OMNH 10330 was reidentified as a left, based on the heaviness of the ridge to the outside of *Camarasaurus* ischia. Though they are about the same length, OMNH 10195 is more gracile than OMNH 10330 and hence they are not from the same individual.

Revised MNI Counts

The revised identifications of numerous bones within each quarry, whether based on associations within the quarry or examinations of the specimens, did not have a large effect on the MNI from each quarry. The greatest effect is seen in Quarry 5. The unidentified sauropod bones that were referred to *Camarasaurus* or *Diplodocus* reduced the Sauropoda MNI to one adult and one juvenile. MNI of *Diplodocus* was increased from two adults to four with the inclusion of the *Barosaurus* material and other sauropod elements. There is still one subadult of *Diplodocus* preserved in Quarry 5. Also, the addition of a saurischian juvenile element could increase the MNI in the quarry, but it is more likely that it belongs to the sauropod juvenile. Thus the overall MNI within Quarry 5 did not change. Upon referral of the *Barosaurus* material to *Diplodocus* in Quarry 6, the MNI for the quarry decreased by one. The only elements previously identified as *Barosaurus* had been a few vertebrae, and therefore did not change the MNI of *Diplodocus*. The MNI did not change for any taxon in Quarry 8 due to the fact that the majority of the unidentified crocodylian material consists of vertebrae, and whether it is included within *Goniopholis* or not, does not affect the counts.

CHAPTER 4

DISCUSSION

Each of the three quarries examined in Cimarron County, Oklahoma, appears to have a unique pattern of bone distribution. In addition the quarries appear to differ in the elements preserved and/or the fauna that is represented in the quarry. Although they are all from a gray mudstone and (based on the fauna) maybe from the same general stratigraphic zone in the Morrison Formation (West 1978) the scatter patterns and the beds underlying them, suggest that they are not all from the same depositional environment.

Quarries 5 and 6 probably represent floodplain environments in which carcasses of numerous individuals died over time and laid exposed until enough floods occurred to bury them; in both cases, bones lie in a gray mudstone. The patterns of bones and the fauna (Table 4) represented in Quarry 8 are interpreted as representing a small pond or lake environment. This means that the MNI for each quarry probably does not represent animals that died in a mass kill or catastrophic event.

The gray mudstone of Quarry 5 and Quarry 6 overlies a thick white fluvial sandstone. It is also sandier than the mudstones in the other quarries and has red streaks (West, 1978). This succession of sandstone followed by mudstone might happen on a floodplain in close proximity to a river, where the coarser sediments fall out as the flood begins to lose its energy. The red streaks could be caused by oxidation of some of the sediments or from oxidation around plant roots growing on a floodplain.

The bones from Quarry 5 and Quarry 6 were also covered by carbonate concretions. This happens in paleosols that formed in an arid or semi-arid environment (Martin et al. 1993 and Demko et al. 2004). Evaporation of moisture in the soil would cause calcite to precipitate out, solidifying around the bones and creating carbonate nodules and concretions in the soil.

Both Quarry 5 and Quarry 6 contain juveniles and subadults referred to genera also represented by adults within the quarries (Tables 5 and 6). In a seasonal semi-arid environment, stress during the dry season could have killed young and old dinosaurs and left them on a flood plain. It is not possible to determine whether the young dinosaurs, or the adult for that matter, were killed by a predator because the surfaces of most of the bones have been severely affected by the preparation to the specimens. It is also not possible to determine whether they died because of a drought. There seems to be a large assortment of taxa all buried in the same layer, but they may not have all died at the same time; weathering of some of the bones indicates they were exposed on a surface for time before becoming buried.

The evidence indicates that individual carcasses from quarries 5 and 6 probably accumulated over time, lying exposed to weathering on the floodplain before becoming buried by subsequent floods. The differences in the patterns of bone scatter, the amount of fracture to bones, the elements preserved, and the amount of association/ articulation of elements between Quarry 5 and Quarry 6 suggest they represent different areas of a floodplain that were subjected to different sets of taphonomic processes.

Quarry 5

The patchy distribution of bones in Quarry 5 (CD) could be caused by a lag deposit in a river, deposition in a sediment trap caused by depressions in the paleotopography of the floodplain, or animals preserved where they died. River lag deposits are typically found in poorly sorted coarser sediments and conglomerates, lacking lamination. The fact that the bone layer deposit at Quarry 5 is in mudstone (fine-grained sediments showing laminations in some places) can be used as evidence that is probably not a lag deposit. Also the evidence discussed above seems to agree with its being a floodplain deposit.

Areas of the quarry where the majority of bones closely approximated bones are from one genus appear to favor interpretation as a floodplain deposit where the individuals were buried near where they died (*Saurophaganax maximus* patch; CD gridline 58-69 and the *Diplodocus* patches) and their bones were not mixed or moved far by the flooding events that eventually buried them. This can be argued for large skeletal elements, but smaller ones should be transported by the floods unless they were blocked by larger bones. This could be the reason for the more scattered elements of *Camarasaurus* in Quarry 5. In the western portion of the quarry, the largest elements of *Camarasaurus* are clumped and the bones of a pelvic girdle can be easily associated. *Camarasaurus* vertebrae are found farther east and are more scattered (except farthest east where they are articulated). Even farther east, mixed with the bones of *Diplodocus* and other dinosaurs, the *Camarasaurus* manual and pedal bones were scattered until they were caught between the larger bones of other dinosaurs. There are some *Camarasaurus* elements that do not fit this pattern (large bones scattered on the eastern side of the quarry). Some of the larger *Camarasaurus* remains in the eastern part of the quarry are elements that probably belonged to another individual than the one in the western part because there are three ischia in the quarry, two in the west and one much farther east. Evidence of size-sorting may be present, in other genera, but to a lesser extent than the *Camarasaurus* material.

It seems likely that water transport cause the size-sorted scattering of the *Camarasaurus* material. The small elements were washed farther from the place of death and accumulated with the remains of other dinosaur genera. The larger bones in both the west and the east areas of the quarry probably did not move far from where the animal died to where the elements were later buried. The articulation of some of the *Camarasaurus* vertebrae also indicates that the strength of the current was probably not great enough to move the larger skeletal elements.

The *Diplodocus* material is found in several large patches in Quarry 5 (CD). Large and small elements are found together with random bones of other genera mixed in. This tends to favor the hypothesis that they died and were buried with little transport, but to complicate things, within these clumps are large elements of *Apatosaurus*. There is also a large limb bone of *Apatosaurus* in the patch of *Saurophaganax* material.

The scatter of the *Apatosaurus* material could mean that the dinosaur died at an earlier time than the other individuals and was scattered by other animals and scavenging as well as flood waters. If the large elements were moved by water alone they would have required a much stronger flood than the ones that accumulated the other bones within the patches.

If the patches of bones in Quarry 5 resulted from depressions in the paleo floodplain, it should be harder to associate bones within a given patch. Bones would have been washed over the floodplain in a large-scale flood and come to rest in depressions as they washed over them. In this situation the patches should be more of a mixture of taxa and not, as the majority of the patches are in Quarry 5, almost entirely monospecific.

The majority of the patterns on the maps for Quarry 5 (CD) can best be explained by animals being preserved on a floodplain in relative proximity to the place where they died. There is some evidence of hydraulic sorting among the *Camarasaurus* bones, but in general floods were not strong enough to move the larger dinosaur bones and the smaller ones were blocked from scattering far by these larger elements. This would also explain the lack of orientation caused by the flowing water and the articulation of some skeletal elements within the quarry.

Quarry 6

The bones in Quarry 6 appear to more concentrated, but at the same time more scattered than the bones in Quarry 5 (CD). It was harder to make associations between bones and more of the bones are fractured (hence the large amount that could not be identified on the maps [CD]). Also, the smaller bones (smaller than vertebrae) appear to be absent. This suggests a stronger water current tumbling bones together, fracturing them, and hydraulically removing the smaller elements. Small bone fragments are numerous, but those could have resulted from fracturing of large elements. The generally higher energy and transport presumably explains the absence of articulated elements in Quarry 6.

Quarry 6 appears to represent a higher energy depositional environment than Quarry 5, perhaps as a result of having been located on a portion of the floodplain closer to the river channel. It would be interesting to know if the fossil horizon at Quarry 6 contained more coarse sediments (e.g., sand) than Quarry 5 because the river would have dropped its coarsest sediments closest to the river and its finer sediments farther out on the floodplain. Langston (1989) makes a passing remark in his report that Quarry 5 had the sandiest matrix except for possible Quarry 6, but nothing definitive is ever stated about the difference in sediment size between the two quarries. Since it was impossible to determine where the fossil horizon had been on my visit to the two quarries, this may never be known.

The lower MNI for Quarry 6 than Quarry 5 (Tables 5 and 6) probably reflects the smaller size of Quarry 6. The quarries themselves are not far apart (Figure 6), but the hill that Quarry 6 was excavated in is much smaller than Quarry 5. It is likely that if it had not become dangerous (and laborious) to continue excavating at Quarry 5, even more material would have been found, thus further increasing the MNI for Quarry 5. It could also be that, if the material from Quarry 6 was not as fragmented and more of it was identifiable, the MNI would be higher.

Quarry 8

The bone orientations seen in the Quarry 8 map have an artificial appearance (CD). The majority of the bones are lined up perfectly north-south, that this is probably a false orientation created by drawing the small bones of this quarry after they had been removed, thus creating the illusion of an orientation not originally present within the quarry.

The bones of Quarry 8 are more delicate and smaller than those of quarries 5 and 6. The largest animals in the Quarry 8 fauna are the two taxa shared with the other two quarries, *Camptosaurus* and Theropoda. Although the bones of Quarry 8 were also found in a gray mudstone, the bones were not covered by concretions as were the fossils from quarries 5 and 6. The lack of concretions saved the bones of Quarry 8 from many of the damaging preparation techniques, leaving the fossils from Quarry 8 in better shape than those from the other quarries. This thin gray mudstone is laterally continuous through the hill of which Quarry 8 was only a small portion (Figure 6).

The fauna (Table 4), which includes fish and semi-aquatic turtles and crocodilians, could represent a river, lake, or pond environment. Mudstones are not typically deposited in river channels, but on the floodplains around the channels. Although fish can be deposited by floods onto floodplains, the highly aquatic make-up of the entire assemblage (including three kinds of fish; Table 4) suggest that Quarry 8 was not on the floodplain, but that it was a small pond. Ponds also have weak currents allowing the crocodilian skulls and some of the turtle shells to remain intact. They would likely remain articulated, unlike numerous other turtle shell pieces, if they were buried faster than other bone material.

Because the Morrison Formation is thought to represent a semi-arid environment with seasonality, this pond may have been ephemeral. Lungfish, present at Quarry 8, are and apparently were well suited to such habitat. These fish can survive during seasonally dry periods because they have lungs as well as gills and can travel over land looking for other pools when theirs dries up. During severe drought, modern lungfish survive by aestivating. They burrow into the damp sediment and create a cocoon around themselves with mucus to aestivate until the wet season returns. Fossils of lungfish in burrows from the Devonian and Triassic suggest that early lungfish could aestivate too (Benton 2005). This makes them ideal fish for a semi-arid, seasonally dry environment. The dinosaurs and semi-aquatic vertebrates could probably travel to find water when their water source dried up.

Ignoring the artificial north-south orientations of individual bones and focusing instead on the smaller patterns within a number of the bone concentrations, especially toward the middle of the quarry, there is an arch or crescent-like distribution of bones (Figure 17; CD). Not all of these arches go in the same direction. One hypothesis for the cause of this pattern is that wind-driven waves in the shallower parts and edges of the pond left the bones in this arrangement.

The evidence seems to indicate that the fauna of Quarry 8 lived in or around an ephemeral pond. As the shoreline fluctuated, animals that died on the shore could be swept into the pond. Conversely, if the pond stayed dried up too long, animals living in it might have died, with their bones later (with the return of water) moved into the patterns seen on the quarry maps by wind-driven waves. Animals that died regularly in the pond would sink to the bottom and, if this was a shallow area of the pond, be moved by wind-driven waves into the patchy and sometimes scattered distribution of Quarry 8. Burial would happen over time as more sediment was added to the pond. The MNI in Quarry 8 also most likely represents animals that died at various times and does not represent a single catastrophic death assemblage.

CHAPTER 5

CONCLUSION

The Morrison Formation of Cimarron County, Oklahoma has a fauna similar to that of the Morrison Formation elsewhere (Tables 1, 2, 3, and 4). The sedimentology and stratigraphy in Cimarron County are similar to those of the Brushy Basin Member of the Morrison Formation farther west, with the same varicolored "jointed clays" that are the most widely recognized characteristics of the Morrison Formation. The three quarries studied in Oklahoma also represent depositional environments (floodplains and ponds) that were previously known from the Morrison Formation in other parts of the country.

It was possible to make reasonable associations of different skeletal parts as belonging to single individuals in each of the three quarries studied (Appendix C). The distribution of fossils within each of the quarries was patchy. Many of these patches contain numerous skeletal elements belonging to the same taxa and were therefore interpreted as belonging to the same individual. The distribution was less clumped in Quarry 6 than in quarries 5 and 8, but it was still possible to associate some skeletal elements within Quarry 6. The information about which fossils can be associated with one another will be important to future studies on the specimens from Cimarron County, Oklahoma. There is still not a mountable skeleton of any one individual, but knowing which skeletal elements are from one individual will allow them to be studied as such.

The ability to associate different bones on the quarry maps led to a reevaluation of numerous bones in the OMNH Collection (Appendix A). Fossils that were not originally identified as completely as others were reexamined in light of their quarry placement and re-identification or identification to a finer taxonomic level was possible in some instances. This will be very valuable to researchers in the future.

The distributional patterns of bone on the quarry maps, the relative ease with which fossil associations could be made, and the number of elements that were articulated are related to the depositional environments of each quarry. Quarry 5 and Quarry 6 are interpreted to represent floodplains, but bones in Quarry 6 were affected by water transport with stronger energy and hence show more bone scattering and fragmentation than those of Quarry 5. Quarry 5 was also affected by transport (presumably due to episodic floods), but appears to have been farther from the river than Quarry 6. For this reason, there is less evidence of hydraulic sorting in Quarry 5 (evidence is mainly seen in the *Camarasaurus* material) and the majority of the bones appears to have been preserved approximately where the respective animals died. Quarry 8 shows arch-like patterns to the bone scatter. In conjunction with the strongly aquatic fauna, this suggests that the bones are distributed mainly near the margin of a pond where they would be affected by wind-driven waves.

LITERATURE CITED

Ash, S. R. and Tidwell, W. D. 1998. Plant megafossils from the Brushy Basin Member of the Morrison Formation near Montezuma Creak Trading Post, southeastern Utah, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 321-339.

Apesteguia, Sebastian. 2005. Evolution of the titanosaur metacarpus, *in* Tidwell, V. and Carpenter, K. (eds.), Thunder-Lizards: The Sauropodomorph Dinosaurs, Indiana University Press, p. 321-345.

Barnes, F. A., 1988, Canyonlands National Park Early History and First Descriptions, Canyon Country Publications, Moab, Utah, 160 p.

Bedell, M. W. Jr. and Trexler, D. L. 2005. First articulated manus of *Diplodocus carnegii*, *in* Tidwell, V. and Carpenter, K. (eds.), Thunder-Lizards: The Sauropodomorph Dinosaurs, Indiana University Press, Bloomington, p. 302-320.

Behrensmeyer, A. K. and Hill, A. P (eds.) 1980. Fossils in the Making: Vertebrate Taphonomy and Paleoecology, University of Chicago Press, Chicago, 338pp.

Benton, M. J. 2005. Vertebrate Paleontology 3rd edition, Blackwell Publishing, Massachusetts, p.67-70.

Bonnan, M. F. and Wedel. M. J. 2004. First occurrence of *Brachiosaurus* (Dinosauria: Sauropoda) from the Upper Jurassic Morrison Formation of Oklahoma: PaleoBios, v. 24, p. 13–21.

Camp, C. L., Welles, S. P., and Green M. 1953. Bibliography of fossil vertebrates 1944-1948: Geological Society of America Memoir, v. 57, 465pp.

Carpenter, K. and Alf, K. 1994. Global distribution of dinosaur eggs, nests, and babies, *in* Carpenter, K., Hirsch, K. F., Horner, J. R. (eds.), Dinosaur Eggs and Babies, Cambridge University Press, Cambridge, p. 15-30.

Carpenter, K and McIntosh, J. 1994. Upper Jurassic sauropod babies from the Morrison Formation, *in* Carpenter, K., Hirsch, K. F., Horner, J. R. (eds.), Dinosaur Eggs and Babies, Cambridge University Press, Cambridge, p. 265-278.

Carter, W. D. and Gualtieri, J. L. 1965. Geology and Uranium-Vanadium deposits of the La Sal Quadrangle, San Juan County, Utah, and Montrose County, Colorado: United States Geological Survey Professional Paper 508, p. 1-82.

Chure, D. J. 1995. A reassessment of the gigantic theropod *Saurophagus maximus* from the Morrison Formation (Upper Jurassic) of Oklahoma, USA, *in* Sun, A. and Wang, Y. (eds.), Sixth Symposium on Mesozoic Terrestrial Ecosystems and Biota, China Ocean Press, Beijing, p. 103–106.

Chure, D. J. 2000. A new species of *Allosaurus* from the Morrison Formation of Dinosaur National Monument (UT-CO) and a revision of the theropod family Allosauridae. Ph.D. Dissertation, Columbia University, New York.

Chure, D. J. and McIntosh, J. S. 1989. A Bibliography of the Dinosauria (exclusive of the Aves): Museum of Western Colorado Paleontology Series, n. 1, 226 pp.

Chure, D. J., Carpenter, K., Litwin, R. J., Hasiotis, S. T., and Evanoff, E. 1998. Appendix, the fauna and flora of the Morrison Formation, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 23, p. 507-537.

Colbert, E. H. 1961. Dinosaurs: Their Discovery and Their World. Dutton, New York, 300pp.

Cross, C. W. 1894. Pike's Peak Colorado: Geological Atlas Folio 1894, United States Geological Survey, 8 pp.

Currie, B. S. 1997. Sequence stratigraphy of nonmarine Jurassic-Cretaceous rocks, central Cordilleran foreland-basin system: Geologic Society of America Bulletin, v. 109, p. 1206-1222.

Currie, B. S. 1998. Upper Jurassic–Lower Cretaceous Morrison and Cedar Mountain Formations, NE Utah–NW Colorado: relationships between nonmarine deposition and early Cordilleran foreland basin development: Journal of Sedimentary Research, v. 68, p. 632–652.

Currie, P. J. and Padian, K. 1997. Encyclopedia of Dinosaurs, Academic Press, New York, p. 184, 185, 451, 515, 756.

Czaplewski, N. J., Cifelli, R. L. and Langston, W. Jr. 1994. Catalog of type and figured fossil vertebrates, Oklahoma Museum of Natural History. Oklahoma Geological Survey Special Publication, v. 94-1, 35 pp.

DeCelles, P. G. 2004. Late Jurassic to Eocene evolution of the Cordilleran Thrust belt and foreland basin system, western USA: American Journal of Science, v. 304, p. 105-168.

DeCelles, P. G. and Currie, B. S.1996. Long-term sediment accumulation in the Middle Jurassic–early Eocene Cordilleran retroarc foreland-basin system: Geology, v. 24, p. 591–594.

Demko, T. M. and Parrish, J. T. 1998. Paleoclimatic setting of the Upper Jurassic Morrison Formation, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 283-296.

Demko T.M., Currie, B.S., and Nicoll, K.A. 2004. Regional paleoclimatic and stratigraphic implications of paleosols and fluvial/overbank architecture in the Morrison Formation (Upper Jurassic), Western Interior, USA: Sedimentary Geology, v. 167, p. 115-135.

Derr, M. E. 1974. Sedimentology structure and depositional environment of paleochannels in the Jurassic Morrison Formation near Green River, Utah: Brigham Young University Geology Studies, v. 21, p. 3-39.

Dilek, Y. and Moores, E. M. 1995. Geology of the Humboldt Igneous Complex, Nevada, and tectonic implications for the Jurassic magmatism in the Cordilleran Orogen, *in* Miller, D. M., Busby, C. (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera. Special Papers, Geological Society of America, v. 299, p. 229-248.

Dodson, P., Behrensmeyer, A. K., Bakker, R. T., and McIntosh, J. S. 1980. Taphonomy and paleoecology of the dinosaur beds of the Jurassic Morrison Formation: Paleobiology, v. 6, p. 208-232.

Dunagan, S. P. 1999. A North American freshwater sponge (*Eospongilla morrisonensis* new genus and species) from the Morrison Formation (Upper Jurassic), Colorado: Journal of Paleontology, v. 73, p. 389-393.

Dunagan, S. P. 2000. Constraining Late Jurassic paleoclimate within the Morrison paleoecosystem: Insights from the continental carbonate record of the Morrison Formation (Colorado, USA), *in* Hall, R. L. and Smith, P. L. (Eds.), Advances in Jurassic Research 2000: GeoResearch Forum, v. 6 Trans Tech Publications, Switzerland, p. 523-532.

Dunagan, S. P. and Turner, C. E. 2004. Regional paleohydrologic and paleoclimatic settings of wetland/lacustrine depositional systems in the Morrison Formation (Upper Jurassic), Western Interior, USA: Sedimentary Geology, v. 167. p. 269-296.

Efremov, I. A. 1940. Taphonomy: A new branch of paleontology. Pan-American Geologist, v. 74, p. 81-93.

Elison, M. W. 1995. Causes and consequences of Jurassic magmatism in the Northern Great Basin: implications for tectonic development, *in* Miller, D. M., Busby, C. (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera. Special Papers, Geological Society of America, v. 299, p. 249-265.

Emmons, S. F., Cross, C. W., and Eldridge, G. H. 1896. Geology of the Denver Basin in Colorado: U.S. Geologic Survey Mon. 27, p. 60-63.

Engelmann, G. F. and Fiorillo, A. R. 2000. The taphonomy and paleoecology of the Upper Jurassic Morrison Formation determined from a field study of fossil locations, *in* Hall, R. L. and Smith, P. L. (eds.), Advances in Jurassic Research 2000: GeoResearch Forum, v. 6 Trans Tech Publications, Switzerland, p. 533-540.

Engelmann, G.F., Chure, D.J., and Fiorillo, A.R. 2004. The implications of a dry climate for the paleoecology of the fauna of the Upper Jurassic Morrison Formation: Sedimentary Geology, v. 167, p. 297-308.

Foster, J. R. 1998. Aspects of vertebrate paleoecology, taphonomy, and biostratigraphy of the Morrison Formation (Upper Jurassic), Rocky Mountain Region, Western United States. PhD. Dissertation. University of Colorado, Boulder.

Foster, J. 2007. Jurassic West: The Dinosaurs of the Morrison Formation and Their World. Indiana University Press, Bloomington, Indiana, 389pp.

Foster, J. R., Hamblin, A. H., and Lockley, M. G. 2000. The oldest evidence of a sauropod dinosaur in the western United States and other important vertebrate trackways from Grand Staircase-Escalante National Monument, Utah: Ichnos, v. 7, p. 169-181.

Gillette, D. D., 1996a. Origin and early evolution of the sauropod dinosaurs of North America: the type locality and stratigraphic position of *Dystrophaeus viaemalae* Cope 1877, *in* Huffman, A.C., Lund, W.R., and Godwin, L.H., (eds.), Geology and Resources of the Paradox Basin, Utah Geological Association Guidebook 25, p. 313-324.

Gillette, D. D., 1996b. Stratigraphic position of the sauropod *Dystrophaeus viaemalae* Cope and its evolutionary implications, *in* Morales, Michael, (ed.), The Continental Jurassic, Museum of Northern Arizona Bulletin 60, p. 59-68.

Gilmore, C. W. 1925. A nearly complete articulated skeleton of *Camarasaurus*, a saurischian dinosaur from the Dinosaur National Monument: Memoirs of the Carnegie Museum, v. 10, p. 347-384.

Gilmore, C. W. 1936. Osteology of *Apatosaurus*, with special reference to specimens in the Carnegie Museum: Memoirs of the Carnegie Museum, v. 11, p. 175-271.

Gould, C. N. 1905. Geology and water resources of Oklahoma: U.S. Geological Survey Water-Supply Paper 148, 178pp.

Good, S. C. 2004. Paleoenvironmental and paleoclimatic significance of freshwater bivalves in the Upper Jurassic Morrison Formation, Western Interior, USA: Sedimentary Geology, v. 167, p. 163-176.

Hallam, A. 1994. Jurassic climates as inferred from the sedimentary and fossil record, *in* Allen, J. R. L., Hoskins, B. J., Sellwood, B. W., Spicer, R. A., and Valdes, P. J., (eds.), Paleoclimates and their modeling with special reference to the Mesozoic Era: Chapman and Hall, London, p. 79-88.

Hasiotis, S. T. 2004. Reconnaissance of Upper Jurassic Morrison Formation ichnofossils, Rocky Mountain Region, USA: paleoenvironmental, stratigraphic, and paleoclimatic significance of terrestrial and freshwater ichnocoenoses: Sedimentary Geology, v. 167, p. 177-268.

Hasiotis, S. T. and Demko, TM. 1996. Terrestrial and freshwater trace fossils, Upper Jurassic Morrison Formation, Colorado Plateau, *in* Morales, Michael, (ed.), The Continental Jurassic, Museum of Northern Arizona Bulletin 60, p. 355-370.

Hasiotis, S. T., Kirkland, J. I., Callison, G. 1998. Crayfish fossils and burrows from the Upper Jurassic Morrison Formation of western Colorado, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers,
v. 22, p. 481-491.

Hatcher, J. B. 1901. *Diplodocus* (Marsh): Its osteology, taxonomy, and probable habits, with a restoration of the skeleton: Memoirs of the Carnegie Museum, v. 1, p.1-63.

Hatcher, J. B. 1902. Structure of the fore limb and manus of *Brontosaurus*: Annals of the Carnegie Museum, v. 1, p. 356-376.

Hatcher, J. B. 1903. Osteology of *Haplocanthosaurus*, with descriptions of a new species, and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus Beds: Memoirs of the Carnegie Museum, v. 2, p. 1-75.

Hattin, D. E. 1986. Carbonate substrates of the Late Cretaceous sea, Central Great Plains and southern Rocky Mountains: Palaios, v. 1, p. 347-367.

Hunt, A. P. and Lucas, S. G. 1987. J. W. Stovall and the Mesozoic of the Cimarron Valley, Oklahoma and New Mexico: New Mexico Geological Society Guidebook, 38th Field Conference, Northern New Mexico, p. 139-151.

Ikejiri, T., Tidwell, V., and Trexler, D. 2005. New adult specimens of *Camarasaurus lentus* highlight ontogenetic variation within the species, *in* Tidwell, V. and Carpenter, K. (eds.), Thunder-Lizards: The Sauropodomorph Dinosaurs, Indiana University Press, p. 154-179.

Jennings, D. S. and Hasiotis, S. T. 2006. Taphonomic analysis of a dinosaur feeding site using Geographic Information Systems (GIS), Morrison Formation, Southern Bighorn Basin, Wyoming, USA: Palaios, v. 21, p. 480-492.

Kay, M. A. 1995. Metamorphism in the Northern Klamath Mountains, Oregon, *in* Miller, D. M., Busby, C. (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera. Special Papers, Geological Society of America, v. 299, p. 173-190.

Kirkland, J. I. 1998. Morrison fishes, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 503-533.

Kowallis, B. J. et al. 1998. The age of the Morrison Formation, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 235-260.

Langston, W. Jr. 1989. A History of Vertebrate Paleontology at the University of Oklahoma, *unpublished report:* held by the Sam Noble Oklahoma Museum of Natural History, Norman, 107 pp.

Larsen, J. 2007. Morphology and relationships of a small-medium theropod dinosaur from the Morrison Formation (Kimmeridgian-Tithonian), Cimarron County, Oklahoma. M.S. Thesis, University of Oklahoma, Norman.

Lawton, T. F. 1994. Tectonic setting of Mesozoic sedimentary basin, Rocky Mountain region, United States, *in* Caputo, M. V., Peterson, J. S., and Franczyk, K. J. (eds.), Mesozoic Systems of the Rocky Mountain Region, USA: Rocky Mountain Section Society for Sedimentary Geology, Denver, p. 1–25.

Lee, W. T. 1902. The Morrison shales of southern Colorado and northern New Mexico: Journal of Geology, v. 10, p. 36-58.

Litwin, R. J., Turner, C. E., and Peterson, F. 1998. Palynological evidence on the age of the Morrison Formation, Western Interior, U.S.: a preliminary report, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 297-320.

Mack, G. H., James, W. C., Monger, H. C., 1993, Classification of paleosols, Geological Society of America Bulletin, v. 105, p. 129-136.

Madsen, J. H. Jr. 1976. *Allosaurus fragilis*: A revised osteology: Utah Geological Survey Bulletin 109, 163 pp.
Madsen, J. H. Jr., McIntosh, J. S., and Berman, D. S. 1995. Skull and atlas-axis complex of the Upper Jurassic sauropod *Camarasaurus* Cope (Reptilia: Saurischia): Bulletin of the Carnegie Museum of Natural History, 31, 115 pp.

Madsen, J. H. Jr. and Welles, S. P. 2000. *Ceratosaurus* (Dinosauria, Theropoda): A revised osteology: Utah Geological Survey Miscellaneous Publication 00-2, 80 pp.

Marsh, O. C. 1896. The dinosaurs of North America: United States Geological Survey, 16th Annual Report, 1894-95, v. 55, p. 133-910.

Martin, G. H., James, W. C., and Monger, H. C. 1993. Classification of paleosols: Geological Society of America Bulletin, v. 105, p. 129-136.

Martin, R. E. 1999. Taphonomy: A Process Approach, Cambridge University Press, Cambridge, 524pp.

McIntosh, J. S. 2005. The genus *Barosaurus* Marsh (Sauropoda, Diplodocidae), *in* Tidwell, V. and Carpenter, K. (eds.), Thunder-Lizards: The Sauropodomorph Dinosaurs, Indiana University Press, p. 38-77.

McKee, E. D., Oriel, S. S., Swanson, V. E., MacLachlan, M. E., MacLachlan, J. C., Ketner, K. B., et al. 1956. Paleotectonic maps of the Jurassic system: U.S. Geological Survey Miscellaneous Investigations Map I-175, scale 1:5000000.

Mook, C. C. 1915. Origin and distribution of the Morrison Formation: Bulletin of the Geological Society of America, v. 26, p. 315-322.

Mook, C. C. 1916. A study of the Morrison Formation; Annals of the New York Academy of Sciences, v. 27, p. 39-191.

Mook, C. C. 1964. New species of *Goniopholis* from the Morrison of Oklahoma: Oklahoma Geology Notes, Oklahoma Geological Survey, The University of Oklahoma, Norman, OK, v. 24, p. 283-287.

Moore, G. T., Hayashida, D. N., Ross, C. A., and Jacobson, S. R. 1992. Paleoclimate of the Kimmeridgian/Tithonian (Late Jurassic) world: I. Results using a general circulation model: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 93, p. 113-150.

Murphy, D. C., van der Hayden, P., Parrish, R. R., Klepacki, D. W., McMillian, W., Struik, L. C., and Gabites, J. 1995. New geochronological constraints on Jurassic deformation of the western edge of North America, Southeastern Canadian Cordillera, *in* Miller, D. M., Busby, C. (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera. Special Papers, Geological Society of America, v. 299, p. 159-171.

Olsen, E. C. 1980. Taphonomy: Its history and role in community evolution, *in* Behrensmeyer, A. K. and Hill, A. P (eds.), Fossils in the Making: Vertebrate Taphonomy and Paleoecology, University of Chicago Press, Chicago, p. 5-19.

Osborn, H. F. 1915. Close of Jurassic and opening of Cretaceous time in North America: Bulletin of the Geological Society of America, v. 26, p. 295-302.

Peterson, F. 1988. Pennsylvanian to Jurassic eolian transportation systems in the western United States: Sedimentary Geology, v. 56, p. 207-260.

Peterson, F. 1994. Sand dunes, sabkhas, streams, and shallow seas: Jurassic Paleogeography in the southern part of the Western Interior Basin, in Caputo, M. V., Peterson, J. A., Franczyk, K. J. (eds.), Mesozoic Systems of the Rocky Mountain Region USA: Rocky Mountain Section Society for Sedimentary Geology, Denver, p. 233-272.

Peterson, F. and Turner-Peterson, C. E. 1987. The Morrison Formation of the Colorado Plateau: recent advances in sedimentology, stratigraphy, and paleotectonics: Hunteria, v. 2, p. 1-18.

Parrish, J. T. and Peterson, F. 1988. Wind direction predicted from global circulation models and wind directions determined from eolian sandstones of the western United States- A comparison: Sedimentary Geology, v. 167, p.139-164.

Parrish, J. T., Peterson, F., and Turner, C. E. 2004. Jurassic "savannah"-plant taphonomy and climate of the Morrison Formation (Upper Jurassic, Western USA): Sedimentary Geology, v. 167, p. 137-162.

Ray, G. R. 1941. Big for his day: Natural History Magazine, v. 48, p. 36-39.

Rees, P. M., Noto, C. R., Parrish, J. M., and Parrish J. T. 2004. Late Jurassic climates, vegetation, and dinosaur distributions: Journal of Geology, v. 112, p. 643-653.

Roca, X. and Nadon, G. C. 2007. Tectonic control on the sequence stratigraphy of nonmarine retroarc foreland basin fills: insights from the Upper Jurassic of central Utah, USA: Journal of Sedimentary Research, v. 77, p. 239-255.

Rothrock, E. P. 1925. Geology of Cimarron County Oklahoma: Oklahoma Geological Survey Bulletin, 34, p. 7-92.

Santos, E. S. and Turner-Peterson, C. E. 1986. Tectonic setting of the San Juan Basin in the Jurassic, *in* Turner-Peterson, C. E., Santos, E. S., and Fisherman, N. S. (eds.), A Basin Analysis Case Study: The Morrison Formation, Grants Uranium Region, New Mexico: American Association of Petroleum Geologists, Studies in Geology 22, p. 27-34.

Schoff, S. L. 1943. Geology and Ground Water Resources of Cimarron County, Oklahoma: Oklahoma Geological Survey Bulletin, v. 64, 317 pp.

Schudack, M. E. 1999. Ostracoda (marine/ nonmarine) and paleoclimate history in the Upper Jurassic of Central Europe and North America: Marine Micropaleontology, v. 37, p. 273-288.

Schudack, M. E., Turner, C. E., and Peterson, F. 1998. Biostratigraphy, paleoecology, and biogeography of charophytes and ostracods from the Upper Jurassic Morrison Formation, Western Interior, USA, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 379-414.

Shipman, P. 1981. Life History of a Fossil: An Introduction to Taphonomy and Paleoecology, Harvard University Press, Cambridge, 232 pp.

Stokes, W. L. 1944. Morrison Formation and related deposits in and adjacent to the Colorado Plateau: Bulletin of the Geological Society of America, v. 55, p. 951-992.

Stovall, J. W. 1932. The Jurassic in Oklahoma: Science, v. 76, p. 122-123.

Stovall, J. W. 1937. Advanced notes on the geology of Cimarron Valley of western Oklahoma: Proceedings of the Oklahoma Academy of Science, v. 17, p. 78-79

Stovall, J. W. 1938. The Morrison of Oklahoma and its dinosaurs: Journal of Geology, v 46, p. 583-600.

Stovall, J. W. 1943. Stratigraphy of the Cimarron Valley (Mesozoic Rocks), *in* Schoff, S. L., Geology and Ground Water Resources of Cimarron County, Oklahoma: Oklahoma Geological Survey Bulletin, v. 64, p. 43-132.

Thorkelson, D. J., Mortensen, J. K., Marsden, H., and Taylor, R. P. 1995. Age and tectonic setting of Early Jurassic episodic volcanism along the northeastern margin of the Hazelton Trough, northern British Columbia, *in* Miller, D. M., Busby, C. (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera. Special Papers, Geological Society of America, v. 299, p. 83-94.

Tidwell, W. D., Britt, B. B. and Ash, S. R. 1998. Preliminary floral analysis of the Mygatt-Moore Quarry in the Jurassic Morrison Formation, west-central Colorado, *in* Carpenter, K., Chure, D., and Kirkland, J. I. (eds.), Modern Geology: The Upper Jurassic Morrison Formation: an Interdisciplinary Study, Gordon and Breach Science Publishers, v. 22, p. 340-378.

Turner, C. E. and Peterson, F. 2004. Reconstruction of the Upper Jurassic Morrison Formation extinct ecosystem- a synthesis: Sedimentary Geology, v. 167, p. 309-355.

Tyler, N. and Ethridge, F. G. 1983. Depositional setting of the Salt Wash Member of the Morrison Formation, southwest Colorado: Journal of Sedimentary Petrology, v. 53, p. 67-82.

Ward, P. L. 1995. Subduction cycles under western North America during the Mesozoic and Cenozoic Eras, *in* Miller, D. M., Busby, C. (eds.), Jurassic Magmatism and Tectonics of the North American Cordillera. Special Papers, Geological Society of America, v. 299, p. 1-45.

Wedel, M.J., and Sanders, R. K. 1998. Using computed tomography to investigate sauropod cervical morphology. Journal of Vertebrate Paleontology, v.18p. 85A.

Weishampel, D. B., Dodson, P., and Osmólska, H. (eds.). 2004. The Dinosauria. University of California Press, Berkley and Los Angeles, 861 pp.

West, E. S. 1978. Biostratigraphy and paleoecology of the Lower Morrison Formation of Cimarron County, Oklahoma. M.S. Thesis, Wichita State University, Wichita, Kansas.

Table 1: List of Morrison Formation vertebrate genera[1] (modified from Foster, 2007)

* ichnotaxa

- **Fish**
  - **Actinopterygii**
    - *Morrolepis*
    - *Hulettia*
    - Amiiformes
    - Pycnodontoidea
    - cf. *Leptolepis*
    - Actinopterygii indet.
  - **Sarcopterygii**
    - *Ceratodus*
- **Amphibians**
  - **Anura (Frogs)**
    - *Enneabatrachus*
    - *Rhadinosteus*
    - Pelobatidae
    - Anura indet.
  - **Caudata (Salamanders)**
    - *Iridotriton*
    - Caudata indet.
- **Reptilia**
  - **Chelonia (Turtles)**
    - *Glyptops*
    - *Dinochelys*
    - *Uluops*
    - *Dorsetochelys*
    - Chelonia indet.
  - **Sphenodontia**
    - *Opisthias*
    - *Theretairus*
    - *Eilenodon*
    - Sphenodontia indet.
  - **Squamata (Lizards)**
    - *Dorsetisaurus*
    - *Parviraptor*
    - *Paramacellodus*
    - *Saurillodon*
    - *Schilleria*
    - Squamata indet.
  - **Choristodera**
    - *Cteniogenys*
- **Crocodylia**
  - *Hallopus*
  - *"Fruitachampsa"*
  - *Goniopholis*
  - *Eutretauranosuchus*
  - *Macelognathus*
  - *Hoplosuchus*
- **Pterosauria**
  - **Dermodactylus*
  - **Mesadactylus*
  - **Kepodactylus*
  - **Comodactylus*
  - **Harpactognathus*
  - **Utahdactylus*
  - *Pterosauria indet.
- **Dinosauria**
  - **Theropoda**
    - *Allosaurus*
    - *Ceratosaurus*
    - *Saurophaganax*
    - *Torvosaurus*
    - *Marshosaurus*
    - *Stokesosaurus*
    - *Ornitholestes*
    - *Coelurus*
    - *Tanycolagreus*
    - *Elaphrosaurus*
    - *Koparion*
  - **Sauropoda**
    - *Brachiosaurus*
    - *Camarasaurus*
    - *Haplocanthosaurus*
    - *Diplodocus*
    - *Barosaurus*
    - *Apatosaurus*
    - *Supersaurus*
    - *Seismosaurus*
    - *Dystrophaeus*
    - *Amphicoelias*

- **Thyreophora**
  - **Stegosauria**
    - *Stegosaurus*
    - *Hesperosaurus*
  - **Ankylosauria**
    - *Mymoorapelta*
    - *Gargoyleosaurus*
    - Ankylosauria indet.
- **Ornithopoda**
  - Cf. *Echinodon*
  - *Othnielosaurus*
  - *Drinker*
  - *Dryosaurus*
  - *Camptosaurus*

- **Mammalia**
  - *Docodon*
  - *Fruitafossor*
  - *Ctenacodon*
  - *Psalodon*
  - *Glirodon*
  - *Zofiabaatar*
  - *Triconolestes*
  - *Aploconodon*
  - *Comodon*
  - *Priacodon*
  - *Trioracodon*
  - *Amphidon*
  - *Tinodon*
  - *Araeodon*
  - *Archaeotrigon*
  - *Euthlastus*
  - *Paurodon*
  - *Comotherium*
  - *Tathiodon*
  - *Foxraptor*
  - *Laolestes*
  - *Dryolestes*
  - *Amblotherium*

[1] This is only a generic list. Species level identification is known for many of these genera.

Table 2: Faunal list of vertebrates found in Quarry 5 (OMNH locality V94), Cimarron County, Oklahoma

- **Archosauria**
  - Archosauria indet.
  - **Dinosauria**
    - **Saurischia**
      - Saurischia indet.
      - **Theropoda**
        - Theropoda indet.
        - **Ceratosauridae**
          - *Ceratosaurus* sp.[2]
        - **Allosauridae**
          - *Saurophaganax maximus*
      - **Sauropoda**
        - Sauropoda indet.
        - **Diplodocidae**
          - *Apatosaurus* sp.
          - **Diplodocus* sp.
          - Diplodocidae indet.
        - **Camarasauridae**
          - *Camarasaurus* sp.
    - **Ornithiscia**
      - **Ornithopoda**
        - **Camptosauridae**
          - *Camptosaurus* sp.
      - **Thyreophora**
        - **Stegosauridae**
          - *Stegosaurus* sp.

---

[2] Represented by a single tooth.

* includes material originally referred to *Barosaurus* sp.

Table 3: Faunal list of vertebrates found in Quarry 6 (OMNH locality V95), Cimarron County, Oklahoma

- **Archosauria**
  - Archosauria indet.
  - **Dinosauria**
    - **Saurischia**
      - **Theropoda**
        - Theropoda indet.
        - **Allosauridae**
          - *Saurophaganax maximus*
      - **Sauropoda**
        - Sauropoda indet.
        - **Diplodocidae**
          - *Apatosaurus* sp.
          - *Diplodocus* sp.
          - Diplodocidae indet.
        - **Camarasauridae**
          - *Camarasaurus* sp.
    - **Ornithiscia**
      - **Ornithopoda**
        - **Camptosauridae**
          - *Camptosaurus* sp.
      - **Thyreophora**
        - **Stegosauridae**
          - *Stegosaurus* sp.

---

* includes material originally referred to *Barosaurus* sp.

Table 4: Faunal list of vertebrates found in Quarry 8 (OMNH locality V97), Cimarron County, Oklahoma

- **Osteichthyes**
  - Osteichthyes indet.
  - **Actinopterygii**
    - Amiiformes
      - Amiiformes, indet.
  - **Sarcopterygii**
    - **Dipnoi**
      - *Ceratodus* sp.
      - *Ceratodus frazieri?*
      - *Ceratodus guentheri*
- **Reptilia**
  - Reptilia indet.
  - **Chelonia**
    - *Glyptops* sp.
    - Chelonia indet.
  - **Archosauria**
    - Archosauria indet.
    - **Crocodylia**
      - *Goniopholis stovalli*
      - Crocodylia indet.
    - **Dinosauria**
      - **Saurischia**
        - **Theropoda**
          - Theropoda indet.
            - Tetanurae indet.
      - **Ornithischia**
        - **Ornithopoda**
          - **Camptosauridae**
            - *Camptosaurus* sp.

Table 5: MNI counts for Quarry 5

Camarasaurus	**2 adults**
	1 subadult
Apatosaurus	**1**
“*Barosaurus*”[3]	**1 regular size**
	1 extra large
Diplodocus	**2 adult**
	1 subadult
unidentified sauropods	**2 adults**
	1 juvenile
Stegosaurus	**1**
Camptosaurus	**1 subadult**
Saurophaganax maximus	**1**
Ceratosaurus	**1**
unidentified archosaurs	**1**
unidentified theropods	**1**

Total= 18 (4 are juveniles to subadults)

---

[3] These specimens are currently referred to Diplodocus; Barosaurus identification is retained to reflect MNI count before the identification of specimens was revised. For a discussion of the revised MNI count see section Revised MNI Counts.

Table 6: MNI counts for Quarry 6

Camarasaurus	**1**
Apatosaurus	**1**
"*Barosaurus*"[3]	**1**
Diplodocus	**1**
Stegosaurus	**1**
Camptosaurus	**1**
Saurophaganax maximus	**1 adult**
	1 juvenile
unidentified archosaurs	**1**
	Total=9 (1 is a juvenile)

---

[3] These specimens are currently referred to *Diplodocus*; *Barosaurus* identification is retained to reflect MNI count before the identification of specimens was revised. For a discussion of the revised MNI count see section Revised MNI Counts.

Table 7: MNI counts for Quarry 8

Amiiformes **1**

Ceratodus frazieri? **1**

Ceratodus guentheri **1**

unidentified archosaurs **1**

unidentified theropods **1**

unidentified tetanuran **1**

Chelonia **3**

Glyptops **1**

Crocodylia **1**

Goniopholis stovalli **5**

Camptosaurus **2**

Total=18

Figure 1: Distribution of the Morrison Formation in the western U.S. and the location of the Kenton dinosaur quarries in the NW tip of OK (modified from Turner and Peterson 2004)

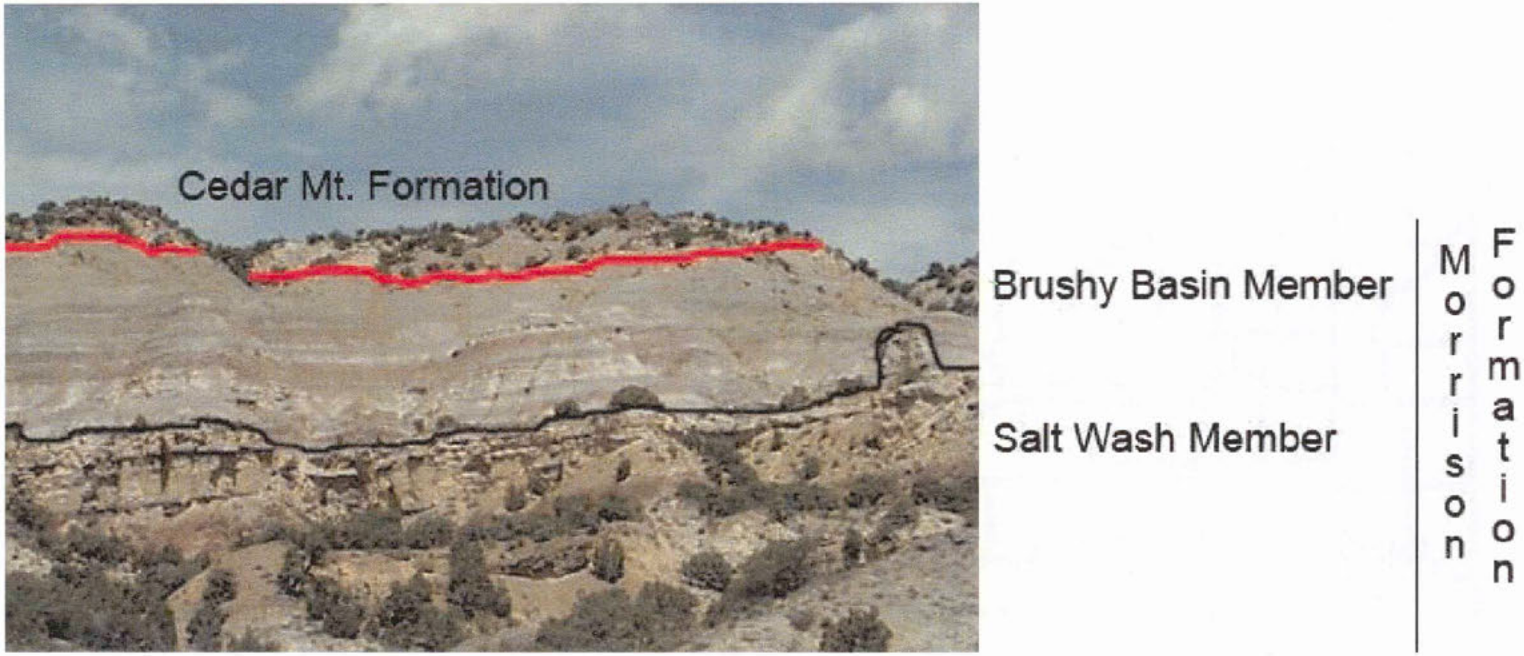


Figure 2: Typical outcrop of the Morrison Formation with the multicolored mudstones of the Brushy Basin Member overlying the sandstones of the Salt Wash Member, as exposed in the Blue Mountains near Dinosaur National Monument, Utah. In this area the Morrison is capped by the Cedar Mountain Formation, shown in the photo above the red line (modified from www.dinoruss.com/utah2kweb/blue_mt_morrison.html)

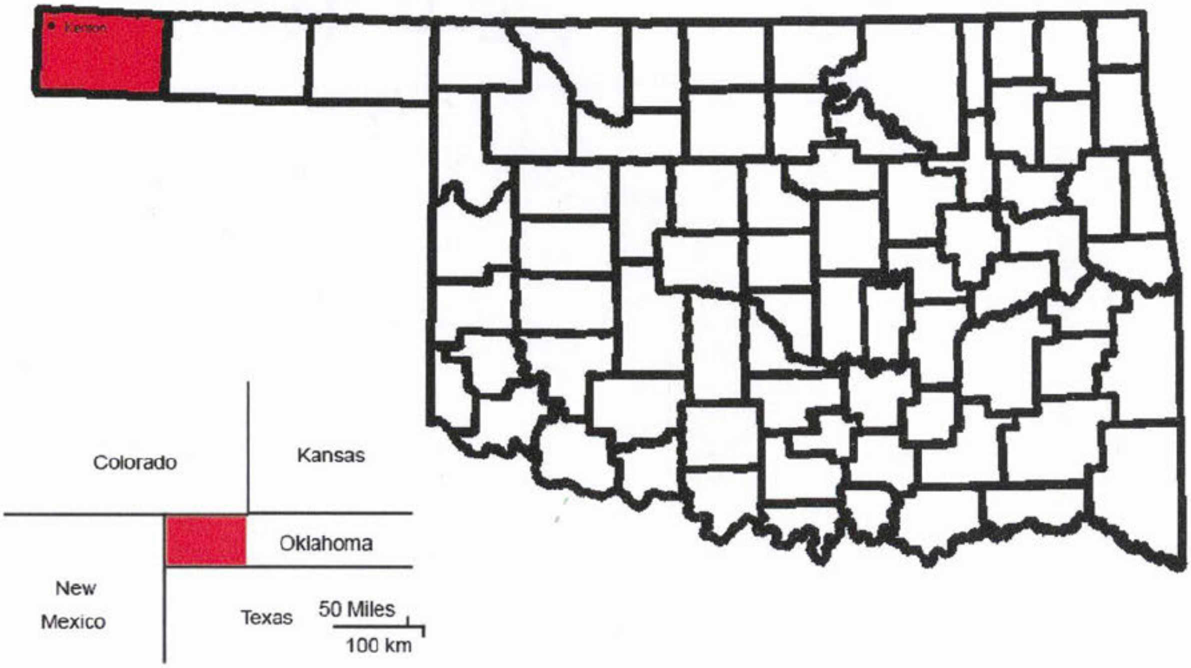


Figure 3: Map of Oklahoma with Cimarron County in red and the town of Kenton marked; small index map shows its relationship to other states (modified from www-nrd.nhtsa.dot.gov)

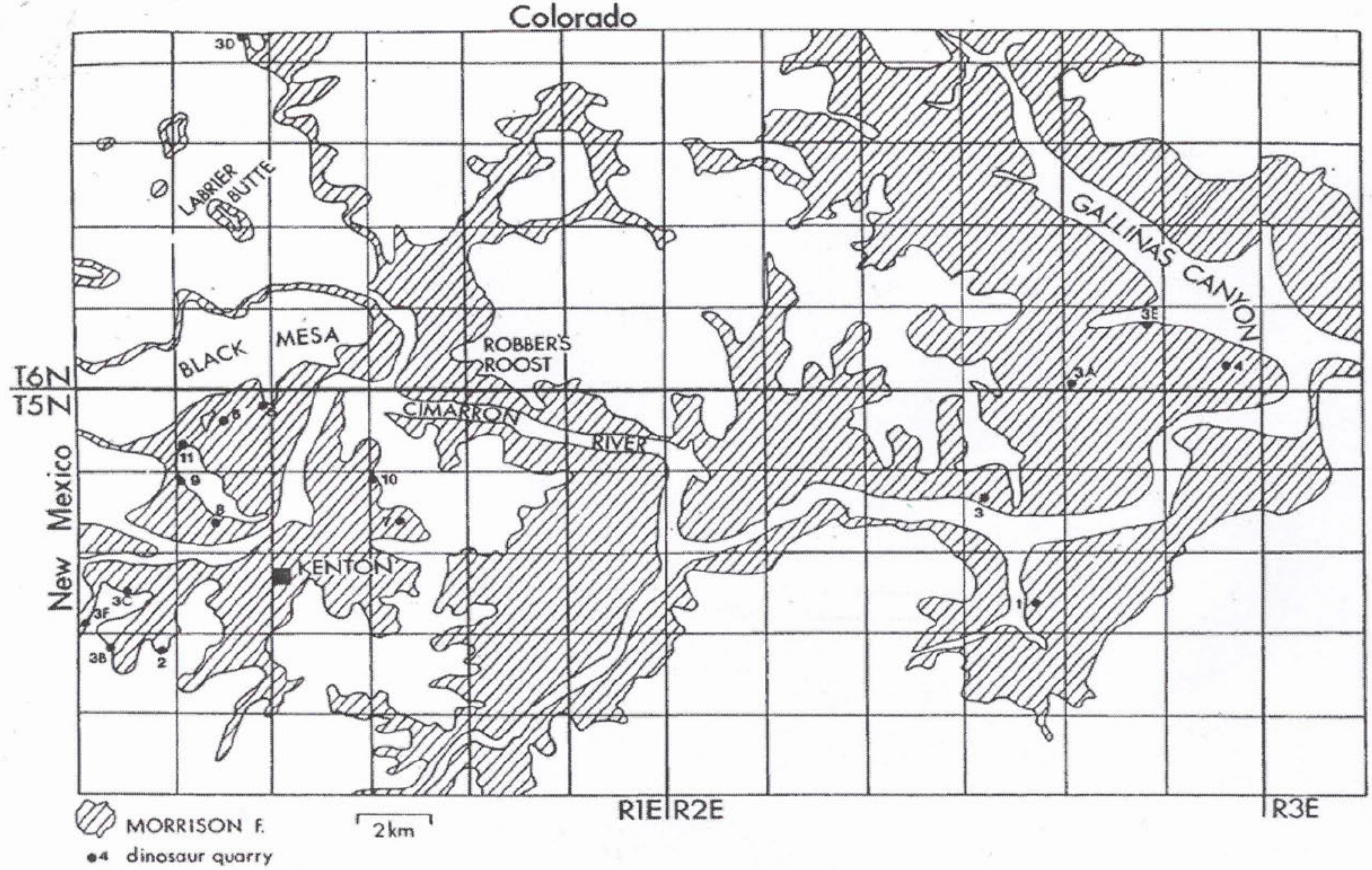
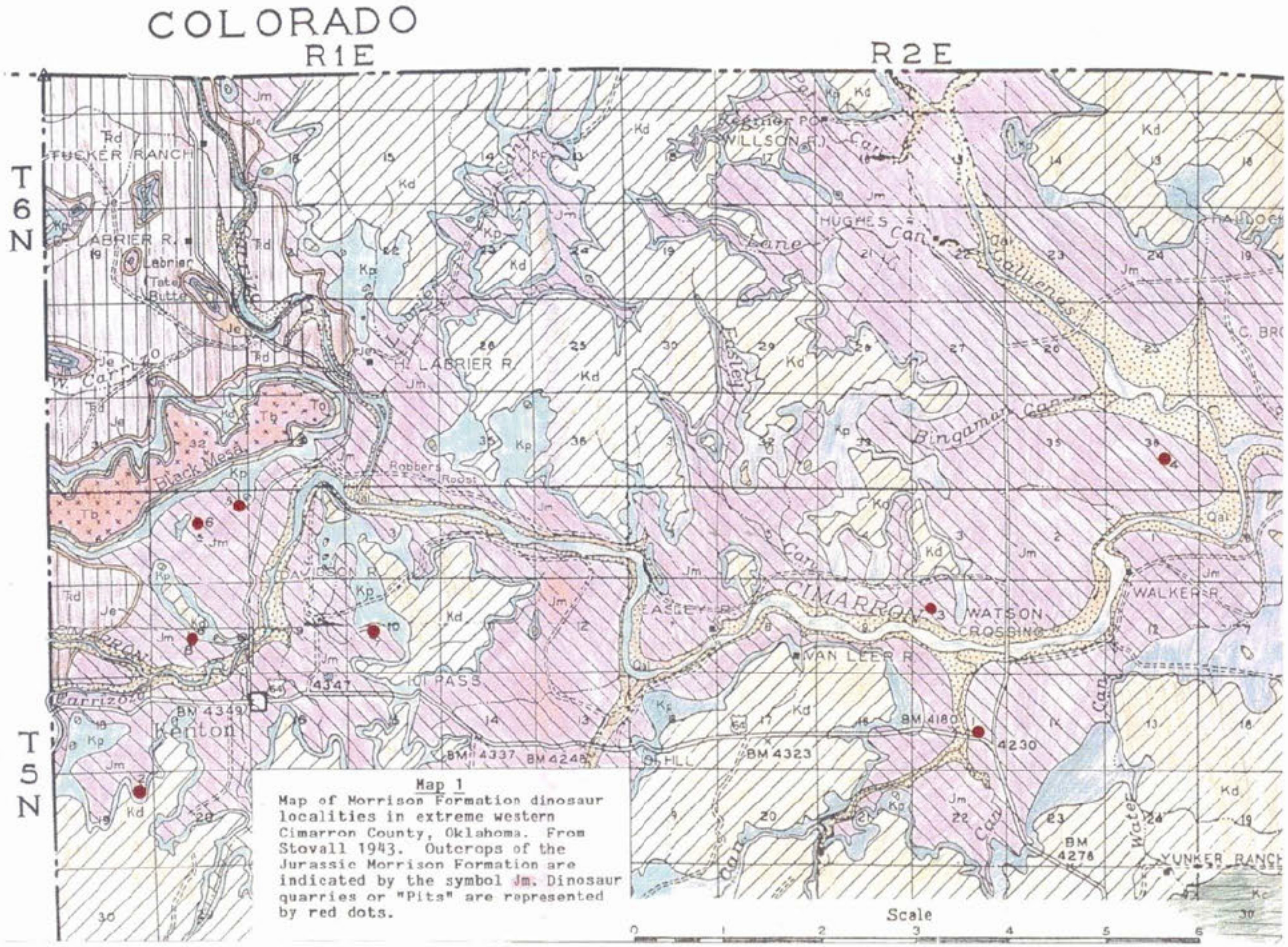


Figure 4: Map showing outcrops of the Morrison Formation in Cimarron County and all the quarries excavated in the 1930s-1940s. Not all were productive. See Figure 6 for up to date quarry numbers (from Hunt and Lucas 1987)

Figure 5: J. W. Stovall, shown in a staged photograph preparing a *Saurophaganax* claw (from Ray 1941)

Qal	Quaternary Alluvium
Tb	Tertiary Basalt
To	Ogallala Formation
Kc	Now Graneros and Greenhorn
Kd	Dakota Formation
Kp	Purgatoire Formation
Jm	Morrison Formation
Je	Exeter Sandstone
TRd	Dockum Group



Map 1
Map of Morrison Formation dinosaur localities in extreme western Cimarron County, Oklahoma. From Stovall 1943. Outcrops of the Jurassic Morrison Formation are indicated by the symbol Jm. Dinosaur quarries or "Pits" are represented by red dots.

Figure 6: Outcrop map of Morrison Formation with the correct locations of the quarries (modified from Langston 1989)

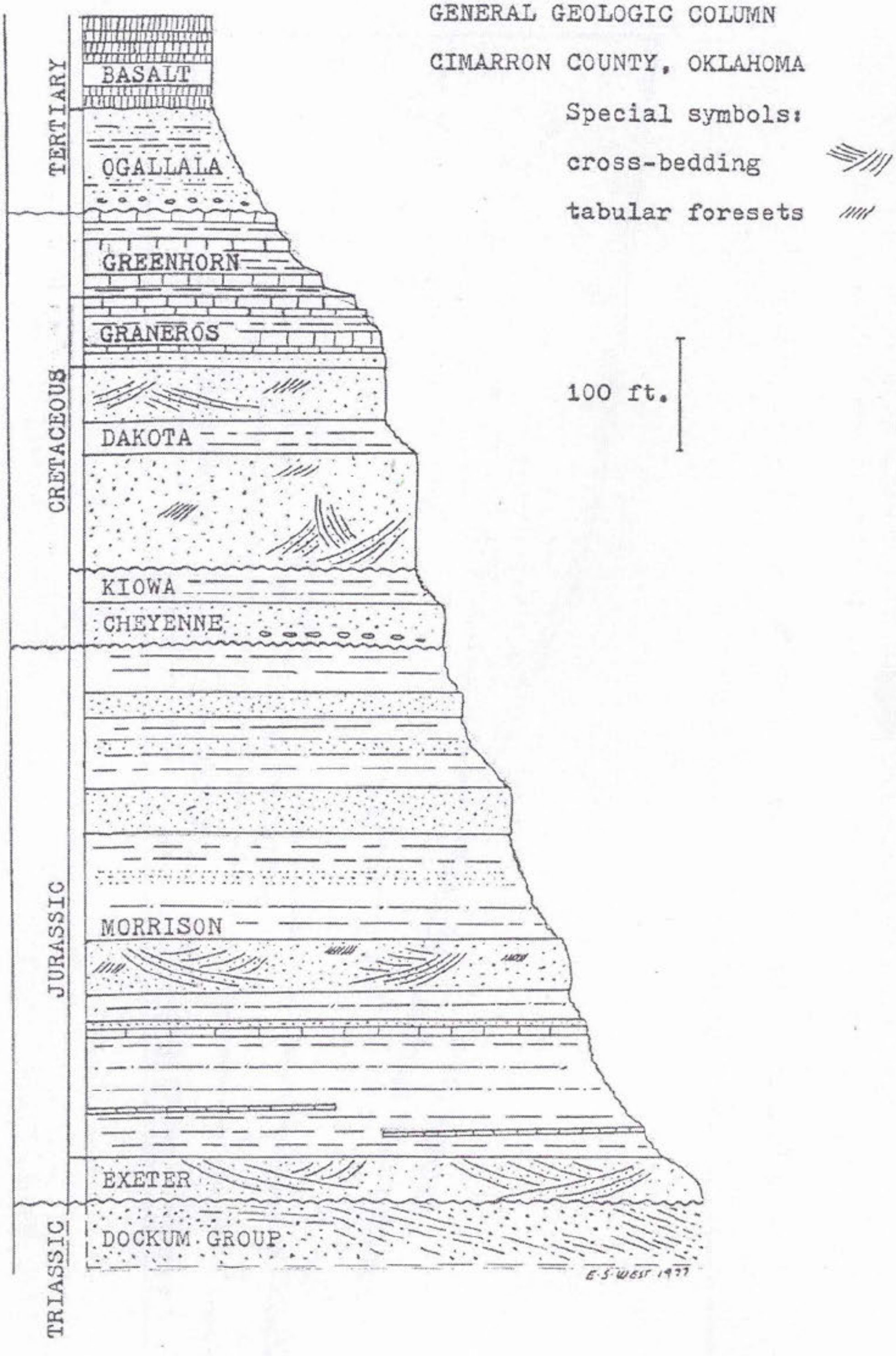


Figure 7: Geologic column of Cimarron County (from West 1978)

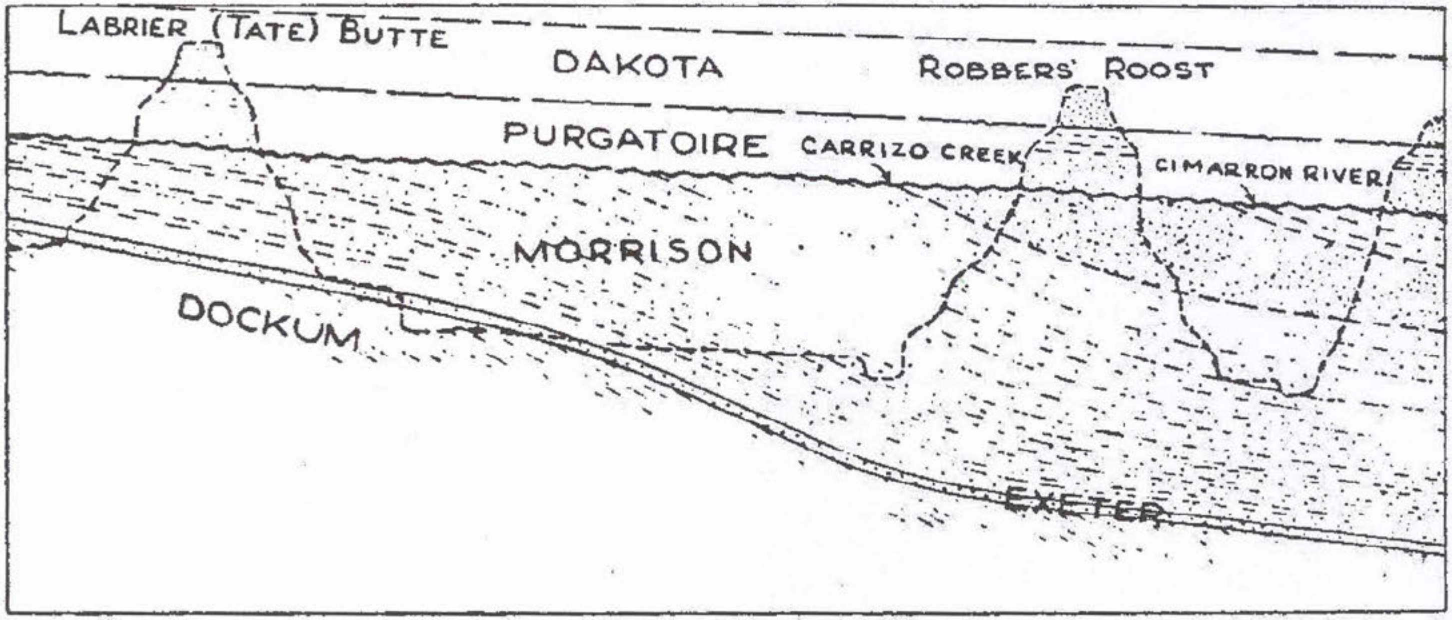


Figure 8: Diagram with the relative locations of the 3 stratigraphic sections of Morrison Formation in Cimarron County and a general correlation between them due to structural deformation that occurred post-Morrison deposition and pre-Cheyenne deformation (from Stovall 1943)

Figure 9: Photograph of Quarry 1 along Highway 64 in Cimarron County, OK with Adrian Hunt in the pit and Martin Lockley on top for scale. The year the picture was taken is unknown, but is probably from the 1980s-1990s (from Foster 2007)

Figure 10: Photograph of Quarry 1 taken by the author in Spring of 2007, replica of an *Apatosaurus* femur on the horizon in the upper left corner is ~1.7 m (5.6 ft) tall

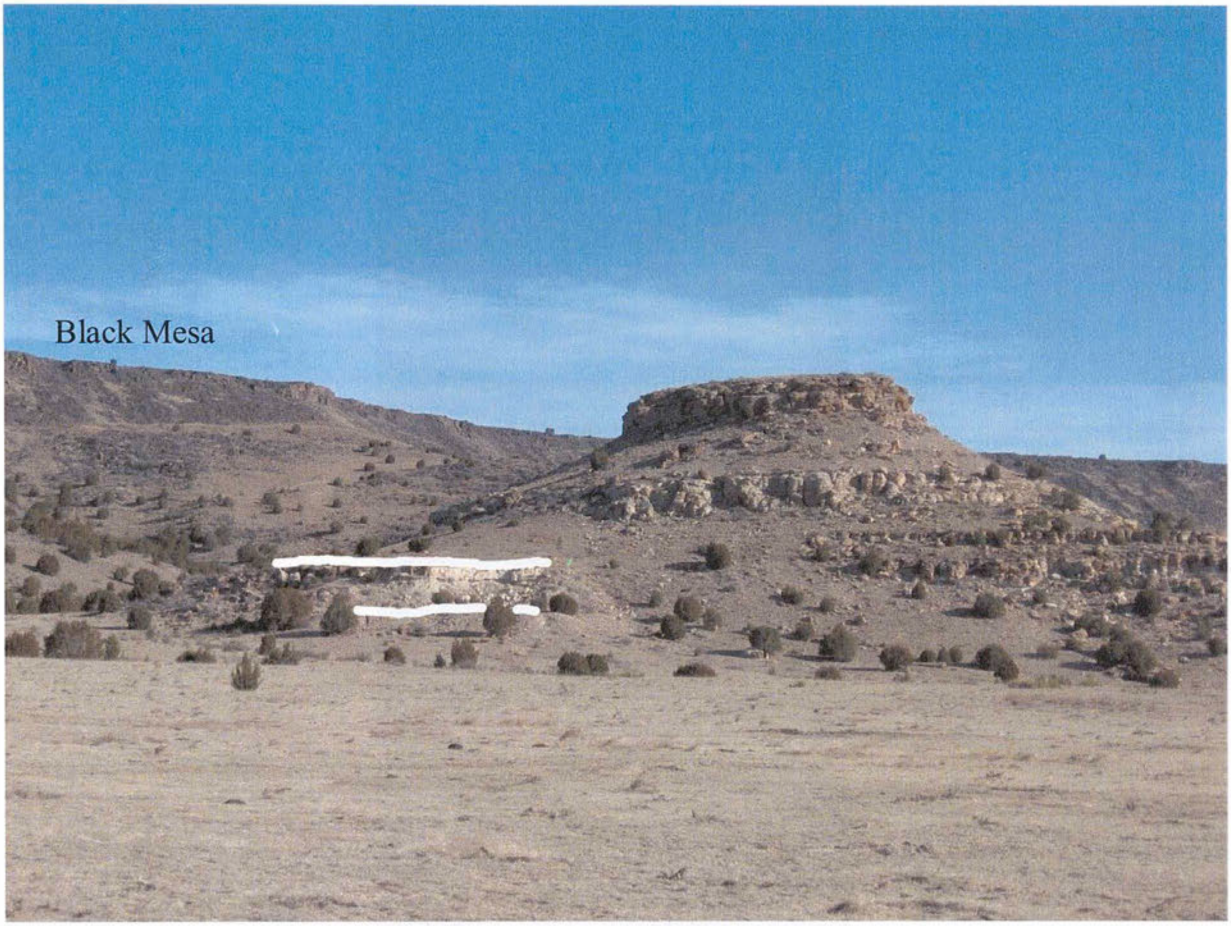


Figure 11: Photograph of Quarry 5 taken by the author in March 2007, quarry outlined in white.

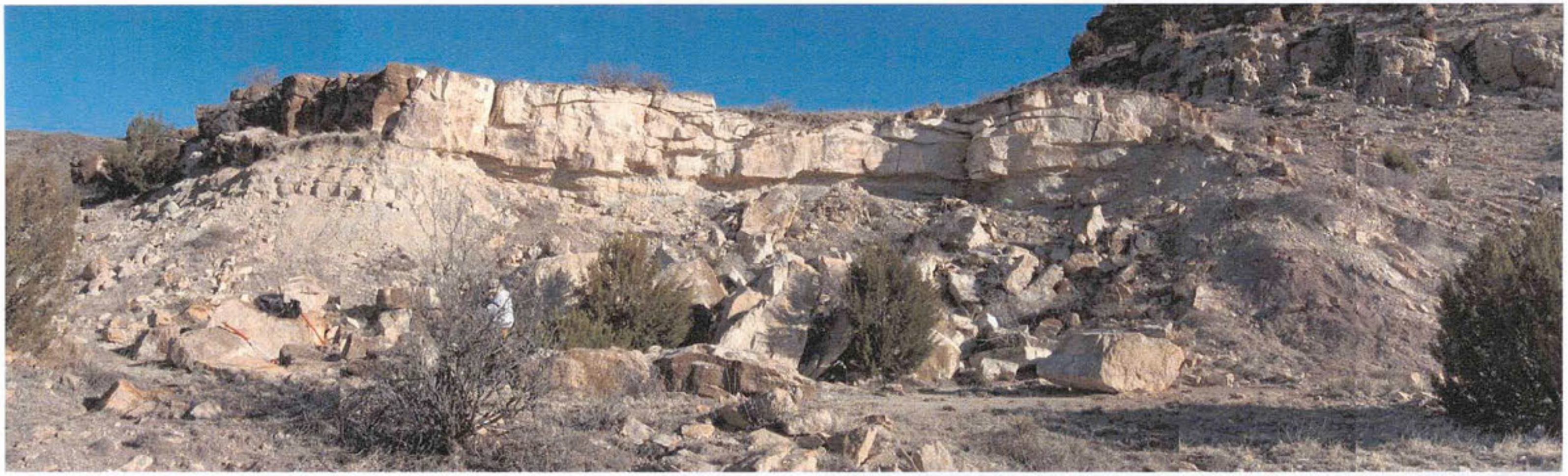


Figure 12: Close-up photograph of Quarry 5 taken by the author in March 2007

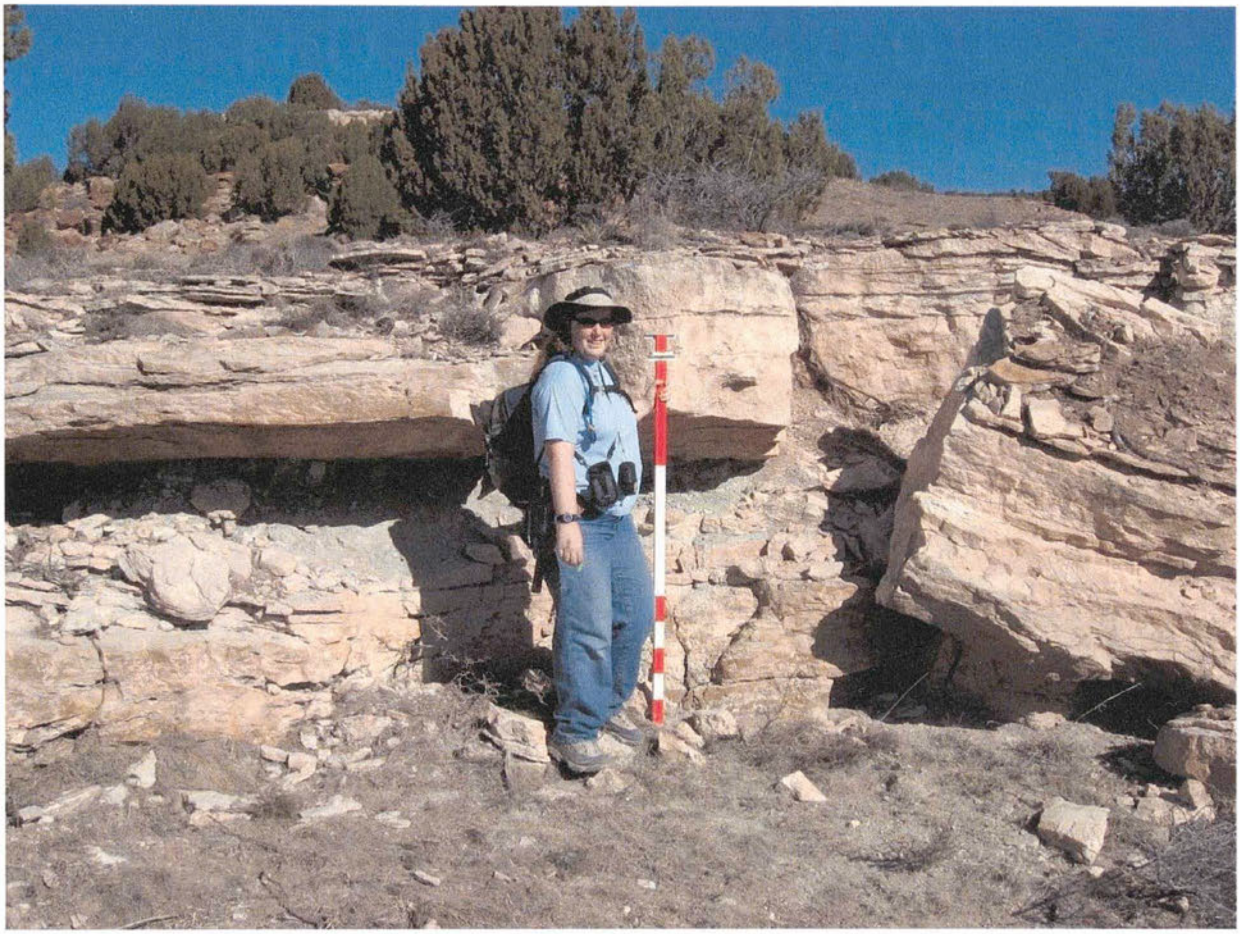


Figure 13: Photograph of Quarry 6 taken by John Guest in March 2007, author and Jacob Staff for scale

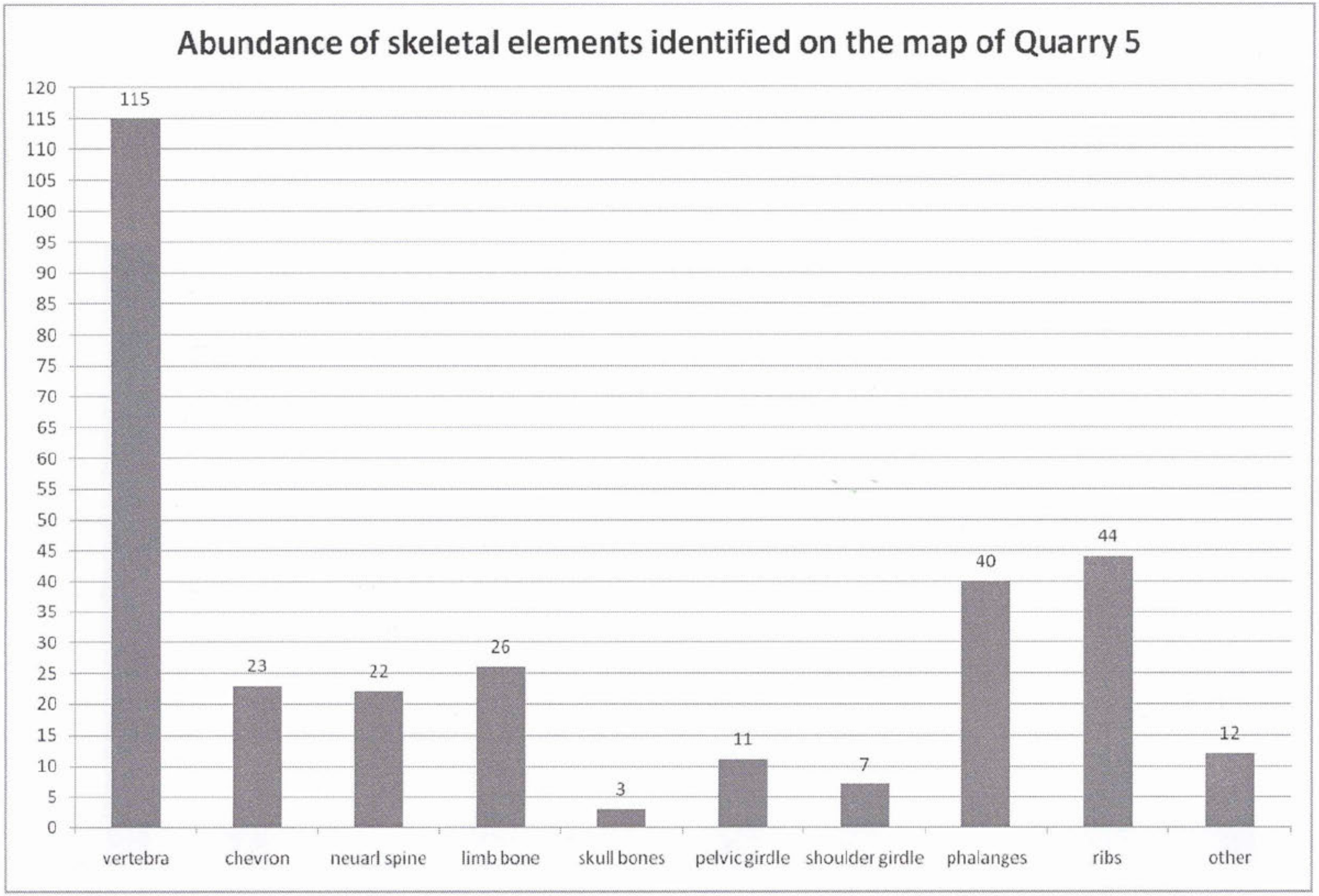

Abundance of skeletal elements identified on the map of Quarry 5
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
115
23
22
26
3
11
7
40
44
12
vertebra
chevron
neuarl spine
limb bone
skull bones
pelvic girdle
shoulder girdle
phalanges
ribs
other

Figure 14

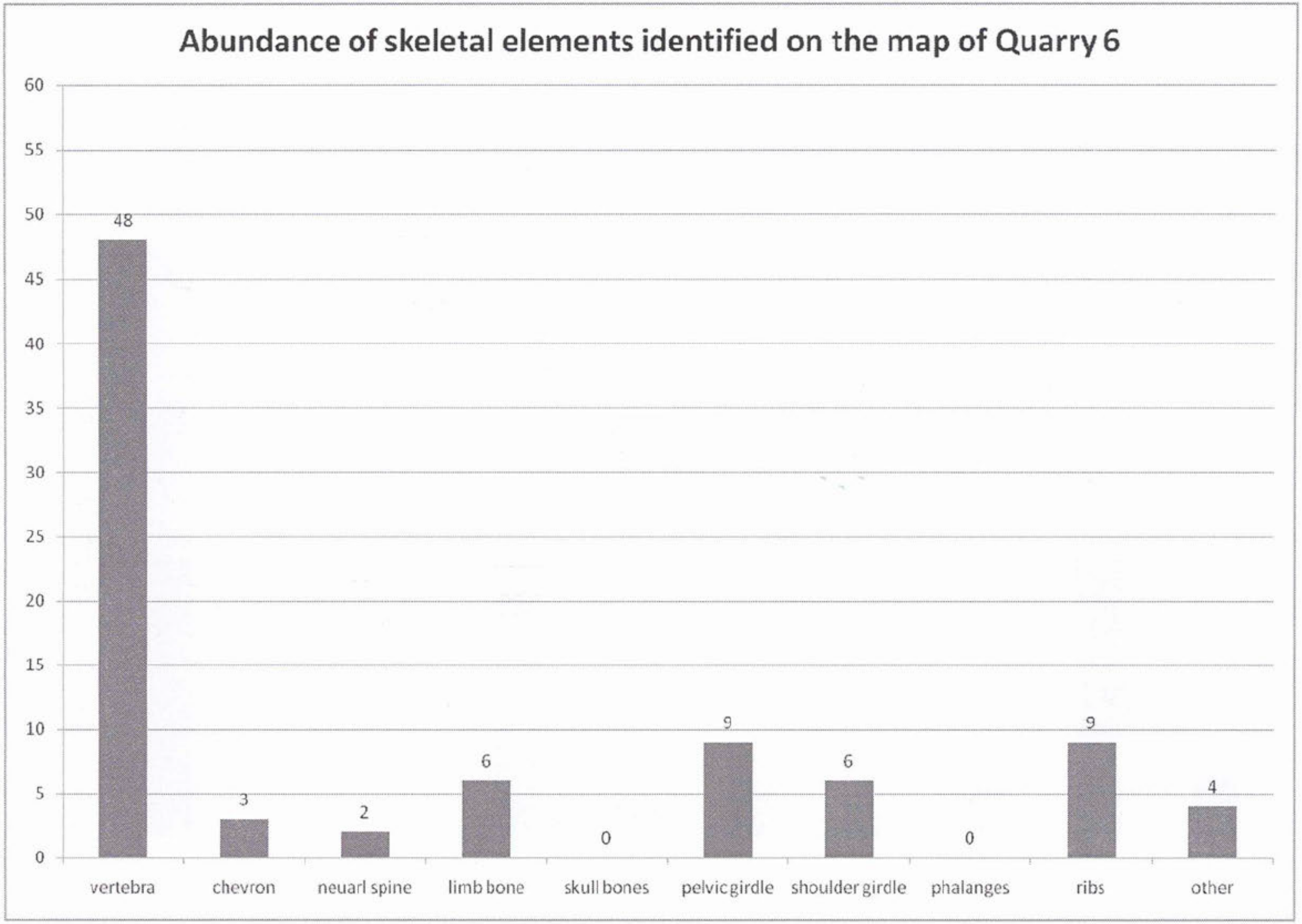

Abundance of skeletal elements identified on the map of Quarry 6
60
55
50
45
40
35
30
25
20
15
10
5
0
48
3
2
6
0
9
6
0
9
4
vertebra
chevron
neuarl spine
limb bone
skull bones
pelvic girdle
shoulder girdle
phalanges
ribs
other

Figure 15

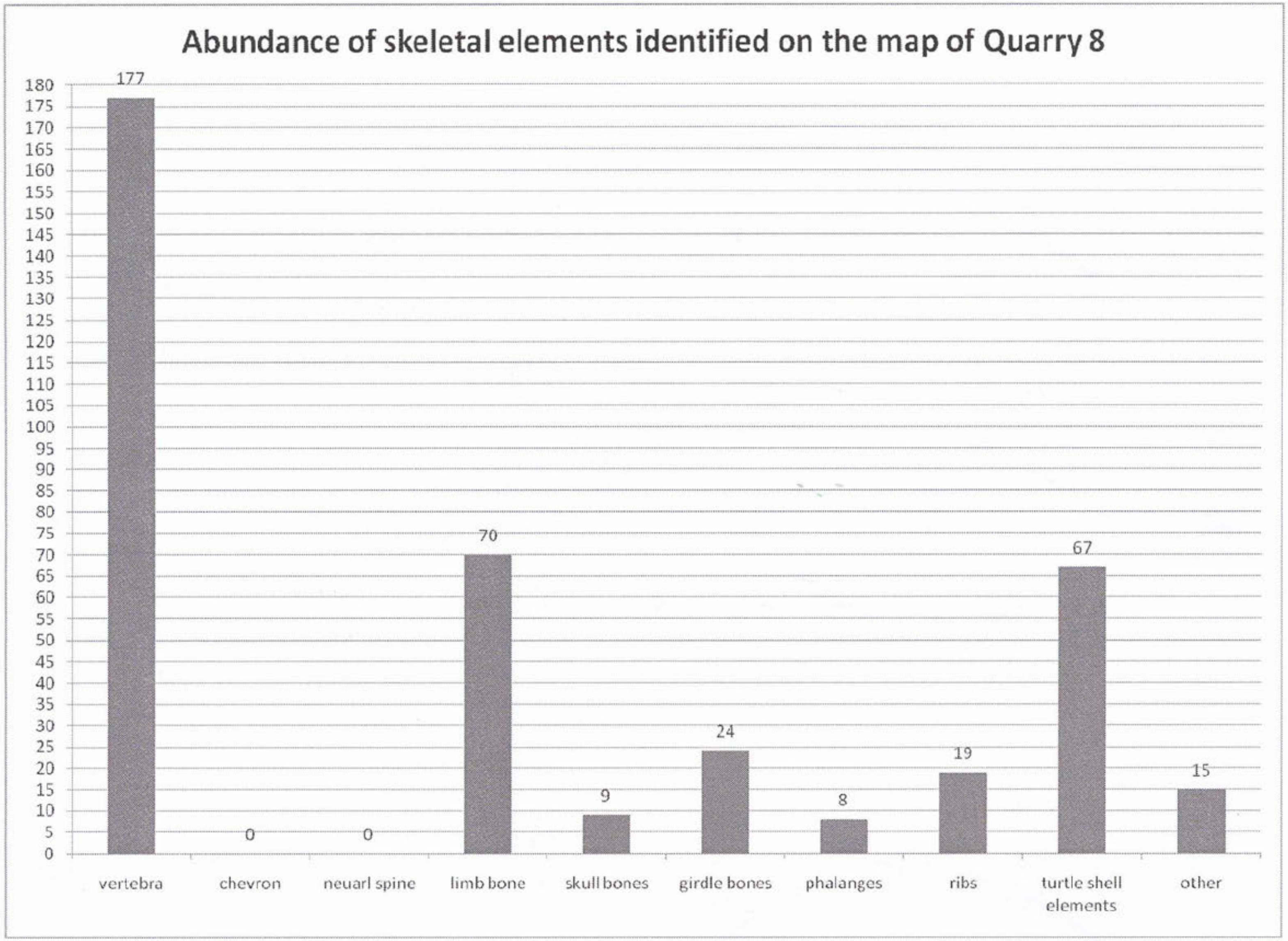

Abundance of skeletal elements identified on the map of Quarry 8
180
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
177
0
0
70
9
24
8
19
67
15
vertebra
chevron
neuarl spine
limb bone
skull bones
girdle bones
phalanges
ribs
turtle shell elements
other

Figure 16

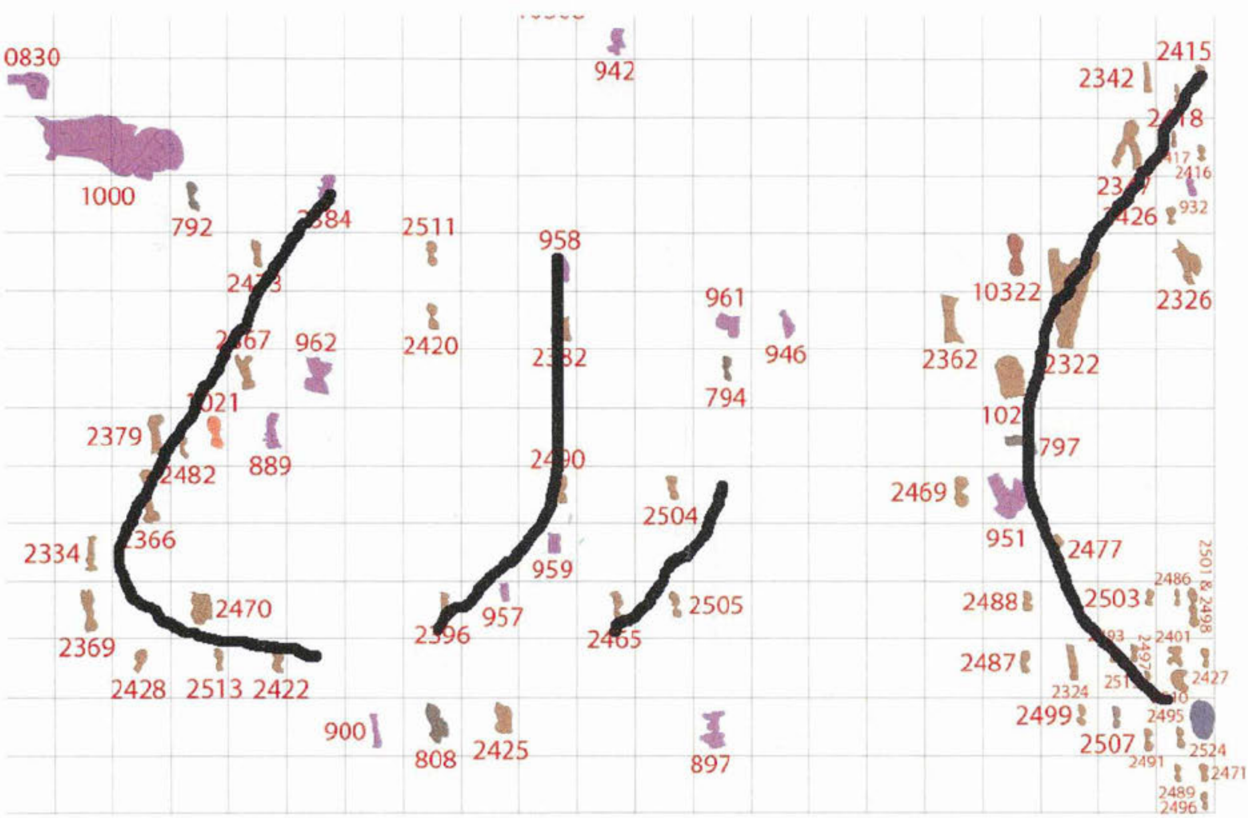


Figure 17: Portion of the quarry map (CD; gridlines x: 21-42, y: 70-84) for Quarry 8 highlighting the arch or crescent shaped pattern seen in some of the patches and scatter.

Appendix A- Identified bones on quarry maps

Sorted by quarry and then by collection #

Revised identifications are listed in **bold** below the original identification

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	1072	Sauropoda	rib fragment	
Quarry 5	1073	Sauropoda	rib fragment	
Quarry 5	1074	Sauropoda	rib fragment	
Quarry 5	1075	Sauropoda	rib fragment	
Quarry 5	1076	Sauropoda	rib fragment	
Quarry 5	1077	Sauropoda	rib fragment	
Quarry 5	1079	*Diplodocus* sp.	vertebra fragments	
Quarry 5	1080	Sauropoda	rib fragment	
		Diplodocus **? sp.**		
Quarry 5	1081	Sauropoda	rib fragment	
Quarry 5	1082	Sauropoda	rib fragment	
Quarry 5	1083	Sauropoda	rib fragment	
Quarry 5	1084	Sauropoda	rib fragment	
Quarry 5	1085	Sauropoda	rib fragment	
Quarry 5	1086	Sauropoda	rib fragment	
Quarry 5	1087	Sauropoda	rib fragment	
Quarry 5	1089	Sauropoda	cervical vertebra fragment	
		Camarasaurus **? sp.**		
Quarry 5	1090	Archosauria	long bone fragment	
		Dinosauria		
Quarry 5	1091	*Diplodocus* ? sp.	scapula, left	
Quarry 5	1345	Archosauria	chevron	
Quarry 5	1491	*Ceratosaurus* sp.	tooth	
Quarry 5	1740	*Apatosaurus* ? sp.	dorsal vertebra, posterior	
Quarry 5	1741	*Camarasaurus* sp.	caudal vertebral centrum	
Quarry 5	1742	Sauropoda	femur fragment?	
		Apatosaurus **? sp.**		
Quarry 5	1747	*Apatosaurus* sp.	caudal vertebra	
Quarry 5	1749	Sauropoda?	sacrum	in 2 pieces on map
		Diplodocus **? sp.**		
Quarry 5	1750	Theropoda?	vertebral centrum	
Quarry 5	1752	*Camarasaurus* ? sp.	dorsal or sacral arch	
Quarry 5	1755	Sauropoda	caudal vertebra, distal	
		Diplodocus **? sp.**		
Quarry 5	1756	Sauropoda	ischium	
		Diplodocus **? sp.**		
Quarry 5	1757	*Stegosaurus* sp.	tail spike	
Quarry 5	1758	Sauropoda	rib fragment	
Quarry 5	1759	Sauropoda	rib fragment	
Quarry 5	1760	Sauropoda	rib fragment	
Quarry 5	1761	Sauropoda	rib fragment	
Quarry 5	1762	Sauropoda	rib fragment	
Quarry 5	1763	Sauropoda	rib fragment	
Quarry 5	1764	Sauropoda	centrum fragment	
		Diplodocus **? sp.**		
Quarry 5	1765	Archosauria	rib head, right	
Quarry 5	1766	Sauropoda	rib fragment	
Quarry 5	1767	Sauropoda	rib fragment	in 2 pieces on map
Quarry 5	1769	Sauropoda	rib fragment	
Quarry 5	1774	Sauropoda	rib fragment	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	1775	Archosauria	rib fragment	
		Dinosauria		
Quarry 5	1776	*Saurophaganax maximus*	sacral vertebrae	2 attached
Quarry 5	1777	Archosauria	skeletal fragment	
Quarry 5	1779	*Camarasaurus* sp.	pubis, left	mate to 1816
Quarry 5	1780	Archosauria	scapula blade fragment, left	
		Sauropoda?	**girdle element**	
Quarry 5	1781	*Diplodocus* sp.	humerus	
Quarry 5	1783	*Apatosaurus* sp.	radius, right	
Quarry 5	1786	Diplodocidae	chevron	
		***Diplodocus* ? sp.**		
Quarry 5	1787	Diplodocidae	chevron	
Quarry 5	1788	Diplodocidae	chevron	
		***Diplodocus* ? sp.**		
Quarry 5	1789	Camarasaurus sp.	coracoid, left	
Quarry 5	1790	Archosauria	rib fragment	
Quarry 5	1791	Archosauria	rib fragment	
Quarry 5	1792	Archosauria	phalanx	
		Sauropoda?		
Quarry 5	1793	*Diplodocus* sp.	femur, left	subadult (half size of adult)
Quarry 5	1794	*Camarasaurus* sp.	femur, right	immature (subadult)
Quarry 5	1797	*Camptosaurus* ? sp.	sacrum	immature (subadult)
Quarry 5	1798	*Diplodocus* ? sp.	dorsal centrum fragment	
Quarry 5	1799	Sauropoda	rib fragment	
Quarry 5	1800	Sauropoda	rib fragment	
Quarry 5	1801	Saurischia	cervical rib	
Quarry 5	1803	Sauropoda?	long bone fragment	
Quarry 5	1804	*Apatosaurus* sp.	coracoid, left	
Quarry 5	1805	Sauropoda	long bone fragment	
Quarry 5	1806	Sauropoda	rib fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1807	Sauropoda	rib fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1808	Sauropoda	rib fragment	
Quarry 5	1814	Sauropoda	rib	
Quarry 5	1815	*Stegosaurus* sp.	femur, left	
Quarry 5	1816	*Camarasaurus* sp.	pubis, right	mate to 1779
Quarry 5	1819	*Diplodocus* sp.	scapula, right	
Quarry 5	1823	Sauropoda	limb bone fragment, proximal	
Quarry 5	1824	Sauropoda	cervical vertebra fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1832	Archosauria	chevron	
			rib fragment	
Quarry 5	1833	*Diplodocus* sp.	chevron	
Quarry 5	1834	*Apatosaurus* sp.	caudal vertebra, distal	
Quarry 5	1835	Diplodocus sp.	chevron	
Quarry 5	1837	Archosauria	chevron	
			rib fragment	
Quarry 5	1838	Archosauria	chevron	
		Dinosauria		
Quarry 5	1839	*Diplodocus* sp.	chevron	
Quarry 5	1840	*Diplodocus* sp.	chevron	in 2 pieces

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	1841	Archosauria	zygapophysis	
Quarry 5	1842	Theropoda?	dorsal vertebra	articulated w/ 2 other dorsal vertebrae
Quarry 5	1843	Archosauria	vertebra fragment	
		***Diplodocus* ? sp.**	**dorsal? vertebra fragment**	
Quarry 5	1844	Sauropoda	cervical vertebra	
		***Camarasaurus* ? sp.**		
Quarry 5	1845	*Diplodocus* sp.	cervical vertebra	
Quarry 5	1850	Sauropoda?	braincase	juvenile?
Quarry 5	1851	Theropoda?	braincase	
		?*Saurophaganax maximus*		
Quarry 5	1853	Archosauria	cervical rib	
		***Camarasaurus* ? sp.**		
Quarry 5	1854	Archosauria	zygapophysis	
		Saurischia	**?sacral rib**	**juvenile?**
Quarry 5	1855	Sauropoda	neural arch fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1856	Archosauria	neural spine	
		***Diplodocus* ? sp.**	**dorsal? neural spine**	
Quarry 5	1857	Diplodocidae	neural spine	
		***Diplodocus* ? sp.**		
Quarry 5	1858	Diplodocidae	neural spine	
Quarry 5	1859	Diplodocidae	neural spine	
		***Diplodocus* ? sp.**		
Quarry 5	1860	Diplodocidae	neural spine	
		Diplodocus? sp.		
Quarry 5	1862	Archosauria	chevron	
			cervical? rib	
Quarry 5	1863	Diplodocidae	neural spine	
Quarry 5	1865	Diplodocidae	caudal neural spine, anterior	
		Diplodocus? sp.		
Quarry 5	1866	Sauropoda	cervical vertebra fragment	
Quarry 5	1867	Sauropoda	cervical vertebra	
Quarry 5	1868	Diplodocidae	dorsal neural spine	
		Diplodocus? sp.		
Quarry 5	1869	Diplodocus sp.	caudal neural spine	
Quarry 5	1870	Diplodocidae	neural spine	
		Diplodocus? sp.		
Quarry 5	1871	Diplodocidae	neural spine	
Quarry 5	1873	Diplodocidae	neural spine	
Quarry 5	1874	Diplodocidae	neural spine	
Quarry 5	1875	Diplodocus	vertebra fragment	
Quarry 5	1877	Sauropoda	vertebra fragment	
		Diplodocus? sp.		
Quarry 5	1879	*Diplodocus* sp.	dorsal neural arch	
Quarry 5	1880	Sauropoda	neural arch fragment	
Quarry 5	1881	Sauropoda	dorsal neural arch, posterior	
		***Diplodocus* ? sp.**		
Quarry 5	1882	Sauropoda	cervical vertebra	
Quarry 5	1886	Theropoda?	centrum	
Quarry 5	1887	Sauropoda	vertebral fragment	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	1888	Diplodocidae	neural spine	
Quarry 5	1889	*Camarasaurus* sp.	neural spine	
Quarry 5	1892	Sauropoda	vertebra fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1893	Sauropoda	cervical vertebra	
		***Diplodocus* ? sp.**		
Quarry 5	1894	Archosauria	zygapophysis	
		Saurischia		
Quarry 5	1895	Diplodocidae	neural arch fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1896	Archosauria	skeletal element	
		Sauropoda?	**?parapophysis of a cervical vertebra**	
Quarry 5	1897	*Apatosaurus* sp.	tibia (proximal half), left	
Quarry 5	1898	*Apatosaurus* sp.	pubis	
Quarry 5	1899	Sauropoda	long bone fragment	
Quarry 5	1900	*Camarasaurus* sp.	neural spine	
Quarry 5	1901	*Camarasaurus* sp.	neural spine	
Quarry 5	1902	Sauropoda	rib fragment	
		***Diplodocus* ? sp.**		
Quarry 5	1903	Sauropoda	rib fragment	
Quarry 5	1909	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	1988	*Apatosaurus* sp.	caudal vertebra	
Quarry 5	1989	*Diplodocus* sp.	caudal centrum fragment	
Quarry 5	2022	*Saurophaganax maximus*	neural arch	
Quarry 5	2030	*Camarasaurus* sp.	metapodial	
Quarry 5	2150	*Barosaurus* sp.	caudal vertebra	
		***Diplodocus* ? sp.**		
Quarry 5	4023	Archosauria	chevron	
		Diplodocidae		
Quarry 5	4024	Archosauria	chevron	
		Sauropoda?	**rib fragment**	
Quarry 5	4025	Camarasaurus sp.	caudal neural spine	
Quarry 5	4026	Barosaurus? sp.	caudal neural spine fragment	
		***Diplodocus* ? sp.**		
Quarry 5	4027	*Camarasaurus* sp.	caudal neural spine	
Quarry 5	4083	Sauropoda	ischiae peduncle of ilium	
		***Diplodocus* ? sp.**		
Quarry 5	9534	*Camptosaurus*? sp.	metapodial fragment	
Quarry 5	9535	Archosauria	chevron fragment	
Quarry 5	9536	Sauropoda?	jaw fragment w/ alveoli	
Quarry 5	10183	*Diplodocus* sp.	fibula (proximal end), left	
Quarry 5	10184	*Diplodocus* sp.	radius	
Quarry 5	10185	*Diplodocus* sp.	ulna	articulated w/ 10186
Quarry 5	10186	*Diplodocus* sp.	radius	articulated w/ 10185
Quarry 5	10187	*Diplodocus* sp.	radius (distal end)	
Quarry 5	10188	*Diplodocus* sp.	astragalus, right	
Quarry 5	10189	*Diplodocus* sp.	astragalus, left	
Quarry 5	10190	Sauropoda	tibia (distal end), right	
		***Diplodocus* ? sp.**		
Quarry 5	10191	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10192	*Diplodocus* sp.	caudal vertebra	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	10193	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10194	*Diplodocus* sp.	chevron	
Quarry 5	10195	*Camarasaurus* sp.	ischium, right	mate to 10227
Quarry 5	10196	Sauropoda	carpal "radiale", left	
Quarry 5	10197	Sauropoda	carpal "radiale", right	
		Camarasaurus **? sp.**		
Quarry 5	10198	Sauropoda	carpal "ulnare", right	
		Camarasaurus **? sp.**		
Quarry 5	10199	*Diplodocus* sp.	metatarsal II, left	
Quarry 5	10200	*Diplodocus* sp.	metatarsal II, right	
Quarry 5	10201	*Diplodocus* sp.	metatarsal I, left	
Quarry 5	10202	Sauropoda	manus, terminal phalanx V, 1	
		Diplodocus **? sp.**		
Quarry 5	10203	Sauropoda	manual phalanx II, 1 or III, 1, right	
		Diplodocus **? sp.**		
Quarry 5	10204	Sauropoda	manus, terminal phalanx V, 1	
Quarry 5	10205	Sauropoda	manus, terminal phalanx IV, 1	
		Diplodocus **? sp.**		
Quarry 5	10206	Sauropoda	pes, phalanx 1, digit II, right	
		Diplodocus **? sp.**		
Quarry 5	10207	Sauropoda	pedal phalanx I, 1, right	
		Diplodocus **? sp.**		
Quarry 5	10208	Sauropoda	pes, phalanx III, 2, right	
		Diplodocus **? sp.**		
Quarry 5	10209	Sauropoda	pes, phalanx II, 2	very small indivigual
		Camarasaurus **? sp.**		
Quarry 5	10210	Sauropoda	pes, phalanx II, 1, right	
Quarry 5	10211	Sauropoda	pes, ungual phalanx I, 2 or II, 3, left	
		Diplodocus **? sp.**		
Quarry 5	10212	Sauropoda	pes, ungual phalanx III, 4, right	
		Diplodocus **? sp.**		
Quarry 5	10213	Sauropoda	pes, ungual phalanx I, 2, right	
Quarry 5	10214	*Diplodocus* sp.	metatarsal IV, right	
Quarry 5	10215	Sauropoda	metacarpal I, left	
		Diplodocus **? sp.**	**metacarpal I, right**	
Quarry 5	10216	*Diplodocus* sp.	metatarsal IV, right	
Quarry 5	10217	Sauropoda	metatarsal IV, left	
		Diplodocus **? sp.**		
Quarry 5	10218	*Camarasaurus* sp.	metacarpal III	
Quarry 5	10219	Sauropoda	metacarpal IV, right	
		Camarasaurus? sp.		
Quarry 5	10220	Sauropoda	metatarsal V, right	
		Diplodocus **? sp.**		
Quarry 5	10221	Sauropoda	metacarpal IV, left?	
		Diplodocus **? sp.**		
Quarry 5	10222	*Camarasaurus* sp.	metacarpal II, left	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	10223	Sauropoda	fibula (proximal end), right	
		***Diplodocus* ? sp.**		
Quarry 5	10224	*Apatosaurus* sp.	scapholunar	
Quarry 5	10225	*Camarasaurus* sp.	metacarpal II, right	
Quarry 5	10226	*Camarasaurus* sp.	metacarpal III, left	
Quarry 5	10227	*Camarasaurus* sp.	ischium, left	mate to 10195
Quarry 5	10228	*Camarasaurus* sp.	metacarpal V, right	
Quarry 5	10229	Diplodocidae	metatarsal V	
		***Diplodocus* ? sp.**		
Quarry 5	10230	Diplodocidae	metatarsal V, left	
Quarry 5	10231	Sauropoda	manus, phalanx I, 2	
		***Diplodocus* ? sp.**		
Quarry 5	10232	*Diplodocus* ? sp.	femur head	
Quarry 5	10234	Sauropoda	tibia (distal end), right	
		***Diplodocus* ? sp.**		
Quarry 5	10235	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10236	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10237	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10238	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10239	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10240	*Barosauru*s sp.	caudal vertebra	large indivigual (11" vert. w/ 9" centra)
		***Diplodocus* ? sp.**		
Quarry 5	10241	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10242	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10243	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10244	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10245	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10246	*Barosaurus* sp.	caudal vertebra	
		***Diplodocus* ? sp.**		
Quarry 5	10247	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10248	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10249	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10250	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10251	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10252	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10253	*Diplodocus* ? sp.	caudal vertebra, anterior	small individual
Quarry 5	10254	*Diplodocus* ? sp.	anterior caudal vertebra	
Quarry 5	10255	*Diplodocus* ? sp.	dorsal centrum	
Quarry 5	10256	*Diplodocus* ? sp.	anterior dorsal centrum	
Quarry 5	10257	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10258	*Diplodocus* ? sp.	anterior caudal centrum (anterior end)	
Quarry 5	10259	*Diplodocus* ? sp.	caudal centrum (anterior end)	
Quarry 5	10260	Sauropoda	caudal centrum (anterior end)	
Quarry 5	10261	Diplodocidae	neural spine	
Quarry 5	10262	*Diplodocus* ? sp.	caudal vertebra	
Quarry 5	10263	*Diplodocus* ? sp.	anterior caudal vertebra (anterior half)	
Quarry 5	10264	*Diplodocus* ? sp.	tibia, right	
Quarry 5	10265	*Saurophaganax maximus*	caudal vertebra	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	10266	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10267	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10268	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10269	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10270	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10271	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10272	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10273	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10274	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10275	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10276	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10278	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10279	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10280	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10281	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10282	*Saurophaganax maximus*	caudal centrum	
Quarry 5	10283	*Saurophaganax maximus*	side of caudal centrum	
Quarry 5	10284	*Saurophaganax maximus*	caudal vertebra and attached chevron	2 fused
Quarry 5	10285	*Saurophaganax maximus*	thoracic centrum	
Quarry 5	10287	*Saurophaganax maximus*	pubic process of ilium?	
Quarry 5	10288	*Saurophaganax maximus*	thoracic centrum	
Quarry 5	10289	*Saurophaganax maximus*	chevron	
Quarry 5	10290	*Saurophaganax maximus*	chevron	
Quarry 5	10291	*Saurophaganax maximus*	chevron	
Quarry 5	10293	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10294	Sauropoda	pedal phalanx 1, digit II, right	
Quarry 5	10296	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10297	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10298	*Apatosaurus* sp.	coracoid, left	
Quarry 5	10299	Sauropoda	fibula, left	
Quarry 5	10300	*Diplodocus* sp.	ulna	
Quarry 5	10301	Sauropoda	caudal centrum (anterior end)	
		***Diplodocus* ? sp.**		
Quarry 5	10302	Sauropoda	ilium (posterior end), right	
		***Diplodocus* ? sp.**		
Quarry 5	10303	*Camarasaurus* sp.	caudal vertebra	
Quarry 5	10304	*Diplodocus* sp.	caudal rib, anterior	
Quarry 5	10326	*Camarasaurus* sp.	caudal vertebra, anterior	articulated w/ 4 other caudal vertebrae
Quarry 5	10328	*Stegosaurus* sp.	humerus, left	
Quarry 5	10329	*Stegosaurus* ? sp.	coracoid	
Quarry 5	10330	*Camarasaurus* sp.	ischium, right	
			ischium, left	
Quarry 5	10331	*Diplodocus* sp.	caudal vertebra, anterior	
Quarry 5	10332	*Apatosaurus* ? sp.	cervical vertebra (posterior half)	
Quarry 5	10333	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10334	*Diplodocus* sp.	dorsal vertebra, 3rd?	
Quarry 5	10335	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10339	*Diplodocus* sp.	caudal vertebra	
Quarry 5	10340	*Barosaurus* sp.	caudal vertebra	
		***Diplodocus* ? sp.**		

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 5	10342	*Camarasaurus* sp.	astragalus, left	
Quarry 5	10344	Sauropoda	caudal vertebrae	6 articulated caudal vertebrae
		***Camarasaurus* ? sp.**		
Quarry 5	10345	*Diplodocus*	caudal vertebra	
Quarry 5	10346	*Saurophaganax maximus*	chevron	
Quarry 5	10347	*Saurophaganax maximus*	chevron	
Quarry 5	10348	*Saurophaganax maximus*	chevron	
Quarry 5	10349	*Diplodocus* sp.	chevron	
Quarry 5	10352	*Diplodocus* sp.	demi-chevron	
Quarry 5	10353	*Saurophaganax maximus*	thoracic vertebra	
Quarry 5	10354	*Saurophaganax maximus*	atlas-axis	
Quarry 5	10355	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10356	*Saurophaganax maximus*	phalanx I	shown as 2 bones
Quarry 5	10357	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10358	*Saurophaganax maximus*	thoracic vertebra	
Quarry 5	10359	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10362	*Saurophaganax maximus*	caudal centrum	
Quarry 5	10363	Sauropoda	manus, phalanx II, 1 or III, 1	
Quarry 5	10364	Theropoda?	caudal vertebra	
		Theropoda	**cervical vertebra, posterior**	**not consistant w/ Allosauridae or *Ceratosaurus***
Quarry 5	10365	*Saurophaganax maximus*	axis vertebra	
Quarry 5	10366	*Saurophaganax maximus*	caudal vertebra	
Quarry 5	10381	*Saurophaganax maximus*	femur, left	
Quarry 5	10385	*Saurophaganax maximus*	chevron	
Quarry 6	1327	*Apatosaurus* sp.	coracoid, left	
Quarry 6	1333	*Diplodocus* sp.	femur fragment, left	
Quarry 6	1753	*Camarasaurus* sp.	caudal vertebra	
Quarry 6	1768	*Camptosaurus* sp.	caudal vertebra, anterior	
Quarry 6	1782	Sauropoda	ilium, sacrum, and fragments	Not *Camarasaurus* nor *Diplodocus*--ID by J. McIntosh, November 1995.
		***Apatosaurus* ? sp.**		
Quarry 6	1795	*Camarasaurus* sp.	caudal vertebra	
Quarry 6	1796	Diplodocidae	tibia, right	
		***Apatosaurus* ? sp.**		
Quarry 6	1802	*Saurophaganax maximus*	ilium	
Quarry 6	1817	*Diplodocus* sp.	dorsal vertebra	
Quarry 6	1818	Sauropoda	dorsal vertebra	
Quarry 6	1825	Sauropoda	rib fragment	
Quarry 6	1826	Sauropoda	rib fragment	
Quarry 6	1950	Sauropoda	fibula? fragment	
Quarry 6	1951	Sauropoda	scapula fragment	
Quarry 6	1952	*Diplodocus* ? sp.	ischium, right	
Quarry 6	1954	*Diplodocus* sp.	caudal vertebra	
Quarry 6	1955	Sauropoda	sternal plate?	
Quarry 6	1956	*Camarasaurus* sp.	caudal vertebra	
Quarry 6	1958	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1959	*Camarasaurus* ? sp.	caudal vertebra	
Quarry 6	1960	*Camarasaurus* ? sp.	neural arch of median caudal	
Quarry 6	1961	*Barosaurus* sp.	caudal centrum	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
		***Diplodocus* ? sp.**		
Quarry 6	1962	*Barosaurus* sp.	caudal centrum	
		***Diplodocus* ? sp.**		
Quarry 6	1963	*Barosaurus* sp.	caudal vertebra	
		***Diplodocus* ? sp.**		
Quarry 6	1964	Sauropoda	prezygapophysis of dorsal vertebra, right	
Quarry 6	1965	Saurophaganax maximus	scapula, right	
Quarry 6	1966	*Camarasaurus* sp.	caudal vertebra	
Quarry 6	1967	Sauropoda	pubis (distal fragment)	
		***Apatosaurus* ? sp.**		
Quarry 6	1968	*Apatosaurus* sp.	ilium fragment	
Quarry 6	1969	*Camarasaurus* sp.	ischium (distal fragment)	
Quarry 6	1970	*Camarasaurus* sp.	neural spine fragment	
Quarry 6	1971	*Barosaurus* sp.	caudal vertebra	
		***Diplodocus* ? sp.**		
Quarry 6	1972	*Camarasaurus* sp.	vertebra fragment	
Quarry 6	1973	Sauropoda	rib fragment	
Quarry 6	1974	Sauropoda	rib fragment	
Quarry 6	1975	Sauropoda	rib fragment	
Quarry 6	1977	Archosauria	rib fragment	
Quarry 6	1978	Sauropoda	rib fragment	
Quarry 6	1979	*Saurophaganax maximus*	ischium, right	
Quarry 6	1980	Sauropoda	rib fragment	
Quarry 6	1981	Sauropoda	rib fragment	
Quarry 6	1982	Archosauria	girdle fragment	
		Dinosauria	**illium fragment**	
Quarry 6	1983	*Saurophaganax maximus*	girdle element?	
Quarry 6	1984	*Saurophaganax maximus*	femur (proximal element)	
Quarry 6	1985	*Saurophaganax maximus*	dorsal vertebra arch fragment	
Quarry 6	1986	*Camarasaurus* sp.	scapula, right	
Quarry 6	1987	*Camarasaurus* sp.	chevron	
Quarry 6	1991	*Apatosaurus* sp.	femur	
Quarry 6	1992	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1993	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1994	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1995	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1996	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1997	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1998	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	1999	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	2000	*Apatosaurus* sp.	caudal vertebra, distal	
Quarry 6	2001	*Saurophaganax maximus*	vertebra	
Quarry 6	2002	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	2003	*Saurophaganax maximus*	vertebra	
Quarry 6	2004	*Saurophaganax maximus*	vertebra	juvenile
Quarry 6	2005	*Saurophaganax maximus*	vertebral centrum	juvenile
Quarry 6	2007	*Saurophaganax maximus*	caudal centrum	
Quarry 6	2008	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	2009	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	2010	*Saurophaganax maximus*	cervical vertebra	
Quarry 6	2012	*Saurophaganax maximus*	vertebra fragment	
Quarry 6	2013	*Saurophaganax maximus*	vertebra	
Quarry 6	2014	*Saurophaganax maximus*	dorsal vertebra, posterior	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 6	2015	*Saurophaganax maximus*	centrum	
Quarry 6	2016	*Saurophaganax maximus*	centrum	
Quarry 6	2017	*Saurophaganax maximus*	centrum	
Quarry 6	2018	*Saurophaganax maximus*	centrum	
Quarry 6	2051	*Apatosaurus* sp.	scapula	
Quarry 6	4021	*Camarasaurus* sp.	neural spine	
Quarry 6	10336	*Camarasaurus* sp.	caudal centrum (squashed)	
Quarry 6	10337	*Barosaurus?* sp.	astragalus, right	
		***Diplodocus* ? sp.**		
Quarry 6	10338	*Apatosaurus* sp.	astragalus	
Quarry 6	10341	*Camarasaurus* sp.	coracoid, right	
Quarry 6	10350	*Camarasaurus* sp.	chevron	
Quarry 6	10351	*Camarasaurus* sp.	chevron	
Quarry 6	10360	*Saurophaganax maximus*	caudal vertebra	
Quarry 6	10361	*Saurophaganax maximus*	thoracic centrum	
Quarry 6	10367	Archosauria	atlas and axis vertebra	
			skeletal element	
Quarry 6	10369	*Camarasaurus* sp.	caudal vertebra w/ arch of another	
Quarry 6	10370	*Camarasaurus* sp.	caudal vertebra	
Quarry 6	10382	*Saurophaganax maximus*	tibia, right	
Quarry 8	786	Crocodylia	humerus	
		?Goniopholis stovalli		
Quarry 8	787	Crocodylia	humerus	
Quarry 8	788	Crocodylia	tibia	
		?Goniopholis stovalli		
Quarry 8	789	Crocodylia	vertebral centrum	
		?Goniopholis stovalli		
Quarry 8	791	Crocodylia	vertebra fragment	
Quarry 8	792	Crocodylia	vertebral centrum	
Quarry 8	793	Crocodylia	vertebral centrum	
Quarry 8	794	Crocodylia	vertebral centrum	
		?Goniopholis stovalli		
Quarry 8	795	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	797	Crocodylia?	ribs & fragments	
		?Goniopholis stovalli		
Quarry 8	798	Crocodylia	coracoid	
		?Goniopholis stovalli		
Quarry 8	799	Crocodylia	femur	
		?Goniopholis stovalli		
Quarry 8	800	Crocodylia	miscellaneous vertebrae	
		?Goniopholis stovalli	**some of the vertebrae if not all**	
Quarry 8	802	Crocodylia	rib	
Quarry 8	803	Crocodylia	coracoid	
Quarry 8	804	Crocodylia	neural arch	
Quarry 8	805	Crocodylia	dermal plates	
		?Goniopholis stovalli		
Quarry 8	806	Crocodylia	scapula, right	
Quarry 8	807	Chelonia	girdle element	
Quarry 8	808	Crocodylia	vertebrae	
		?Goniopholis stovalli		

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	809	Crocodylia	vertebral centrum	
Quarry 8	810	Crocodylia	vertebrae	
		?Goniopholis stovalli		
Quarry 8	811	Crocodylia	vertebra	
Quarry 8	812	Crocodylia	vertebra	
Quarry 8	814	Crocodylia	vertebral centrum	
Quarry 8	820	Crocodylia	vertebral fragments	
Quarry 8	823	Crocodylia	vertebral fragment	
Quarry 8	824	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	825	Crocodylia	vertebra	
Quarry 8	826	Crocodylia	long bone fragment	
		?Goniopholis stovalli		
Quarry 8	827	Crocodylia	vertebra	
Quarry 8	828	Crocodylia	vertebra	
Quarry 8	829	Amiiformes	caudal? centrum	
Quarry 8	830	Crocodylia	vertebral centrum	
Quarry 8	831	Crocodylia	fragment	
		?Goniopholis stovalli		
Quarry 8	832	Crocodylia	vertebra	
Quarry 8	833	Crocodylia	vertebral centrum	
Quarry 8	834	Crocodylia	long bone fragments	
		?Goniopholis stovalli		
Quarry 8	835	Crocodylia	vertebral fragments	
Quarry 8	837	Crocodylia	vertebra	
Quarry 8	838	Crocodylia	vertebra	
Quarry 8	839	Crocodylia	fragments	
		?Goniopholis stovalli		
Quarry 8	840	Crocodylia	fragments	
Quarry 8	844	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	845	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	846	Crocodylia	vertebral centrum	
Quarry 8	847	Crocodylia	vertebra	
Quarry 8	848	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	851	Crocodylia	centrum	
Quarry 8	852	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	853	Crocodylia	centrum	
Quarry 8	854	Crocodylia	centrum	almost articulated w/ 2455 and 2456
		?Goniopholis stovalli		
Quarry 8	855	Crocodylia	centrum	
		?Goniopholis stovalli		
Quarry 8	856	Crocodylia	fragment	
		?Goniopholis stovalli		
Quarry 8	857	Crocodylia	femur (distal fragment)	
Quarry 8	858	Crocodylia	long bone fragment	
Quarry 8	859	Crocodylia	long bone fragment	
Quarry 8	860	Crocodylia	centrum	
Quarry 8	861	Crocodylia	centrum	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	862	Crocodylia	vertebra	
Quarry 8	863	Crocodylia	vertebra	
Quarry 8	864	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	865	Crocodylia	centrum	
Quarry 8	866	Crocodylia	vertebra	
Quarry 8	868	Crocodylia	fragment	
		?Goniopholis stovalli		
Quarry 8	870	Crocodylia	rib	
		?Goniopholis stovalli		
Quarry 8	871	Crocodylia	fragment	
		?Goniopholis stovalli		
Quarry 8	872	Crocodylia	vertebral fragments	
Quarry 8	873	Crocodylia	vertebral fragments	
Quarry 8	874	Crocodylia	vertebral fragments	
Quarry 8	875	Crocodylia	centrum	
Quarry 8	876	Crocodylia	centrum	
Quarry 8	877	Crocodylia	neural arch fragments	
Quarry 8	878	Crocodylia	centrum	
Quarry 8	880	Crocodylia	vertebra	
Quarry 8	881	Crocodylia	vertebra	
Quarry 8	882	Crocodylia	astragalus	
		?Goniopholis stovalli		
Quarry 8	883	Crocodylia	vertebra	
Quarry 8	884	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	885	Crocodylia	vertebra	
		?Goniopholis stovalli		
Quarry 8	887	Chelonia	humerus	
Quarry 8	888	Chelonia	humerus (distal end)	
Quarry 8	889	Chelonia	femur	
Quarry 8	890	Chelonia	humerus (proximal end)	
Quarry 8	891	Chelonia	femur (proximal end)	
Quarry 8	892	Chelonia	long bone fragment	
Quarry 8	893	Chelonia	tibia	
Quarry 8	895	Chelonia	long bone fragment	
Quarry 8	897	Chelonia	fragment	
Quarry 8	900	Chelonia	long bone fragment	
Quarry 8	901	Chelonia	scapulocoracoid	
Quarry 8	902	Chelonia	humerus (distal end)	
Quarry 8	903	Chelonia	scapulocoracoid fragment	
Quarry 8	905	Crocodylia	centrum	
Quarry 8	906	Crocodylia	rib	
Quarry 8	907	Crocodylia	centrum	
Quarry 8	908	Crocodylia	phalanx	
		?Goniopholis stovalli		
Quarry 8	909	Crocodylia	phalanx (distal fragment)	
Quarry 8	910	Crocodylia	metapodial fragment	
		?Goniopholis stovalli		
Quarry 8	912	Crocodylia	centrum fragment	
Quarry 8	913	Crocodylia	centrum fragment	
Quarry 8	914	Crocodylia	centrum	
Quarry 8	915	Crocodylia	centrum	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
		?Goniopholis stovalli		
Quarry 8	916	Crocodylia	centrum	
Quarry 8	920	Reptilia	fragment	
		?Goniopholis stovalli		
Quarry 8	922	Crocodylia	phalanx (proximal fragment)	
Quarry 8	923	Reptilia	metapodial?	
		?Goniopholis stovalli		
Quarry 8	925	Reptilia	carpal/tarsal?	
Quarry 8	926	Reptilia	fragment	
Quarry 8	928	Chelonia	shell fragment	
Quarry 8	929	Chelonia	shell fragment	
Quarry 8	931	Chelonia	shell fragment	
Quarry 8	932	Chelonia	neurals	
Quarry 8	933	Chelonia	shell fragment	
Quarry 8	934	Chelonia	pleurals	
Quarry 8	935	Chelonia	pleural	
Quarry 8	936	Chelonia	pleural	
Quarry 8	937	Chelonia	pleural	
Quarry 8	938	Chelonia	plastron fragment	
Quarry 8	939	Chelonia	plastron fragment	
Quarry 8	940	Chelonia	neural plate	
Quarry 8	941	Chelonia	plastron fragment	
Quarry 8	942	Chelonia	plastron fragment	
Quarry 8	943	Chelonia	plastron fragment	
Quarry 8	945	Chelonia	plastron fragment	
Quarry 8	946	Chelonia	plastron fragment	
Quarry 8	949	Chelonia	plastron fragment	
Quarry 8	950	Chelonia	plastron fragment	
Quarry 8	951	Chelonia	plastron fragment	
Quarry 8	952	Chelonia	plastron fragment	
Quarry 8	953	Chelonia	plastron fragment	
Quarry 8	954	Chelonia	carapace fragment	
Quarry 8	955	Chelonia	carapace fragment	
Quarry 8	956	Chelonia	carapace fragment	
Quarry 8	957	Chelonia	peripheral plates	
Quarry 8	958	Chelonia	carapace fragment	
Quarry 8	959	Chelonia	carapace fragment	
Quarry 8	961	Chelonia	plastron frament	
Quarry 8	962	Chelonia	carapace fragment	
Quarry 8	963	Chelonia	carapace fragment	
Quarry 8	964	Chelonia	carapace fragment	
Quarry 8	965	Chelonia	peripheral plates	
Quarry 8	967	Chelonia	carapace fragment	
Quarry 8	968	Chelonia	carapace fragment	
Quarry 8	969	Chelonia	shell fragment	
Quarry 8	970	Chelonia	peripheral plate	
Quarry 8	971	Chelonia	peripheral plate	
Quarry 8	972	Chelonia	carapace fragment	
Quarry 8	975	Chelonia	carapace fragment	
Quarry 8	976	Chelonia	carapace fragment	
Quarry 8	977	Chelonia	peripheral plates	
Quarry 8	978	Chelonia	shell fragments	
Quarry 8	979	Chelonia	long bone fragment	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	981	Crocodylia	neural arch	
		?Goniopholis stovalli		
Quarry 8	982	Crocodylia	centrum	
Quarry 8	983	Chelonia	scapulocoracoid	
Quarry 8	984	Chelonia	scapulocoracoid	
Quarry 8	985	Chelonia	scapulocoracoid	
Quarry 8	986	Chelonia	pleural plate	
Quarry 8	987	Chelonia	shell fragment	
Quarry 8	988	Chelonia	shell fragment	
Quarry 8	990	Chelonia	vertebra, girdle fragment	
Quarry 8	991	Chelonia	shell fragments	
Quarry 8	993	Chelonia	neural plates	
Quarry 8	994	Crocodylia	pubis	
		?Goniopholis stovalli		
Quarry 8	996	Chelonia	section of carapace	
Quarry 8	1000	Chelonia	shell segments	
Quarry 8	1001	Chelonia	shell fragments	
Quarry 8	1002	Chelonia	plastron fragment	
Quarry 8	1003	Chelonia	pleural plate	
Quarry 8	1004	Chelonia	entoplastron	
Quarry 8	1005	Chelonia	carapace fragment	
Quarry 8	1006	Chelonia	shell fragment	
Quarry 8	1007	Chelonia	shell fragment	
Quarry 8	1021	Reptilia	centrum	
Quarry 8	1022	Crocodylia	long bone fragments	
Quarry 8	1023	Reptilia	centrum fragment	
Quarry 8	1024	Reptilia	rib	
Quarry 8	1037	Chelonia	skeleton and shell fragments in plaster	
Quarry 8	1503	Crocodylia	centrum fragments	
Quarry 8	2148	Crocodylia?	skeletal element	
Quarry 8	2321	Goniopholis stovalli	mandible, left	
Quarry 8	2322	Goniopholis stovalli	skull	
Quarry 8	2323	Glyptops sp.	costal plate	
Quarry 8	2326	Goniopholis stovalli	mandible (posterior portion)	
Quarry 8	2327	Goniopholis stovalli	skull fragment	
Quarry 8	2330	Glyptops sp.	costal plate	
Quarry 8	2331	Goniopholis stovalli	femur (missing distal end)	
Quarry 8	2332	Goniopholis stovalli	femur (shaft), right	
Quarry 8	2333	Crocodylia	femur (shaft)	
Quarry 8	2334	Goniopholis stovalli	ulna? (lacking distal end), left?	
Quarry 8	2335	Archosauria	femur or humerus? (proximal end)	
Quarry 8	2336	Goniopholis stovalli	femur or humerus (distal end)	
Quarry 8	2337	Crocodylia?	long bone (shaft)	
Quarry 8	2339	Crocodylia?	rib	
Quarry 8	2340	Crocodylia?	long bone fragment	
Quarry 8	2341	Goniopholis stovalli	fibula?	
Quarry 8	2342	Goniopholis stovalli	tibia?	
Quarry 8	2343	Crocodylia	long bone shaft fragment	
Quarry 8	2344	Goniopholis stovalli	radius or tibia	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	2345	Chelonia	marginal osteoscute	
Quarry 8	2346	Crocodylia	rib fragment	
		?Goniopholis stovalli		
Quarry 8	2347	Goniopholis stovalli	mandible	
Quarry 8	2348	Goniopholis stovalli	tibia	
Quarry 8	2350	Archosauria	femur fragments, left	
Quarry 8	2351	Archosauria	fragment	
Quarry 8	2352	Archosauria	tibia? (proximal fragment), humerus (distal fragment)	
Quarry 8	2353	*Goniopholis stovalli*	portion of cranium	
Quarry 8	2355	*Goniopholis stovalli*	tibia, left	
Quarry 8	2356	*Goniopholis stovalli*	tibia, left	
Quarry 8	2357	*Goniopholis stovalli*	tibia, left	
Quarry 8	2358	*Goniopholis stovalli*	tibia, left	
Quarry 8	2359	*Goniopholis stovalli*	rib	
Quarry 8	2360	*Goniopholis stovalli*	ulna, left	
Quarry 8	2361	*Goniopholis stovalli*	tibia, left	
Quarry 8	2362	*Goniopholis stovalli*	tibia, right	
Quarry 8	2363	*Goniopholis stovalli*	humerus, left	
Quarry 8	2364	*Goniopholis stovalli*	rib	
Quarry 8	2365	*Goniopholis stovalli*	femur, left	
Quarry 8	2366	*Goniopholis stovalli*	femur, right	
Quarry 8	2367	*Goniopholis stovalli*	femur, left	
Quarry 8	2368	*Goniopholis stovalli*	femur, right	
Quarry 8	2369	*Goniopholis stovalli*	femur, left	
Quarry 8	2370	*Goniopholis stovalli*	humerus, left	
Quarry 8	2371	*Goniopholis stovalli*	femur, right	2 pieces
Quarry 8	2372	*Goniopholis stovalli*	radius	
Quarry 8	2373	*Goniopholis stovalli*	metapodial?	
Quarry 8	2374	*Goniopholis stovalli*	tibia?	
Quarry 8	2375	*Goniopholis stovalli*	fibula or radius	
Quarry 8	2376	*Glyptops* sp.	ischium	
Quarry 8	2378	*Goniopholis stovalli*	rib	
Quarry 8	2379	*Goniopholis stovalli*	radius	
Quarry 8	2380	*Goniopholis stovalli*	radius	
Quarry 8	2381	*Goniopholis stovalli*	rib	
Quarry 8	2382	*Goniopholis stovalli*	coracoid, right	
Quarry 8	2383	*Goniopholis stovalli*	rib	
Quarry 8	2384	Chelonia	humerus?	
Quarry 8	2385	*Goniopholis stovalli*	ischium	
Quarry 8	2386	*Goniopholis stovalli*	maxilla?	
Quarry 8	2387	Crocodylia	ischium	
Quarry 8	2388	*Goniopholis stovalli*	dentary, left	
Quarry 8	2389	*Goniopholis stovalli*	ischium	
Quarry 8	2390	Chelonia	plastron fragment	
Quarry 8	2391	*Goniopholis stovalli*	metapodial?	
Quarry 8	2392	*Goniopholis stovalli*	skull	on display at SNOMNH
Quarry 8	2393	*Goniopholis stovalli*	fibula	
Quarry 8	2394	*Goniopholis stovalli*	rib	
Quarry 8	2395	*Goniopholis stovalli*	rib	
Quarry 8	2396	*Goniopholis stovalli*	rib	
Quarry 8	2397	*Goniopholis stovalli*	rib	
Quarry 8	2398	*Goniopholis stovalli*	rib head	
Quarry 8	2400	Osteichthyes	vertebra	
Quarry 8	2401	*Goniopholis stovalli*	axial peg	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	2403	*Glyptops* sp.	plastron fragment	
Quarry 8	2405	*Glyptops* sp.	shell fragment	
Quarry 8	2408	*Glyptops* sp.	plastron fragment	
Quarry 8	2411	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2412	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2413	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2414	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2415	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2416	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2417	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2418	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2419	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2420	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2421	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2422	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2423	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2424	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2425	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2426	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2427	*Goniopholis stovalli*	centrum fragment	
Quarry 8	2428	*Goniopholis stovalli*	sacral? vertebrae	
Quarry 8	2429	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2430	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2431	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2432	*Goniopholis stovalli*	dorsal centrum half	
Quarry 8	2433	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2434	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2435	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2436	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2437	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2438	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2439	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2440	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2442	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2443	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2445	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2446	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2447	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2448	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2449	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2451	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2452	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2453	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2454	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2455	*Goniopholis stovalli*	caudal vertebra	almost articulated w/ 2456 and 854
Quarry 8	2456	*Goniopholis stovalli*	caudal vertebra	almost articulated w/ 854 and 2455
Quarry 8	2458	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2459	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2460	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2462	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2463	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2464	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2465	*Goniopholis stovalli*	dorsal vertebra	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	2466	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2467	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2468	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2469	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2470	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2471	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2472	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2473	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2474	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2476	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2477	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2478	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2479	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2480	*Goniopholis stovalli*	cervical? vertebra	
Quarry 8	2481	*Goniopholis stovalli*	caudal? vertebra	
Quarry 8	2482	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2483	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2484	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2486	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2487	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2488	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2489	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2490	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2491	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2492	*Goniopholis stovalli*	caudal vertebra	
Quarry 8	2493	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2494	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2495	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2496	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2497	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2498	*Goniopholis stovalli*	dorsal vertebra	articulated w/ 2501
Quarry 8	2499	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2500	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2501	*Goniopholis stovalli*	dorsal vertebra	articulated w/ 2498
Quarry 8	2502	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2503	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2504	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2505	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2506	*Goniopholis stovalli*	dorsal vertebra	
Quarry 8	2507	Archosauria	dorsal or caudal vertebra centrum	
		?Goniopholis stovalli		
Quarry 8	2509	*Goniopholis stovalli*	axial peg	
Quarry 8	2510	*Goniopholis stovalli*	axial peg	
Quarry 8	2511	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2512	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2513	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2514	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2515	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2517	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2518	*Goniopholis stovalli*	cervical vertebra	
Quarry 8	2522	*Goniopholis stovalli*	sacral vertebra	
Quarry 8	2524	*Glyptops* sp.	plastron fragment	
Quarry 8	2533	Chelonia	humerus (proximal end)	
Quarry 8	2534	Chelonia	ilium	

Appendix A continued

Locality	OMNH #	Taxon	Element	Other information
Quarry 8	2535	Chelonia	girdle element	
Quarry 8	2536	Chelonia	girdle element	
Quarry 8	2538	Chelonia	girdle element	
Quarry 8	2540	Reptilia	centrum	toothmarks? on ventral side
Quarry 8	2541	Crocodylia	rib head	
		?Goniopholis stovalli		
Quarry 8	4033	*Ceratodus frazieri*?	upper tooth plate	
Quarry 8	4133	Archosauria	quadrate?	
Quarry 8	4134	Theropoda	pubis (proximal end)	
Quarry 8	4135	Archosauria	ilium fragment	
		?Goniopholis stovalli		
Quarry 8	4137	Archosauria	girdle fragment	
		Theropoda?		
Quarry 8	10305	*Camptosaurus* sp.	femur, left	
Quarry 8	10306	*Camptosaurus* sp.	femur, right	
Quarry 8	10307	*Camptosaurus* sp.	femur, right	
Quarry 8	10308	*Camptosaurus* sp.	tibia, right	
Quarry 8	10309	*Camptosaurus* sp.	sacral centra	2 and a half
Quarry 8	10310	*Camptosaurus* sp.	cervical centrum	
Quarry 8	10311	*Camptosaurus* sp.	thoracic centrum	
Quarry 8	10312	*Camptosaurus* sp.	rib scraps, etc.	
Quarry 8	10314	*Camptosaurus* sp.	thoracic centrum	
Quarry 8	10319	*Camptosaurus* sp.	thoracic centrum	
Quarry 8	10320	Theropoda	ilium (incomplete), right	mate to 10321
		small-medium Tetanuran		**(Larsen 2007)**
Quarry 8	10321	Theropoda	ilium (incomplete), left	mate to 10320
		small-medium Tetanuran		**(Larsen 2007)**
Quarry 8	10322	Theropoda	femur	
		small-medium Tetanuran		**(Larsen 2007)**
Quarry 8	10323	Theropoda	tibia, shaft	
		small-medium Tetanuran		**same element as 10324 (Larsen 2007)**
Quarry 8	10324	Theropoda	femur? (distal end)	
		small-medium Tetanuran	**tibia (head) right**	**same element as 10323 (Larsen 2007)**
Quarry 8	70830	Chelonia	shell fragment	

Appendix B: All elements (including unidentified specimens) in the OMNH collection from quarries 5, 6, and 8

Sorted by quarry, then by taxon, and then by element. Specimens in **bold** were not found on the quarry maps. Does not reflect revisions in specimen identification.

Locality	Specimen #	Taxon	Element
Quarry 5	1747	*Apatosaurus* sp.	caudal vertebra
Quarry 5	1988	*Apatosaurus* sp.	caudal vertebra
Quarry 5	1834	*Apatosaurus* sp.	caudal vertebra, distal
Quarry 5	1804	*Apatosaurus* sp.	coracoid, left
Quarry 5	10298	*Apatosaurus* sp.	coracoid, left
Quarry 5	**1746**	***Apatosaurus* sp.**	**manual ungual phalanx, digit I, left**
Quarry 5	1898	*Apatosaurus* sp.	pubis
Quarry 5	1783	*Apatosaurus* sp.	radius, right
Quarry 5	10224	*Apatosaurus* sp.	scapholunar
Quarry 5	1897	*Apatosaurus* sp.	tibia (proximal half), left
Quarry 5	10332	*Apatosaurus*? sp.	cervical vertebra (posterior half)
Quarry 5	1740	Apatosaurus? sp.	dorsal vertebra, posterior
Quarry 5	**1861**	**Archosauria**	**braincase**
Quarry 5	**9533**	**Archosauria**	**carpal/tarsal**
Quarry 5	**9532**	**Archosauria**	**carpal/tarsal?**
Quarry 5	1853	Archosauria	cervical rib
Quarry 5	1345	Archosauria	chevron
Quarry 5	1832	Archosauria	chevron
Quarry 5	**1836**	**Archosauria**	**chevron**
Quarry 5	1837	Archosauria	chevron
Quarry 5	1838	Archosauria	chevron
Quarry 5	1862	Archosauria	chevron
Quarry 5	4023	Archosauria	chevron
Quarry 5	4024	Archosauria	chevron
Quarry 5	**1890**	**Archosauria**	**chevron fragment**
Quarry 5	9535	Archosauria	chevron fragment
Quarry 5	1090	Archosauria	long bone fragment
Quarry 5	1948	Archosauria	long bone fragment
Quarry 5	**1743**	**Archosauria**	**long bone fragment?**
Quarry 5	**1849**	**Archosauria**	**neural arch base**
Quarry 5	1856	Archosauria	neural spine
Quarry 5	1792	Archosauria	phalanx
Quarry 5	1775	Archosauria	rib fragment
Quarry 5	1790	Archosauria	rib fragment
Quarry 5	1791	Archosauria	rib fragment
Quarry 5	1765	Archosauria	rib head
Quarry 5	1780	Archosauria	scapula blade fragment, left
Quarry 5	1896	Archosauria	skeletal element
Quarry 5	1777	Archosauria	skeletal fragment
Quarry 5	**1848**	**Archosauria**	**skull fragment?**
Quarry 5	1843	Archosauria	vertebra fragment
Quarry 5	**9530**	**Archosauria**	**vertebra fragment**
Quarry 5	**9531**	**Archosauria**	**vertebra fragment**
Quarry 5	1841	Archosauria	zygapophysis
Quarry 5	1854	Archosauria	zygapophysis

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 5	**1878**	**Archosauria**	**zygapophysis**
Quarry 5	1894	Archosauria	zygapophysis
Quarry 5	**10295**	***Barosaurus* sp.**	**caudal centrum**
Quarry 5	2150	*Barosaurus* sp.	caudal vertebra
Quarry 5	10240	*Barosaurus* sp.	caudal vertebra
Quarry 5	10246	*Barosaurus* sp.	caudal vertebra
Quarry 5	10340	*Barosaurus* sp.	caudal vertebra
Quarry 5	4026	*Barosaurus* ? sp.	caudal vertebra neural spine fragment
Quarry 5	10326	*Camarasaurus* sp.	anterior caudal vertebra
Quarry 5	10342	*Camarasaurus* sp.	astragalus, left
Quarry 5	4025	*Camarasaurus* sp.	caudal neural spine
Quarry 5	4027	*Camarasaurus* sp.	caudal neural spine
Quarry 5	10303	*Camarasaurus* sp.	caudal vertebra
Quarry 5	1741	*Camarasaurus* sp.	caudal vertebral centrum
Quarry 5	1789	*Camarasaurus* sp.	coracoid, left
Quarry 5	1794	*Camarasaurus* sp.	femur (immature= subadult), right
Quarry 5	**10233**	***Camarasaurus* sp.**	**ischium**
Quarry 5	10227	*Camarasaurus* sp.	ischium, left
Quarry 5	10195	*Camarasaurus* sp.	ischium, right
Quarry 5	10330	*Camarasaurus* sp.	ischium, right
Quarry 5	10222	*Camarasaurus* sp.	metacarpal II, left
Quarry 5	10225	*Camarasaurus* sp.	metacarpal II, right
Quarry 5	10218	*Camarasaurus* sp.	metacarpal III
Quarry 5	10226	*Camarasaurus* sp.	metacarpal III, left
Quarry 5	10228	*Camarasaurus* sp.	metacarpal V, right
Quarry 5	2030	*Camarasaurus* sp.	metapodial
Quarry 5	1889	*Camarasaurus* sp.	neural spine
Quarry 5	1900	*Camarasaurus* sp.	neural spine
Quarry 5	1901	*Camarasaurus* sp.	neural spine
Quarry 5	1779	*Camarasaurus* sp.	pubis, left
Quarry 5	1816	*Camarasaurus* sp.	pubis, right
Quarry 5	1752	Camarasaurus? sp.	dorsal or sacral arch
Quarry 5	**9534**	***Camptosaurus* ? sp.**	**metapodial fragment**
Quarry 5	1797	*Camptosaurus* ? sp.	sacrum (immature)
Quarry 5	1491	*Ceratosaurus* sp.	tooth
Quarry 5	1865	Diplodocidae	anterior caudal neural spine
Quarry 5	1786	Diplodocidae	chevron
Quarry 5	1787	Diplodocidae	chevron
Quarry 5	1788	Diplodocidae	chevron
Quarry 5	1868	Diplodocidae	dorsal neural spine
Quarry 5	10229	Diplodocidae	metatarsal V
Quarry 5	10230	Diplodocidae	metatarsal V, left
Quarry 5	1895	Diplodocidae	neural arch fragment
Quarry 5	**1748**	**Diplodocidae**	**neural spine**
Quarry 5	1857	Diplodocidae	neural spine
Quarry 5	1858	Diplodocidae	neural spine
Quarry 5	1859	Diplodocidae	neural spine
Quarry 5	1860	Diplodocidae	neural spine
Quarry 5	1863	Diplodocidae	neural spine
Quarry 5	**1864**	**Diplodocidae**	**neural spine**
Quarry 5	1870	Diplodocidae	neural spine

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 5	1871	Diplodocidae	neural spine
Quarry 5	**1872**	**Diplodocidae**	**neural spine**
Quarry 5	1873	Diplodocidae	neural spine
Quarry 5	1874	Diplodocidae	neural spine
Quarry 5	1888	Diplodocidae	neural spine
Quarry 5	10261	Diplodocidae	neural spine
Quarry 5	10345	*Diplodocus* sp.	caudal vertebra
Quarry 5	10334	*Diplodocus* sp.	3rd? dorsal vertebra
Quarry 5	10258	*Diplodocus* sp.	anterior caudal centrum, anterior end
Quarry 5	10304	*Diplodocus* sp.	anterior caudal rib
Quarry 5	10331	*Diplodocus* sp.	anterior caudal vertebra
Quarry 5	10254	*Diplodocus* sp.	anterior caudal vertebra attached to 1875 & 10252
Quarry 5	10263	*Diplodocus* sp.	anterior caudal vertebra, anterior half
Quarry 5	10189	*Diplodocus* sp.	astragalus, left
Quarry 5	10188	*Diplodocus* sp.	astragalus, right
Quarry 5	1989	*Diplodocus* sp.	caudal centrum fragment
Quarry 5	10259	*Diplodocus* sp.	caudal centrum, anterior end
Quarry 5	1869	*Diplodocus* sp.	caudal neural spine
Quarry 5	10191	*Diplodocus* sp.	caudal vertebra
Quarry 5	10192	*Diplodocus* sp.	caudal vertebra
Quarry 5	10193	*Diplodocus* sp.	caudal vertebra
Quarry 5	10235	*Diplodocus* sp.	caudal vertebra
Quarry 5	10236	*Diplodocus* sp.	caudal vertebra
Quarry 5	10237	*Diplodocus* sp.	caudal vertebra
Quarry 5	10238	*Diplodocus* sp.	caudal vertebra
Quarry 5	10239	*Diplodocus* sp.	caudal vertebra
Quarry 5	10241	*Diplodocus* sp.	caudal vertebra
Quarry 5	10242	*Diplodocus* sp.	caudal vertebra
Quarry 5	10243	*Diplodocus* sp.	caudal vertebra
Quarry 5	10244	*Diplodocus* sp.	caudal vertebra
Quarry 5	10245	*Diplodocus* sp.	caudal vertebra
Quarry 5	10247	*Diplodocus* sp.	caudal vertebra
Quarry 5	10248	*Diplodocus* sp.	caudal vertebra
Quarry 5	10249	*Diplodocus* sp.	caudal vertebra
Quarry 5	10250	*Diplodocus* sp.	caudal vertebra
Quarry 5	10251	*Diplodocus* sp.	caudal vertebra
Quarry 5	10253	*Diplodocus* sp.	caudal vertebra
Quarry 5	10257	*Diplodocus* sp.	caudal vertebra
Quarry 5	10262	*Diplodocus* sp.	caudal vertebra
Quarry 5	10296	*Diplodocus* sp.	caudal vertebra
Quarry 5	10297	*Diplodocus* sp.	caudal vertebra
Quarry 5	10333	*Diplodocus* sp.	caudal vertebra
Quarry 5	10335	*Diplodocus* sp.	caudal vertebra
Quarry 5	10339	*Diplodocus* sp.	caudal vertebra
Quarry 5	10252	*Diplodocus* sp.	caudal vertebra attached to 1875 and 10254
Quarry 5	1845	*Diplodocus* sp.	cervical vertebra
Quarry 5	**1953**	***Diplodocus* sp.**	**cervical vertebra**
Quarry 5	**10343**	***Diplodocus* sp.**	**cervical vertebra (flattened)**
Quarry 5	**1078**	***Diplodocus* sp.**	**cervical vertebra fragments**
Quarry 5	1833	*Diplodocus* sp.	chevron
Quarry 5	1835	*Diplodocus* sp.	chevron

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 5	1839	*Diplodocus* sp.	chevron
Quarry 5	1840	*Diplodocus* sp.	chevron
Quarry 5	10194	*Diplodocus* sp.	chevron
Quarry 5	10349	*Diplodocus* sp.	chevron
Quarry 5	10352	*Diplodocus* sp.	demi-chevron
Quarry 5	1879	*Diplodocus* sp.	dorsal neural arch
Quarry 5	1793	*Diplodocus* sp.	femur (subadult), left
Quarry 5	10183	*Diplodocus* sp.	fibula (proximal), left
Quarry 5	1781	*Diplodocus* sp.	humerus
Quarry 5	10201	*Diplodocus* sp.	metatarsal I, left
Quarry 5	10214	*Diplodocus* sp.	metatarsal IV, right
Quarry 5	10216	*Diplodocus* sp.	metatarsal IV, right
Quarry 5	10184	*Diplodocus* sp.	radius
Quarry 5	10186	*Diplodocus* sp.	radius
Quarry 5	10187	*Diplodocus* sp.	radius (distal end)
Quarry 5	1819	*Diplodocus* sp.	scapula, right
Quarry 5	10264	*Diplodocus* sp.	tibia, right
Quarry 5	10185	*Diplodocus* sp.	ulna
Quarry 5	10300	*Diplodocus* sp.	ulna
Quarry 5	1079	*Diplodocus* sp.	vertebra fragments
Quarry 5	10256	*Diplodocus* ? sp.	anterior dorsal centrum
Quarry 5	10255	*Diplodocus* ? sp.	dorsal centrum
Quarry 5	1798	*Diplodocus* ? sp.	dorsal centrum fragment
Quarry 5	10232	*Diplodocus* ? sp.	femur head
Quarry 5	10199	*Diplodocus* ? sp.	metatarsal II, left
Quarry 5	10200	*Diplodocus* ? sp.	metatarsal II, right
Quarry 5	1091	*Diplodocus* ? sp.	scapula, left
Quarry 5	1801	Saurischia	cervical rib
Quarry 5	10354	*Saurophaganax maximus*	atlas-axis
Quarry 5	10365	*Saurophaganax maximus*	axis vertebra
Quarry 5	10282	*Saurophaganax maximus*	caudal centrum
Quarry 5	10362	*Saurophaganax maximus*	caudal centrum
Quarry 5	**1751**	***Saurophaganax maximus***	**caudal vertebra**
Quarry 5	1909	*Saurophaganax maximus*	caudal vertebra
Quarry 5	**1922**	***Saurophaganax maximus***	**caudal vertebra**
Quarry 5	**1923**	***Saurophaganax maximus***	**caudal vertebra**
Quarry 5	**2020**	***Saurophaganax maximus***	**caudal vertebra**
Quarry 5	10265	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10266	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10267	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10268	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10269	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10270	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10271	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10272	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10273	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10274	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10275	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10276	*Saurophaganax maximus*	caudal vertebra
Quarry 5	**10277**	***Saurophaganax maximus***	**caudal vertebra**
Quarry 5	10278	*Saurophaganax maximus*	caudal vertebra

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 5	10279	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10280	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10281	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10293	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10355	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10357	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10359	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10366	*Saurophaganax maximus*	caudal vertebra
Quarry 5	10284	*Saurophaganax maximus*	caudal vertebra (2, fused) and attached chevron
Quarry 5	**10292**	***Saurophaganax maximus***	**cervical centrum**
Quarry 5	10289	*Saurophaganax maximus*	chevron
Quarry 5	10290	*Saurophaganax maximus*	chevron
Quarry 5	10291	*Saurophaganax maximus*	chevron
Quarry 5	10346	*Saurophaganax maximus*	chevron
Quarry 5	10347	*Saurophaganax maximus*	chevron
Quarry 5	10348	*Saurophaganax maximus*	chevron
Quarry 5	10385	*Saurophaganax maximus*	chevron
Quarry 5	10381	*Saurophaganax maximus*	femur, left
Quarry 5	**2021**	***Saurophaganax maximus***	**neural arch**
Quarry 5	2022	*Saurophaganax maximus*	neural arch
Quarry 5	**10286**	***Saurophaganax maximus***	**neural arch, posterior sacral vertebra?**
Quarry 5	10356	*Saurophaganax maximus*	phalanx I
Quarry 5	10287	*Saurophaganax maximus*	pubic process of ilium?
Quarry 5	1776	*Saurophaganax maximus*	sacral vertebrae, 2 attached
Quarry 5	10283	*Saurophaganax maximus*	side of caudal centrum
Quarry 5	10285	*Saurophaganax maximus*	thoracic centrum
Quarry 5	10288	*Saurophaganax maximus*	thoracic centrum
Quarry 5	10353	*Saurophaganax maximus*	thoracic vertebra
Quarry 5	10358	*Saurophaganax maximus*	thoracic vertebra
Quarry 5	10344	Sauropoda	articulated caudal vertebrae
Quarry 5	10196	Sauropoda	carpal "radiale", left
Quarry 5	10197	Sauropoda	carpal "radiale", right
Quarry 5	10198	Sauropoda	carpal "ulnare", right
Quarry 5	10301	Sauropoda	caudal centrum (anterior end)
Quarry 5	10260	Sauropoda	caudal centrum (anterior end)
Quarry 5	1764	Sauropoda	centrum fragment
Quarry 5	**1876**	**Sauropoda**	**centrum fragment**
Quarry 5	**1088**	**Sauropoda**	**cervical dorsal neural spine**
Quarry 5	1844	Sauropoda	cervical vertebra
Quarry 5	1867	Sauropoda	cervical vertebra
Quarry 5	1882	Sauropoda	cervical vertebra
Quarry 5	1893	Sauropoda	cervical vertebra
Quarry 5	1089	Sauropoda	cervical vertebra fragment
Quarry 5	1824	Sauropoda	cervical vertebra fragment
Quarry 5	1866	Sauropoda	cervical vertebra fragment
Quarry 5	1755	Sauropoda	distal caudal vertebra
Quarry 5	1742	Sauropoda	femur fragment?
Quarry 5	10223	Sauropoda	fibula (proximal end), right
Quarry 5	10299	Sauropoda	fibula, left
Quarry 5	10302	Sauropoda	ilium (posterior end), right
Quarry 5	4083	Sauropoda	ischiae peduncle of ilium

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 5	1756	Sauropoda	ischium
Quarry 5	1805	Sauropoda	long bone fragment
Quarry 5	1899	Sauropoda	long bone fragment
Quarry 5	10203	Sauropoda	manual phalanx II, 1 or III, 1, right
Quarry 5	10231	Sauropoda	manus, phalanx I, 2
Quarry 5	10363	Sauropoda	manus, phalanx II, 1 or III, 1
Quarry 5	10205	Sauropoda	manus, terminal phalanx IV, 1
Quarry 5	10202	Sauropoda	manus, terminal phalanx V, 1
Quarry 5	10204	Sauropoda	manus, terminal phalanx V, 1
Quarry 5	10215	Sauropoda	metacarpal I, left
Quarry 5	10221	Sauropoda	metacarpal IV, left?
Quarry 5	10219	Sauropoda	metacarpal IV, right
Quarry 5	10217	Sauropoda	metatarsal IV, left
Quarry 5	10220	Sauropoda	metatarsal V, right
Quarry 5	1855	Sauropoda	neural arch fragment
Quarry 5	1880	Sauropoda	neural arch fragment
Quarry 5	**4245**	**Sauropoda**	**neural arch fragment**
Quarry 5	10294	Sauropoda	pedal phalanx 1, digit II, right
Quarry 5	10207	Sauropoda	pedal phalanx I, 1, right
Quarry 5	10206	Sauropoda	pes, phalanx 1, digit II, right
Quarry 5	10210	Sauropoda	pes, phalanx II, 1, right
Quarry 5	10209	Sauropoda	pes, phalanx II, 2
Quarry 5	10208	Sauropoda	pes, phalanx III, 2, right
Quarry 5	10211	Sauropoda	pes, ungual phalanx I, 2 or II, 3, left
Quarry 5	10213	Sauropoda	pes, ungual phalanx I, 2, right
Quarry 5	10212	Sauropoda	pes, ungual phalanx III, 4, right
Quarry 5	1881	Sauropoda	posterior dorsal neural arch
Quarry 5	1823	Sauropoda	proximal limb bone fragment
Quarry 5	1814	Sauropoda	rib
Quarry 5	1072	Sauropoda	rib fragment
Quarry 5	1073	Sauropoda	rib fragment
Quarry 5	1074	Sauropoda	rib fragment
Quarry 5	1075	Sauropoda	rib fragment
Quarry 5	1076	Sauropoda	rib fragment
Quarry 5	1077	Sauropoda	rib fragment
Quarry 5	1080	Sauropoda	rib fragment
Quarry 5	1081	Sauropoda	rib fragment
Quarry 5	1082	Sauropoda	rib fragment
Quarry 5	1083	Sauropoda	rib fragment
Quarry 5	1084	Sauropoda	rib fragment
Quarry 5	1085	Sauropoda	rib fragment
Quarry 5	1086	Sauropoda	rib fragment
Quarry 5	1087	Sauropoda	rib fragment
Quarry 5	1758	Sauropoda	rib fragment
Quarry 5	1759	Sauropoda	rib fragment
Quarry 5	1760	Sauropoda	rib fragment
Quarry 5	1761	Sauropoda	rib fragment
Quarry 5	1762	Sauropoda	rib fragment
Quarry 5	1763	Sauropoda	rib fragment
Quarry 5	1766	Sauropoda	rib fragment
Quarry 5	1769	Sauropoda	rib fragment

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 5	1774	Sauropoda	rib fragment
Quarry 5	1799	Sauropoda	rib fragment
Quarry 5	1800	Sauropoda	rib fragment
Quarry 5	1806	Sauropoda	rib fragment
Quarry 5	1807	Sauropoda	rib fragment
Quarry 5	1808	Sauropoda	rib fragment
Quarry 5	1902	Sauropoda	rib fragment
Quarry 5	1903	Sauropoda	rib fragment
Quarry 5	1767	Sauropoda	rib fragment attached to K-354
Quarry 5	10234	Sauropoda	tibia (distal end), right
Quarry 5	10190	Sauropoda	tibia (distal end), right
Quarry 5	1877	Sauropoda	vertebra fragment
Quarry 5	1892	Sauropoda	vertebra fragment
Quarry 5	1875	Sauropoda	vertebra fragment attached to 10254 and 10252
Quarry 5	1887	Sauropoda	vertebral fragment
Quarry 5	**1891**	**Sauropoda**	**zygapophysis**
Quarry 5	1850	Sauropoda?	braincase (juvenile?)
Quarry 5	9536	Sauropoda?	jaw fragment w/ alveoli
Quarry 5	1803	Sauropoda?	long bone fragment
Quarry 5	1749	Sauropoda?	sacrum
Quarry 5	1815	*Stegosaurus* sp.	femur, left
Quarry 5	10328	*Stegosaurus* sp.	humerus, left
Quarry 5	1757	*Stegosaurus* sp.	tail spike
Quarry 5	10329	*Stegosaurus*? sp.	coracoid
Quarry 5	1851	Theropoda?	braincase
Quarry 5	**1785**	**Theropoda?**	**caudal vertebra**
Quarry 5	10364	Theropoda?	caudal vertebra
Quarry 5	1886	Theropoda?	centrum
Quarry 5	1842	Theropoda?	dorsal vertebra
Quarry 5	**1846**	**Theropoda?**	**skull fragment**
Quarry 5	**1847**	**Theropoda?**	**skull fragment**
Quarry 5	**1852**	**Theropoda?**	**skull fragment**
Quarry 5	**1754**	**Theropoda?**	**vertebra**
Quarry 5	1750	Theropoda?	vertebral centrum
Quarry 6	10338	*Apatosaurus* sp.	astragalus
Quarry 6	1327	*Apatosaurus* sp.	coracoid, left
Quarry 6	2000	*Apatosaurus* sp.	distal caudal vertebra
Quarry 6	1991	*Apatosaurus* sp.	femur
Quarry 6	1968	*Apatosaurus* sp.	ilium fragment
Quarry 6	2051	*Apatosaurus* sp.	scapula
Quarry 6	10367	Archosauria	atlas and axis vertebra
Quarry 6	**1957**	**Archosauria**	**carpal/tarsal?**
Quarry 6	1982	Archosauria	girdle fragment
Quarry 6	**4022**	**Archosauria**	**ischium (proximal fragment)**
Quarry 6	1977	Archosauria	rib fragment
Quarry 6	**2006**	**Archosauria**	**rib fragment**
Quarry 6	1961	*Barosaurus* sp.	caudal centrum
Quarry 6	1962	*Barosaurus* sp.	caudal centrum
Quarry 6	1963	*Barosaurus* sp.	caudal vertebra
Quarry 6	1971	*Barosaurus* sp.	caudal vertebra

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 6	10337	*Barosaurus?* sp.	astragalus, right
Quarry 6	1753	*Camarasaurus* sp.	caudal vertebra
Quarry 6	1795	*Camarasaurus* sp.	caudal vertebra
Quarry 6	1956	*Camarasaurus* sp.	caudal vertebra
Quarry 6	1966	*Camarasaurus* sp.	caudal vertebra
Quarry 6	10370	*Camarasaurus* sp.	caudal vertebra
Quarry 6	10369	*Camarasaurus* sp.	caudal vertebra w/ arch of another
Quarry 6	1987	*Camarasaurus* sp.	chevron
Quarry 6	10350	*Camarasaurus* sp.	chevron
Quarry 6	10351	*Camarasaurus* sp.	chevron
Quarry 6	10341	*Camarasaurus* sp.	coracoid, right
Quarry 6	1969	*Camarasaurus* sp.	ischium (distal fragment)
Quarry 6	4021	*Camarasaurus* sp.	neural spine
Quarry 6	1970	*Camarasaurus* sp.	neural spine fragment
Quarry 6	1986	*Camarasaurus* sp.	scapula, right
Quarry 6	10336	*Camarasaurus* sp.	squashed caudal centrum
Quarry 6	1972	*Camarasaurus* sp.	vertebra fragment
Quarry 6	1959	*Camarasaurus?* sp.	caudal vertebra
Quarry 6	1960	Camarasaurus? sp.	neural arch of median caudal
Quarry 6	1768	*Camptosaurus* sp.	anterior caudal vertebra
Quarry 6	**10380**	***Camptosaurus* sp.**	**dorsal vertebral centrum**
Quarry 6	1796	Diplodocidae	tibia, right
Quarry 6	1954	*Diplodocus* sp.	caudal vertebra
Quarry 6	1817	*Diplodocus* sp.	dorsal vertebra
Quarry 6	1333	*Diplodocus* sp.	femur fragment, left
Quarry 6	1952	*Diplodocus?* sp.	ischium, right
Quarry 6	**10383**	***Saurophaganax maximus***	**articulated tibia, fibula, astragalus, calcaneus**
Quarry 6	2007	*Saurophaganax maximus*	caudal centrum
Quarry 6	1958	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1992	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1993	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1994	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1995	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1996	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1997	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1998	*Saurophaganax maximus*	caudal vertebra
Quarry 6	1999	*Saurophaganax maximus*	caudal vertebra
Quarry 6	2002	*Saurophaganax maximus*	caudal vertebra
Quarry 6	2008	*Saurophaganax maximus*	caudal vertebra
Quarry 6	2009	*Saurophaganax maximus*	caudal vertebra
Quarry 6	10360	*Saurophaganax maximus*	caudal vertebra
Quarry 6	2015	*Saurophaganax maximus*	centrum
Quarry 6	2016	*Saurophaganax maximus*	centrum
Quarry 6	2017	*Saurophaganax maximus*	centrum
Quarry 6	2018	*Saurophaganax maximus*	centrum
Quarry 6	2010	*Saurophaganax maximus*	cervical vertebra
Quarry 6	1985	*Saurophaganax maximus*	dorsal vertebra arch fragment
Quarry 6	1984	*Saurophaganax maximus*	femur (proximal element)
Quarry 6	1983	*Saurophaganax maximus*	girdle element?
Quarry 6	1802	*Saurophaganax maximus*	ilium

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 6	1979	*Saurophaganax maximus*	ischium, right
Quarry 6	2014	*Saurophaganax maximus*	posterior dorsal vertebra
Quarry 6	1965	*Saurophaganax maximus*	scapula, right
Quarry 6	10361	*Saurophaganax maximus*	thoracic centrum
Quarry 6	10382	*Saurophaganax maximus*	tibia, right
Quarry 6	2001	*Saurophaganax maximus*	vertebra
Quarry 6	2003	*Saurophaganax maximus*	vertebra
Quarry 6	2013	*Saurophaganax maximus*	vertebra
Quarry 6	2012	*Saurophaganax maximus*	vertebra fragment
Quarry 6	2004	*Saurophaganax maximus*	vertebra (juvenile)
Quarry 6	2005	*Saurophaganax maximus*	vertebral centrum (juvenile)
Quarry 6	**2046**	**Sauropoda**	**cervical vertebra**
Quarry 6	1818	Sauropoda	dorsal vertebra
Quarry 6	1950	Sauropoda	fibula? fragment
Quarry 6	1782	Sauropoda	ilium, sacrum, and fragments
Quarry 6	**1976**	**Sauropoda**	**neural spine fragment**
Quarry 6	1964	Sauropoda	prezygapophysis of dorsal vertebra, right
Quarry 6	1967	Sauropoda	pubis (distal fragment)
Quarry 6	1825	Sauropoda	rib fragment
Quarry 6	1826	Sauropoda	rib fragment
Quarry 6	1973	Sauropoda	rib fragment
Quarry 6	1974	Sauropoda	rib fragment
Quarry 6	1975	Sauropoda	rib fragment
Quarry 6	1978	Sauropoda	rib fragment
Quarry 6	1980	Sauropoda	rib fragment
Quarry 6	1981	Sauropoda	rib fragment
Quarry 6	1951	Sauropoda	scapula fragment
Quarry 6	1955	Sauropoda	sternal plate?
Quarry 6	**2078**	***Stegosaurus* sp.**	**caudal vertebra**
Quarry 8	829	Amiiformes	caudal? centrum
Quarry 8	**1026**	**Amiiformes**	**centra**
Quarry 8	**815**	**Amiiformes**	**trunk centra**
Quarry 8	**816**	**Amiiformes**	**trunk centra**
Quarry 8	2507	Archosauria	dorsal or caudal vertebra centrum
Quarry 8	**2349**	**Archosauria**	**femur (shaft)**
Quarry 8	2350	Archosauria	femur fragments, left
Quarry 8	2335	Archosauria	femur or humerus? (proximal end)
Quarry 8	2351	Archosauria	fragment
Quarry 8	4137	Archosauria	girdle fragment
Quarry 8	4135	Archosauria	ilium fragment
Quarry 8	**4136**	**Archosauria**	**neural spine fragment**
Quarry 8	4133	Archosauria	quadrate?
Quarry 8	2352	Archosauria	tibia? (proximal fragment), humerus (distal end)
Quarry 8	10310	*Camptosaurus* sp.	cervical centrum
Quarry 8	10305	*Camptosaurus* sp.	femur, left
Quarry 8	10306	*Camptosaurus* sp.	femur, right
Quarry 8	10307	*Camptosaurus* sp.	femur, right
Quarry 8	**10325**	***Camptosaurus* sp.**	**neural arch of thoracic vertebra**
Quarry 8	10312	*Camptosaurus* sp.	rib scraps, etc.
Quarry 8	10309	*Camptosaurus* sp.	sacral centra (2.5)

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	10311	*Camptosaurus* sp.	thoracic centrum
Quarry 8	10314	*Camptosaurus* sp.	thoracic centrum
Quarry 8	**10315**	***Camptosaurus* sp.**	**thoracic centrum**
Quarry 8	**10316**	***Camptosaurus* sp.**	**thoracic centrum**
Quarry 8	10319	*Camptosaurus* sp.	thoracic centrum
Quarry 8	**10317**	***Camptosaurus* sp.**	**thoracic vertebra**
Quarry 8	**10318**	***Camptosaurus* sp.**	**thoracic vertebra**
Quarry 8	10308	*Camptosaurus* sp.	tibia, right
Quarry 8	**10313**	***Camptosaurus* sp.**	**vertebra**
Quarry 8	4033	*Ceratodus frazieri?*	upper tooth plate
Quarry 8	**896**	***Ceratodus guentheri***	**upper tooth plate**
Quarry 8	**843**	**Chelonia**	**carapace and plastron fragments**
Quarry 8	954	Chelonia	carapace fragment
Quarry 8	955	Chelonia	carapace fragment
Quarry 8	956	Chelonia	carapace fragment
Quarry 8	958	Chelonia	carapace fragment
Quarry 8	959	Chelonia	carapace fragment
Quarry 8	962	Chelonia	carapace fragment
Quarry 8	963	Chelonia	carapace fragment
Quarry 8	964	Chelonia	carapace fragment
Quarry 8	967	Chelonia	carapace fragment
Quarry 8	968	Chelonia	carapace fragment
Quarry 8	972	Chelonia	carapace fragment
Quarry 8	**973**	**Chelonia**	**carapace fragment**
Quarry 8	**974**	**Chelonia**	**carapace fragment**
Quarry 8	975	Chelonia	carapace fragment
Quarry 8	976	Chelonia	carapace fragment
Quarry 8	**980**	**Chelonia**	**carapace fragment**
Quarry 8	1005	Chelonia	carapace fragment
Quarry 8	1004	Chelonia	entoplastron
Quarry 8	889	Chelonia	femur
Quarry 8	891	Chelonia	femur (proximal)
Quarry 8	897	Chelonia	fragment
Quarry 8	**992**	**Chelonia**	**fragment**
Quarry 8	807	Chelonia	girdle element
Quarry 8	2535	Chelonia	girdle element
Quarry 8	2536	Chelonia	girdle element
Quarry 8	**2537**	**Chelonia**	**girdle element**
Quarry 8	2538	Chelonia	girdle element
Quarry 8	887	Chelonia	humerus
Quarry 8	888	Chelonia	humerus (distal end)
Quarry 8	902	Chelonia	humerus (distal end)
Quarry 8	890	Chelonia	humerus (proximal end)
Quarry 8	2533	Chelonia	humerus (proximal end)
Quarry 8	2384	Chelonia	humerus?
Quarry 8	2534	Chelonia	ilium
Quarry 8	**894**	**Chelonia**	**ilium, left**
Quarry 8	892	Chelonia	long bone fragment
Quarry 8	895	Chelonia	long bone fragment

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	**898**	**Chelonia**	**long bone fragment**
Quarry 8	**899**	**Chelonia**	**long bone fragment**
Quarry 8	900	Chelonia	long bone fragment
Quarry 8	979	Chelonia	long bone fragment
Quarry 8	2345	Chelonia	marginal osteoscute
Quarry 8	**2539**	**Chelonia**	**marginal osteoscute**
Quarry 8	940	Chelonia	neural plate
Quarry 8	**1030**	**Chelonia**	**neural plate**
Quarry 8	993	Chelonia	neural plates
Quarry 8	932	Chelonia	neurals
Quarry 8	**917**	**Chelonia**	**pelvis fragment**
Quarry 8	**966**	**Chelonia**	**peripheral plate**
Quarry 8	970	Chelonia	peripheral plate
Quarry 8	971	Chelonia	peripheral plate
Quarry 8	957	Chelonia	peripheral plates
Quarry 8	965	Chelonia	peripheral plates
Quarry 8	977	Chelonia	peripheral plates
Quarry 8	938	Chelonia	plastron fragment
Quarry 8	939	Chelonia	plastron fragment
Quarry 8	941	Chelonia	plastron fragment
Quarry 8	942	Chelonia	plastron fragment
Quarry 8	943	Chelonia	plastron fragment
Quarry 8	**944**	**Chelonia**	**plastron fragment**
Quarry 8	945	Chelonia	plastron fragment
Quarry 8	946	Chelonia	plastron fragment
Quarry 8	**947**	**Chelonia**	**plastron fragment**
Quarry 8	**948**	**Chelonia**	**plastron fragment**
Quarry 8	949	Chelonia	plastron fragment
Quarry 8	950	Chelonia	plastron fragment
Quarry 8	951	Chelonia	plastron fragment
Quarry 8	952	Chelonia	plastron fragment
Quarry 8	953	Chelonia	plastron fragment
Quarry 8	1002	Chelonia	plastron fragment
Quarry 8	2390	Chelonia	plastron fragment
Quarry 8	961	Chelonia	plastron frament
Quarry 8	935	Chelonia	pleural
Quarry 8	936	Chelonia	pleural
Quarry 8	937	Chelonia	pleural
Quarry 8	986	Chelonia	pleural plate
Quarry 8	1003	Chelonia	pleural plate
Quarry 8	**998**	**Chelonia**	**pleural plates**
Quarry 8	934	Chelonia	pleurals
Quarry 8	901	Chelonia	scapulocoracoid
Quarry 8	983	Chelonia	scapulocoracoid
Quarry 8	984	Chelonia	scapulocoracoid
Quarry 8	985	Chelonia	scapulocoracoid
Quarry 8	903	Chelonia	scapulocoracoid fragment
Quarry 8	996	Chelonia	section of carapace
Quarry 8	**997**	**Chelonia**	**shell**
Quarry 8	928	Chelonia	shell fragment

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	929	Chelonia	shell fragment
Quarry 8	**930**	**Chelonia**	**shell fragment**
Quarry 8	931	Chelonia	shell fragment
Quarry 8	933	Chelonia	shell fragment
Quarry 8	**960**	**Chelonia**	**shell fragment**
Quarry 8	969	Chelonia	shell fragment
Quarry 8	987	Chelonia	shell fragment
Quarry 8	988	Chelonia	shell fragment
Quarry 8	1006	Chelonia	shell fragment
Quarry 8	1007	Chelonia	shell fragment
Quarry 8	70830	Chelonia	shell fragment
Quarry 8	**70830**	**Chelonia**	**shell fragment**
Quarry 8	978	Chelonia	shell fragments
Quarry 8	**989**	**Chelonia**	**shell fragments**
Quarry 8	991	Chelonia	shell fragments
Quarry 8	1001	Chelonia	shell fragments
Quarry 8	**1008**	**Chelonia**	**shell fragments**
Quarry 8	**1029**	**Chelonia**	**shell fragments**
Quarry 8	1000	Chelonia	shell segments
Quarry 8	**1028**	**Chelonia**	**skeleton and shell fragments**
Quarry 8	1037	Chelonia	skeleton and shell fragments in plaster
Quarry 8	893	Chelonia	tibia
Quarry 8	990	Chelonia	vertebra, girdle fragment
Quarry 8	**921**	**Crocodylia**	**articular fragment?**
Quarry 8	882	Crocodylia	astragalus
Quarry 8	**904**	**Crocodylia**	**calcaneum**
Quarry 8	**2545**	**Crocodylia**	**carpal/tarsal?**
Quarry 8	**2546**	**Crocodylia**	**carpal/tarsal?**
Quarry 8	**850**	**Crocodylia**	**centrum**
Quarry 8	851	Crocodylia	centrum
Quarry 8	853	Crocodylia	centrum
Quarry 8	854	Crocodylia	centrum
Quarry 8	855	Crocodylia	centrum
Quarry 8	860	Crocodylia	centrum
Quarry 8	861	Crocodylia	centrum
Quarry 8	865	Crocodylia	centrum
Quarry 8	**867**	**Crocodylia**	**centrum**
Quarry 8	**869**	**Crocodylia**	**centrum**
Quarry 8	875	Crocodylia	centrum
Quarry 8	876	Crocodylia	centrum
Quarry 8	878	Crocodylia	centrum
Quarry 8	**879**	**Crocodylia**	**centrum**
Quarry 8	905	Crocodylia	centrum
Quarry 8	907	Crocodylia	centrum
Quarry 8	**911**	**Crocodylia**	**centrum**
Quarry 8	914	Crocodylia	centrum
Quarry 8	915	Crocodylia	centrum
Quarry 8	916	Crocodylia	centrum
Quarry 8	982	Crocodylia	centrum

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	**1504**	**Crocodylia**	**centrum**
Quarry 8	912	Crocodylia	centrum fragment
Quarry 8	913	Crocodylia	centrum fragment
Quarry 8	1503	Crocodylia	centrum fragments
Quarry 8	798	Crocodylia	coracoid
Quarry 8	798	Crocodylia	coracoid
Quarry 8	803	Crocodylia	coracoid
Quarry 8	**1034**	**Crocodylia**	**dermal plate**
Quarry 8	805	Crocodylia	dermal plates
Quarry 8	799	Crocodylia	femur
Quarry 8	857	Crocodylia	femur (distal fragment)
Quarry 8	2333	Crocodylia	femur (shaft)
Quarry 8	831	Crocodylia	fragment
Quarry 8	856	Crocodylia	fragment
Quarry 8	868	Crocodylia	fragment
Quarry 8	871	Crocodylia	fragment
Quarry 8	839	Crocodylia	fragments
Quarry 8	840	Crocodylia	fragments
Quarry 8	**841**	**Crocodylia**	**fragments**
Quarry 8	786	Crocodylia	humerus
Quarry 8	787	Crocodylia	humerus
Quarry 8	2387	Crocodylia	ischium
Quarry 8	826	Crocodylia	long bone fragment
Quarry 8	858	Crocodylia	long bone fragment
Quarry 8	859	Crocodylia	long bone fragment
Quarry 8	834	Crocodylia	long bone fragments
Quarry 8	1022	Crocodylia	long bone fragments
Quarry 8	2343	Crocodylia	long bone shaft fragment
Quarry 8	910	Crocodylia	metapodial fragment
Quarry 8	**796**	**Crocodylia**	**miscellaneous teeth**
Quarry 8	800	Crocodylia	miscellaneous vertebrae
Quarry 8	804	Crocodylia	neural arch
Quarry 8	981	Crocodylia	neural arch
Quarry 8	877	Crocodylia	neural arch fragments
Quarry 8	**2544**	**Crocodylia**	**neural spine**
Quarry 8	**2547**	**Crocodylia**	**osteoderm**
Quarry 8	**2548**	**Crocodylia**	**osteoderm fragments**
Quarry 8	908	Crocodylia	phalanx
Quarry 8	**1405**	**Crocodylia**	**phalanx**
Quarry 8	909	Crocodylia	phalanx (distal fragment)
Quarry 8	922	Crocodylia	phalanx (proximal fragment)
Quarry 8	994	Crocodylia	pubis
Quarry 8	**1033**	**Crocodylia**	**quadrate**
Quarry 8	**2525**	**Crocodylia**	**quadrate**
Quarry 8	802	Crocodylia	rib
Quarry 8	870	Crocodylia	rib
Quarry 8	906	Crocodylia	rib
Quarry 8	2346	Crocodylia	rib fragment
Quarry 8	**2407**	**Crocodylia**	**rib head**
Quarry 8	2541	Crocodylia	rib head

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	**2542**	**Crocodylia**	**rib head**
Quarry 8	**2543**	**Crocodylia**	**rib head**
Quarry 8	806	Crocodylia	scapula, right
Quarry 8	**821**	**Crocodylia**	**teeth**
Quarry 8	**822**	**Crocodylia**	**teeth**
Quarry 8	**836**	**Crocodylia**	**teeth**
Quarry 8	**999**	**Crocodylia**	**teeth**
Quarry 8	**1011**	**Crocodylia**	**teeth**
Quarry 8	**1012**	**Crocodylia**	**teeth**
Quarry 8	**1013**	**Crocodylia**	**teeth**
Quarry 8	**1014**	**Crocodylia**	**teeth**
Quarry 8	**1016**	**Crocodylia**	**teeth**
Quarry 8	**1018**	**Crocodylia**	**teeth**
Quarry 8	**842**	**Crocodylia**	**teeth and bone fragments**
Quarry 8	788	Crocodylia	tibia
Quarry 8	**1010**	**Crocodylia**	**ungual phalanx**
Quarry 8	795	Crocodylia	vertebra
Quarry 8	811	Crocodylia	vertebra
Quarry 8	812	Crocodylia	vertebra
Quarry 8	824	Crocodylia	vertebra
Quarry 8	825	Crocodylia	vertebra
Quarry 8	827	Crocodylia	vertebra
Quarry 8	828	Crocodylia	vertebra
Quarry 8	832	Crocodylia	vertebra
Quarry 8	837	Crocodylia	vertebra
Quarry 8	838	Crocodylia	vertebra
Quarry 8	844	Crocodylia	vertebra
Quarry 8	845	Crocodylia	vertebra
Quarry 8	847	Crocodylia	vertebra
Quarry 8	848	Crocodylia	vertebra
Quarry 8	**849**	**Crocodylia**	**vertebra**
Quarry 8	852	Crocodylia	vertebra
Quarry 8	862	Crocodylia	vertebra
Quarry 8	863	Crocodylia	vertebra
Quarry 8	864	Crocodylia	vertebra
Quarry 8	866	Crocodylia	vertebra
Quarry 8	880	Crocodylia	vertebra
Quarry 8	881	Crocodylia	vertebra
Quarry 8	883	Crocodylia	vertebra
Quarry 8	884	Crocodylia	vertebra
Quarry 8	885	Crocodylia	vertebra
Quarry 8	**1009**	**Crocodylia**	**vertebra**
Quarry 8	791	Crocodylia	vertebra fragment
Quarry 8	808	Crocodylia	vertebrae
Quarry 8	810	Crocodylia	vertebrae
Quarry 8	**813**	**Crocodylia**	**vertebral centra**
Quarry 8	789	Crocodylia	vertebral centrum
Quarry 8	**790**	**Crocodylia**	**vertebral centrum**
Quarry 8	792	Crocodylia	vertebral centrum

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	793	Crocodylia	vertebral centrum
Quarry 8	794	Crocodylia	vertebral centrum
Quarry 8	809	Crocodylia	vertebral centrum
Quarry 8	814	Crocodylia	vertebral centrum
Quarry 8	830	Crocodylia	vertebral centrum
Quarry 8	833	Crocodylia	vertebral centrum
Quarry 8	846	Crocodylia	vertebral centrum
Quarry 8	823	Crocodylia	vertebral fragment
Quarry 8	820	Crocodylia	vertebral fragments
Quarry 8	835	Crocodylia	vertebral fragments
Quarry 8	872	Crocodylia	vertebral fragments
Quarry 8	873	Crocodylia	vertebral fragments
Quarry 8	874	Crocodylia	vertebral fragments
Quarry 8	**886**	**Crocodylia**	**vertebral fragments**
Quarry 8	2337	Crocodylia?	long bone (shaft)
Quarry 8	2340	Crocodylia?	long bone fragment
Quarry 8	**2338**	**Crocodylia?**	**long bone? Fragments**
Quarry 8	**801**	**Crocodylia?**	**miscellaneous fragments**
Quarry 8	2339	Crocodylia?	rib
Quarry 8	797	Crocodylia?	ribs & fragments
Quarry 8	2148	Crocodylia?	skeletal element
Quarry 8	**1017**	**Crocodylia?**	**ungual phalanx**
Quarry 8	**2404**	***Glyptops* sp.**	**costal fragment**
Quarry 8	2323	*Glyptops* sp.	costal plate
Quarry 8	2330	*Glyptops* sp.	costal plate
Quarry 8	**2410**	***Glyptops* sp.**	**girdle element**
Quarry 8	2376	*Glyptops* sp.	ischium
Quarry 8	**2329**	***Glyptops* sp.**	**plastron fragment**
Quarry 8	2403	*Glyptops* sp.	plastron fragment
Quarry 8	2408	*Glyptops* sp.	plastron fragment
Quarry 8	2524	*Glyptops* sp.	plastron fragment
Quarry 8	2405	*Glyptops* sp.	shell fragment
Quarry 8	**2406**	***Glyptops* sp.**	**shell fragment**
Quarry 8	**2409**	***Glyptops* sp.**	**shell fragment**
Quarry 8	**2325**	***Goniopholis stovalli***	**"stacked" osteoscutes**
Quarry 8	2401	*Goniopholis stovalli*	axial peg
Quarry 8	2509	*Goniopholis stovalli*	axial peg
Quarry 8	2510	*Goniopholis stovalli*	axial peg
Quarry 8	2411	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2412	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2413	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2414	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2415	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2416	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2417	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2418	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2419	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2420	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2421	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2422	*Goniopholis stovalli*	caudal vertebra

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	2423	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2424	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2425	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2426	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2454	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2455	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2456	*Goniopholis stovalli*	caudal vertebra
Quarry 8	**2457**	***Goniopholis stovalli***	**caudal vertebra**
Quarry 8	2490	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2491	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2492	*Goniopholis stovalli*	caudal vertebra
Quarry 8	2481	*Goniopholis stovalli*	caudal? vertebra
Quarry 8	2427	*Goniopholis stovalli*	centrum fragment
Quarry 8	2458	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2459	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2460	*Goniopholis stovalli*	cervical vertebra
Quarry 8	**2461**	***Goniopholis stovalli***	**cervical vertebra**
Quarry 8	2462	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2463	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2464	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2486	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2487	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2488	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2489	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2511	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2512	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2513	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2514	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2515	*Goniopholis stovalli*	cervical vertebra
Quarry 8	**2516**	***Goniopholis stovalli***	**cervical vertebra**
Quarry 8	2517	*Goniopholis stovalli*	cervical vertebra
Quarry 8	2518	*Goniopholis stovalli*	cervical vertebra
Quarry 8	**2521**	***Goniopholis stovalli***	**cervical vertebra**
Quarry 8	2480	*Goniopholis stovalli*	cervical? vertebra
Quarry 8	2382	*Goniopholis stovalli*	coracoid, right
Quarry 8	2388	*Goniopholis stovalli*	dentary, left
Quarry 8	2432	*Goniopholis stovalli*	dorsal centrum half
Quarry 8	2433	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2434	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2435	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2436	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2437	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2438	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2439	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2440	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	**2441**	***Goniopholis stovalli***	**dorsal vertebra**
Quarry 8	2442	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2443	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	**2444**	***Goniopholis stovalli***	**dorsal vertebra**
Quarry 8	2445	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2446	*Goniopholis stovalli*	dorsal vertebra

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	2447	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2448	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2449	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	**2450**	***Goniopholis stovalli***	**dorsal vertebra**
Quarry 8	2451	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2452	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2453	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2465	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2466	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2467	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2468	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2469	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2470	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2471	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2472	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2473	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2474	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	**2475**	***Goniopholis stovalli***	**dorsal vertebra**
Quarry 8	2476	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2477	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2478	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2479	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2493	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2494	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2495	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2496	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2497	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2498	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2499	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2500	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2501	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2502	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2503	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2504	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2505	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	2506	*Goniopholis stovalli*	dorsal vertebra
Quarry 8	**2519**	***Goniopholis stovalli***	**dorsal vertebra**
Quarry 8	**2520**	***Goniopholis stovalli***	**dorsal vertebra**
Quarry 8	2331	*Goniopholis stovalli*	femur (missing distal end)
Quarry 8	2332	*Goniopholis stovalli*	femur (shaft), right
Quarry 8	2336	*Goniopholis stovalli*	femur or humerus (distal end)
Quarry 8	2365	*Goniopholis stovalli*	femur, left
Quarry 8	2367	*Goniopholis stovalli*	femur, left
Quarry 8	2369	*Goniopholis stovalli*	femur, left
Quarry 8	**2354**	***Goniopholis stovalli***	**femur, right**
Quarry 8	2366	*Goniopholis stovalli*	femur, right
Quarry 8	2368	*Goniopholis stovalli*	femur, right
Quarry 8	2371	*Goniopholis stovalli*	femur, right- 2 pieces
Quarry 8	2393	*Goniopholis stovalli*	fibula
Quarry 8	2375	*Goniopholis stovalli*	fibula or radius
Quarry 8	2341	*Goniopholis stovalli*	fibula?

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	2370	*Goniopholis stovalli*	humerus left
Quarry 8	2363	*Goniopholis stovalli*	humerus, left
Quarry 8	2385	*Goniopholis stovalli*	ischium
Quarry 8	2389	*Goniopholis stovalli*	ischium
Quarry 8	2347	*Goniopholis stovalli*	mandible
Quarry 8	2326	*Goniopholis stovalli*	mandible (posterior portion)
Quarry 8	2321	*Goniopholis stovalli*	mandible, left
Quarry 8	2386	*Goniopholis stovalli*	maxilla?
Quarry 8	2373	*Goniopholis stovalli*	metapodial?
Quarry 8	2391	*Goniopholis stovalli*	metapodial?
Quarry 8	**2508**	***Goniopholis stovalli***	**neural arch**
Quarry 8	**2324**	***Goniopholis stovalli***	**osteoscute**
Quarry 8	2353	*Goniopholis stovalli*	portion of cranium
Quarry 8	2372	*Goniopholis stovalli*	radius
Quarry 8	**2377**	***Goniopholis stovalli***	**radius**
Quarry 8	2379	*Goniopholis stovalli*	radius
Quarry 8	2380	*Goniopholis stovalli*	radius
Quarry 8	2344	*Goniopholis stovalli*	radius or tibia
Quarry 8	2359	*Goniopholis stovalli*	rib
Quarry 8	2364	*Goniopholis stovalli*	rib
Quarry 8	2378	*Goniopholis stovalli*	rib
Quarry 8	2381	*Goniopholis stovalli*	rib
Quarry 8	2383	*Goniopholis stovalli*	rib
Quarry 8	2394	*Goniopholis stovalli*	rib
Quarry 8	2395	*Goniopholis stovalli*	rib
Quarry 8	2396	*Goniopholis stovalli*	rib
Quarry 8	2397	*Goniopholis stovalli*	rib
Quarry 8	2398	*Goniopholis stovalli*	rib head
Quarry 8	2429	*Goniopholis stovalli*	sacral vertebra
Quarry 8	2430	*Goniopholis stovalli*	sacral vertebra
Quarry 8	2431	*Goniopholis stovalli*	sacral vertebra
Quarry 8	2482	*Goniopholis stovalli*	sacral vertebra
Quarry 8	2483	*Goniopholis stovalli*	sacral vertebra
Quarry 8	2484	*Goniopholis stovalli*	sacral vertebra
Quarry 8	**2485**	***Goniopholis stovalli***	**sacral vertebra**
Quarry 8	2522	*Goniopholis stovalli*	sacral vertebra
Quarry 8	**2523**	***Goniopholis stovalli***	**sacral vertebra centrum**
Quarry 8	2428	*Goniopholis stovalli*	sacral? vertebrae
Quarry 8	2322	*Goniopholis stovalli*	skull
Quarry 8	2392	*Goniopholis stovalli*	skull (on display)
Quarry 8	**2328**	***Goniopholis stovalli***	**skull (posterior portion)**
Quarry 8	2327	*Goniopholis stovalli*	skull fragment
Quarry 8	2348	*Goniopholis stovalli*	tibia
Quarry 8	2355	*Goniopholis stovalli*	tibia, left
Quarry 8	2356	*Goniopholis stovalli*	tibia, left
Quarry 8	2357	*Goniopholis stovalli*	tibia, left
Quarry 8	2358	*Goniopholis stovalli*	tibia, left
Quarry 8	2361	*Goniopholis stovalli*	tibia, left
Quarry 8	2362	*Goniopholis stovalli*	tibia, right
Quarry 8	2342	*Goniopholis stovalli*	tibia?
Quarry 8	2374	*Goniopholis stovalli*	tibia?

Appendix B continued

Locality	Specimen #	Taxon	Element
Quarry 8	2360	*Goniopholis stovalli*	ulna, left
Quarry 8	2334	*Goniopholis stovalli*	ulna?, (lacking distal end), left?
Quarry 8	**2399**	**Osteichthyes**	**vertebra**
Quarry 8	2400	Osteichthyes	vertebra
Quarry 8	925	Reptilia	carpal/tarsal?
Quarry 8	1021	Reptilia	centrum
Quarry 8	**1025**	**Reptilia**	**centrum**
Quarry 8	2540	Reptilia	centrum
Quarry 8	1023	Reptilia	centrum fragment
Quarry 8	920	Reptilia	fragment
Quarry 8	926	Reptilia	fragment
Quarry 8	**995**	**Reptilia**	**girdle element?**
Quarry 8	**918**	**Reptilia**	**head of long bone**
Quarry 8	**919**	**Reptilia**	**head of long bone**
Quarry 8	**1031**	**Reptilia**	**limb element fragments**
Quarry 8	923	Reptilia	metapodial?
Quarry 8	**924**	**Reptilia**	**metapodial?**
Quarry 8	1024	Reptilia	rib
Quarry 8	**927**	**Reptilia**	**rib fragment**
Quarry 8	**1020**	**Reptilia?**	**coprolite**
Quarry 8	**1032**	**Reptilia?**	**coprolites**
Quarry 8	**1036**	**Reptilia?**	**coprolites**
Quarry 8	10324	Theropoda	distal end of femur?
Quarry 8	10322	Theropoda	femur
Quarry 8	10321	Theropoda	incomplete ilium, left
Quarry 8	10320	Theropoda	incomplete ilium, right
Quarry 8	4134	Theropoda	pubis (proximal portion)
Quarry 8	10323	Theropoda	tibia, shaft
Quarry 8	**817**	**Theropoda**	**tooth**
Quarry 8	**818**	**Theropoda**	**tooth**
Quarry 8	**1019**	**Theropoda**	**tooth**
Quarry 8	**2402**	**Theropoda**	**tooth**
Quarry 8	**819**	**Vertebrata**	**fragments**

Appendix C: Associated bones from quarries 5, 6, and 8

Sorted by Quarry and then by associated taxon
Specimens that are associated are inside the same black box

Quarry 5

1740	*Apatosaurus*? sp.	dorsal vertebra, posterior
1742	Sauropoda	femur fragment?

1089	Sauropoda	cervical vertebra fragment
1816	*Camarasaurus* sp.	pubis, right
1844	Sauropoda	cervical vertebra
1853	Archosauria	cervical rib
2030	*Camarasaurus* sp.	metapodial
10195	*Camarasaurus* sp.	ischium, right
10227	*Camarasaurus* sp.	ischium, left

1741	*Camarasaurus* sp.	caudal vertebral centrum
1900	*Camarasaurus* sp.	neural spine
1901	*Camarasaurus* sp.	neural spine
4027	*Camarasaurus* sp.	caudal neural spine
10326	*Camarasaurus* sp.	anterior caudal vertebra (articulated w/ 4 other caudals)
10344	Sauropoda	6 articulated caudal vertebrae

10197	Sauropoda	carpal "radiale", right
10198	Sauropoda	carpal "ulnare", right
10209	Sauropoda	pes, phalanx II, 2
10218	*Camarasaurus* sp.	metacarpal III
10219	Sauropoda	metacarpal IV, right
10225	*Camarasaurus* sp.	metacarpal II, right
10226	*Camarasaurus* sp.	metacarpal III, left

1835	*Diplodocus* sp.	chevron
1839	*Diplodocus* sp.	chevron
1860	Diplodocidae	neural spine
10214	*Diplodocus* sp.	metatarsal IV, right
10217	Sauropoda	metatarsal IV, left
10248	*Diplodocus* sp.	caudal vertebra

Appendix C continued

Quarry 5

1080	Sauropoda	rib fragment
1091	*Diplodocus* ? sp.	scapula, left
1781	*Diplodocus* sp.	humerus
1806	Sauropoda	rib fragment
1807	Sauropoda	rib fragment
1902	Sauropoda	rib fragment
10185	*Diplodocus* sp.	ulna (articulated w/ 10186)
10186	*Diplodocus* sp.	radius (articulated w/ 10185)
10187	*Diplodocus* sp.	radius (distal end)
10202	Sauropoda	manus, terminal phalanx V, 1
10203	Sauropoda	manual phalanx II, 1 or III, 1, right
10205	Sauropoda	manus, terminal phalanx IV, 1
10206	Sauropoda	pes, phalanx 1, digit II, right
10223	Sauropoda	fibula (proximal end), right
10234	Sauropoda	tibia (distal end), right

1756	Sauropoda	ischium
1764	Sauropoda	centrum fragment
1786	Diplodocidae	chevron
1798	*Diplodocus* ? sp.	dorsal centrum fragment
1843	Archosauria	vertebra fragment
1895	Diplodocidae	neural arch fragment
10184	*Diplodocus* sp.	radius
10240	*Diplodocus* sp.	caudal vertebra
10253	*Diplodocus* sp.	caudal vertebra (anterior)
10258	*Diplodocus* sp.	anterior caudal centrum, anterior end
10259	*Diplodocus* sp.	caudal centrum, anterior end
10296	*Diplodocus* sp.	caudal vertebra
10297	*Diplodocus* sp.	caudal vertebra
10331	*Diplodocus* sp.	anterior caudal vertebra
10335	*Diplodocus* sp.	caudal vertebra
10301	Sauropoda	caudal centrum (anterior end)

10188	*Diplodocus* sp.	astragalus, right
10189	*Diplodocus* sp.	astragalus, left
10211	Sauropoda	pes, ungual phalanx I, 2 or II, 3, left

Appendix C continued

Quarry 5

1749	Sauropoda?	sacrum (in 2 pieces)
1755	Sauropoda	distal caudal vertebra
1788	*Diplodocus* sp.	chevron
1824	Sauropoda	cervical vertebra fragment
1833	*Diplodocus* sp.	chevron
1840	*Diplodocus* sp.	chevron
1856	Archosauria	neural spine
1857	Diplodocidae	neural spine
1859	Diplodocidae	neural spine
1865	Diplodocidae	anterior caudal neural spine
1870	Diplodocidae	neural spine
1875	*Diplodocus* sp.	vertebra fragment
1877	Sauropoda	vertebra fragment
1881	Sauropoda	posterior dorsal neural arch
1892	Sauropoda	vertebra fragment
1893	Sauropoda	cervical vertebra
10190	Sauropoda	tibia (distal), right
10194	*Diplodocus* sp.	chevron
10200	*Diplodocus*? sp.	metatarsal II, right
10201	*Diplodocus* sp.	metatarsal I, left
10207	Sauropoda	pedal phalanx I, 1, right
10208	Sauropoda	pes, phalanx III, 2, right
10212	Sauropoda	pes, ungual phalanx III, 4, right
10215	Sauropoda	metacarpal I, left
10216	*Diplodocus* sp.	metatarsal IV, right
10220	Sauropoda	metatarsal V, right
10221	Sauropoda	metacarpal IV, left?
10229	Diplodocidae	metatarsal V
10231	Sauropoda	manus, phalanx I, 2
10334	*Diplodocus* sp.	3rd? dorsal vertebra
10237	*Diplodocus* sp.	caudal vertebra
10339	*Diplodocus* sp.	caudal vertebra
10242	*Diplodocus* sp.	caudal vertebra
10243	*Diplodocus* sp.	caudal vertebra
10246	*Diplodocus* sp.	caudal vertebra
10247	*Diplodocus* sp.	caudal vertebra
10249	*Diplodocus* sp.	caudal vertebra
10250	*Diplodocus* sp.	caudal vertebra
10251	*Diplodocus* sp.	caudal vertebra
10252	*Diplodocus* sp.	caudal vertebra
10253	*Diplodocus* sp.	caudal vertebra

Appendix C continued

Quarry 5

continue association from previous page		
10254	*Diplodocus* sp.	anterior caudal vertebra
10256	*Diplodocus*? sp.	anterior dorsal centrum
10257	*Diplodocus* sp.	caudal vertebra
10263	*Diplodocus* sp.	anterior caudal vertebra (anterior half)
10264	*Diplodocus* sp.	tibia, right
10302	Sauropoda	ilium (posterior end), right
10349	*Diplodocus* sp.	chevron

1079	*Diplodocus* sp.	vertebra fragments
1855	Sauropoda	neural arch fragment
1868	Diplodocidae	dorsal neural spine
10183	*Diplodocus* sp.	fibula (proximal), left
10245	*Diplodocus* sp.	caudal vertebra
10255	*Diplodocus*? sp.	dorsal centrum
10333	*Diplodocus* sp.	caudal vertebra

1750	Theropoda?	vertebral centrum
1842	Theropoda?	dorsal vertebra, articulated w/ 2 other dorsal vertebrae

10353	*Saurophaganax maximus*	thoracic vertebra
10365	*Saurophaganax maximus*	axis vertebra

Appendix C continued

Quarry 5

1909	*Saurophaganax maximus*	caudal vertebra
10265	*Saurophaganax maximus*	caudal vertebra
10266	*Saurophaganax maximus*	caudal vertebra
10267	*Saurophaganax maximus*	caudal vertebra
10268	*Saurophaganax maximus*	caudal vertebra
10269	*Saurophaganax maximus*	caudal vertebra
10270	*Saurophaganax maximus*	caudal vertebra
10271	*Saurophaganax maximus*	caudal vertebra
10273	*Saurophaganax maximus*	caudal vertebra
10274	*Saurophaganax maximus*	caudal vertebra
10275	*Saurophaganax maximus*	caudal vertebra
10276	*Saurophaganax maximus*	caudal vertebra
10278	*Saurophaganax maximus*	caudal vertebra
10279	*Saurophaganax maximus*	caudal vertebra
10280	*Saurophaganax maximus*	caudal vertebra
10281	*Saurophaganax maximus*	caudal vertebra
10282	*Saurophaganax maximus*	caudal centrum
10283	*Saurophaganax maximus*	side of caudal centrum
10284	*Saurophaganax maximus*	caudal vertebra (2, fused) and attached chevron
10285	*Saurophaganax maximus*	thoracic centrum
10287	*Saurophaganax maximus*	pubic process of ilium?
10289	*Saurophaganax maximus*	chevron
10290	*Saurophaganax maximus*	chevron
10346	*Saurophaganax maximus*	chevron
10347	*Saurophaganax maximus*	chevron
10357	*Saurophaganax maximus*	caudal vertebra
10358	*Saurophaganax maximus*	thoracic vertebra
10359	*Saurophaganax maximus*	caudal vertebra
10362	*Saurophaganax maximus*	caudal centrum
10381	*Saurophaganax maximus*	femur, left
10385	*Saurophaganax maximus*	chevron

1757	*Stegosaurus* sp.	tail spike
10328	*Stegosaurus* sp.	humerus, left

Appendix C continued

Quarry 6

1782	Sauropoda	ilium, sacrum, and fragments
1967	Sauropoda	pubis (distal fragment)
1968	*Apatosaurus* sp.	ilium fragment
1991	*Apatosaurus* sp.	femur

1956	*Camarasaurus* sp.	caudal vertebra
1960	*Camarasaurus?* sp.	neural arch of median caudal

1795	*Camarasaurus* sp.	caudal vertebra
1966	*Camarasaurus* sp.	caudal vertebra
1969	*Camarasaurus* sp.	ischium (distal fragment)
1970	*Camarasaurus* sp.	neural spine fragment
1972	*Camarasaurus* sp.	vertebra fragment
1986	*Camarasaurus* sp.	scapula, right
4021	*Camarasaurus* sp.	neural spine
10369	*Camarasaurus* sp.	caudal vertebra w/ arch of another

1958	*Saurophaganax maximus*	caudal vertebra
1994	*Saurophaganax maximus*	caudal vertebra
1998	*Saurophaganax maximus*	caudal vertebra
1999	*Saurophaganax maximus*	caudal vertebra

1996	*Saurophaganax maximus*	caudal vertebra
2002	*Saurophaganax maximus*	caudal vertebra
10361	*Saurophaganax maximus*	thoracic centrum

2001	*Saurophaganax maximus*	vertebra
2009	*Saurophaganax maximus*	caudal vertebra

2004	*Saurophaganax maximus*	vertebra (juvenile)
2005	*Saurophaganax maximus*	vertebral centrum (juvenile)

2015	*Saurophaganax maximus*	centrum
2017	*Saurophaganax maximus*	centrum

Appendix C continued

Quarry 8

10305	*Camptosaurus* sp.	femur, left
10307	*Camptosaurus* sp.	femur, right

10306	*Camptosaurus* sp.	femur, right
10308	*Camptosaurus* sp.	tibia, right

929	Chelonia	shell fragment
931	Chelonia	shell fragment
934	Chelonia	pleurals
935	Chelonia	pleural
936	Chelonia	pleural
938	Chelonia	plastron fragment
939	Chelonia	plastron fragment
940	Chelonia	neural plate
941	Chelonia	plastron fragment
949	Chelonia	plastron fragment
955	Chelonia	carapace fragment
956	Chelonia	carapace fragment
964	Chelonia	carapace fragment
977	Chelonia	peripheral plates
993	Chelonia	neural plates
2403	*Glyptops* sp.	plastron fragment
2538	Chelonia	girdle element

968	Chelonia	carapace fragment
971	Chelonia	peripheral plate
984	Chelonia	scapulocoracoid
985	Chelonia	scapulocoracoid
986	Chelonia	pleural plate
988	Chelonia	shell fragment
1037	Chelonia	skeleton and shell fragments in plaster

887	Chelonia	humerus
895	Chelonia	long bone fragment
2376	*Glyptops* sp.	ischium
2405	*Glyptops* sp.	shell fragment

Appendix C continued

Quarry 8

895	Chelonia	long bone fragment
903	Chelonia	scapulocoracoid fragment
979	Chelonia	long bone fragment

943	Chelonia	plastron fragment
952	Chelonia	plastron fragment
954	Chelonia	carapace fragment

1000	Chelonia	shell segments
70830	Chelonia	shell fragment

795	Crocodylia	vertebra
2363	*Goniopholis stovalli*	humerus, left
2411	*Goniopholis stovalli*	caudal vertebra
2412	*Goniopholis stovalli*	caudal vertebra
2467	*Goniopholis stovalli*	dorsal vertebra
2472	*Goniopholis stovalli*	dorsal vertebra
2477	*Goniopholis stovalli*	dorsal vertebra
2483	*Goniopholis stovalli*	sacral vertebra
2517	*Goniopholis stovalli*	cervical vertebra

810	Crocodylia	of several vertebrae w/ same number
826	Crocodylia	long bone fragment
834	Crocodylia	one of several long bone fragments w/ same number
839	Crocodylia	fragments
864	Crocodylia	vertebra
868	Crocodylia	fragment
870	Crocodylia	rib
882	Crocodylia	astragalus
885	Crocodylia	vertebra
2364	*Goniopholis stovalli*	rib
2423	*Goniopholis stovalli*	caudal vertebra
2480	*Goniopholis stovalli*	cervical? vertebra

Appendix C continued

Quarry 8

799	Crocodylia	femur
800	Crocodylia	one of several miscellaneous vertebrae w/ same number
848	Crocodylia	vertebra
915	Crocodylia	centrum
920	Reptilia	fragment
2433	*Goniopholis stovalli*	dorsal vertebra

804	Crocodylia	neural arch
809	Crocodylia	vertebral centrum
812	Crocodylia	vertebra
814	Crocodylia	vertebral centrum
820	Crocodylia	vertebral fragments
823	Crocodylia	vertebral fragment
825	Crocodylia	vertebra
827	Crocodylia	vertebra
828	Crocodylia	vertebra
832	Crocodylia	vertebra
833	Crocodylia	vertebral centrum
835	Crocodylia	vertebral fragments
837	Crocodylia	vertebra
860	Crocodylia	centrum
861	Crocodylia	centrum
862	Crocodylia	vertebra
863	Crocodylia	vertebra
865	Crocodylia	centrum
866	Crocodylia	vertebra
872	Crocodylia	vertebral fragments
873	Crocodylia	vertebral fragments
874	Crocodylia	vertebral fragments
875	Crocodylia	centrum
876	Crocodylia	centrum
877	Crocodylia	neural arch fragments
878	Crocodylia	centrum
880	Crocodylia	vertebra
905	Crocodylia	centrum
907	Crocodylia	centrum

Appendix C continued

Quarry 8

2334	*Goniopholis stovalli*	ulna?, lacking distal end, left?
2366	*Goniopholis stovalli*	femur, right
2369	*Goniopholis stovalli*	femur, left
2379	*Goniopholis stovalli*	radius
2422	*Goniopholis stovalli*	caudal vertebra
2428	*Goniopholis stovalli*	sacral? vertebrae
2470	*Goniopholis stovalli*	dorsal vertebra
2482	*Goniopholis stovalli*	sacral vertebra
2513	*Goniopholis stovalli*	cervical vertebra

808	Crocodylia	3 vertebrae w/ same number
831	Crocodylia	fragment
2346	Crocodylia	rib fragment
2481	*Goniopholis stovalli*	caudal? vertebra
2522	*Goniopholis stovalli*	sacral vertebra

788	Crocodylia	tibia
2336	*Goniopholis stovalli*	femur or humerus (distal end)
2348	*Goniopholis stovalli*	tibia
2360	*Goniopholis stovalli*	ulna, left
2380	*Goniopholis stovalli*	radius
2388	*Goniopholis stovalli*	dentary, left
2413	*Goniopholis stovalli*	caudal vertebra
2419	*Goniopholis stovalli*	caudal vertebra
2424	*Goniopholis stovalli*	caudal vertebra
2468	*Goniopholis stovalli*	dorsal vertebra

789	Crocodylia	vertebral centrum
800	Crocodylia	2 of several miscellaneous vertebrae w/ same number
994	Crocodylia	pubis
2361	*Goniopholis stovalli*	tibia, left
2452	*Goniopholis stovalli*	dorsal vertebra
2454	*Goniopholis stovalli*	caudal vertebra
2458	*Goniopholis stovalli*	cervical vertebra
2459	*Goniopholis stovalli*	cervical vertebra
4135	Archosauria	ilium fragment

Appendix C continued

Quarry 8

797	Crocodylia?	ribs & fragments
824	Crocodylia	vertebra
871	Crocodylia	fragment
884	Crocodylia	vertebra
2322	*Goniopholis stovalli*	skull
2326	*Goniopholis stovalli*	mandible (posterior portion)
2342	*Goniopholis stovalli*	tibia?
2347	*Goniopholis stovalli*	mandible
2362	*Goniopholis stovalli*	tibia, right
2415	*Goniopholis stovalli*	caudal vertebra
2416	*Goniopholis stovalli*	caudal vertebra
2417	*Goniopholis stovalli*	caudal vertebra
2418	*Goniopholis stovalli*	caudal vertebra
2426	*Goniopholis stovalli*	caudal vertebra

this cluster may be associated with above cluster!		
2324	*Goniopholis stovalli*	osteoscute
2427	*Goniopholis stovalli*	centrum fragment
2469	*Goniopholis stovalli*	dorsal vertebra
2471	*Goniopholis stovalli*	dorsal vertebra
2477	*Goniopholis stovalli*	dorsal vertebra
2486	*Goniopholis stovalli*	cervical vertebra
2487	*Goniopholis stovalli*	cervical vertebra
2488	*Goniopholis stovalli*	cervical vertebra
2489	*Goniopholis stovalli*	cervical vertebra
2491	*Goniopholis stovalli*	caudal vertebra
2493	*Goniopholis stovalli*	dorsal vertebra
2495	*Goniopholis stovalli*	dorsal vertebra
2496	*Goniopholis stovalli*	dorsal vertebra
2497	*Goniopholis stovalli*	dorsal vertebra
2498	*Goniopholis stovalli*	dorsal vertebra (articulated with 2501)
2499	*Goniopholis stovalli*	dorsal vertebra
2501	*Goniopholis stovalli*	dorsal vertebra (articulated with 2498)
2503	*Goniopholis stovalli*	dorsal vertebra
2507	Archosauria	dorsal or caudal vertebra centrum
2510	*Goniopholis stovalli*	axial peg
2515	*Goniopholis stovalli*	cervical vertebra

Appendix C continued

Quarry 8

800	Crocodylia	couple miscellaneous vertebrae
805	Crocodylia	dermal plates
845	Crocodylia	vertebra
852	Crocodylia	vertebra
2344	*Goniopholis stovalli*	radius or tibia
2361	*Goniopholis stovalli*	tibia, left
2383	*Goniopholis stovalli*	rib
2435	*Goniopholis stovalli*	dorsal vertebra
2453	*Goniopholis stovalli*	dorsal vertebra

844	Crocodylia	vertebra
2463	*Goniopholis stovalli*	cervical vertebra
2479	*Goniopholis stovalli*	dorsal vertebra

2445	Goniopholis stovalli	dorsal vertebra
2447	Goniopholis stovalli	dorsal vertebra

800	Crocodylia	one of several miscellaneous vertebrae w/ same number
854	Crocodylia	centrum
855	Crocodylia	centrum
923	Reptilia	metapodial?
2541	Crocodylia	rib head
2357	*Goniopholis stovalli*	tibia, left
2365	*Goniopholis stovalli*	femur, left
2368	*Goniopholis stovalli*	femur, right
2370	*Goniopholis stovalli*	humerus, left
2374	*Goniopholis stovalli*	tibia?
2437	*Goniopholis stovalli*	dorsal vertebra
2438	*Goniopholis stovalli*	dorsal vertebra
2455	*Goniopholis stovalli*	caudal vertebra
2456	*Goniopholis stovalli*	caudal vertebra
2458	*Goniopholis stovalli*	cervical vertebra
2460	*Goniopholis stovalli*	cervical vertebra

Appendix C continued

Quarry 8

798	Crocodylia	coracoid
800	Crocodylia	2 of several miscellaneous vertebrae w/ same number
856	Crocodylia	fragment
908	Crocodylia	phalanx
910	Crocodylia	metapodial fragment
981	Crocodylia	neural arch
1022	Crocodylia	long bone fragments
2378	*Goniopholis stovalli*	rib
2381	*Goniopholis stovalli*	rib
2391	*Goniopholis stovalli*	metapodial?
2392	*Goniopholis stovalli*	skull
2395	*Goniopholis stovalli*	rib
2397	*Goniopholis stovalli*	rib
2434	*Goniopholis stovalli*	dorsal vertebra
2442	*Goniopholis stovalli*	dorsal vertebra
2448	*Goniopholis stovalli*	dorsal vertebra
2462	*Goniopholis stovalli*	cervical vertebra
2464	*Goniopholis stovalli*	cervical vertebra

794	Crocodylia	vertebral centrum
808	Crocodylia	vertebrae
2396	*Goniopholis stovalli*	rib
2425	*Goniopholis stovalli*	caudal vertebra
2465	*Goniopholis stovalli*	dorsal vertebra
2490	*Goniopholis stovalli*	caudal vertebra
2504	*Goniopholis stovalli*	dorsal vertebra
2505	*Goniopholis stovalli*	dorsal vertebra

786	Crocodylia	humerus
1022	Crocodylia	one of several long bone fragments w/ same number
2358	*Goniopholis stovalli*	tibia, left

4134	Theropoda	pubis (proximal)
4137	Archosauria	girdle fragment
10324	Theropoda	tibia (head), right

Appendix C continued

Quarry 8

10320	Theropoda	ilium (incomplete), right
10321	Theropoda	ilium (incomplete), left

may be associated with 10320 and 10321		
10322	Theropoda	femur
10323	Theropoda	tibia, shaft

VERTEBRATE FOSSIL ASSOCIATIONS AND TAPHONOMY IN THE MORRISON FORMATION (UPPER JURASSIC) CIMARRON COUNTY, OKLAHOMA

Quarry Map

A Master's of Science Thesis in Geology

by Carisa N. Bomberger

This volume is the property of the University of Oklahoma, but the literary rights of the author are a separate property and must be respected. Passages must not be copied or closely paraphrased without the previous written consent of the author. If the reader obtains any assistance from this volume, he must give proper credit in his own work.

I grant the University of Oklahoma Libraries permission to make a copy of my thesis upon the request of individuals or libraries. This permission is granted with the understanding that a copy will be provided for research purposes only, and that requestors will be informed of these restrictions.

NAME [redacted] [redacted]

DATE 12-14-07

A library which borrows this thesis for use by its patrons is expected to secure the signature of each user.

This thesis by CARISA N. BOMBERGER has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

NAME AND ADDRESS	DATE

OU-138