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2012, pp. 407-412. https://doi.org/10.56577/FFC-63.407

in:

Geology of the Warm Springs Region, Lucas, Spencer G.; McLemore, Virginia T.; Lueth, Virgil W.; Spielmann, Justin A.; Krainer, Karl, New Mexico Geological Society 63rd Annual Fall Field Conference Guidebook, 580 p. https://doi.org/10.56577/FFC-63

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New Mexico Geological Society Guidebook, 63rd Field Conference, Warm Springs Region, 2012, p. 407-412.

THE SUB-CRETACEOUS UNCONFORMITY IN NEW MEXICO

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Abstract—Except locally in the Bisbee basin of southwestern New Mexico, the base of the Cretaceous System in New Mexico is an unconformity. Within the Bisbee basin, the base of the Cretaceous overlies Jurassic, Paleozoic, and Proterozoic rocks in the complex floor of the basin and along its margins. The broad (~500 km wide) region north of the backarc Bisbee basin and related Chihuahua trough was uplifted, tilted slightly north, and erosionally beveled as the basin developed during the Late Jurassic–Early Cretaceous. In eastern New Mexico, this beveled region was subsequently onlapped and buried by upper Albian marine, deltaic and fluvial deposits related to the late Early Cretaceous Kiowa–Skull Creek transgression of the Western Interior Seaway. There, upper Albian beds overstep progressively older rocks to the south (ranging from Upper Jurassic in northeastern New Mexico to Permian in south-central New Mexico), resulting in a southward-increasing, pre-Cretaceous lacuna. The subsequent, more extensive Greenhorn transgression (Cenomanian, early Late Cretaceous) produced an analogous southward-increasing lacuna on what is now the southern Colorado Plateau, where the Dakota Sandstone oversteps rocks ranging from the Lower Cretaceous Burro Canyon Formation in northwestern New Mexico to Permian and possibly Proterozoic rocks near Silver City.

INTRODUCTION

The stratigraphic record in New Mexico is riddled with unconformities. In fact, the majority of geologic time there is represented by lacunae associated with these unconformities (e.g., Kottlowski et al., 1956). In some cases, unconformities truncate progressively older or younger beds across a broad region, producing a lacuna of regionally variable duration. Such unconformities provide evidence of tectonism (tilting) and erosion prior to renewed deposition. The base of the Cretaceous System throughout much of New Mexico is an example of such an unconformity.

The nature of the sub-Cretaceous unconformity varies in New Mexico, and can be subdivided into three somewhat overlapping regions. These regions include: (1) northwestern New Mexico and eastern Arizona, where the base of the Cretaceous system is the Upper Cretaceous (Cenomanian) Dakota Sandstone, except where the Lower Cretaceous Burro Canyon Formation is present in the north (Saucier, 1974). South of the eroded edge of the Burro Canyon Formation, the Dakota Sandstone overlies rocks ranging from Late Jurassic to Permian and possibly Proterozoic in age; (2) southwestern New Mexico and adjacent regions of Mexico and Arizona where great thicknesses of Lower Cretaceous deposits accumulated in the Bisbee basin–Chihuahua trough and overlie Proterozoic, Paleozoic, and Jurassic rocks; and (3) eastern New Mexico where a thin, upper Albian succession unconformably overlies Jurassic, Triassic, and Permian strata.

NORTHWESTERN NEW MEXICO

Throughout most of the southern Colorado Plateau, the base of the Cretaceous section is represented by the Dakota Sandstone (because of regionally inconsistent nomenclature, I use the term Dakota *Sandstone* for the basal strata associated with the Cenomanian Greenhorn transgression [e.g., Molenaar, 1983], and Dakota *Group* for upper Albian–Cenomanian, mostly arenaceous strata in northeastern New Mexico [e.g., Lucas and Estep, 2000]). In most places the base of the Dakota Sandstone (the Oak Canyon Member) consists of paralic strata of Late Cretaceous (Cenomanian) age, but locally in north-central New Mexico the basal Dakota is an imprecisely dated, valley-filling fluvial sandstone (the Encinal Canyon Member; Aubrey, 1988; Lucas and Estep, 2000). In north-central New Mexico, the Four Corners region, and in southern Utah the base of the Cretaceous System is composed of fluvial strata of the Lower Cretaceous Burro Canyon Formation (Aubrey, 1996), a probable correlative of the Barremian to lower Cenomanian Cedar Mountain Formation (Kirtland et al., 1999). The Burro Canyon is, in turn, overlain by the Dakota Sandstone. The duration of the lacuna represented by the sub-Dakota unconformity where it overlies the Burro Canyon Formation is probably ~5–10 Ma million years, based on the timescale of Gradstein et al. (2004). Because of insufficient age control, the lacuna associated with the unconformity beneath the Burro Canyon Formation where it overlies the Upper Jurassic Morrison Formation is poorly constrained, but is probably ~20–50 m.y.

Southward from the Four Corners region, the Dakota Sandstone progressively oversteps Jurassic, Triassic, and Permian strata over a distance of ~450 km (Fig. 1). The southward-beveling unconformity beneath the Cenomanian Dakota Sandstone on the Colorado Plateau has been described by previous workers (Repenning and Page, 1956; Bilodeau, 1986; Dickinson et al., 1989; Potochnik, 2001). In the region of southwestern New Mexico near Silver City, the basal unit of the Cretaceous System (variously termed the Beartooth Quartzite, the Beartooth Sandstone, or the Beartooth Member of the Mojado Formation) overlies Permian and Proterozoic rocks. The Beartooth is undated. It is considered by some to be Early Cretaceous (Albian) in age (Lucas and Estep, 1998), but by others to be equivalent in whole or part to the Cenomanian Dakota Sandstone (Jones, 1967; Chafetz, 1982, Molenaar, 1983; Mack, 1987a, b; Lawton, 2004). The Beartooth is overlain by the Mancos Formation (formerly Colorado Formation), locally of late middle Cenomanian age (Lucas and Estep, 1998).

SOUTHWESTERN NEW MEXICO

In the Bisbee basin area of southwestern New Mexico and southeastern Arizona, the Upper Jurassic–Lower Cretaceous Bisbee Group (ascending, the Hell-to-Finish, U-Bar, and Mojado formations) is as much as ~2–4 km thick and overlies strata of Jurassic, Permian, and Proterozoic age (Lawton, 2004). The Bisbee Group contains both continental and marine strata; the proportion of marine strata diminishes toward the west (Fig. 1; Dickinson and Lawton, 2001).

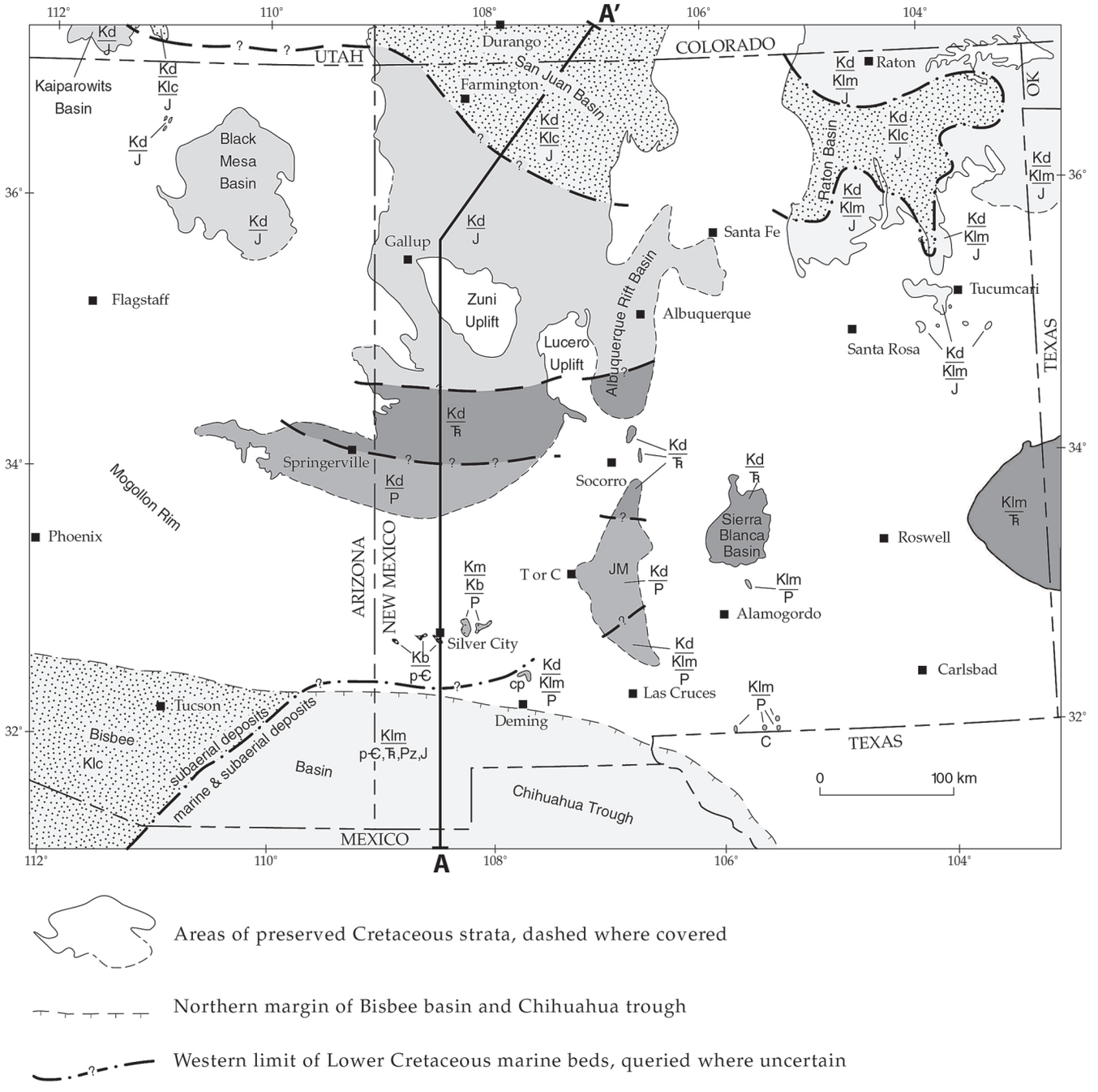


FIGURE 1. Map showing the distribution of preserved Cretaceous rocks in New Mexico, selected contact relationships within the Cretaceous System, and the age of the pre-Cretaceous subcrop. Timescale is Gradstein et al. (2004). Abbreviations are: Kd–Cenomanian Dakota Sandstone and equivalents; Klc–Lower Cretaceous continental deposits (includes the Burro Canyon Formation in northwestern New Mexico, Albian fluvial-deltaic deposits in northeastern New Mexico[(Mateer, 1985, fig. 3], and the subaerial part of the Bisbee Group in Arizona[(Dickinson and Lawton, 2001, fig.]); Klm–Lower Cretaceous marine or mixed continental/marine rocks; Kb–Beartooth Sandstone (see text); Km–Mancos Formation; J–Jurassic, Tr–Triassic; P–Permian; Pz–Paleozoic; pC–Proterozoic; C–Cornudas Mountains; cp–Cooke's Peak; JM–Jornada del Muerto; T or C–Truth or Consequences. A–A' is line of section for Figure 2.

In a narrow, deep keel of the Bisbee basin that runs west-northwest through the northern part of the bootheel of New Mexico, Lower Cretaceous strata conformably overlie Upper Jurassic beds (Lawton, 2004, fig. 6). North and south of this keel, Lower Cretaceous beds lap unconformably over older rocks. On the northern flank of the Bisbee basin near Cookes Peak, upper Albian to earliest Cenomanian beds of the upper Bisbee Group (Mojado Formation) lap unconformably across the Lower Permian Abo Formation, and are, in turn, overlain by the upper Cenomanian Mancos Formation (Lucas and Estep, 1998). The pre-Cretaceous lacuna near Cookes Peak encompasses ~200 m.y.

EASTERN NEW MEXICO

Like the sub-Dakota Sandstone unconformity on the Colorado Plateau, the erosional base of the Cretaceous system in eastern New Mexico bevels down-section to the south. The basal Cretaceous strata there, however, are somewhat older (late Albian) than the Dakota Sandstone to the west. These Albian beds are thin (generally <80 m) and overstep progressively older beds, ranging in age from Jurassic to Permian, to the south (Fig. 1).

In northeastern New Mexico, Lower Cretaceous (upper Albian) strata unconformably overlie Upper Jurassic rocks and consist of fluvial, deltaic and marine beds that are assigned (ascending) to the Lytle Sandstone, the Glencairn (or Tucumcari) Formation, and the Dakota Group (=Mesa Rica Sandstone, Pajarito Formation, and Romeroville Sandstone; Mateer, 1985, 1987; Lucas and Estep, 2000). Where Albian beds overlie the Upper Jurassic Morrison Formation in northeastern New Mexico, the lacuna associated with the sub-Cretaceous unconformity is ~40–45 m.y.

The Romeroville Sandstone (upper Dakota Group) unconformably overlies the Pajarito Formation and may be correlative with the Upper Cretaceous (Cenomanian) Oak Canyon Member of the Dakota Sandstone to the west (Lucas et al., 1998). Because the Romeroville has not been directly dated, the duration of the pre-Romeroville lacuna is not well constrained, but probably encompasses part of the latest Albian and/or early Cenomanian. Extensive Lower Cretaceous fluvial-deltaic deposits are present in northeastern New Mexico (Fig. 1; Mateer, 1985; Holbrook and Dunbar-Wright, 1992). The relationship of these deltaic deposits with the fluvial Burro Canyon Formation to the west has not been evaluated.

A large area of Lower Cretaceous strata as much as 60 m thick lies mostly hidden beneath the Ogallala Group on the southern Great Plains east of Roswell (Fallin, 1988). These strata were lithologically correlated to the Antlers, Walnut, Comanche Peak, Kiamichi, and Duck Creek formations of Texas by Fallin (1988). If this correlation is correct, then these strata range in age from late Aptian to late Albian. Fossils and lithotypes from a small exposure of these strata near North Lake, however, support a more limited age assignment (late Albian) and a different correlation (to the Tucumcari Formation) (Kues and Lucas, 1993, Lucas and Estep, 2000). Lower Cretaceous beds in east-central New Mexico unconformably overlie Upper Triassic beds of the Chinle (or Dockum) Group. If the base of the Cretaceous is upper Albian, the lacuna associated with the sub-Cretaceous unconformity there is ~100 m.y. in duration.

In the northern Sacramento Mountains ~30 km northeast of Alamogordo, a small outlier of the upper Albian Mesa Rica Sandstone unconformably overlies the Permian San Andres Formation (Lucas, 1991). The lacuna associated with this unconformity encompasses ~180 m.y. A short distance to the north in the Sierra Blanca Basin, Cretaceous strata unconformably overlie the Upper Triassic Chinle Group. The basal Cretaceous strata in the western Sierra Blanca Basin are undated but are probably the Cenomanian Dakota Sandstone (D. Koning, 2010, pers. commun.), although elsewhere in the basin the presence of Lower Cretaceous strata cannot be ruled out.

Cretaceous strata are preserved beneath Cenozoic deposits in the Jornada del Muerto region, but are only exposed southeast of Socorro near Carthage where they overlie the Triassic Chinle Group (Hook, 1983), in the northern San Andres Mountains (Kottlowski et al., 1956) where they overlie the Permian Artesia Group (S.G. Lucas, 2012, written commun.), and near Truth or Consequences (Bushnell, 1953; Thompson, 1955; Melvin, 1963; Wallin, 1983) and in the southern San Andres Mountains (Kottlowski et al., 1956) where they overlie the Permian San Andres Formation.

Near Carthage, the basal Cretaceous strata are correlated to the Cenomanian Dakota Sandstone (Hook, 1983). The basal Cretaceous strata near Truth or Consequences and in the northern San Andres Mountains are undated. Although regarded as probably Cenomanian Dakota Sandstone (Bushnell, 1953; Thompson, 1955; Melvin, 1963; Wallin, 1983, Kottlowski et al., 1956), it is possible that unrecognized Lower Cretaceous beds are present in these areas beneath the Dakota Sandstone. In the southern San Andres Mountains, a thin succession of upper Albian strata is present beneath the Dakota Sandstone. These strata were correlated to the Fryingpan Spring Member of the Mojado Formation by Lucas and Estep (1998).

In the Cornudas Mountains of south-central New Mexico and adjacent Texas, scattered exposures of middle to upper Albian marine strata are preserved (Kues and Lucas, 1993; McNeill and Nutt, 1998; Lucas and Estep, 2000). These beds unconformably overlie Lower Permian strata; the lacuna associated with this unconformity is ~200 m.y. in duration.

DISCUSSION

The oldest Cretaceous strata in New Mexico occur in the deep keel of the Bisbee basin, where they conformably overlie Jurassic strata (Fig. 2; Lawton, 2004). Elsewhere in the state the base of the Cretaceous is an unconformity. Throughout most of the Bisbee basin, the Lower Cretaceous fill lapped across older rocks of the complex floor of the developing basin, culminating in the onlap of the northern basin margin late in the Albian. The time-transgressive nature of the basal fill of the Bisbee basin thus provides a fragmentary record of the evolution of the basin, which has been interpreted by Dickinson and Lawton (2001) as a back-arc rift basin.

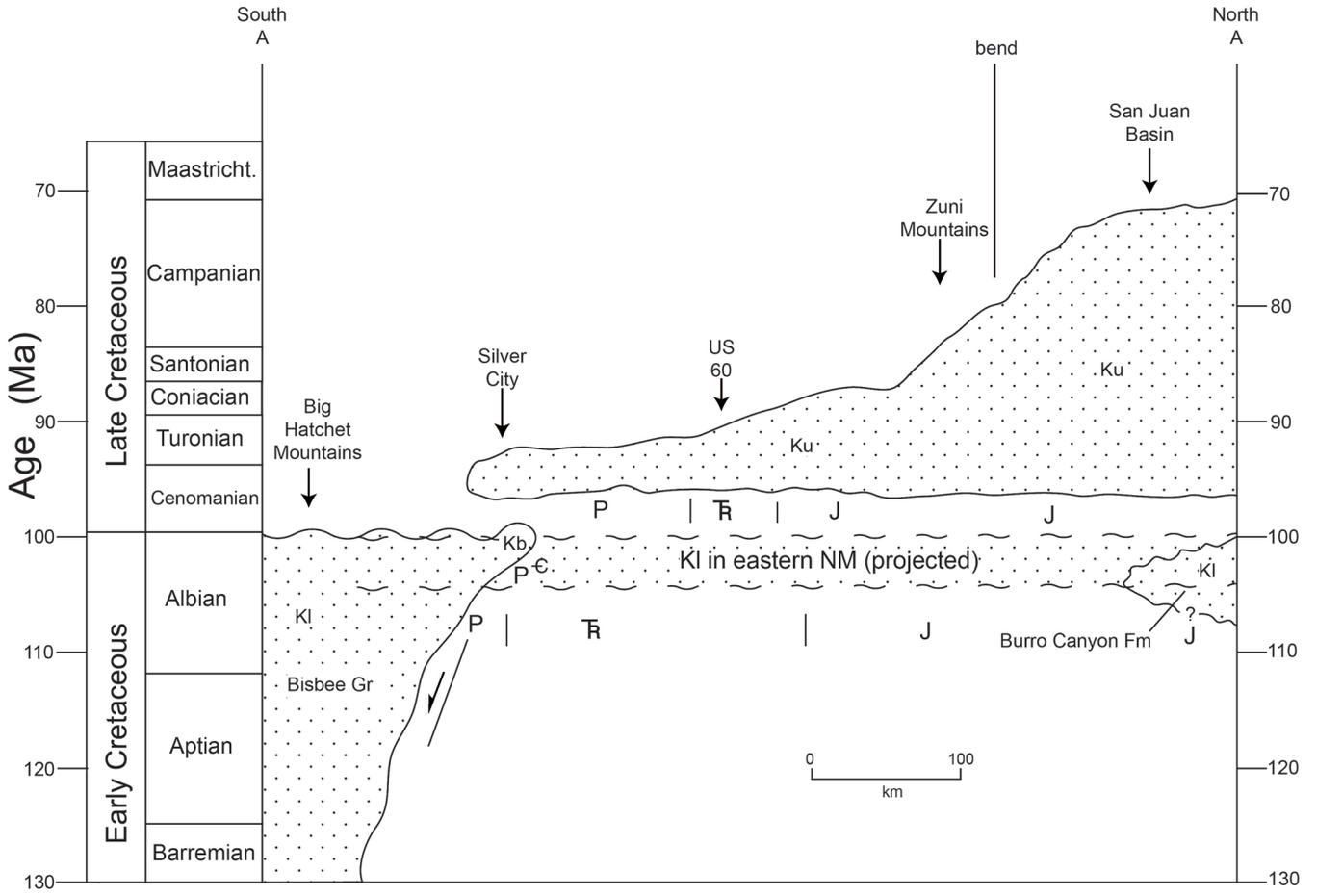


FIGURE 2. Schematic time-stratigraphic cross-section showing relationships between Lower and Upper Cretaceous strata, age of pre-Cretaceous subcrop, and Lower Cretaceous stratigraphy projected from eastern New Mexico. Line of section is shown in Figure 1. Abbreviations are: Ku–Upper Cretaceous; Kl–Lower Cretaceous; J–Jurassic; Tr–Triassic; P–Permian; pC–Proterozoic. Note that the Beartooth Sandstone (Kb) is not precisely dated, and may be Cenomanian in age (see text).

A broad region north of the Bisbee basin–Chihuahua trough that encompasses central and northern New Mexico was uplifted, tilted north, and beveled by erosion as a result of rift-flank tectonism during the Late Jurassic–Early Cretaceous (Bilodeau, 1986; Dickinson and Lawton, 2001). Because the effective elastic thickness of this region is only ~5-30 km (Watts, 2001), the breadth of the uplifted region (~500 km) suggests tectonism was driven by processes in the mantle. It is possible that the southern part of Burro Canyon Formation, which accumulated near the northern toe of the rift-shoulder uplift, may represent detritus eroded from the rift-flank to the south. Northeast-directed paleoflow measurements and isopach trends in the Burro Canyon Formation (Saucier, 1974, Grant and Owen, 1974; Owen et al., 1978; 2005) support this inference, although no detailed studies of provenance and sediment dispersal patterns for this unit have yet been attempted.

Late Albian sedimentation in eastern New Mexico occurred in response to the Kiowa–Skull Creek transgression of the Western Interior Seaway (Lucas et al., 1998). This transgression affected eastern New Mexico, but not regions to the west (with the possible exception of the valley-filling Encinal Canyon Member of the Dakota Sandstone on the eastern Colorado Plateau). Upper Albian deposits lapped across the north-tilted and beveled flank of the Bisbee basin-Chihuahua trough , producing the southward-increasing, pre-Cretaceous lacuna we see in eastern New Mexico today.

During the Cenomanian, the subsequent, regionally extensive Greenhorn transgression caused much of the Colorado Plateau to become flooded by the epeiric seaway. This transgression resulted in the deposition of the Dakota Sandstone across the north-tilted and beveled strata of what is now the southern Colorado Plateau, much as had occurred in eastern New Mexico ~5–10 m.y. earlier.

ACKNOWLEDGMENTS

Research was supported by the New Mexico Bureau of Geology and Mineral Resources. I thank Spencer Lucas for many informative conversations. The figures were drafted by Leo Gab-

aldon and Stephanie Chavez. The manuscript was improved by reviews from Tim Lawton and Spencer Lucas.

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Great view of a four-mule and freight wagon on the road from the Victorio Chief Mine in the Caballo Mountains of Sierra County New Mexico, ca 1908. NMBGMR Photo Archive No. p-01746