Upper Cretaceous and Paleogene stratigraphy and sedimentation adjacent to the Nacimiento uplift, southeastern San Juan Basin

Larry N. Smith, 1992, pp. 251-256

in:
San Juan Basin IV, Lucas, S. G.; Kues, B. S.; Williamson, T. E.; Hunt, A. P.; [eds.], New Mexico Geological Society 43rd Annual Fall Field Conference Guidebook, 411 p.

This page is intentionally left blank to maintain order of facing pages.

UPPER CRETACEOUS AND PALEOGENE STRATIGRAPHY AND SEDIMENTATION ADJACENT TO THE NACIMIENTO UPLIFT, SOUTHEASTERN SAN JUAN BASIN, NEW MEXICO

LARRY N. SMITH
Shell Western E&P Inc., P.O. Box 991, Houston, Texas 77001

Abstract—Uppermost Cretaceous and Paleogene terrestrial strata in the San Juan Basin record the local disruption and partitioning of the Cretaceous foreland basin by Laramide-aged uplifts. The importance of unconformities within the stratigraphic section, which includes the Fruitland Formation, Kirtland Shale and Ojo Alamo Sandstone, and the nature of the Cretaceous/Tertiary boundary has been controversial, especially in the southeastern San Juan Basin near the Nacimiento uplift. Surface and subsurface mapping has recently identified an unconformity-bound sand-rich fluvial unit, here referred to as "unit B," between the Fruitland/Kirtland and Ojo Alamo formations, which may explain some of the earlier mapping problems. "Unit B" on Mesa Portales contains distinct channel sandstones and interbedded siltstones and mudrocks that show mottling and oxidation profiles typical of a high energy fluvial system with well-drained floodplains. Paleocurrent measurements clearly show that deposition of much of "unit B" was related to north-to-south paleoslopes. Detrital lithologies indicate that sandstones of "unit B" and the Ojo Alamo Sandstone were derived from similar bedrock lithologies. North-to-south directed channels, parallel to the Nacimiento uplift, were responsible for depositing "unit B," the Ojo Alamo Sandstone, the upper Nacimiento Formation and the Cuba Mesa Member of the San Jose Formation. Maintenance of the position of channels parallel and adjacent to the Nacimiento uplift represents continued syntectonic sedimentation in this region from the Late Cretaceous through the early Eocene.

INTRODUCTION

Uppermost Cretaceous and Paleogene terrestrial strata in the San Juan Basin were deposited during northeast deltaic progradation following withdrawal of the Cretaceous seaway and subsequent Laramide (Late Cretaceous–Eocene) uplift within the southern Rocky Mountains (Baltz, 1967; Fassett and Hinds, 1971; Smith et al., 1985; Ayers et al., 1990; Smith, 1991). The stratigraphic and temporal significance of erosional contacts near the Cretaceous/Tertiary boundary has been controversial, especially in the southeastern San Juan Basin near the Nacimiento uplift (Fig. 1). Arguments for single or multiple unconformities at and near the K/T boundary (Baltz, 1967; Fassett and Hinds, 1971; Sikkink, 1987) have been countered by a hypothesis of nearly continuous sedimentation across the contact (Klute, 1986). Here, I present data that show the stratigraphic positions of regional unconformities in the Upper Cretaceous through Lower Eocene section and present a model that describes sedimentation adjacent to the episodically active Nacimiento uplift. A complete treatment of stratigraphic problems involving the Fruitland, Kirtland and Ojo Alamo formations is beyond the scope of this report.

STRATIGRAPHY

The stratigraphic sequence of interest includes the Fruitland Formation, Kirtland Shale, Ojo Alamo Sandstone, Nacimiento Formation and San Jose Formation (Fig. 1). The Fruitland Formation and Kirtland Shale are each composed of fine- to medium-grained sandstone and shale (see Hunt et al., this guidebook). The units are typically distinguished by the occurrence of coal only in the stratigraphically lower Fruitland Formation (Fassett and Hinds, 1971, p. 19). A regionally correlative thin shale above the last coal has been a useful marker for picking the contact in subsurface (Ayers et al., 1990). Using either definition, subsurface correlation of the Fruitland Formation and Kirtland Shale from their type areas to the southeastern San Juan Basin has shown that the Kirtland Shale is removed by erosion and the Fruitland Formation is truncated east-southeast of T21N, R5–7W, approximately 40–48 km (24–30 mi) due east of the outcrops at Mesa Portales (Fassett and Hinds, 1971; Ayers et al., 1990).

Baltz (1967) distinguished the informal units "A" and "B" in the Fruitland and Kirtland (undivided) in the southeastern San Juan Basin based on the greater percentage and coarser grained nature of sandstone in the stratigraphically higher "unit B" (Fig. 2). "Unit A" is composed of silty shale, carbonceous shale, coal and some fine-grained sandstones that locally contain marine fossils. "Unit B" is distinguished by a basal, very coarse- to fine-grained, crossbedded sandstone, which locally contains large pieces of silicified wood. Multiple coarse-grained, lenticular sandstones in "unit B" are separated by drab gray-green, red and locally purple mudrocks and siltstones and bentonitic gray clay. Baltz (1967) showed that "unit B" erosionally overlies the lower Fruitland and cuts it out locally where "unit B" overlies the Pictured Cliffs Sandstone. Fassett and Hinds (1971) distinguished in the southeastern San Juan Basin, but did not map or show correlations for, "sandstone beds that seem to be lithologically different from sandstone beds in the Fruitland throughout the rest of the basin" (p. 17). These sandstones are in the bed that corresponds to "unit B" and were inferred to represent deposition both contemporaneous with the Fruitland Formation and Kirtland Shale, and post-Fruitland deposition in channels on a sub–Ojo Alamo Sandstone unconformity (p. 19). "Unit B" at Mesa Portales is equivalent, in part, to the "upper Kirtland Shale sandstone facies" of Klute (1986).

The upper contact of the Fruitland Formation with the Ojo Alamo Sandstone in the southeastern San Juan Basin has been contentious as to its position and its conformable or unconformable nature (see discussion by Klute, 1986 and Fassett et al., 1987). The series of medium- to coarse-grained sandstones and interbedded mudrocks in "unit B" in the Mesa Portales area are overlain by a thick sandstone that has been universally referred to the Ojo Alamo Sandstone, although not all workers believe it to be the basal sandstone of the formation (Fig. 2). An abrupt transition from Cretaceous to Paleocene palynomorphs in a shale sequence adjacent to a lenticular, coarse-grained sandstone body has been interpreted as an unconformable contact with sandstones and shales of the Ojo Alamo Sandstone over the Fruitland Formation (Fassett and Hinds, 1971; Fassett et al., 1987). Based on lithologic similarities between the coarse-grained sandstones and apparent intertonguing of the sandstones and shales on Mesa Portales, Klute (1986) concluded that the "Kirtland Shale" and Ojo Alamo Sandstone contact is conformable. She did not discuss the evidence for regional truncation of the Kirtland Shale. I propose that strata of "unit B" may be recognized as a separate stratigraphic unit containing one or more unconformities near the Nacimiento uplift (Fig. 2). Details of the significance of the sandstones in the sequence described as "unit B" are discussed in detail below.

Mudrocks and fine- to coarse-grained sandstones of the Paleocene Nacimiento Formation conformably overlie the Ojo Alamo Sandstone.

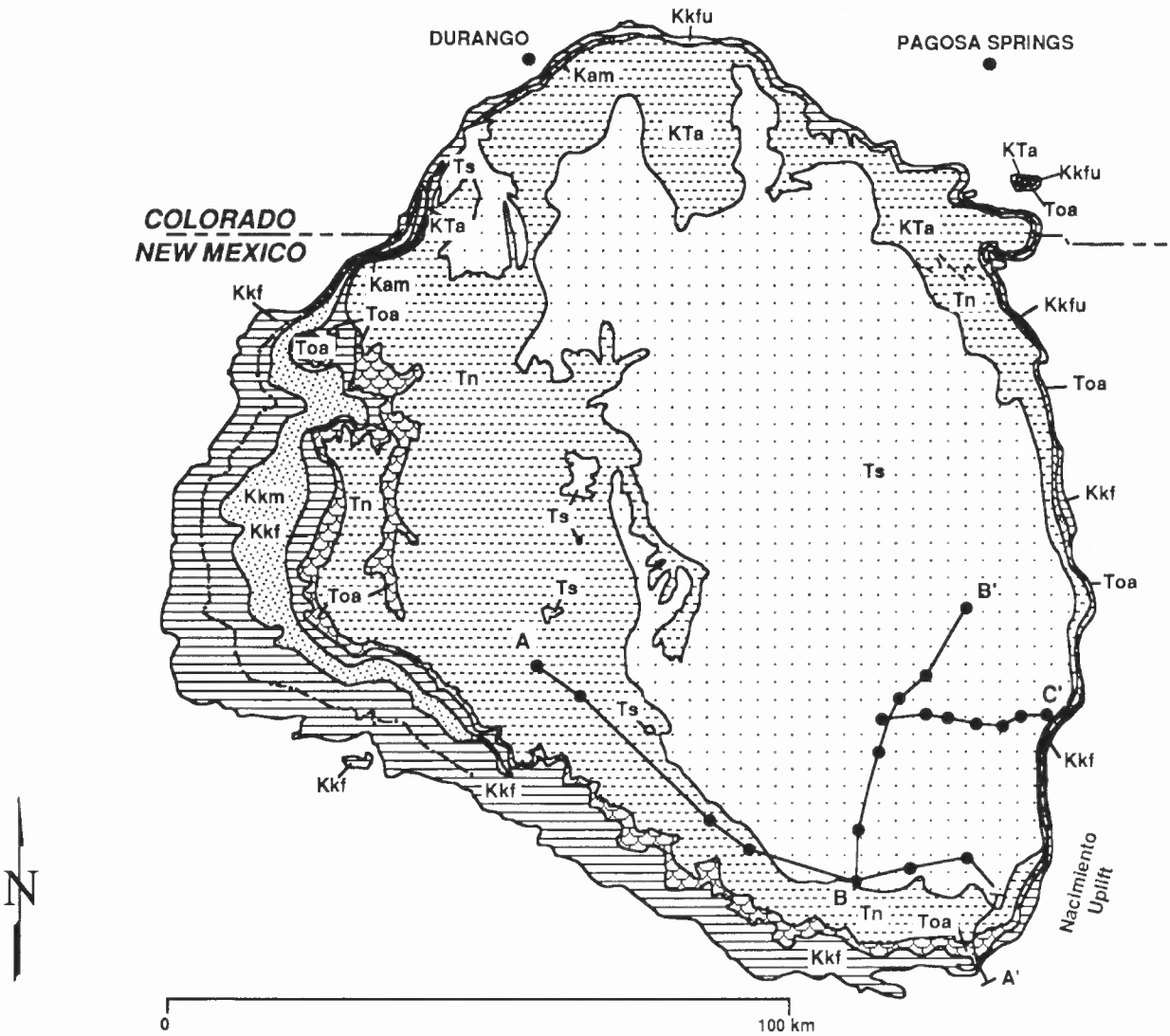


FIGURE 1. Geologic map of the San Juan Basin with locations of cross sections. Geology is modified from Dane and Bachman (1965), Tweto (1979) and Manley et al. (1987). Kkf = Fruitland Formation and lower member and Naashoibito Member of Kirtland Shale; Kkm = Farmington Sandstone Member of Kirtland Shale; Kkfu = undifferentiated Kirtland and Fruitland Formations; KTa = Animas Formation; Kam = McDermott Member of Animas Formation; Toa = Paleocene Ojo Alamo Sandstone; Tn = Paleocene Nacimiento Formation; Ts = lower Eocene San Jose Formation.

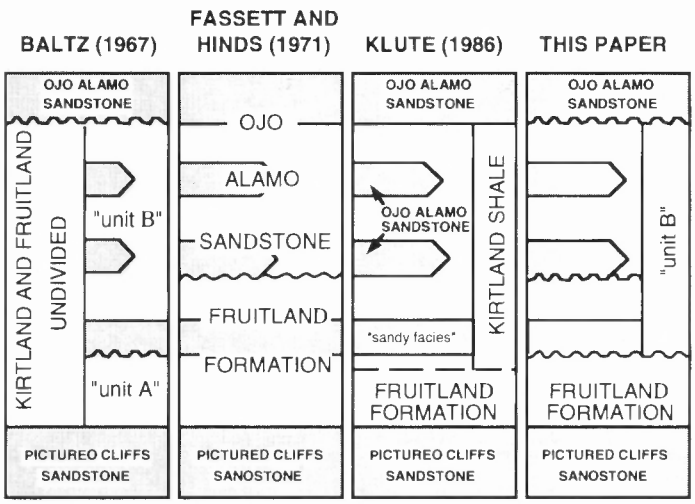


FIGURE 2. Partial history of nomenclature for Upper Cretaceous and Paleocene strata at Mesa Portales. Fassett et al. (1987) and Sikkink (1987) follow the nomenclature of Fassett and Hinds (1971).

Sandstone bodies in the Nacimiento are conspicuous along the south end of Mesa de Cuba (Fig. 3) and in the subsurface to the north. The Nacimiento Formation is unconformably overlain by thick, coarse-grained sandstone of the Cuba Mesa Member of the San Jose Formation throughout the southeastern San Juan Basin.

SIGNIFICANCE OF "UNIT B"

Regionally, the Fruitland Formation displays a regressive sequence from delta plain and coal swamp to fluvial environments. The Fruitland Formation and Kirtland Shale were deposited by streams that flowed northeast, toward the retreating Cretaceous seaway (Fassett and Hinds, 1971; Smith et al., 1986). "Unit B" on Mesa Portales contains distinct channel sandstones and interbedded siltstones and mudrocks that show mottling and oxidation profiles typical of a high energy fluvial system with well-drained floodplains (Figs. 4, 5, 6). "Unit B" is lithologically distinct from the relatively fine-grained Fruitland Formation and more similar to sandstones and mudrocks of the Ojo Alamo Sandstone and Nacimiento Formation. Paleocurrent measurements from the upper, coarse-grained channel sandstones clearly show that north-to-south paleoslopes influenced the deposition of much of "unit B" (Fig. 4). Because paleocurrent measurements have not yet been made in the lower portion of "unit B," it is unclear when paleoslope reversed from

FIGURE 3. Panorama of the southwestern side of Mesa de Cuba, view to northeast. Conspicuous channel sandstones in the Nacimiento Formation are indicated by arrows.

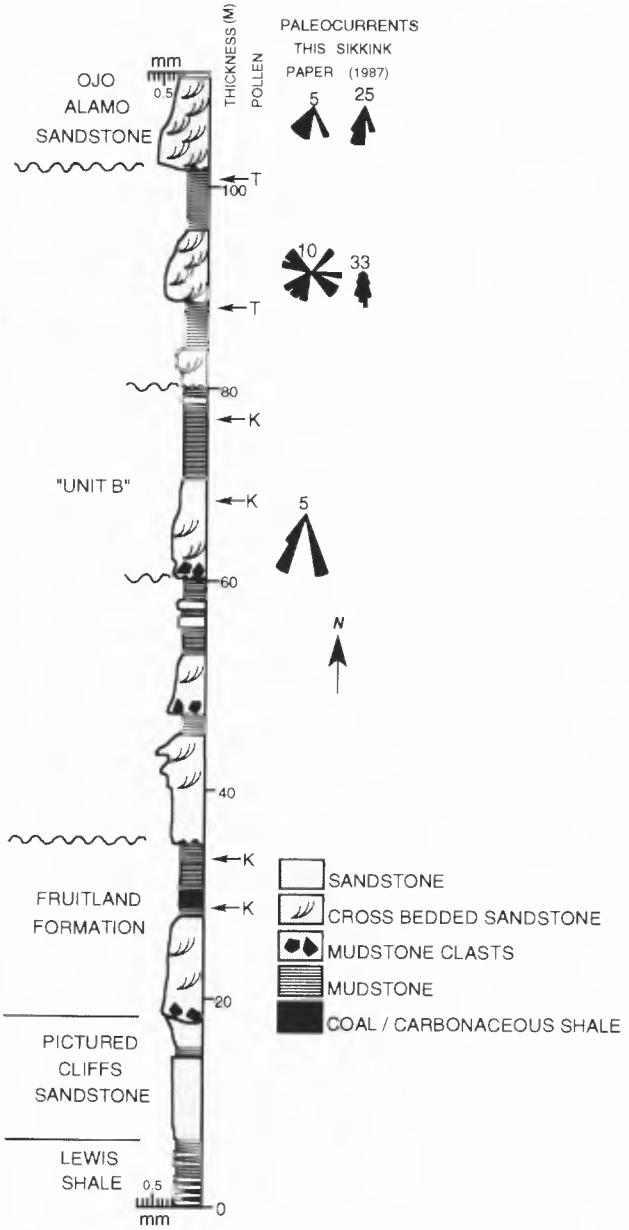
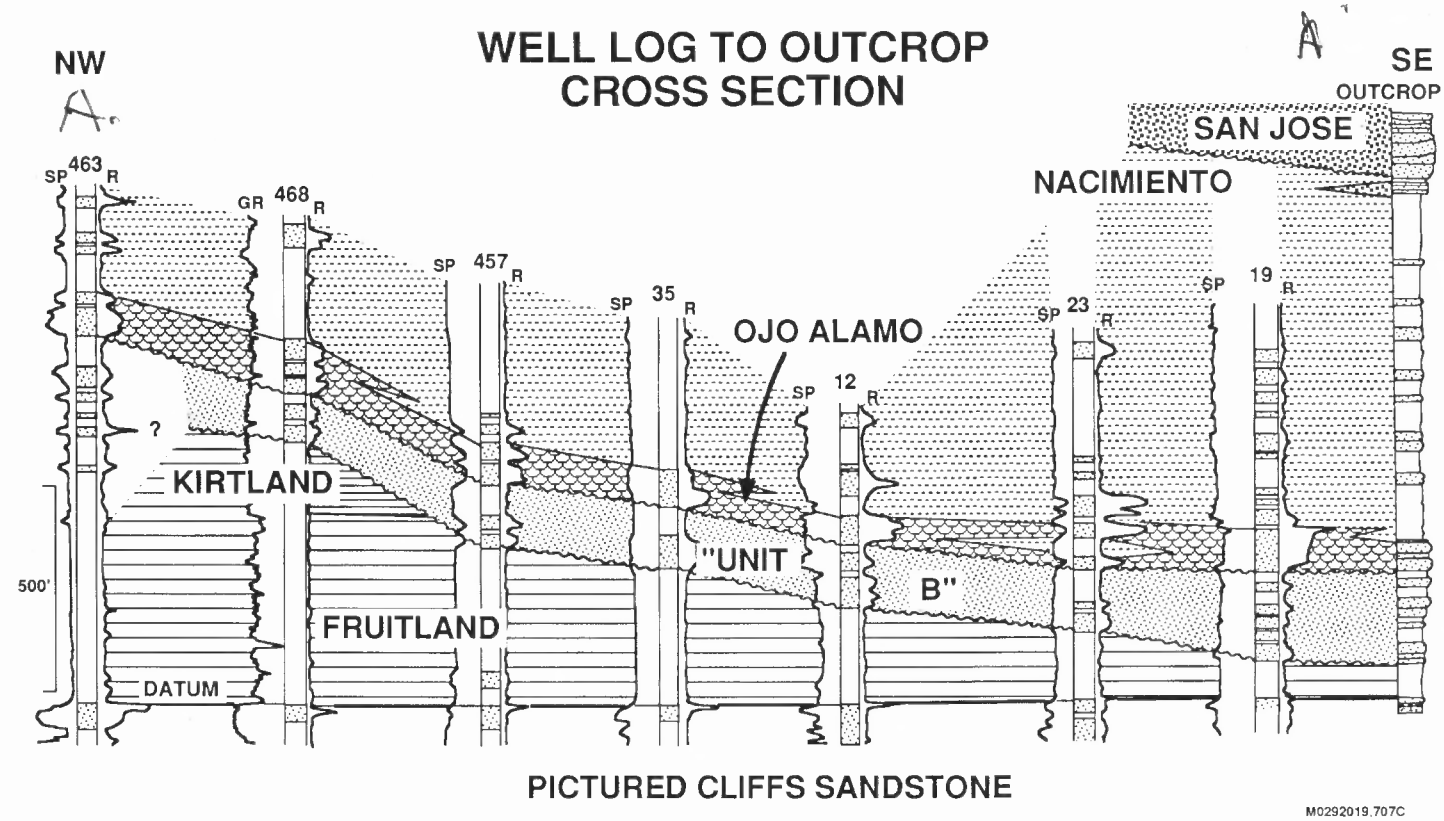


FIGURE 4. Simplified measured section of Mesa Portales (after Siemers, 1975, p. 96–97). Rose diagrams to right depict paleocurrent measurements made in sandstones.

FIGURE 5. Southeastern end of Mesa Portales, showing the Fruitland Formation in the foreground and sandstones of "unit B" and the Ojo Alamo Sandstone in the background. View to northwest.

FIGURE 6. Photograph of floodplain and levee mudrock and fine sandstone overlain by lower sheet sandstone of "unit B."



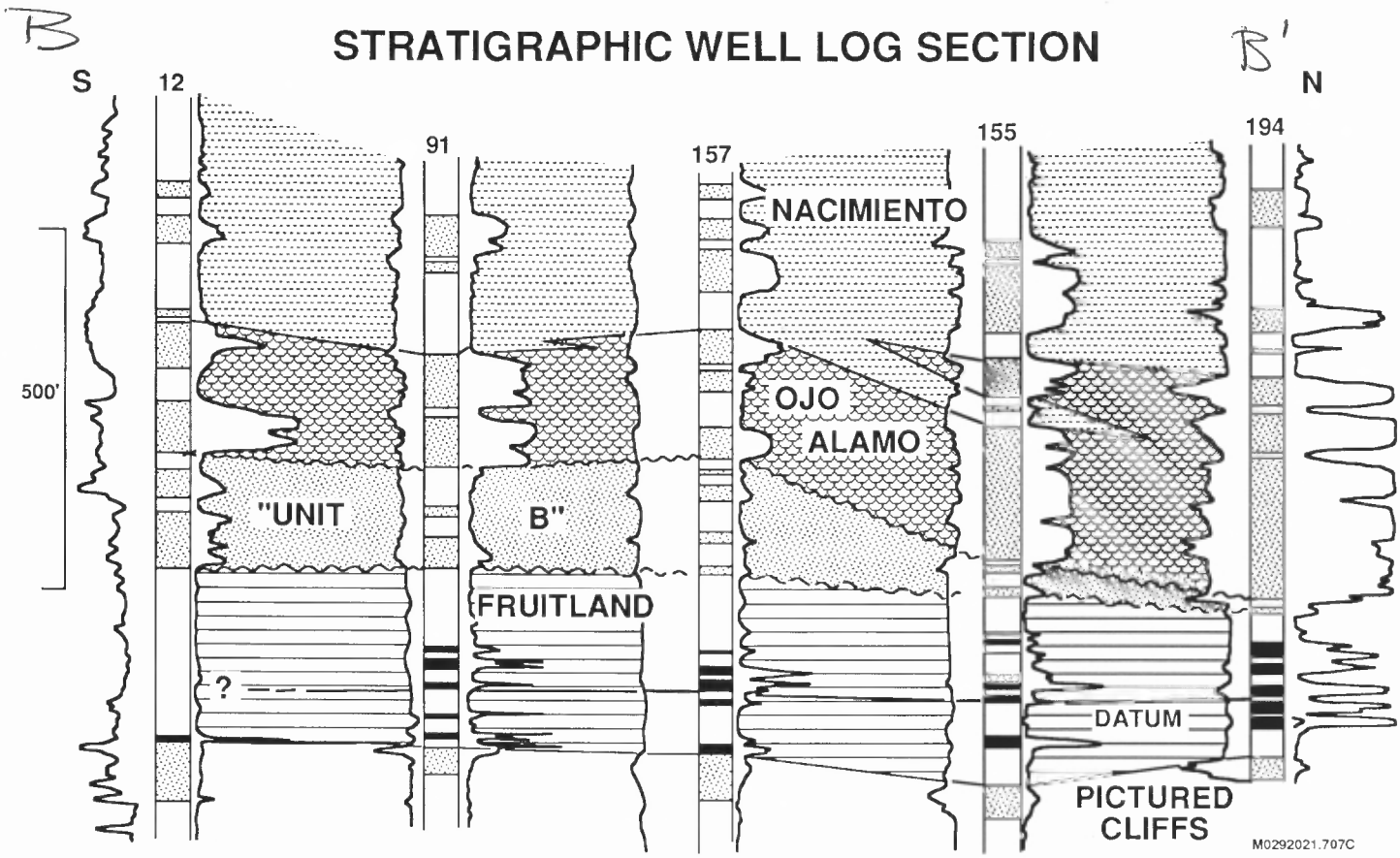


FIGURE 7. A. Cross section tying units recognized in outcrop to the subsurface. Measured section is modified from Baltz (1967) and Siemers (1975) between Mesa Portales (secs. 25 and 26, T20N, R2W) and Mesa de Cuba (secs. 11 and 12). B. Cross section showing lack in continuity of "unit B" to the north.

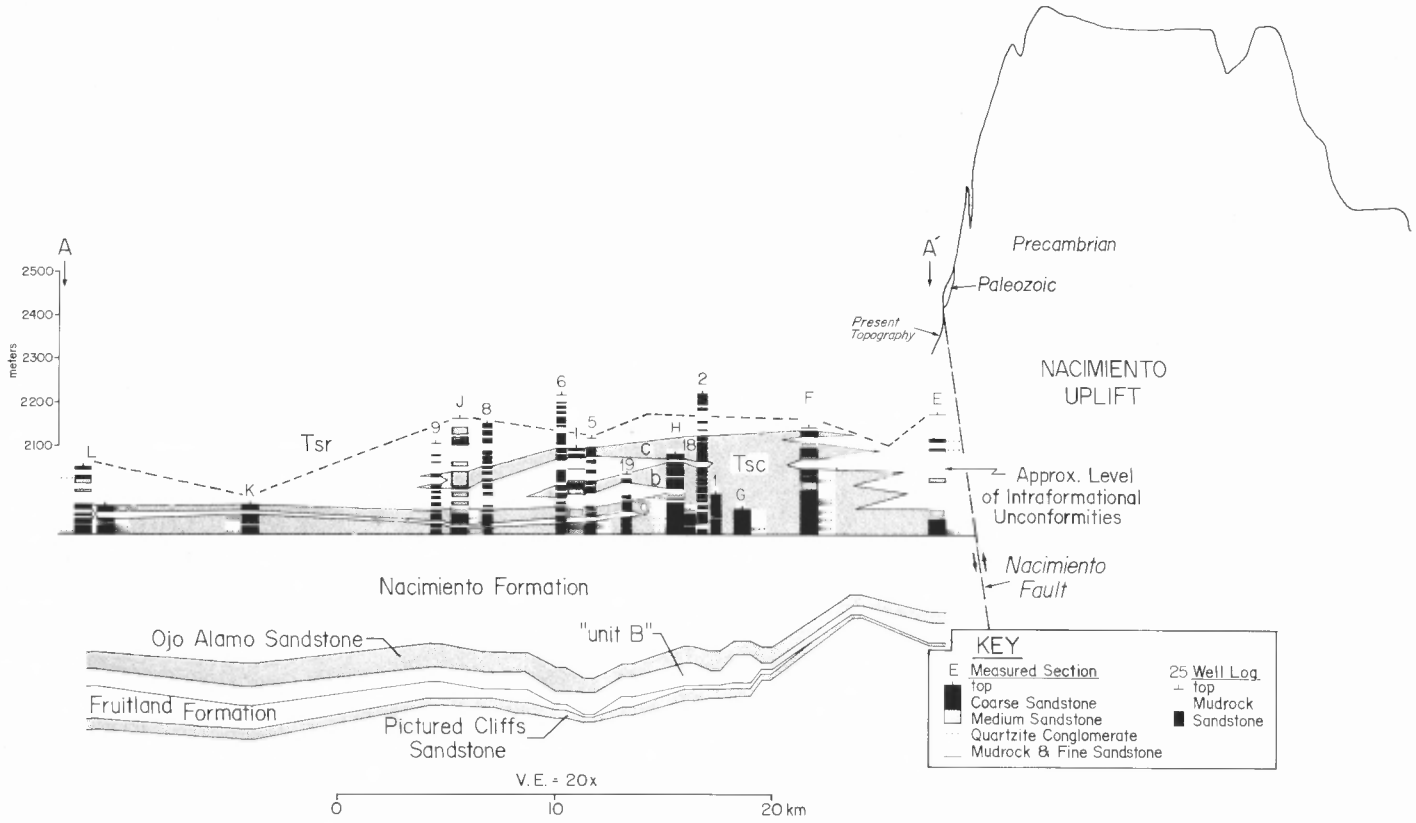


FIGURE 8. Stratigraphic east-west cross section of the upper Nacimiento Formation and lower San Jose Formation near the north end of the Nacimiento uplift. Paleoflow toward the south is inferred by paleocurrent measurements made in outcrops northeast and south of the cross section. The vertical stacking of sandstones in the Nacimiento and San Jose Formations indicates that channel belts persisted in locations parallel to the Nacimiento uplift.

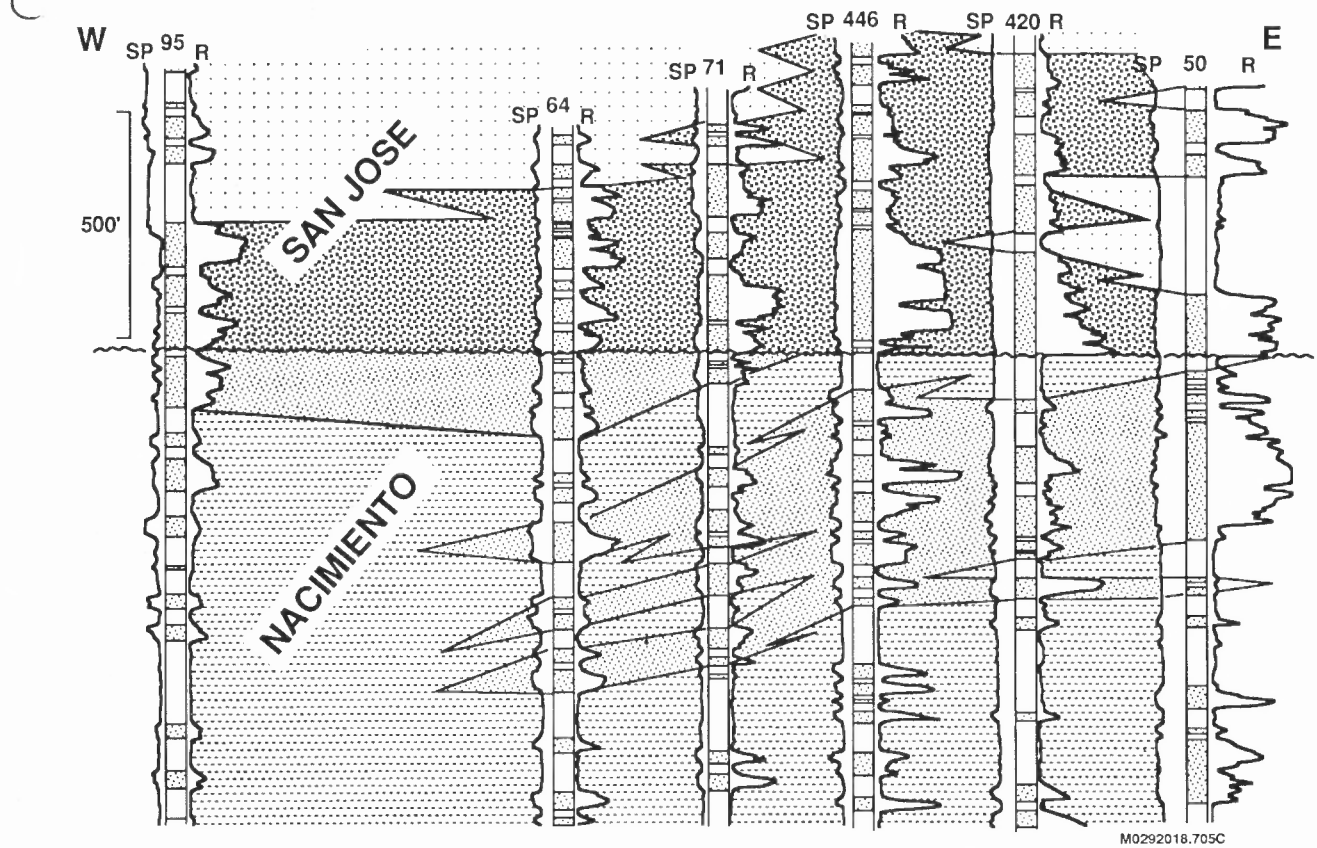


FIGURE 9. East-west well log, structural cross section (B-B' in Fig. 1) shows vertically stacked channel sandstones in the upper Nacimiento Formation and lower San Jose Formation.

dominantly northeast- to south-directed, but it was clearly before deposition of the first regionally continuous sandstone of the Ojo Alamo Sandstone. At least the upper tabular and sheet sandstones of "unit B" and the superjacent Ojo Alamo Sandstone apparently were deposited by generally north-to-south flowing channels that drained areas with similar bedrock lithologies, as indicated by similar sandstone compositions (Klute, 1986).

Correlation of a composite section, measured from Mesa Portales to Mesa de Cuba, with subsurface data demonstrates the regional continuity of "unit B" (Fig. 7A). Successive truncation of regional markers in the Kirtland Shale and Fruitland Formation along the base of sandstones below the Ojo Alamo Sandstone was shown by Ayers et al. (1990, fig. 8). Subsurface mapping and correlation of approximately 250 well logs in the southwestern San Juan Basin show that "unit B" is truncated by the Ojo Alamo sandstone on the north (Smith, 1991, and unpubl. data; Fig. 7B). Mapping of the unit, and understanding of its relationship to the upper Kirtland Shale, is incomplete beyond the western edge of the cross section in Fig. 7B. Recognition of a regionally important unconformity between the base of the Paleocene Ojo Alamo Sandstone and below strata of "unit B" that contain Cretaceous pollen in the southeastern San Juan Basin suggests that Laramide-aged uplift and erosion near the present Nacimiento uplift began in the Late Cretaceous.

The contrast in lithology between "unit B" and the Fruitland Formation and presence of an angular unconformity between the units suggests that "unit B" should be recognized as a distinct stratigraphic unit. Further work is required to resolve the position of the unconformities at the base of, and possibly within, "unit B," as well as its relationship with the Kirtland Shale, before formal stratigraphic nomenclature can be proposed. In any case, recognition and mapping of fluvial strata in the southeastern San Juan Basin between sandstones clearly correlative to the Ojo Alamo Sandstone and dinosaur-bearing strata of the Kirtland Shale and Fruitland Formation may resolve much of the controversy surrounding the nature of the Cretaceous/Tertiary boundary in this area.

STRATIGRAPHIC MODEL FOR LARAMIDE SEDIMENTATION NEAR THE NACIMIENTO UPLIFT

The location of north-to-south flowing channels parallel to the Nacimiento uplift in the southeastern San Juan Basin is common to "unit B," the Ojo Alamo Sandstone, the upper Nacimiento Formation, and the Cuba Mesa Member of the San Jose Formation (Fig. 8; Smith, 1988). Parallelism of channel belts to basin marginal uplifts is due to tectonic loading of the basin margin, forming a synclinal axis along which drainage is located (e.g., Lawton, 1985; Smith, 1988). The existence of channel sandstones above and below angular unconformities in the southeastern San Juan Basin at the Nacimiento/San Jose (Fig. 9) and Ojo Alamo/"unit B" contacts are inferred to be analogous. Maintenance of the position of channels adjacent to the Nacimiento uplift represents continued syntectonic sedimentation in this region from the Late Cretaceous through the early Eocene.

Significant erosion of the Kirtland Shale and Fruitland Formation along the unconformity at the base of "unit B" is due to regional uplift or tilting in the southeastern San Juan Basin. Deposition of coarse-grained fluvial sediment on angular unconformities along the uplift may indicate the initiation of flexural subsidence due to faulting and folding along the Nacimiento fault.

REFERENCES

Ayers, W. B. Jr., Kaiser, W. R., Ambrose, W. A., Swartz, T. E., Laubach, S. E., Tremain, C. M. and Whitehead, N. H. III, 1990, Geologic evaluation of critical production parameters for coalbed methane resources, Part I, San Juan Basin: Gas Research Institute Contract No. 5087-214-1544 Annual Report.

Baltz, E. H., 1967, Stratigraphy and regional tectonic implications of part of Upper Cretaceous and Tertiary rocks, east-central San Juan Basin, New Mexico: U.S. Geological Survey, Professional Paper 552, 101 p.

Dane, C. H. and Bachman, G. O., 1965, Geologic map of New Mexico: U.S. Geological Survey, scale 1:500,000.

Fassett, J. E. and Hinds, J. S., 1971, Geology and fuel resources of the Fruitland Formation and Kirtland Shale of the San Juan Basin, New Mexico and Colorado: U.S. Geological Survey, Professional Paper 676, 76 p.

Fassett, J. E., Lucas, S. G. and O'Neill, F. M., 1987, Dinosaurs, pollen, and spores, and the age of the Ojo Alamo Sandstone, San Juan Basin, New Mexico: Geological Society of America, Special Paper 209, p. 17–34.

Klute, M. A., 1986, Sedimentology and sandstone petrography of the upper Kirtland Shale and Ojo Alamo Sandstone, Cretaceous-Tertiary boundary, western and southern San Juan Basin, New Mexico: American Journal of Science, v. 286, p. 463–488.

Lawton, T. F., 1985, Style and timing of frontal structures, thrust belt, central Utah: American Association of Petroleum Geologists Bulletin, v. 69, p. 1145–1159.

Manley, K., Scott, G. R. and Wobus, R. A., 1987, Geologic map of the Aztec 1°×2° quadrangle, northwestern New Mexico and southern Colorado: U.S. Geological Survey, Miscellaneous Investigations Map I-1730, scale 1:250,000.

Siemers, C. T., 1975, Upper Jurassic and Upper Cretaceous stratigraphy and sedimentology—Eastern San Juan Basin, New Mexico: AAPG-SEPM Rocky Mountain Section, Field trips to central New Mexico, p. 1–98.

Sikkink, P. G. L., 1987, Lithofacies relationships and depositional environment of the Tertiary Ojo Alamo Sandstone and related strata, San Juan Basin, New Mexico and Colorado: Geological Society of America, Special Paper 209, p. 81–104.

Smith, L. N., 1988, Basin analysis of the Lower Eocene San Jose Formation, San Juan Basin, New Mexico and Colorado [Ph.D. dissertation]: Albuquerque, University of New Mexico, 166 p.

Smith, L. N., 1991, Laramide sedimentation and tectonics of the SE San Juan Basin: Geological Society of America, Abstracts with Programs, v. 23, no. 4, p. 95.

Smith, L. N., Lucas, S. G. and Elston, W. E., 1985, Paleogene stratigraphy, sedimentation, and volcanism of New Mexico; *in* Flores, R. M. and Kaplan, S. S., eds., Cenozoic paleogeography of west-central United States: Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, Denver, p. 293–315.

Smith, L. N., Lucas, S. G. and Hunt, A., 1986, Stratigraphic and sediment-dispersal evidence for drainage networks in Cretaceous and Paleogene Laramide Highlands, SW Colorado and NW New Mexico: Geological Society of America, Abstracts with Programs, v. 18, p. 754.

Tweto, O., 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000.