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LITHOLOGIC CORRELATION OF THE DAKOTA SANDSTONE AND ADJACENT UNITS ALONG THE EASTERN FLANK OF THE SAN JUAN BASIN, NEW MEXICO

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INTRODUCTION

In the San Juan Basin of northwestern New Mexico the detailed stratigraphic relationships of the Dakota Sandstone with (1) underlying sandstone units and (2) the overlying and partly intertonguing Mancos Shale have been an enigma. Several authors have noted this, as well as the intra-Dakota co-relation problems, and have attempted to solve these specific problems (for example: Tyrrell, 1959; Dane, 1960; Owen, 1966). A major step toward solving the correlation problems within the Dakota in the southeastern part of the San Juan Basin was made by Landis and others (1973); however, perhaps the area of most difficult correlation occurs along the eastern flank of the basin.

The purposes of this paper are (1) to summarize the lithologic correlation of the members of the Dakota Sandstone and the intertonguing lower part of the Mancos Shale along the eastern flank of the San Juan Basin and (2) to discuss the stratigraphic relationships of the underlying Burro Canyon Formation and Jackpile sandstone in that area. The authors are sympathetic with the view of Rodgers (1959) that the term correlation should be restricted to time-correlation but, as Shaw (1964, p. 82) has pointed out, the word correlation also has been used widely for rock-correlation. In this paper correlation is used in the latter sense, for laterally traceable rock-stratigraphic units. We really have no other generally usable word for rock-correlation unless one wishes to coin terms such as lithoequivalence and chronoequivalence.

Several recent investigations have called attention to the need for a detailed investigation of the stratigraphic relationships of the Mancos Shale, Dakota Sandstone, Burro Canyon Formation and upper part of the Morrison Formation along the eastern flank of the San Juan Basin—especially in the Holy Ghost Spring area where the Dakota outcrop crosses New Mexico Highway 44 (fig. 1). Comparison of stratigraphic investigations south and west of Highway 44 (Siemers, Flesch and Ruetschilling, 1974; Siemers and others, 1975) with studies north and east of Highway 44 (Grant and Owen, 1974; Owen, 1975) indicated that it is an area of significant changes in the relationships of the Dakota and Mancos stratigraphic units. It became obvious to us that those changes could only be documented by measuring and describing closely-spaced sections and by mapping the Holy Ghost Spring quadrangle in considerable stratigraphic detail. The area is moderately covered by alluvium and terrace gravels so that a clear understanding of the complex stratigraphy is crucial for the interpretation of the numerous isolated small outcrops.

Recent geologic mapping of the Holy Ghost Spring quadrangle was undertaken by Woodward and Martinez (1974) and more recently by Santos (1975). The critical portions of the Holy Ghost Spring quadrangle were mapped by the authors during the summer of 1975 and will be published, along with a detailed report, by the New Mexico Bureau of Mines and Mineral Resources, whose financial support for this study we gratefully acknowledge. This paper is a summary of portions of the more extensive study. We also thank former Bowling Green students James G. Jolly, Wayne A. Bartlett and Bruce I. May; and former University of New Mexico students Richard L. Ruetschilling and the late Gary A. Flesch for assistance in the field.

RELATIONSHIP OF DAKOTA, BURRO CANYON AND JACKPILE

In the northern part of the east flank of the San Juan Basin and in the Chama basin the Dakota Sandstone unconformably overlies a white, kaolinitic, pebbly, crossbedded sandstone with local, interbedded, variegated pale-green and pale-red mudstone that some have called the Burro Canyon Formation (Saucier, 1974) or Cedar Mountain Formation (Young, 1960). Most authors (Smith and others, 1961; Landis and Dane, 1967; Grant and Owen, 1974) have included these beds in the lowermost part of the Dakota, especially for mapping purposes. Because of their distinctive lithology and conformable upper contact these beds are separated from the Dakota in this paper, although they are not everywhere mappable separately. The lower contact of the Burro Canyon with the Brushy Basin Member mudstones of the Morrison Formation is generally an unconformable scour surface at the base of a fluvial channel-fill and of less regional significance than the basal Dakota unconformity. The Burro Canyon has been identified as a Lower Cretaceous unit in its type area (Stokes, 1952) about 150 miles to the northwest, but no age-diagnostic fossils have been reported from it in the eastern San Juan Basin.

In the southern part of the eastern flank of the San Juan Basin and in the Laguna area, the Dakota Sandstone unconformably overlies a white, kaolinitic, fine-to-medium grained sandstone with local, interbedded, variegated pale-green to pale-red mudstone that most authors (Moench and Schlee, 1967; Flesch, 1974; Santos, 1975) have called the Jackpile

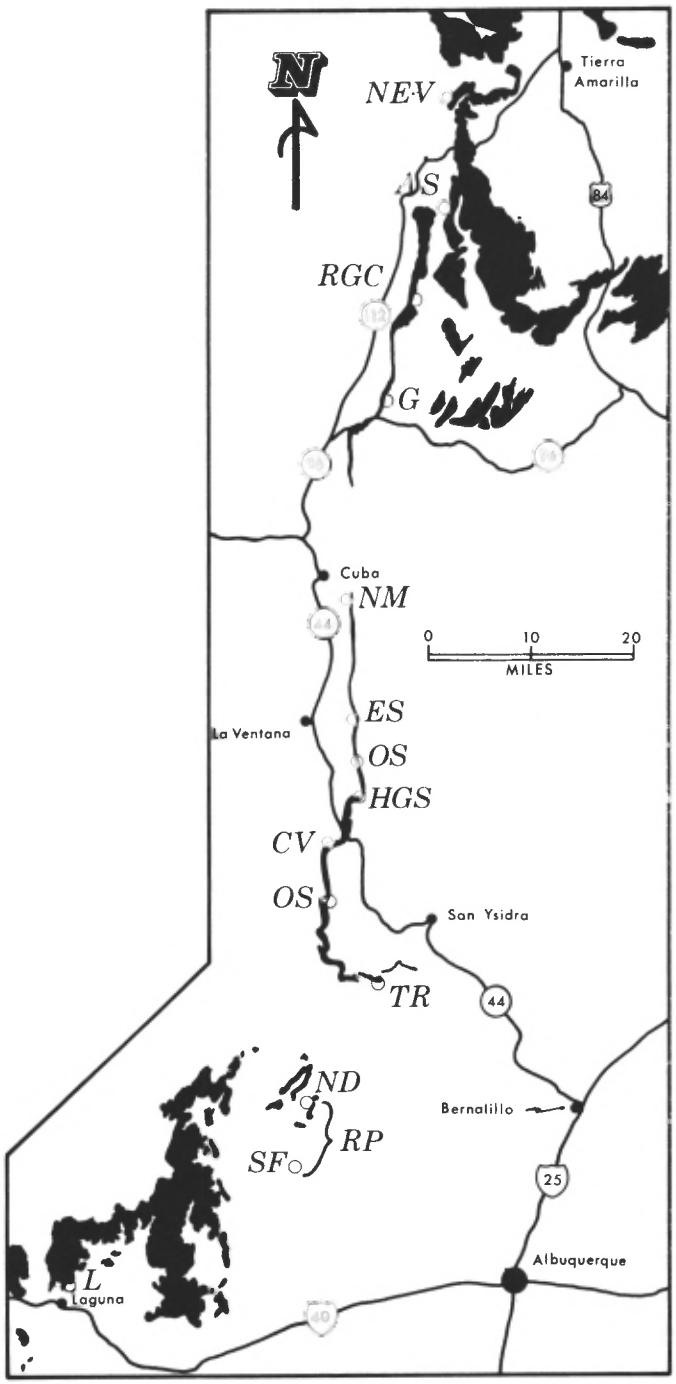

Figure 1. Index map of eastern flank of San Juan Basin. Location of measured sections plotted on Figure 2 are indicated by letter abbreviations. Dakota outcrop is indicated by black pattern.

sandstone, an informal unit in the uppermost part of the Morrison Formation. It is impossible to continuously trace the Jackpile in outcrop from the Jackpile mine near Laguna north to the southern end of the Nacimiento uplift because of gaps of several miles between exposures in the Rio Puerco fault zone. However, Saucier (1974) and Santos, (1975) have correlated it across the Rio Puerco fault zone in drill holes and Santos (1975, plate 1) has mapped the Jackpile north along the Nacimiento uplift to the Nacimiento mine near Cuba. Local pinchouts of the Jackpile do occur (Santos, 1975, p. 5, 13, plate 1 and 2). Young (1960, p. 164) mapped the Cedar Mountain (Burro Canyon) south to its zero isopach near the Nacimiento mine section. Therefore, a sandstone called Burro Canyon, probably Lower Cretaceous, may be traced south to the Cuba area and a sandstone called Jackpile, generally regarded as Upper Jurassic because of proximity to the Morrison mudstones (but lacking age-diagnostic fossils), may be traced north to the Cuba area. Their stratigraphic position subjacent to the Dakota and lithologic similarity indicate their correlation with one another. Swift (1956), in fact, made this correlation and informally called the combined Burro Canyon-Jackpile the Deadmans Peak formation all along the eastern flank of the San Juan Basin. The only noticeable differences between the Burro Canyon and Jackpile are: (1) along the eastern flank of the San Juan Basin the Burro Canyon generally has a sharp, erosional basal contact while the Jackpile commonly has a gradational, but locally erosional, basal contact; (2) the Burro Canyon is generally conglomeratic while the Jackpile is generally free of conglomeratic beds except for a few pebbles locally near the base. Saucier (1974, p. 213-215) has addressed this identification problem and has concluded that the Burro Canyon is reworked Morrison, a conclusion with which we agree, although it may not be reworked Jackpile. However, Saucier (p. 213) indicated that the Burro Canyon may overlie the Jackpile along the Nacimiento uplift in the area between our Elk Spring and Chamisa Vega section (fig. 2). In this area, the sub-Dakota sandstone at the Holy Ghost Spring and Rito Olguin sections is non-conglomeratic and essentially the same as what has been identified as Jackpile to the south. The Elk Spring exposure is quite interesting. Neither Woodward and Schumacher (1973, p. 6) nor Santos (1975, plate 1) identified the sub-Dakota sandstone at this locality as the Burro Canyon, but Saucier (1974, p. 215) interpreted it as the southernmost, thin, erosional edge of the Burro Canyon. At Elk Spring, the non-conglomeratic sandstone overlies conglomeratic sandstone containing not only chert and quartz pebbles, but also a basal conglomerate of green mudstone boulders. If one uses the non-conglomeratic versus conglomeratic criteria for differentiating the Jackpile from the Burro Canyon, one would conclude that the Jackpile overlies the Burro Canyon at Elk Spring. It may be possible (but doubtful) that the basal conglomerate at Elk Spring is in a channel sandstone in the uppermost part of the Brushy Basin Member of the Morrison.

The authors feel that the whole Burro Canyon-Jackpile problem along the eastern flank of the San Juan Basin is still unsolved. The Jackpile may not extend north to the Nacimiento uplift area; the Burro Canyon may not extend south of the Chama basin area; the Burro Canyon and Jackpile may be the same rock-stratigraphic unit; the Burro Canyon may overlap the Jackpile; or the Jackpile may overlap the Burro Canyon. Additional study is needed.

DAKOTA SANDSTONE AND MANCOS SHALE

General

As Landis and others (1973) have documented, the upper part of the Dakota Sandstone and the lower part of the Mancos Shale have an intertonguing relationship. The intertonguing is well developed along the eastern flank of the San Juan Basin (fig. 2). Only two stratigraphic horizons can be traced along the entire eastern flank. The unconformity at the

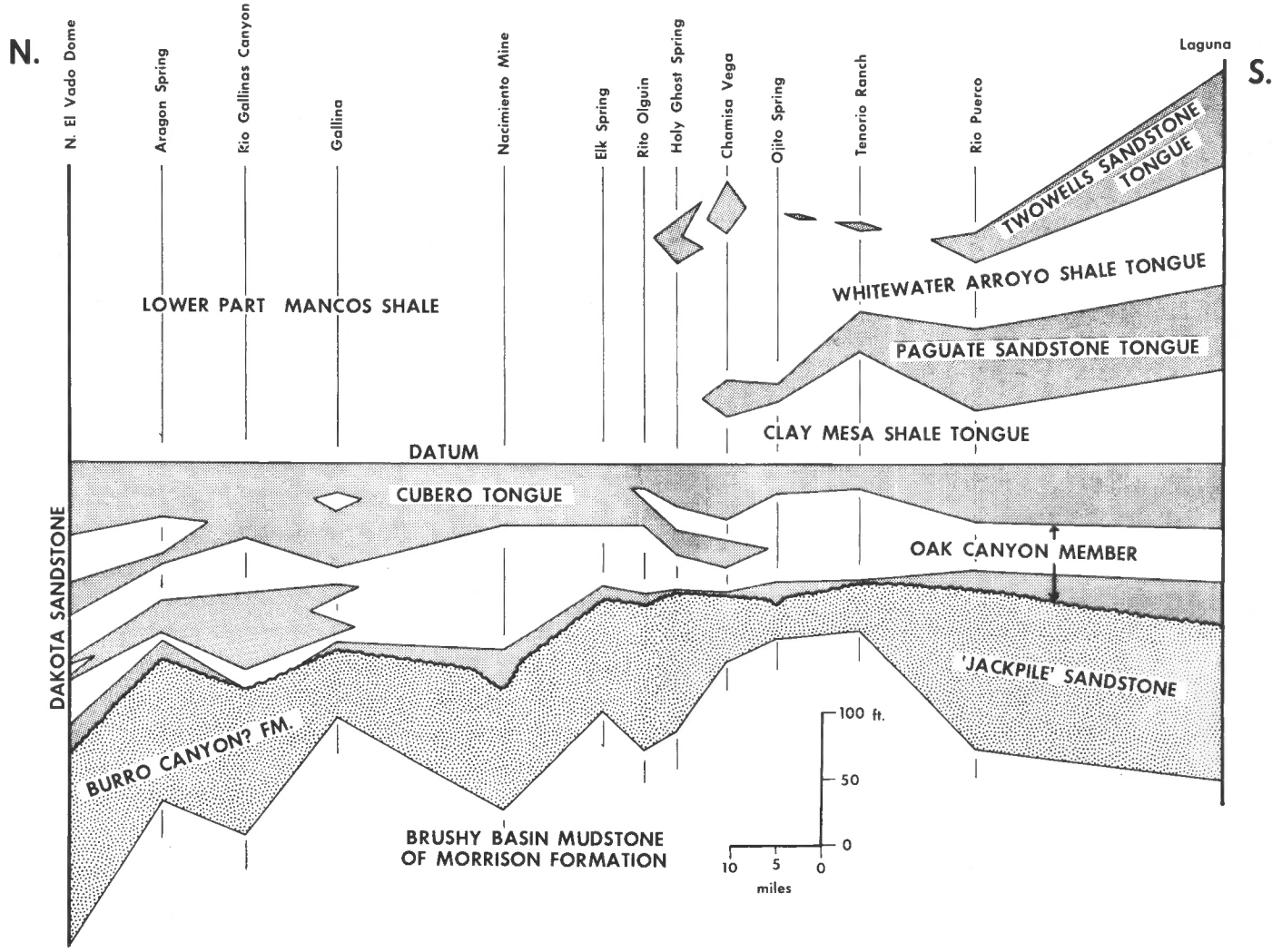

Figure 2. Generalized stratigraphic cross-section of Dakota Sandstone and adjacent units along the eastern flank of the San Juan Basin. See Figure 1 for location of named measured sections.

base of the Dakota and the top of the Cubero Sandstone Tongue of the Dakota (which is not a tongue along the eastern flank). The latter was chosen as the datum in Figure 2 instead of the channeled base of the Dakota. Bentonite beds, including a very prominent one in the Oak Canyon Member of the Dakota (Siemers and others, 1975, p. 30 and 37), are also useful as datum planes locally, but could not be identified at all of the localities included on Figure 2.

The Oak Canyon and Cubero members can be traced throughout the eastern flank area (fig. 2). The exact placement of the contact between these two members is locally debatable because of intertonguing (in the area between the Elk Spring and Ojito Spring sections) of sandstone beds near the middle of the Oak Canyon (from the Gallina section north). However, the base of the Oak Canyon and top of the Cubero are relatively easily fixed. The top of the Cubero is the top of the Dakota in the northern San Juan Basin.

The Clay Mesa Shale Tongue of the Mancos and the Paguate Sandstone Tongue of the Dakota are not identifiable north of the Chamisa Vega section because of the wedgeout of the Paguate Sandstone near the Highway 44 crossing of the outcrop belt (fig. 2). The Twowells Sandstone Tongue of the Dakota becomes quite lenticular in the Rio Puerco area and lenses in and out northward as far as the area of the Holy Ghost Spring section along the Nacimiento uplift (fig. 2). These sandstone lenses, as much as 40 feet thick, are at the same stratigraphic level as the Twowells and are lithologically identical, so they were assigned as lentils of the Twowells. Landis and others (1973, p. 40-41) suggested that a calcareous concretionary, sandy zone in the Mancos 9 miles north of the Holy Ghost Spring section probably represents the Twowells also. However, the Twowells extends no farther north, if that far. We recognize the Twowells north only to about halfway between the Holy Ghost Spring and Rito Olguin sections (fig. 2). The Whitewater Arroyo Shale Tongue of the Mancos is coexstensive with the Twowells and therefore cannot be identified north of the Twowells lensout. The sandstone called the Tres Hermanos by Lee (1912, p. 615) in the Chama basin area is now known to be the Cubero.

Above the Twowells is the lower part of the main body of the Mancos Shale. From the Chamisa Vega section north, the Greenhorn Limestone Member of the Mancos may be traced, lying about 80 feet above the Twowells and as much as 200 feet or more above the top of the Cubero where the Twowells is absent. Approximately 200 feet above the Greenhorn is the Semilla Sandstone Member of the Mancos (Dane and others,

1968) which can be mapped in the area near the southern part of the Nacimiento uplift.

Oak Canyon Member

The Oak Canyon Member of the Dakota consists of a thin basal transgressive sandstone unit, with unconformable contact on underlying beds, and an overlying, dark-grey to black shale unit that contains some thin bentonite beds at most localities. However the member varies in several ways. Although the Oak Canyon is composed mostly of marine sediments, it has some fluvial sandstones at its base that are especially well developed in channels cut into the underlying beds (for example, at the Ojito Spring section). Such a channel fill has yielded uppermost Lower Cretaceous (Albian) pollen near Acoma, 15 miles southwest of Laguna (Maxwell, 1976). Locally, the basal sandstone unit is commonly conglomerate and very thin or absent (for example, at the Holy Ghost Spring and Rio Gallinas Canyon sections). Until fairly recently, many authors, i.e. Hunt, 1936, p. 39-40; Young, 1960, p. 176; Moench and Schlee, 1967, p. 22 classified this basal sandstone unit as the entire Dakota Sandstone in the southern part of the San Juan Basin and considered beds now known as the upper part of the Oak Canyon, the Cubero, the Clay Mesa, the Paguate, the Whitewater Arroyo and the Twowells as part of the Mancos Shale. Local intertonguing of the upper part of the Oak Canyon with the lower part of the Cubero occurs between the Elk Spring and Ojito Spring sections and a marine sandstone lens occurs in the middle part of the Oak Canyon in the northern part of the eastern flank (fig. 2). A few fossils occur in the Oak Canyon. *Skolithos* and *Thalassinoides* burrows are present in the basal sandstone unit, especially along the unconformity; highly bioturbated sandstones with abundant *Planolites;* some *Thalassanoides;* and locally, abundant *Ophiomorphia* occur in higher sandstones in the Oak Canyon. Locally abundant concentrations of bivalves and gastropods occur in calcareous beds within the upper shale unit.

Cubero Sandstone

The Cubero is a well developed, fine-grained, marine sandstone with a transitional basal contact and a sharp, mesa- or hogback-forming upper surface. It contains silty and sandy bioturbated shale lenses at several localities. Its most striking characteristic, especially in the northern part of the eastern flank, is the presence of extremely abundant *Ophiomorpha* and *Thalassanoides* burrows along with other trace fossils. A few bivalves occur locally in calcareous beds and concretions.

Clay Mesa Shale and Whitewater Arroyo Shale

These tongues of the Mancos Shale in the upper part of the Dakota are essentially identical lithologically. They consist of dark-gray, montmorillonitic, silty shales. Calcareous concretions, thin, calcareous siltstone or sandstone and bentonite beds are present at many localities. Extensive bioturbation is common in the coarser grained parts. A few ammonites are present, especially in the Whitewater Arroyo.

Paguate Sandstone

The Paguate Sandstone is very similar to the Cubero in the southern part of the eastern flank, although it is generally somewhat thicker, very fine-grained and contains abundant calcareous concretions in its well developed lower transition zone with the Clay Mesa Shale. North of the Tenorio Ranch section, it thins dramatically and becomes interbedded, flaggy, calcareous sandstone and shale as it gradually wedges out into the Mancos Shale. The Paguate is highly bioturbated where thick; so much so, that individual trace fossils are difficult to recognize. It contains bivalves where calcareous.

Twowells Sandstone

The Twowells is lithologically distinctive and easily differentiated from the other Dakota Sandstone members on close examination. It differs in being coarser grained, with a few pebbles at most exposures, quite glauconitic, and containing at least some beds that have well developed crossbedding only slightly disturbed by long, vertical *Ophiomorpha* burrows. Locally it is quite fossiliferous and contains large ammonites in the transition zone with the Whitewater Arroyo Shale at the Chamisa Vega section and abundant shark teeth and bivalves in the Twowells lens just south of the Ojio Spring section.

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