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THE WHITE ROCK MESA MEMBER OF THE DAKOTA SANDSTONE (CRETACEOUS) OF THE SAN JUAN BASIN, NEW MEXICO AND COLORADO, A FORMAL NEW LITHOSTRATIGRAPHIC UNIT TO REPLACE THE INFORMAL "DAKOTA MAIN BODY"

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ABSTRACT.—The White Rock Mesa Member of the Dakota Sandstone in the San Juan Basin of New Mexico and Colorado is formally named in this paper to replace the informal "Dakota main body" from a stratotype near Gallup, NM. It is an eastward-thinning clastic wedge of fluvial sandstone, carbonaceous shale, and coal that rests on the K-3 unconformity, which truncates lower Dakota members, the Burro Canyon Formation, and the Morrison Formation. A series of marine-flooding surfaces mark the top of the White Rock Mesa Member, and it grades into shoreface sandstones of the lower parasequence of the Cubero Sandstone Tongue of the Dakota to the east. It averages approximately 30 meters in thickness and is present in the western two thirds of the San Juan Basin.

INTRODUCTION

Landis et al (1973) introduced the informal stratigraphic name "Dakota main body" for a fluvial complex of sandstone, carbonaceous shale, and thin, lenticular coals in the lower part of the Dakota Sandstone of the western San Juan Basin, apparently following Owen (1966, p. 1025), who casually mentioned ".... the main body of Dakota Sandstone..." to contrast it with marine tongues of Dakota Sandstone in the San Juan Basin. This informal unit has been used by a number of authors since 1973, and it has been confused and miscorrelated with the Encinal Canyon Member (Aubry, 1988, p.62-63; 1992, p. 12) on the north flank of the San Juan Basin and the Oak Canyon Member of the Dakota (Landis et al., 1973, p. 31) on the south flank of the San Juan Basin, in part because of its vague description. The precise stratigraphic position of the "Dakota main body" above a newly recognized unconformity, K-3, is now known (Owen and Head, 2001; Owen and Owen, 2003), so the "Dakota main body" now deserves its own formal name and precise definition as the White Rock Mesa Member of the Dakota Sandstone, formally named in this paper.

DEFINITION

Name and type locality

The name comes from White Rock Mesa, approximately 14 kilometers northeast of Gallup, NM in the north half of Sec. 36, T. 16 N., R. 17 W., Church Rock 7.5 minute topographic quadrangle, Mc Kinley County, New Mexico (Fig. 1). White Rock Mesa has not been used as a lithostratigraphic name in the U.S., and this name was reserved for our use by the Geologic Names Committee of the U.S. Geological Survey.

Stratotype and lithologic description

The stratotype and lithologic description are illustrated in Figure 2 and the approximate location of the measured section on the outcrop at the west end of White Rock Mesa is shown on Figure 1. Figure 3 is a photograph of the type locality at the west end of White Rock Mesa. The stratotype contains all three lithologies that typify the White Rock Mesa Member, in order of abundance: (1) gray, tan-weathering, fine- to medium-grained, crossbedded, quartz/chert sandstone that is locally pebbly, especially near the K-3 unconformity and at the base of channel-fills; (2) dark gray to black, silty, carbonaceous shale; and (3) thin, lenticular coal beds with a high ash content. The White Rock Mesa Member is approximately 30 meters thick near the stratotype and throughout most of its extent, but thickness varies, mainly due to relief on the basal K-3 unconformity and proportion of shale versus sandstone. A log from a water well near Yah-ta-hey, 26 kilometers west of the stratotype is included as Figure 4 to aid in subsurface recognition of the White Rock Mesa Member.

Definition of boundaries

The lower boundary of the White Rock Mesa Member is the K-3 unconformity (Fig. 3), which is present throughout the dis-

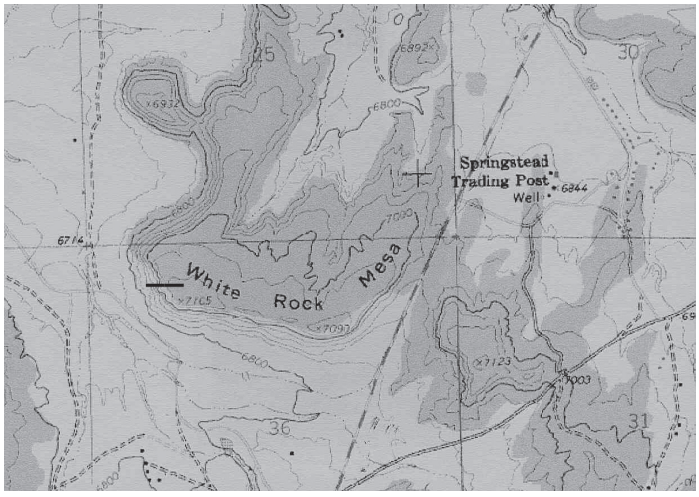

FIGURE 1. Topographic map of White Rock Mesa. Stratotype measured approximately along horizontal bar at west end of White Rock Mesa. USGS Church Rock 7.5' Quadrangle.

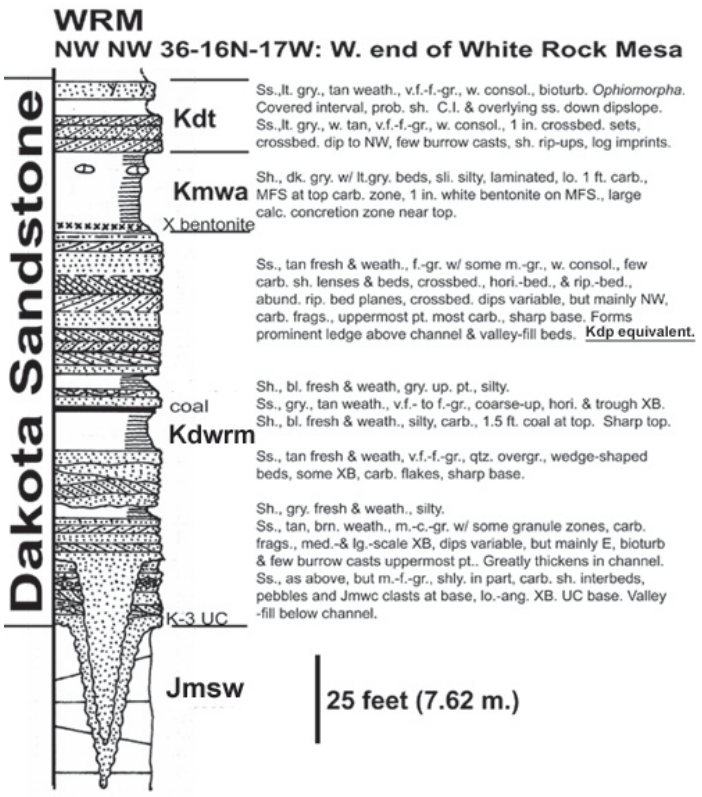

FIGURE 2. Stratotype of White Rock Mesa Member of Dakota Sandstone. Kdt = Twowells Sandstone Tongue of Dakota Sandstone; Kmwa = Whitewater Arroyo Shale Tongue of Mancos Shale; Kdwrm = White Rock Mesa Member of Dakota Sandstone; Jmsw = Salt Wash Sandstone Member of Morrison Formation; K-3 UC = K-3 unconformity. Modified from Owen and Owen (2003, p. 329).

tribution of the White Rock Mesa Member. This unconformity is a channeled erosional truncation surface that cuts down section westward from the Oak Canyon Member to the Encinal Canyon Member of the Dakota. Farther westward, it continues to cut down across the K-2 unconformity, the Burro Canyon Formation, the K-1 unconformity, the Brushy Basin Member of the Morrison Formation, and the Salt Wash (also known as the Westwater Canyon--see Lucas and Heckert, 2003, p. 296) Sandstone Member of the Morrison, such as at the stratotype, where a prominent channel-fill is displayed. South of the San Juan Basin, in the Zuni embayment, this stratigraphic downcutting continues through the Salt Wash, the J-5 unconformity, the Zuni Sandstone, the J-2 unconformity, and into the upper part of the Chinle Group (Owen and Sparks, 1989). The erosional truncation below the K-3 unconformity is due to a slight eastward dip of the underlying strata. The unconformity was cut during a relative sea-level fall. This could have been a eustatic fall or a result of tilting by subsidence in the Western Interior Basin to the east or uplift in the thrust-belt source area to the west, or both.

The upper boundary is generally one of several marine-flooding surfaces, which can be, from east to west, at the base of the upper parasequence of the Cubero Sandstone, the Clay Mesa Shale, the Paguate Sandstone, the Whitewater Arroyo Shale, the Twowells Sandstone, or even the Graneros Shale near the Four Corners. Locally, the overlying unit, especially the Paguate Sandstone, has channeled into the White Rock Mesa Member, such as in the area east of the stratotype (especially in Second Canyon, 8 kilometers east of the stratotype) to just east of Mt. Powell, where a local pebble-lag is present. Where the overlying lithology above the marine-flooding surface is shale, *Thalassanoides* burrow casts occur locally in approximately the upper 30 centimeters of the White Rock Mesa Member. At the stratotype, the Whitewater Arroyo Shale directly overlies the White Rock Mesa Member, and the uppermost sandstone bed in the White Rock Mesa Member is at the stratigraphic level of the Paguate Sandstone Tongue developed to the east of Second Canyon. The X bentonite, a widespread surface and subsurface marker bed, is very near the base of the Whitewater Arroyo Shale Tongue at the stratotype (Fig. 2).

The eastern edge of the White Rock Mesa Member is defined where it grades into the shoreface sandstones of the lower parasequence of the Cubero Sandstone, which is also at approximately the zone where the K-3 unconformity grades into a correlative conformity, but this surface is locally scoured. This zone is mostly in the subsurface of the San Juan Basin, approximately along a line from north of Chama near the Colorado state line to 13 kilometers west of San Mateo, New Mexico, north of Grants. On the outcrop, the White Rock Mesa Member is present all across the Dakota outcrop belt in Colorado, the west flank of the outcrop belt of the San Juan Basin near the Arizona state line, and the south outcrop belt eastward to west of San Mateo. Farther to the east and northeast, including the east flank outcrop belt of the San Juan Basin and the Chama Basin, only the shoreface Cubero Sandstone is present at that horizon. Figure 5 is a map of the area within the Dakota outcrop belt around the San Juan Basin illustrating the area where the White Rock Mesa Member is present

FIGURE 3. Photograph of Dakota Sandstone/Salt Wash Sandstone at west end of White Rock Mesa, New Mexico, where stratotype was measured. Kdwrm = White Rock Mesa Member of Dakota Sandstone; Jmsw = Salt Wash Sandstone Member of Morrison Formation. K-3 UC = K-3 unconformity indicated by heavy black line. The outcrop is most easily climbed to the left of the K-3 symbol. Modified from Owen and Owen (2003, p. 328).

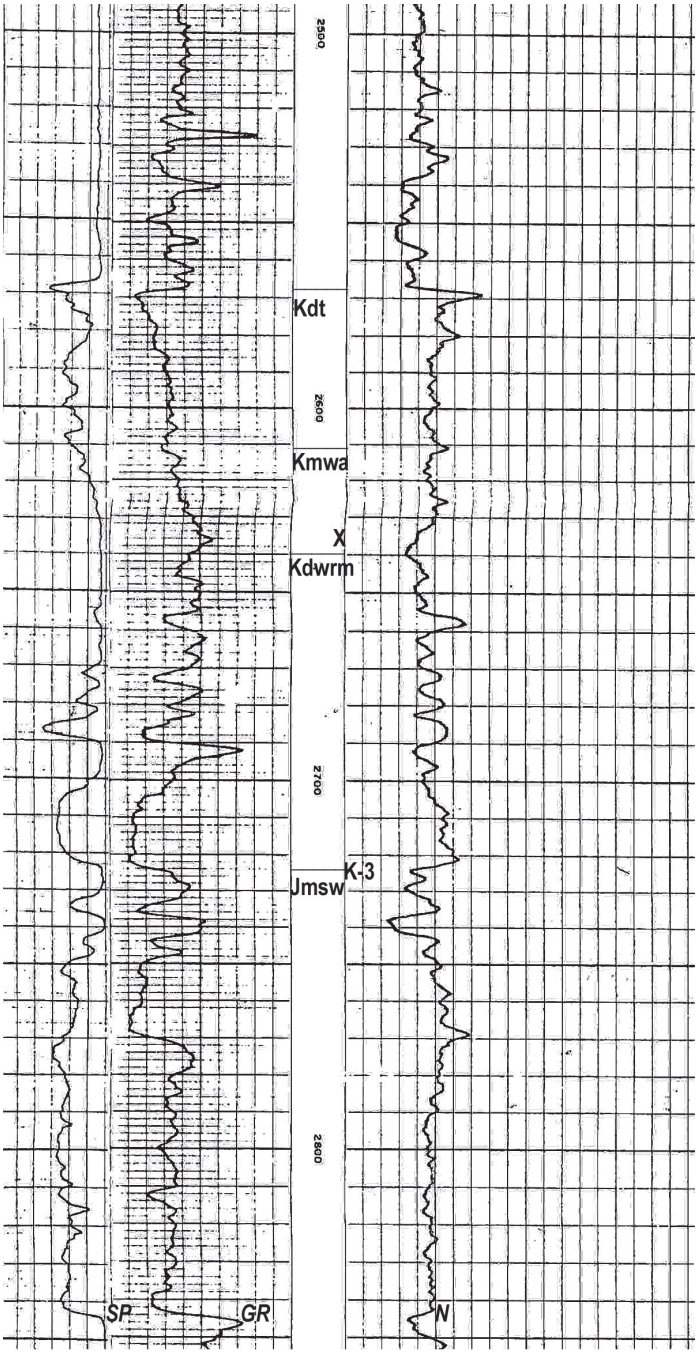

FIGURE 4. Subsurface log of the Dakota Sandstone and adjacent lithostratigraphic units in the City of Gallup Munoz #1 Water Well located in NE, NE, NW, Sec. 17, T.16N, R18W, near the village of Yah-ta-hey, approximately 26 kilometers west of the stratotype. Approximately 107 meters (350 feet) of strata are represented on this portion of the well log, 26 meters of which is included in the White Rock Mesa. Kdt = Twowells Sandstone Tongue of Dakota Sandstone; Kmwa = Whitewater Arroyo Shale Tongue of Mancos Shale; Kdwrm = White Rock Mesa Member of Dakota Sandstone; Jmsw = Salt Wash Sandstone Member of Morrison Formation; X = X bentonite; K-3 = K-3 unconformity; *SP* = spontaneous potential; *GR* = gamma ray; *N* = neutron.

and absent. Figure 6 is a cross-section, based on outcrops, along the south flank of the San Juan Basin from the stratotype east to Laguna, NM. It clearly shows the conformable extension of the K-3 unconformity horizon eastward at the base of the Cubero and the onlap of the upper part of the Cubero on the White Rock Mesa.

Age, Correlation, and Genesis

The Dakota Sandstone in the San Juan Basin is of early Late Cretaceous age, contained entirely within the Cenomanian Stage (Cobban, 1977). The lowest age-diagnostic fossils reported from the Dakota Sandstone are middle Cenomanian ammonites that occur in the middle of the Oak Canyon Member (Cobban, 1977, p. 3). Only trace fossils of uncertain age are known from the Encinal Canyon Member--presumably it is no older than early Cenomanian. In the San Juan Basin, only the Burro Canyon Formation is considered as Early Cretaceous (Aptian-Albian) in age, based on palynomorphs (Tschudy, et al., 1984). In northeastern New Mexico and eastern Colorado, the Dakota is older, at least partially of late Early Cretaceous age.

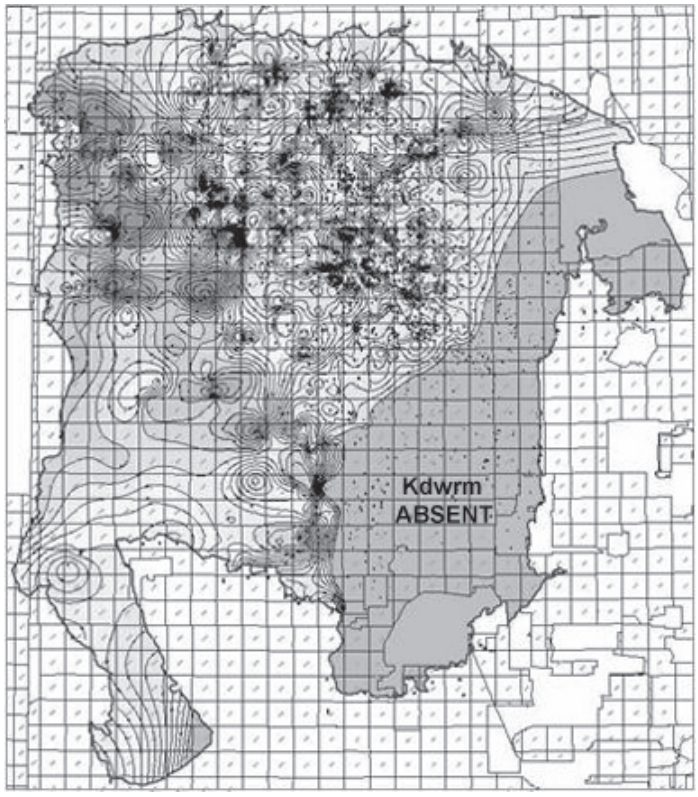

FIGURE 5. Map of the distribution of the White Rock Mesa Member of the Dakota Sandstone in the San Juan Basin, NM, CO, UT, and AZ. The irregular outline inside the rectangle is the approximate outcrop of the top of the Dakota Sandstone. The small squares on the map are townships that are 6 miles (9.66 kilometers) across. Note that the White Rock Mesa is absent in the solid grey area in the eastern part of the map, where the lower parasequence of the Cubero Sandstone Tongue of the Dakota Sandstone occupies its approximate stratigraphic position.

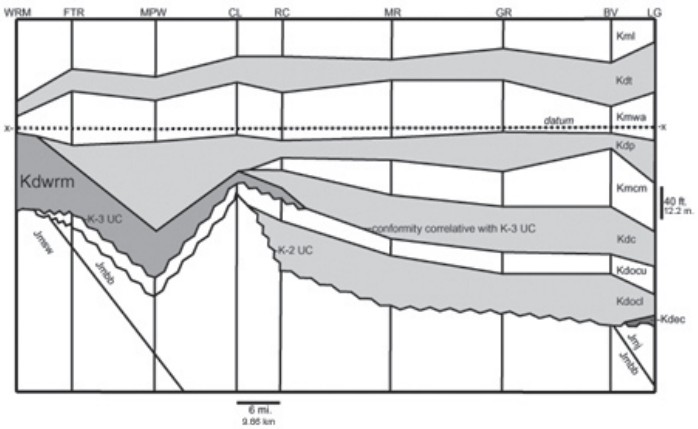

FIGURE 6. West-East stratigraphic cross-section of Dakota Sandstone and adjacent units across southern San Juan Basin outcrop belt from White Rock Mesa on west to Laguna on east. Kml = lower Mancos Shale; Kdt = Twowells Sandstone; Kmwa = Whitewater Arroyo Shale; x = X bentonite; Kdp = Paguate Sandstone; Kmcm = Clay Mesa Shale; Kdc = Cubero Sandstone; Kdwrm = White Rock Mesa Member; Kdocu = upper Oak Canyon shale; Kdocl = lower Oak Canyon sandstone; Kdec = Encinal Canyon Sandstone; Jmj = Jackpile Sandstone; Jmbb = Brushy Basin Shale; Jmsw = Salt Wash Sandstone. Modified from Owen and Owen (2003, p. 326).

The White Rock Mesa Member does not extend east of the San Juan Basin, but it may be correlated westward into the Black Mesa Basin of Arizona. This member is a generally westward-thickening clastic wedge of fluvial channel sandstones and overbank, carbonaceous shale with locally developed, thin, backswamp coals. Sandstone is the predominant lithology. Fluvial paleocurrents have an easterly mean flow direction, as derived from measurements of crossbedding (Owen et al., 1978), although a north-northwesterly mean is apparent in the Four Corners area (Kostura, 1975, p. 59)[1].

CONCLUSIONS

The eastern-thinning clastic wedge of fluvial sandstone, carbonaceous shale, and coal in the lower-to-middle part of the Dakota Sandstone, formerly known as the informal "Dakota main body" is formally named as the White Rock Mesa Member. It rests on the K-3 unconformity, averages approximately 30 meters in thickness, and is present in the western two thirds of the San Juan Basin and to the south and west.

ACKNOWLEDGMENTS

We are very grateful to the Navajo Nation for permits to access their lands and for allowing us to do a detailed study at White Rock Mesa. Persons wishing to visit the type locality of the White Rock Mesa Member must obtain a permit from the Navajo Nation Minerals Department, P.O. Box 1910; Window Rock, AZ 86515.

Nancy R. Stamm of the US Geological Survey, Geologic Names Committee, was very helpful in researching and reserving the stratigraphic name White Rock Mesa for this paper.

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FOOTNOTE

[1] All paleocurrent azimuth data in Kostura, 1975, need a +27° correction because of a sign error in the declination correction (p. 121).