DEPARTMENT OF THE INTERIOR
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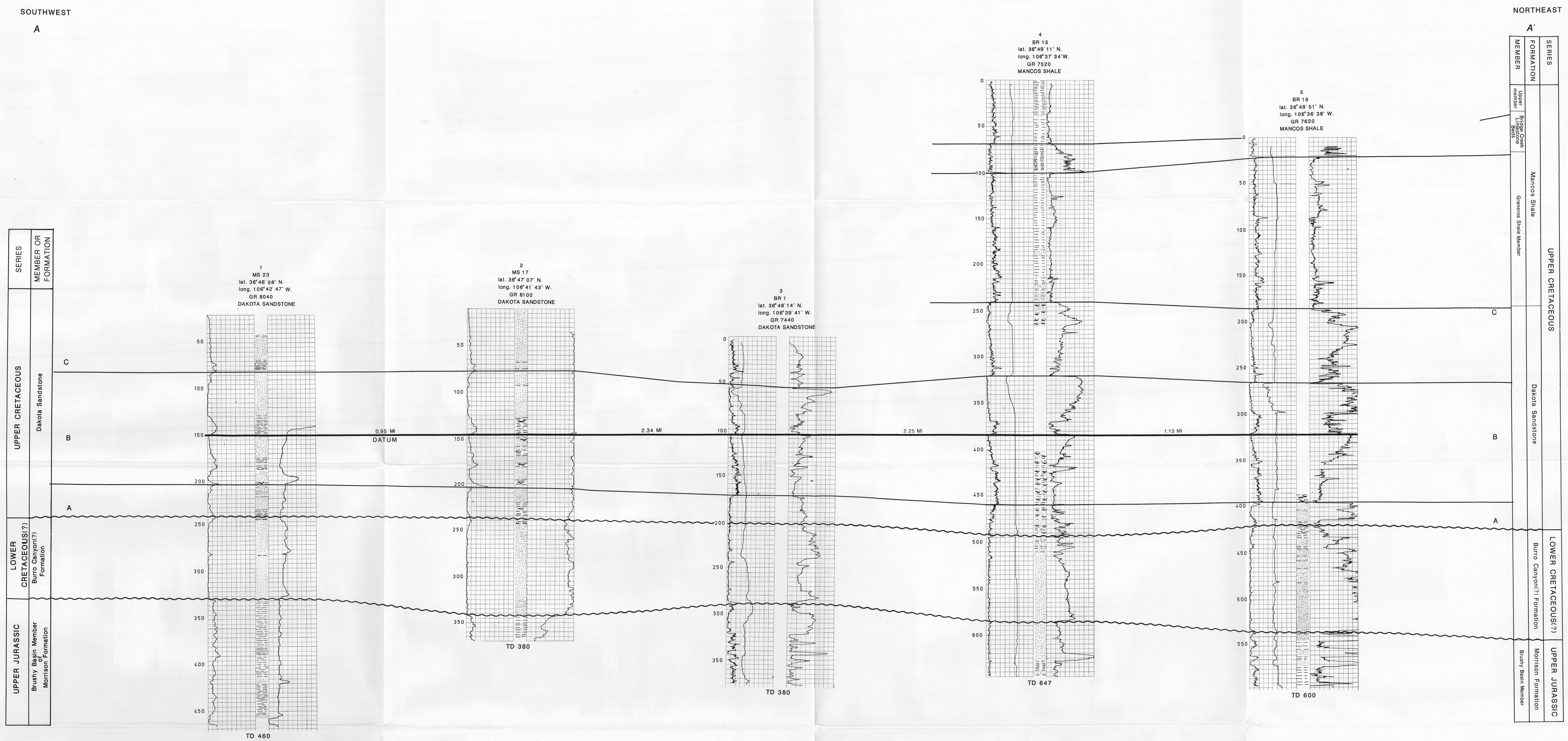
MISCELLANEOUS FIELD STUDIES
MAP MF-1496-D
SHEET 1 OF 2



EXPLANATION

NOTE: Information available for drill holes include the following from left to right: gamma-ray log, spontaneous-potential log, lithologic descriptions from drill-hole cuttings, and resistivity log. Some wells may not have all logs. Distance between wells is shown along datum. Formation exposed at the surface shown below name and location of drill hole

CORRELATION LINE

UNCONFORMITY

DATUM--Top of persistent sandstone in middle sequence of Dakota Sandstone

GR 7200 GROUND ELEVATION, IN FEET

TD 300 TOTAL DEPTH OF WELL, IN FEET

SYNCLINE

ANTICLINE

DOME

LITHOLOGIC SYMBOLS

Sandstone

Conglomeratic sandstone

Shale or mudstone

Limestone

Siltstone

Soil

Carbonaceous

Covered interval

P Planolites

C Highly carbonaceous shale, lignite

Chert

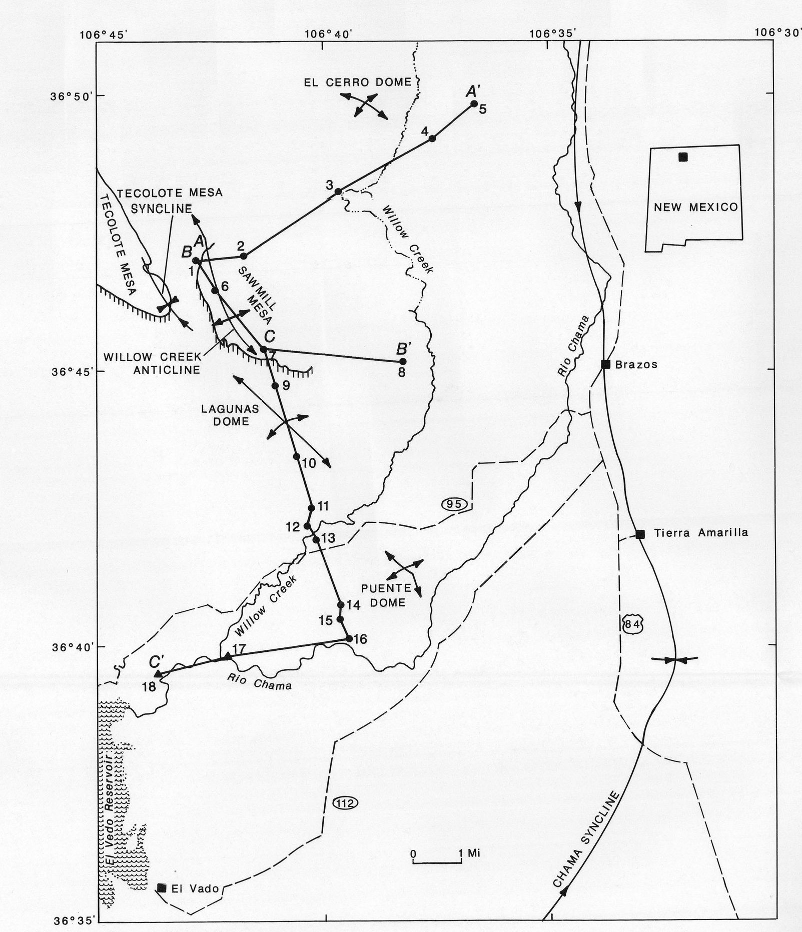


Figure 1.--Index map showing lines of cross sections and locations of drill holes (•) and measured sections (▲).

SURFACE TO SUBSURFACE CROSS SECTIONS SHOWING CORRELATION OF THE DAKOTA SANDSTONE, BURRO CANYON(?) FORMATION, AND UPPER PART OF THE MORRISON FORMATION IN THE CHAMA-EL VADO AREA, CHAMA BASIN, RIO ARRIBA COUNTY, NEW MEXICO

By
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DISCUSSION

This report shows the correlation of the Dakota Sandstone, Burro Canyon(?) Formation, and the upper part of the Morrison Formation in the Chama basin from El Cerro dome, just west of Chama, to El Vado Reservoir. Criteria needed to recognize these formations both at the outcrop and in the subsurface is also included.

The identification of contacts between the Dakota Sandstone, Burro Canyon(?) Formation, and the upper part of the Morrison Formation in the Chama basin have, in the past, presented problems for the stratigrapher, primarily in areas where the contact between the Dakota and the Burro Canyon(?) and the Burro Canyon(?) and the Brushy Basin Member of the Morrison is sandstone on sandstone. Geologic mapping by Woodward and others (1976) has included the lithologic sequence referred to in this report as the Burro Canyon(?) as an upper part of the Morrison Formation. Smith and others (1961) suggested that this same lithologic sequence is equivalent to the Burro Canyon Formation, but they mapped it with the Dakota Sandstone. Geologic maps by Ridgley (1979; 1983b) show the Burro Canyon(?) as a separate formation and map unit.

A complete sequence of the Dakota-upper Morrison interval is not exposed in the report area except in the vicinity of the confluence of Willow Creek and Rio Chama (fig. 1, nos. 17 and 18). Descriptions of the rock units in the Dakota-upper Morrison interval were taken from measured sections (fig. 1, nos. 17 and 18) and from lithologic descriptions of drill-hole cuttings where available (fig. 1, nos. 1-16).

The geophysical logs shown in cross sections *A-A'*, *B-B'*, and *C-C'* are from holes that were drilled during a period of active uranium exploration. The choice of a datum was difficult because of the presence of two unconformities. Commonly geologists use the base of the Dakota, which is an unconformity, as the datum. This practice tends to visually portray rocks directly below the unconformity as being laterally equivalent, which often is not the case. The datum chosen for this report is a laterally persistent sandstone in the middle interval of the Dakota Sandstone that is present in all of the drill holes holes and in the measured section (fig. 1, no. 17). The choice of this datum makes the undulatory nature of the unconformity at the top of the Burro Canyon(?) Formation readily apparent. The true nature of the unconformity between the Burro Canyon(?) and the upper part of the Morrison is less apparent in the cross sections because of the lack of a good marker bed in the upper part of the Morrison to use as a datum and the shallow penetration of the drill holes. Correlations were based on a combination of lithologic information, field relationships, and characteristic geophysical log responses.

Outcropping rocks in the report area include the Mancos Shale, the Dakota Sandstone, the Burro Canyon(?) Formation, and the Brushy Basin Member of the Morrison Formation. The Mancos Shale will not be discussed in this report. The Dakota Sandstone occurs stratigraphically below the Mancos Shale and above the Burro Canyon(?). On the basis of gamma-ray, spontaneous-potential (SP), and resistivity curves, as well as outcrop observations, the Dakota Sandstone can be divided into three intervals A, B, and C, from the base to the top. These three intervals represent three different but transitional environments of deposition that are characteristic of a delta destructional sequence overlain by a barrier island sequence both of which formed during periods of regressive sedimentation, however, both were subsequently modified during periods of transgressive sedimentation.

Interval A of the Dakota consists primarily of a tan, gray or white, medium- to coarse-grained, locally conglomeratic sandstone that may contain thin (less than 1 ft thick), gray to black carbonaceous shale beds or shale partings. However, at a few localities, this sandstone overlies a basal gray siltstone or carbonaceous shale (see *A-A'*). Interval A may be correlative with the Encinal Canyon Member (Aubrey, in press) of the Dakota in the southern part of the San Juan basin. Pebbles in the conglomerate are mainly white and gray chert. Pebbles of tripolitic white chert, red and black chert, and metamorphic and volcanic rock, especially rhyolite, are locally abundant. Carbonaceous matter is present, but is less abundant than in sandstone of the overlying interval B. Trough crossbedding is prominent in sandstone of interval A.

Some sandstone beds of interval A, although stacked, exhibit flat bases, transitional middles, and inward-sloping tops in many curves on SP and gamma-ray logs that are indicative of fining upward sequences. Curves on gamma-ray and SP logs of other sandstone beds in interval A exhibit blunt bases and tops with minor middle interdigitations. These SP and gamma-ray patterns represent multiple stacking of partially preserved fluvial sequences. The stacked blocky to slightly serrate responses on the gamma-ray and SP logs and high responses on the resistivity logs of interval A are interpreted as indicating lower alluvial plain overlain by alluvial-deltaic facies. These log patterns as well as field relations support the interpretation that sandstone beds of interval A represent point-bar deposits. A thin, highly resistive sandstone at the top of interval A is interpreted as a transgressive marine sandstone that overlies an erosion surface cut on the top of the fluvial-deltaic sequence; this resistive sandstone marks the beginning of the initial trangression of the Dakota sea in the report area.

Interval B of the Dakota is composed of a series of carbonaceous siltstone or shale overlain by flat-topped carbonaceous sandstone. The tan or dark-gray sandstone is medium to fine grained, crossbedded, and commonly silicified. Tabular and trough crossbeds are both locally abundant. The contact between sandstone and overlying carbonaceous shale is sharp; however, the contact between sandstone and underlying shale may be discrete, but for the most part is transitional. Horizontal *Planolites* are abundant in flat-lying sandstone beds in the section measured at Willow Creek (*A-A'*, no. 17). Many of the sandstone beds, especially the top bed in interval B and the bed whose top was used as the datum in this report are laterally continuous for several miles. Other sandstone beds pinch out laterally in short distances. Locally, these sandstone beds are stacked in a thick interval with no carbonaceous shale interbeds. No well-developed coals were reported in the lithologic logs; however, near Willow Creek several beds of highly carbonaceous shale or lignite crop out (*A-A'*, no. 17).

Beginning at the base of interval B, curves of the gamma-ray and SP logs and field relationships show several coarsening upward sequences consisting of a silty, shaley interval with minor, discontinuous sandstone beds capped by a laterally persistent sandstone. Thick sandstone beds in the lower part of interval B have flat curves at the tops and outward-sloping curves at the transitional bases on the gamma-ray and SP logs. Thick sandstone beds in the upper part of interval B have flat curves at the tops and bases on the gamma-ray and SP logs. Stacked sandstone beds in the upper part of interval B are visible in the logs of several drill holes (*A-A'*, no. 5; *C-C'*, no. 9).

Interval B is interpreted as including delta-destructional facies. The shaley intervals represent interdistributary bay fill and coastal-marsh deposits. The lower sandstone beds represent distributary channel fill, crevasse splays, and reworked, sometimes locally stacked bar-finger deposits. The upper or very laterally extensive sandstone beds represent, locally stacked, offshore distributary mouth-bar deposits that have been laterally reworked during periods of transgression. Interval B shows features characteristic of destruction of a prograding delta in which wave action periodically began to destroy and rework deltaic sediments that were deposited during periods of regressive deltaic sedimentation. The overall effect was that deeper water sediments were deposited over shallower water sediments, locally producing a stacking of sandstone lenses, as the shoreline was pushed landward.

Interval C of the Dakota is characterized by a thick tan, medium- to fine-grained, laminated to crossbedded upper sandstone sequence that overlies a relatively thin sequence of carbonaceous siltstone, shale, and very fine grained sandstone. No shale interbeds are present within the upper sandstone, although shale partings may be present. The basal part of the upper sandstone is commonly transitional with the underlying fine-grained, carbonaceous sandstone, siltstone, or shale. The lower sandstone, siltstone, and shale interval thickens from north to south.

The upper sandstone beds in interval C are distinct from interval B sandstones both in the report area (*C-C'*, no. 17) and in outcrops further south. To the south of the report area the lower part of the upper sandstone beds contain *Thalassinoides*, a marine trace fossil characteristic of the lower shoreface facies. In a correlation of the Dakota by Owen and Siemers (1977) ranging from the eastern part of the San Juan basin to the southwestern part of the Chama basin, a similar-appearing sandstone was called the Cubero Tongue of the Dakota Sandstone. Owen and Siemers (1977) described the Cubero as a marine sandstone, having a transitional base and a sharp top, that contains *Ophiomorpha*, *Thalassinoides*, or bivalves.

In interval C the curves of the gamma-ray logs show a gradual coarsening upward profile which are markedly distinct from the underlying interval B. Resistivity log responses for the lower part of interval C recorded in the drill holes of cross section *A-A'* differ from those recorded in the drill holes of cross section *C-C'*. Curves on SP logs in cross sections *A-A'* and *B-B'* are absent or nondescript. Curves on the SP logs in cross section *C-C'* indicate a silty, shaley, and sandy lower sequence that is capped by a relatively thick upper sequence of sandstone beds; the upper sandstone beds have blocky curves on the gamma-ray and SP logs and pronounced curves on the resistivity logs. Curves on the gamma-ray, SP, and resistivity logs show the presence of at least two distinct sandstone beds, having flat curves at the top and slightly sloping curves at the base. No shale interbeds are present.

Sediments comprising the rocks of interval C accumulated in an environment different from that of intervals A and B and reflect a change in the type of sedimentation from dominantly deltaic to a barred coast. The upper sandstone beds are offshore or barrier bars that are a composite of regressive and transgressive marine sandstones. Sediments comprising the sandstone beds accumulated during progressive buildup of the bars during regressive periods; intermittant lateral reworking of offshore bars occurred during transgressive periods. Owen (1973) interpreted similar sandstone beds comprising the Cubero as coastal-beach or barrier-island sandstones.

The silty, sandy, and shaley sequence below the upper marine sandstone beds in interval C represent delta-front sand, silt, and clay beds that may be overlain by lagoonal facies in the southern part of the report area.

The cross sections in the Dakota show the following thickness relationships: Interval A includes a thick sand lobe (*A-A'*, nos. 1-3; *B-B'*, nos. 1 and 6) in the western part of the report area that probably represented a local depocenter during early Dakota deposition. Interval B is characterized by relatively constant thickness, although there is local variation in thickness between drill holes both above and below the datum. Interval C appears to be significantly thinner in cross section *A-A'* than in cross section *C-C'* to the south. The thicker upper sandstones of the Dakota in interval C, seen in cross section *C-C'*, represent additional stacking of sandstone lenses that formed as the shoreline moved landward as transgression proceeded to the south.

The contact of the Dakota with the overlying marine, carbonaceous Mancos Shale is sharp. The contact with the underlying Burro Canyon(?) is a sharp, undulatory erosion surface that represents a major unconformity; sandstone or gray shale of the Dakota overlies sandstone or green mudstone of the Burro Canyon(?).

In the Chama basin the lithologic sequence of conglomeratic sandstone, sandstone, and a minor amount of red, green, and pale-purple mudstone and siltstone that occurs stratigraphically between the Upper Jurassic Morrison Formation and the Upper Cretaceous Dakota Sandstone has been called the Burro Canyon Formation by several workers (Craig and others, 1959; Smith and others, 1961; and Saucier, 1974). Although similarities in lithology and stratigraphic position exist between this sequence and the Lower Cretaceous Burro Canyon in western Colorado, no direct correlation has been made between the two. Consequently, in the Chama basin this sequence is called the Burro Canyon(?) Formation in this report and is assigned an Early Cretaceous(?) age.

The Burro Canyon(?) in the northern part of the basin is predominantly a white, tan, red, or pink, medium- to coarse- grained, commonly conglomeratic, trough-crossbedded and planar-laminated sandstone. Fine-grained sandstone is present locally. Pebbles in the conglomerate consist primarily of pale-tan, gray, white, and cream chert and silicified limestone that contains crinoid stems. Lesser amounts of red, black, and green chert pebbles are present. In some drill holes (*B-B'*, no. 6; *C-C'*, no. 11), the Burro Canyon(?) consists of two thick sandstone intervals separated by a red mudstone bed. However, at other localities the intervening mudstone is absent due to internal truncation and the Burro Canyon(?) consists almost entirely of sandstone. In a few drill holes the upper sandstone interval is overlain by a red or green siltstone or mudstone sequence that is absent in other drill holes owing to removal by pre-Dakota erosion.

The curves defining intervals B and C of the Dakota differ significantly on the gamma-ray, resistivity, and SP logs from curves for the Burro Canyon(?) Formation. In many cases, however, the distinction is less apparent between the curves defining interval A of the Dakota and those defining the Burro Canyon(?) because both sandstone sequences represented by these curves were deposited in fluvial environments. Overall the Burro Canyon(?) is a fairly clean sandstone, as shown by the gamma-ray profile. Curves on the SP logs show a vertical stacking of channel-fill sandstones interbedded with a minor amount of fine-grained overbank material. This is in contrast to the sandstones of interval A of the Dakota which may show preservation of thin fine-grained material at the top of a sandstone unit. Sandstone beds of the Burro Canyon(?) represent deposition in a braided fluvial environment whereas, sandstones of interval A of the Dakota represent deposition as point bar deposits in lower alluvial-plain and alluvial-deltaic environments.

Sandstone beds in the upper part of the Burro Canyon(?) have a more serrate SP curve profile and show greater resistivity than sandstone beds in the lower part of the formation. In drill holes where the Burro Canyon(?) is thinner, this upper sandstone interval is also thin or absent, having been removed by erosion prior to deposition of the overlying Dakota Sandstone. Where the upper sandstone is thin or absent, the contact between the Dakota and Burro Canyon(?) is commonly sandstone on sandstone. However, locally, the contact is a thin hard, green mudstone, present in the measured sections and in some drill holes (*A-A'*, nos. 1,2, and 5; *B-B'*, nos. 1 and 7; and *C-C'*, nos. 7, 11, 12, 15, 17, and 18). In the southern part of the basin this mudstone is generally absent, but where locally present it is red or pale purple and consists primarily of kaolinite and some mixed-layer illite and quartz and caps different parts of the Burro Canyon(?). The kaolinitic mudstone may have formed as a soil horizon on top of the eroded Burro Canyon(?).

Contact of the Burro Canyon(?) with the underlying upper part of the Morrison is unconformable and is commonly sandstone on light-green or tan mudstone. Locally, however the contact may be sandstone on sandstone. In the later case field observations show the upper Morrison sandstones to be quite different in terms of composition and lateral geometry from those of the Burro Canyon(?).

The unconformity that separates the Burro Canyon(?) from the Brushy Basin Member of the Morrison is an undulatory surface that has less relief than the Dakota-Burro Canyon(?) unconformity. Although difficult to illustrate in the cross sections because of the lack of an identifiable Morrison marker bed in the geophysical logs, the Burro Canyon(?), where it crops out in the southern part of the report area and in areas to the south, does cut out mudstone and sandstone in the upper part of the Brushy Basin.

Only the upper 100 ft of the Morrison is discussed in this report because that is about all that is exposed just west of the confluence of Willow Creek with Rio Chama (*C-C'*, no. 18); in addition, most geophysical logs included in this report are only for drill holes that penetrate approximately the upper 50 ft of the Morrison. Both at the outcrop and in the cuttings from drill holes in the Chama-El Vado area, the upper Morrison consists primarily of green mudstone with minor hard, dense, red, maroon, and tan mudstone and lenticular tan sandstone and conglomeratic sandstone. Generally the upper mudstone beds are pale green or tan, however, maroon, red, and pale-green hard mudstones are locally present at the very top of the formation. A thick (10-20 ft average, but locally as much as 40 ft) medium- to coarse-grained, conglomeratic sandstone is present in the upper 80 ft of the Morrison, throughout the basin. Pebbles in this conglomerate consist primarily of red, green, yellow, tan, cream, and gray chert. Red and green chert are more abundant than in the overlying Burro Canyon(?). Abundant clasts of blue-green clay, as much as to 1/2 in. in length, are present near the base of this conglomerate.

Sandstone beds of the upper Morrison are medium to fine grained; trough crossbedding is common where the sandstone beds exceed 10 ft in thickness. Where the sandstone beds are thinner, planar cross-stratification is common and the upper and lower parts of individual sandstone beds are commonly flat bedded. Upper Morrison sandstone beds are seen to be laterally discontinuous in outcrops and in the subsurface in the area of cross section *A-A'* and elsewhere in the basin. Weathering of upper Morrison sandstones is quite distinct from the overlying Burro Canyon(?) sandstone. Clusters of grains are cemented with iron oxide (limonite) or calcite which gives the upper Morrison sandstone a characteristic speckled appearance.

Curves of the upper Morrison Formation on gamma-ray, SP, and resistivity logs show serrate profiles characteristic of thin mudstone, claystone, or shale and sandstone sequences. Thin sandstone beds in this interval tend to have flat top and base curves on the SP logs and very pronounced, sharp curves on the resistivity logs. Thicker sandstone beds have a blocky to serrate curve profile on the gamma-ray and SP logs and a blocky to slightly serrate curve profile on the resistivity logs. On the gamma-ray and SP logs, curves for the upper parts of the thicker sandstone beds show a gradual fining upward profile reflecting a gradual change from sandstone into the overlying mudstone. The resistivity profile also shows a gradual to abrupt decrease from the sandstone into the overlying mudstone. The geophysical log responses support an interpretation that sediments comprising the sandstone and mudstone beds of the upper part of the Morrison Formation were deposited in low-energy fluvial or fluvial-lacustrine environments characterized by predominantly meandering stream and overbank deposits.

Where sandstone beds of the upper part of the Morrison Formation, with or without an intervening mudstone, directly underlie the Burro Canyon(?), the differences in their gamma-ray, SP, and resistivity profiles can be used to distinguish them from sandstones of the Burro Canyon(?) (*A-A'*, no. 3; *C-C'*, no. 9).

Principal structural features in the area include domes and tightly folded anticlines and synclines on the west side of the Chama syncline; numerous normal faults offset strata in this area. The structural features were believed by Muehlberger (1967, p. 65) to be of Laramide or younger age. However, Landis and Dane (1967) suggested that pre-Cretaceous structure might be more complex than that expressed by Cretaceous rocks; their suggestion was based on changes in the relative elevation of Precambrian rocks in the subsurface in New Mexico determined by Foster and Stipp (1961).

In the report area, there does not appear to be a ubiquitous correlation between known structures and the thickness of the Dakota and Burro Canyon(?) (Ridgley, 1983a). For some structures, such as El Cerro dome, the thickest preserved Burro Canyon(?) is on the flanks of domes or in adjacent synclines. However on other structures, such as the Willow Creek anticline and the Puente dome, the thickest preserved Burro Canyon(?) is centered on top of the structure. These relationships suggest that local movement on some of the structural features may have occurred, either during deposition or erosion of the Burro Canyon(?), and that other structures may have remained quiescent or were not developed and therefore did not affect erosion or deposition of the Dakota or Burro Canyon(?). Movement on most structures may indeed have been at a much later time, as suggested by Meuhlberger (1967).

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