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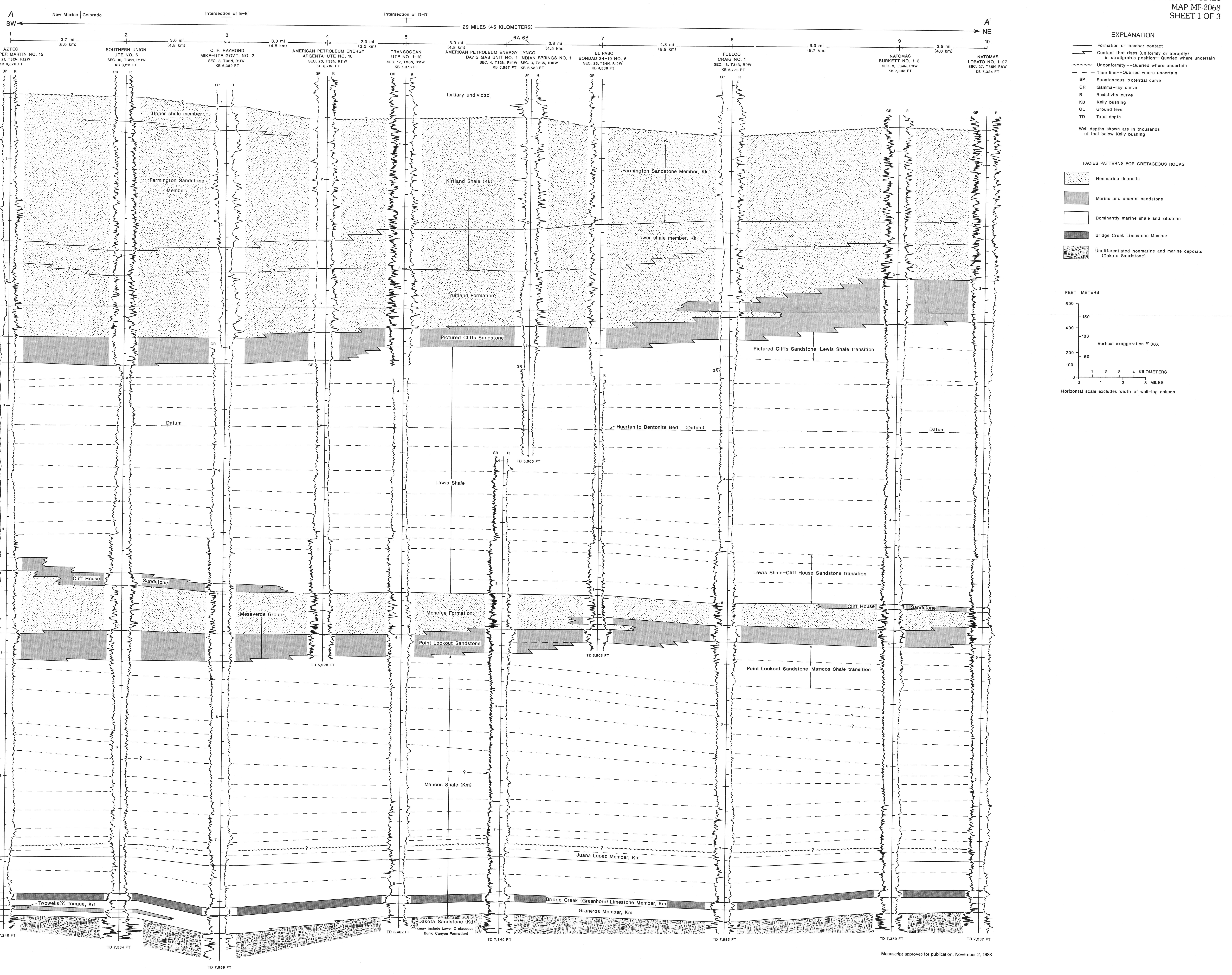
MISCELLANEOUS FIELD STUDIES
MAP MF-2068
SHEET 1 OF 3



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INTRODUCTION

The five stratigraphic cross sections across the northern part of the San Juan Basin shown in this report use well-log data to illustrate physical relations of Upper Cretaceous rocks across the deep (northern) part of this gas-producing basin (fig. 1). The sections are located inside the steep flanking monoclines in the deep, low-dipping part of the basin where drilled thicknesses in all but one well are essentially true thicknesses. Table 1 lists the wells shown on the cross sections.

On the basis of detailed correlations of closely spaced borehole geophysical logs (generally 2-4 mi apart), numerous time marker beds or time lines were established within the offshore marine section. These time marker beds provide reference surfaces of deposition from which several depositional features can be documented. Depositional features such as (1) continuity or discontinuity of lithologic units, (2) lateral facies relations, and (3) diachroniety and stratigraphic rising of coastal sandstone units associated with regressions and transgressions of the seaway as well as post-depositional features, such as (1) low-relief differential compaction, (2) cut out of section by faulting, and (3) paleostructure, can be recognized. Because of the discontinuous nature of nonmarine deposition, detailed correlation of beds was not attempted in the nonmarine section although correlations over limited areas within the coal-bearing sections may be possible on larger scale cross sections.

The datum for all sections is the Huerfanito Bentonite Bed of the Lewis Shale, a prominent marker bed in the upper part of the Lewis Shale. This bed is believed to have been deposited on a nearly flat basin floor in this part of the basin.

METHODS

The borehole logs used in these cross sections were digitized by hand-tracing the spontaneous potential (SP) or gamma-ray logs and the conductivity logs. If conductivity logs were not available, the resistivity logs were used. If conductivity or resistivity logs were not available, other logs such as neutron logs in wells 15 and 35 and transit-time log in well 42 were used. The original logs that were traced were at a scale of 1 in. = 50 ft; the logs were then plotted at a scale of 1 in. = 200 ft with the amplitude of the logs adjusted to a scale of lesser magnitude to better fit the cross sections. In addition, the conductivity logs were converted to a resistivity scale. Most of the correlations were made by using the original conductivity logs with the wide amplitude range, however, in attenuating the amplitude, the basis for many of the correlations is less obvious. In a few places, well logs between the control wells shown on the cross sections were used to corroborate the correlations. Correlations of marker beds on each cross section were made separately and the correlated marker beds are not necessarily the same on all sections. In general, the marker beds shown are those that could be correlated the farthest on each cross section and attempts were made to show a marker bed at least every 100-200 vertical ft, although many more could have been shown. The marker beds shown may not be the most prominent correlatable beds in a particular area or part of the section. The final cross sections were reduced to the present size (vertical scale of 1 in. = 300 ft) for convenience in handling them.

TIME MARKER BEDS

The many time marker beds are based mostly on conductivity or resistivity patterns in the marine shale section; these patterns reflect a variety of obvious to subtle lithologic changes within the thick shale sections, such as discrete bentonite beds, bentonitic zones, silty or sandy zones, and variations in calcium carbonate content. Some of the well-log markers are reflected as solitary conductivity spikes, but most are conductivity patterns over intervals of as much as 100 ft that can be recognized from well to well. Although some spikes on gamma-ray logs can be correlated, many seem to be random and cannot be correlated, however, an overall pattern of variations in gamma-ray deflections over several tens of feet is useful for correlating. The SP curves differentiate sandstone and shale in the upper part of the stratigraphic section, but in the lower, deeper part of the basin, the SP response is greatly attenuated, and in most cases this log has been replaced by the gamma-ray log on the cross sections.

STRATIGRAPHY

The following is a brief description of the rock units, in ascending order, in the northern part of the San Juan Basin with comments relating to depositional features shown on the cross sections, and to the contacts as interpreted from the geophysical logs. For discussion of ages of the Cretaceous rocks, refer to Peterson and Kirk (1977) or Molenaar (1983).

DAKOTA SANDSTONE

The Dakota Sandstone consists of sandstone, shale, and minor amounts of conglomerate and coal, all of which were deposited along and landward from the advancing Western Interior sea. The major part is fluvial in origin, but the upper part consists of paludal and back-barrier facies that grade upward into the overlying Mancos Shale. In some places the two formations intertongue. Most wells did not penetrate, or the logs did not extend to, the base of the Dakota. A few wells penetrated the upper part of the Upper Jurassic Morrison Formation, which consists mostly of variegated nonmarine shale. The lower part of the interval shown as Dakota on the cross sections may include the Lower Cretaceous Burro Canyon Formation. Harr (1988) considers much of the lower half of the main interval shown as Dakota as Burro Canyon Formation. Separation of these two formations can be made in outcrops, but is difficult on well logs. The upper contact of the Dakota is usually placed at the top of the highest sandstone. In some places, this is a discontinuous offshore shelf sandstone; hence the contact shifts abruptly in some places. The Twowells and Paguate Tongues of the Dakota are discontinuous shelf sandstone units that were correlated into the northern San Juan Basin from the southern margins of the basin (Molenaar, 1988), where they were named; they are sometimes referred to as "Graneros sands" in the subsurface. Harr (1988) and Bowman (1978a) call what we show as Paguate or the section equivalent to the Paguate as Dakota "A".

MANCOS SHALE

The Mancos Shale is a thick, dominantly shale formation that was deposited offshore as the Cretaceous seaway first transgressed and then regressed across the entire San Juan Basin. The shale is generally dark gray, silty in parts, calcareous in varying amounts, and locally bentonitic. Thin beds of bentonite are common in most parts of the Mancos. In this part of the San Juan Basin, three members are recognized in the lower part of the Mancos Shale; the Graneros, Bridge Creek Limestone, and Juana Lopez Members.

Graneros Member

The Graneros Member, about 100-150 ft thick, is the basal member of the Mancos. Discontinuous sandstone tongues of the Dakota occur in the lower part of the member. Much of the upper part of the Graneros is coeval with the lower half of the Greenhorn Limestone near Pueblo, Colorado.

Bridge Creek (Greenhorn) Limestone Member

The Bridge Creek Limestone Member of the Mancos Shale, about 60 ft thick, consists of interbedded calcareous shale and argillaceous limestone. It is a widespread unit throughout the area and its contacts are well defined on geophysical logs. The lower contact is marked by a prominent bentonite bed. Formerly known as the Greenhorn Limestone Member, the name Bridge Creek Limestone Member was recently applied to the member because it more accurately relates the unit to the Bridge Creek Member of the Greenhorn Limestone near Pueblo, Colorado (Huffman, 1987; Kirk and others, 1988).

Unnamed Shale Member

An unnamed shale member 200-300 ft thick separates the Bridge Creek Limestone Member from the overlying Juana Lopez Member. This unnamed member consists of dark-gray to black, calcareous shale containing several prominent bentonite or other marker beds. Variations in calcium carbonate content is indicated by changes in response on resistivity logs. Higher resistivities (excursion to right) indicate greater carbonate content. The relatively high gamma-ray radiation of parts of this shale member compared with other parts of the Mancos Shale suggests that these parts are richer in organic matter and may be hydrocarbon source rocks.

Juana Lopez Member

The Juana Lopez Member of the Mancos Shale (sometimes referred to as the Sanastee Sandstone Member of the Mancos) consists of about 100 ft of interbedded shale, siltstone or very fine grained sandstone, and calcarenite. It is very fossiliferous and contains late Turonian fossils of two or three molluscan fossil zones (Dane and others, 1966). The unit was projected into this part of the basin from the south, where the upper and lower contacts of the member are better defined on SP and resistivity logs.

Unconformity in lower part of Mancos Shale

An unconformity in the lower part of the Mancos Shale, which is commonly referred to as the basal Niobrara unconformity, was projected between marker beds from the south-central part of the basin, where an angular relationship is present and discontinuous sandstone units (Tocito Sandstone Lentil of the Mancos) lie above the unconformity (Penttila, 1964; McCubbin, 1969; Molenaar, 1973, 1988). As much as 300 ft of uppermost Turonian-lowermost Coniacian strata (Gallup Sandstone interval) is apparently truncated or abruptly thins across a 15-30 mi wide northwest-trending band in the central San Juan Basin. There is no apparent truncation in the northern part of the San Juan Basin and the position of the unconformity, shown as at the top of the Juana Lopez, is queried. It may be related to a low stand of sea level and, in this part of the basin, may be represented by a nondepositional hiatus. Physical evidence of this unconformity has not been reported from exposures in the Durango area.

Remaining part of Mancos Shale

A 400- to 500-ft-thick interval above the unconformity is characterized by greater resistivity on logs. This interval is interpreted to consist of interbedded shales of variable carbonate content and possibly very fine grained sandstone or siltstone. The lowermost part is equivalent to the Tocito Sandstone Lentil of the Mancos, which is the main reservoir of the oil fields in the south-central part of the San Juan Basin. No recognizable Tocito is present on the cross sections in this part of the basin. At least part of the remaining 400-500-ft interval is equivalent to the El Vado Sandstone Member of the Mancos, which was named by Landis and Dane (1967) for a 100-ft-thick section of interbedded sandstone and shale that crops out on the east side of the San Juan Basin. Fassett and Jentgen (1978) extended the El Vado Member into the subsurface at Blanco Tocito, South field 35 mi south of the Colorado-New Mexico border. We think that it is not warranted to extend the El Vado terminology into the Colorado part of the San Juan Basin because (1) much of the El Vado interval designated by Fassett and Jentgen is calcareous shale in this part of the basin, and (2) there is no indication of sandstone in this part of the section in exposures near Durango (Zapp, 1949).

It should be noted that the top of various high resistivity "kicks" that occur in the upper part of this 400-500-ft interval were sometimes reported in the early years as the top of the Gallup Sandstone by some workers in the San Juan Basin. The Gallup Sandstone actually is below the unconformity and occurs only in the southern part of the San Juan Basin (Molenaar, 1973).

The remaining major part of the Mancos Shale consists of less calcareous shale that, in its upper part, grades into the overlying Point Lookout Sandstone; the bounding lithologies near the contact consist of interbedded sandstone and shale with sandstone content increasing upward. Thus, the placement of the contact is arbitrary, often depending on the sensitivity of the log response. Some workers may place the contact as much as 200 ft (60 m) lower than that shown on the cross sections.

Time marker beds in Mancos Shale

The numerous time marker beds, which were already discussed, show parallelism in the lower part of the Mancos, but the upper-middle part shows marked basinward (northeast) depositional dip. In relation to higher time marker beds in the upper part of the Mancos, which are assumed to have been almost flat when deposited, the dipping marker beds or clinoforms represent the slope of the basin (after compaction). The steepest dipping time marker beds, between wells 18 and 19 on cross section B-B′, have a dip of about 0.6° or 55 ft/mi.

POINT LOOKOUT SANDSTONE

The Point Lookout Sandstone is a regressive coastal sandstone that rises in stratigraphic position as it progrades from southwest to northeast across the San Juan Basin. The formation consists of interbedded very fine grained sandstone and shale in the lower part and grades upward into massive fine-grained sandstone. The upper contact is well marked by the generally abrupt change from massive sandstone to the overlying shaly and coaly rocks of the Menefee Formation.

MENEFEE FORMATION

The Menefee Formation consists of carbonaceous shale, siltstone, sandstone, and coal. It was deposited in back-barrier swamp and coastal-plain environments and, to the southwest, the middle part grades to upper delta-plain and alluvial-plane environments. The Menefee grades seaward (northeastward) into coastal sandstones of the Point Lookout and Cliff House Sandstones. In the northeasternmost part of the San Juan Basin (cross section C-C′), it grades entirely into marine deposits of the combined Point Lookout and Cliff House Sandstones, called the Mesaverde Formation. The upper contact of the Menefee is placed at the base of a thick marine sandstone (Cliff House) if present, or at the change from the spiky log character of the carbonaceous section below to the more correlatable thin sandstone and shale section of the marine Lewis Shale above.

CLIFF HOUSE SANDSTONE

The Cliff House Sandstone is a coastal sandstone unit that was deposited as the seaway transgressed to the southwest. As shown on the cross sections, the Cliff House Sandstone is restricted to the thicker, more massive sandstone bodies immediately overlying the Menefee Formation. Some workers, however, place the top of the Cliff House Sandstone at the top of a transition zone of interbedded sandstone and shale about 400 ft above the Menefee (Zapp, 1949). On the cross sections, this interval is labeled "Lewis Shale-Cliff House Sandstone transition." In tracing this zone to the south, the lower part grades into the massive sandstones of the Cliff House, but the upper part loses the sandstone interbeds and better fits in the Lewis Shale (C.M. Molenaar, unpub. data, 1988). Two anomalous sandstone buildups, apparently offshore-bar sandstones, are present in the lower part of this 400-ft-thick zone in well 32 on cross section C-C′. Within much of the northern San Juan Basin, the Cliff House, as used here, is poorly developed. Where present, it consists of onlapping shingle-like wedges that rise in stratigraphic position to the southwest.

LEWIS SHALE

The Lewis Shale, a thick dominantly shale formation, was deposited offshore as the seaway again transgressed and regressed across the northern two thirds of the San Juan Basin. Like the Mancos Shale, it contains numerous time marker beds. The Huerfanito Bentonite Bed, which was used as a datum for all the sections, is a prominent marker bed that can be correlated throughout its extent in the San Juan Basin (Fassett and Hinds, 1971; Molenaar, 1988). The time marker beds are generally parallel, but a slight basinward (northeast) depositional dip is indicated.

The contact of the Lewis Shale with the overlying Pictured Cliffs Sandstone, like the Mancos-Point Lookout contact, is gradational and the placement of the contact over several hundred feet is arbitrary.

PICTURED CLIFFS SANDSTONE

The Pictured Cliffs Sandstone is a regressive coastal sandstone that was associated with the final retreat of the Western Interior sea from the San Juan Basin area. Like the Point Lookout Sandstone, it rises markedly in stratigraphic position as it progrades to the northeast. In places it intertongues with the underlying Lewis Shale and the overlying Fruitland Formation. Consisting of interbedded very fine grained sandstone and shale in the lower part, the Pictured Cliffs grades upward into massive fine-grained sandstone. The SP log response of the Pictured Cliffs is greatly attenuated, probably because of clay content. The gamma-ray log responses are also somewhat attenuated when compared to the response in the Point Lookout. The contact with the overlying Fruitland Formation is based on the log-character change of the more varied lithologies in the Fruitland.

FRUITLAND FORMATION

Like the Menefee Formation, the Fruitland was deposited in back-barrier swamp and coastal-plain environments. It consists of carbonaceous shale, siltstone, sandstone, and coal. Fassett (1986) reports that the coal beds are much thicker and more extensive in the Fruitland than those in the Menefee. The contact of the Fruitland and overlying Kirtland Shale is usually placed at the top of the highest coal bed or carbonaceous shale by most workers in the San Juan Basin (Fassett and Hinds, 1971); this is difficult to ascertain on logs at the scale used, but because the contact is generally associated with the top of a sandy interval, the latter criterion was used and the contact is queried on all of the sections.

KIRTLAND SHALE

The Kirtland Shale consists of nonmarine sandstone, siltstone, and mudstone that was deposited on an alluvial plain. It is divided into three units called, in ascending order, the lower shale member, Farmington Sandstone Member, and upper shale member. The two shale members are informal units. The lower shale member is apparent on most SP and resistivity logs, although the upper contact shifts in stratigraphic position. The Farmington Sandstone Member is a thick interval of sandstone and shale bodies. Beds within the member do not seem to be correlatable and are apparently discontinuous. The contact with the overlying upper shale member, where present, is highly questionable. Because of poor log definition, discontinuous beds of sandstone, and the possibility that it may not be a mappable unit, the upper shale member is shown only in limited areas on the cross sections. Fassett and Hinds (1971) did not recognize the upper shale member as a mappable rock unit.

TERTIARY ROCKS

Undivided Tertiary rocks unconformably overlie the Kirtland Shale. These rocks are included in the Animas Formation in most of the area of the cross sections. The Ojo Alamo Sandstone, which is a thick sandstone unit throughout much of the New Mexico part of the San Juan Basin, is present at the south end of cross sections B-B′ and C-C′, probably the eastern two-thirds of E-E′, and possibly in well 41 on D-D′. Its presence is queried on the sections because of difficulties in distinguishing it from sandstones in the Animas Formation on the well logs. Fassett and Hinds (1971), however, show the Ojo Alamo to be present in the areas shown on the cross sections. The Ojo Alamo pinches out northward by truncation or depositional pinchout. Its northward limit is shown by Fassett and Hinds (1971, fig. 9). The Animas Formation consists of volcanogenic sandstone, conglomerate, and variegated shale. In outcrops from Durango southwest toward the New Mexico border, the Animas contains a lower member, the McDermott, which is latest Cretaceous in age. This member probably extends into the northern area of the cross sections, but it could not be identified on geophysical logs.

It is difficult or impossible to ascertain the contact between the Kirtland Shale and the overlying Tertiary rocks (except for the Ojo Alamo Sandstone) on geophysical logs. Detailed well-sample examination or palynological sampling would be necessary to determine the contact. In outcrops, however, it is easier to pick the contact because of the volcanogenic and conglomeratic character of the Tertiary rocks. The contact shown on the cross sections is highly questionable and is based on limited outcrop control and projection of isopach trends of underlying rocks as shown by Fassett and Hinds (1971).

POST-DEPOSITIONAL FEATURES

Post-depositional features observed on the cross sections are generally subtle. With the numerous time marker beds that are correlated and the vertical exaggeration of the cross sections, however, some features are apparent. Examples of differential compaction, faulting, and paleostructure are given.

DIFFERENTIAL COMPACTION

Differential compaction feature occurs in parts of the stratigraphic section that contain lithologies of variable compactibility, such as lenticular sandstone bodies laterally adjacent to shale or coal units. The most obvious differential compaction feature occurs in the Menefee Formation on cross section C-C′ between wells 28 and 30. A thick channel sandstone in the middle of the Menefee in well 29 is laterally adjacent to a shale and coal-bearing section in wells 28 and 30. The differential compaction and compensating deposition seems to have occurred during deposition of the overlying 200 ft of strata.

FAULTING

Normal faults, which result in part of the stratigraphic section being cut out, can be recognized by abrupt convergence of time marker beds between wells. Some convergences, however, are progressive and are due to depositional thinning. The only fault definitively recognized on the cross sections is at about 6,900 ft in well 39 (cross section D-D′), where 30 ft of stratigraphic section is missing.

PALEOSTRUCTURE

Paleostructural effects shown on the cross sections are very subtle and probably represent small differences in subsidence. The difference in thickness of the interval between the Bridge Creek Limestone Member and the Huerfanito Bentonite Bed is the result of subtle paleostructure. No patterns can be recognized, but there is a suggestion of early growth of the Ignacio anticline near the intersection of cross sections C-C′ and D-D′.

GAS RESERVOIRS AND PRODUCTIVITY

Part of the northern San Juan Basin is within the large San Juan Basin gas field, which produces from Cretaceous rocks and is the second largest gas field in the conterminous United States. Although the Colorado part of the basin does not have the productivity of the larger New Mexico part, significant gas production and reserves do occur in this northern deeper part of the basin (Irwin, 1983). Because the area covered by the cross sections includes several gas pools of the Ignacio Blanco field and the well logs on the cross sections include the reservoirs, a brief discussion follows.

The gas production within the entire basin is in the structurally low part of the basin and is considered to be controlled largely by stratigraphy and hydrodynamics. However, the broad Ignacio and Bondad anticlines or structures in the northern San Juan Basin are important in focusing production in the area. The main producing sandstone reservoirs are in the Mesaverde Group, primarily the Point Lookout Sandstone; the Dakota Sandstone; and to a lesser extent, the Pictured Cliffs Sandstone. In addition to the conventional sandstone reservoirs, significant coal-bed methane production is currently being developed in coal beds of the Fruitland Formation (Fassett, 1988).

The main reservoir in the Dakota Sandstone is the lower fluvial part, which is coarser grained than the transitional and marine sandstones above (Bowman, 1978a). Harr (1988) calls the lower fluvial complex the Burro Canyon Formation. An uppermost marine shelf sandstone, referred to as Dakota "A" sandstone by Harr (1988) and Bowman (1978a), is a secondary reservoir. The cumulative production from the Dakota in this part of the basin through 1986 was 233.8 billion cubic feet (BCF) of gas (Harr, 1988).

The Point Lookout Sandstone is the main producing reservoir in the Mesaverde pool. Channel sandstones in the Menefee Formation probably contribute less than 10 percent of the total Mesaverde production, and the Cliff House Sandstone contributes still less (Bowman, 1978b). The Cliff House Sandstone is best developed near the southwest end of cross section A-A′, where it is productive. Although the area of production from the Point Lookout covers most of the basinal area, the best production occurs along a 3-4 mi wide belt between the southern part of T. 34 N., R. 10 W. to the New Mexico State line in T. 32 N., R. 7 W. (Harr, 1988). The cross sections show the best sandstone development in the Point Lookout along this belt. The cumulative production from the Mesaverde Group through 1986 was 526.6 BCF (Harr, 1988).

The cumulative production in the Ignacio Blanco field from the combined Pictured Cliffs Sandstone and Fruitland Formation through 1986 was 57.6 BCF (Harr, 1988), which is only 10-11 percent of the Mesaverde production. The producing area of the Pictured Cliffs and Fruitland is much smaller, much of it being on the Ignacio and Bondad structures (Craney, 1978). The Pictured Cliffs was formerly considered to be the main reservoir of the combined formations, and lenticular channel sandstones and coal of the Fruitland as secondary reservoirs, but Harr (1988) believes that the Fruitland coal contributed the major part of the gas. Coal-bed methane from Fruitland coal beds is now estimated to contain 4 trillion cubic feet of recoverable gas in the Ignacio Blanco field (Harr, 1988).

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Table 1.--List of wells used on cross sections of Upper Cretaceous rocks in the northern San Juan Basin, southwestern Colorado

Well	Well name	Location: Section	Tps.	Rgs.	County	State
1	Aztec Oil & Gas Culpepper Martin No. 15	21	32 N.	12 W.	San Juan	New Mexico
2	Southern Union Gas Co. Ute No. 6	16	32 N.	11 W.	La Plata	Colorado
3	C. F. Raymond Mike-Ute Gov't. No. 2	3	32 N.	11 W.	---do---	Do.
4	American Petroleum Energy Argenta-Ute No. 10	23	33 N.	11 W.	---do---	Do.
5	Transocean Oil Ute No. 1-12	12	33 N.	11 W.	---do---	Do.
6A	American Petroleum Energy Davis Gas Unit No. 1	4	33 N.	10 W.	---do---	Do.
6B	Lynco Oil Corp. Indian Springs No. 1	3	33 N.	10 W.	---do---	Do.
7	El Paso Natural Gas Co. Bondad 34-10 No. 6	26	34 N.	10 W.	---do---	Do.
8	Fuelco Craig No. 1	16	34 N.	9 W.	---do---	Do.
9	Natomas North America Burkett No. 1-3	3	34 N.	8 W.	---do---	Do.
10	Natomas North America Lobato No. 1-27	27	35 N.	8 W.	---do---	Do.
11	Delhi Taylor Barnes No. 1	26	32 N.	11 W.	San Juan	New Mexico
12	El Paso Natural Gas Co. Carter-Ute No. 2	23	32 N.	10 W.	La Plata	Colorado
13	Amoco Production Co. Southern Ute 1-12 No. 1	12	32 N.	10 W.	---do---	Do.
14	Amoco Production Co. Bonds Gas Unit No. 1-E	1	32 N.	10 W.	---do---	Do.
15	E. L. Fundingsland Sunical-Gov't. No. 9-D	29	33 N.	9 W.	---do---	Do.
16A	Tex-Star Oil & Gas Corp. Smith-Ute No. 1	10	33 N.	9 W.	---do---	Do.
16B	Mesa Petroleum Co. Ute Indian No. 3A	10	33 N.	9 W.	---do---	Do.
17	Pacific Northwest Pipeline Bondad 33-9 No. 12-1	1	33 N.	9 W.	---do---	Do.
18	Jones & Pellow Oil Ute No. 1	30	34 N.	8 W.	---do---	Do.
19	Fuelco Sun-Tyner-Lunt No. 1	18	34 N.	8 W.	---do---	Do.
20	Natomas North America Case No. 1-10	10	34 N.	8 W.	---do---	Do.
21	Natomas North America Neleigh No. 1-7	7	34 N.	7 W.	---do---	Do.
22	Natomas North America Gearhart No. 1-31	31	35 N.	7 W.	---do---	Do.
23	Aztec Oil & Gas Wilmer Canyon No. 1	24	32 N.	8.W	San Juan	New Mexico
24	Jerome P. McHugh Ute No. 3	20	32 N.	7 W.	La Plata	Colorado
25	Amoco Production Co. Wirt Gas Unit D No. 1-E	8	32 N.	7 W.	---do---	Do.
26	Mobil Oil Co. Southern Ute Gov't. No. 22-33	33	33 N.	7 W.	---do---	Do.
27	El Paso Natural Gas Co. Ignacio 33-7 No. 17	21	33 N.	7 W.	---do---	Do.
28	Lama Corp. Edie No. 1-2	2	33 N.	7 W.	---do---	Do.
29	Fuelco Southern Ute No. 1	26	34 N.	7 W.	---do---	Do.
30	Natomas North America Harper No. 1-13	13	34 N.	7 W.	---do---	Do.
31	Natomas North America Hays No. 1-11	11	34 N.	7 W.	---do---	Do.
32	Natomas North America Jones No. 1-32	32	35 N.	6 W.	---do---	Do.
33	Arco Oil & Gas Southern Ute 33-11, No. 10-1	10	33 N.	11 W.	---do---	Do.
34	Skelly Oil Co. Ute-E No. 1	9	33 N.	10 W.	---do---	Do.
35	Pacific Northwest Pipeline Bondad 33-9 No. 6-7	7	33 N.	9 W.	---do---	Do.
36	El Paso Natural Gas Co. Bondad 33-9 No. 33	13	33 N.	9 W.	---do---	Do.
37	Amerada Petroleum Corp. Harmon No. 1	17	33 N.	8 W.	---do---	Do.
38	Amoco Production Co. Jessi Hahn No. 1	15	33 N.	8 W.	---do---	Do.
39	C. F. Raymond McElvain No. 3	24	33 N.	8 W.	---do---	Do.
40	Shar-Alan Oil Posty-Ute No. 1	23	33 N.	7 W.	---do---	Do.
41	Fuelco-Sun Hott No. 1	30	33 N	6 W.	---do---	Do.
42	Sun Oil Co. Mildred A. Wright No. 1	16	33 N.	5 W.	Archuleta	Colorado
43A	C. F. Raymond BJ-Ute No. 1	6	32 N.	10 W.	La Plata	Colorado
43B	El Paso Natural Gas Co. NW Cedar Hill 32-10 No. 14-8	8	32 N.	10 W.	---do---	Do.
44A	Pan American Petroleum Corp. Southern Ute 1-3 No. 1	3	32 N.	10 W.	---do---	Do.
44B	Compass Exploration Inc. North Cox Canyon No. 1-3	3	32 N.	10 W.	---do---	Do.
45	Skelly Oil Co. Sam Burch No. 9	4	32 N.	9 W.	---do---	Do.
46	Atlantic Richfield Co. Southern Ute 32-9 No. 2-1	2	32 N.	9 W.	---do---	Do.
47	Compass Exploration Inc. Trail Canyon No. 1-6	6	32 N.	8 W.	---do---	Do.
48A	Lynco Oil Corp. East Bondad No. 1	3	32 N.	8 W.	---do---	Do.
48B	Compass Exploration Inc. Trail Canyon No. 2-3	3	32 N.	8 W.	---do---	Do.
49A	Atlantic Richfield Co. Southern Ute 32-8 No. 12-3	12	32 N.	8 W.	---do---	Do.
49B	Arco Oil & Gas Southern Ute 32-8 No. 12-5	12	32 N.	8 W.	---do---	Do.
50	Mobil Oil Co. Southern Ute No. 24-10	10	32 N.	7 W.	---do---	Do.
51	Tex-Star Oil & Gas McDonald No. 1	7	32 N.	6 W.	---do---	Do.
52	Feldt & Maytag Tubbs No. 1	9	32 N.	6 W.	---do---	Do.
53	Feldt & Maytag Luchini No. 1	12	32 N.	6 W.	Archuleta	Colorado

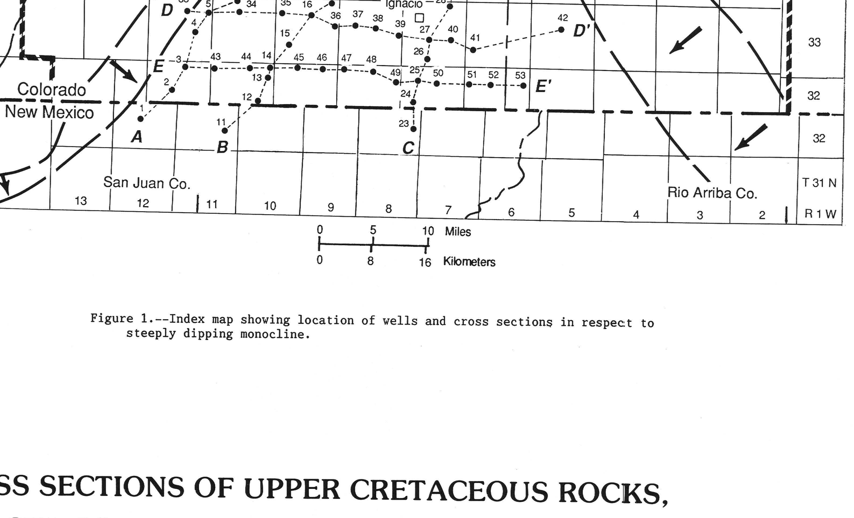

Figure 1.--Index map showing location of wells and cross sections in respect to steeply dipping monocline.

NORTH-SOUTH STRATIGRAPHIC CROSS SECTIONS OF UPPER CRETACEOUS ROCKS, NORTHERN SAN JUAN BASIN, SOUTHWESTERN COLORADO

By
C.M. Molenaar and J.K. Baird

1989

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