THE DEWEY LAKE FORMATION: END STAGE DEPOSIT OF A PERIPHERAL FORELAND BASIN

by

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ABSTRACT

The red siltstones and fine grained sandstones of the Dewey Lake Formation (Late Permian?) have always been relegated to a rather insignificant role in the geologic history of the Permian Basin. The present study suggests that they are, in fact, an important key to understanding the tectonic evolution of the southwestern United States.

Field work, in southeastern New Mexico, reveals that the Dewey Lake is fluvial in origin. Broad, shallow channels filled with thin horizontal laminations and flanked by laterally thinning wings comprise a large portion of the formation. Floodplain deposits, consisting of interbedded siltstone and silty claystone, are also very common.

The Dewey Lake displays many of the sedimentologic and morphologic characteristics associated with ephemeral fluvial systems. Some of these characteristics are an abundance of horizontal lamination and silty claystone drapes, the existence of interbedded siltstone and silty claystone interpreted to be the distal portion of sheet floods, and the presence of broad channels with laterally thinning wings. The Dewey Lake is, therefore, believed to have been deposited on a very extensive northwest sloping fluvial plain. Movement of sediment across this plain

occurred only sporadically, during brief and localized flash floods.

It has previously been theorized that the Dewey Lake was extensively eroded prior to the deposition of the Santa Rosa Formation (Middle to Late Triassic). The results of the present study suggest that the thickness variations in the Dewey Lake are not a reflection of post depositional erosion but syndepositional differences in the subsidence rates of the Central Basin Platform and Delaware Basin. Increased subsidence of the Delaware Basin is reflected by the fact that the base of the Dewey Lake Formation is offset 100 m (300 ft) along the major northwest trending fault zone separating the Delaware Basin and Central Basin Platform. The Delaware Basin, therefore, appears to have been tectonically active throughout the deposition of the Dewey Lake Formation.

If the thickness variations in the Dewey Lake are due to subsidence rather than erosion then the contact between the Dewey Lake and the overlying Santa Rosa Formation is conformable. The Santa Rosa has been dated as Middle to Late Triassic in northeastern New Mexico; if this date is applicable to the Santa Rosa in southeastern New Mexico it dictates that the deposition of the Dewey Lake Formation continued into the Early Triassic.

A major unconformity separates Lower Permian and Cretaceous strata in the Fort Worth, Val Verde and Marfa Basins of Texas. This unconformity, which also exists in northwestern Chihuahua, clearly indicates that a large region of central Texas and northern Mexico was uplifted and eroded during the latest Permian ? and early Mesozoic. The location and timing of this uplift suggests that it was the source of the silt and fine sand comprising the Dewey Lake Formation. A close geographic and temporal relationship between this uplift and Late Triassic rift basins suggests that it originated as a pre - rift bulge.

The very extensive nature of this uplift suggests that the alluvial plain to the north (i.e. the Dewey Lake and Quartermaster Formations) extended significantly beyond the area of west Texas and eastern New Mexico. The western portion of this plain is theorized to be the redbed facies of the Moenkopi Formation (Early Triassic). Apparent similarities in age, stratigraphic positon, lithology and paleoslope all support the concept that the Dewey Lake and Moenkopi Formations are components of a single lithologic unit.

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INTRODUCTION

The red siltstones and fine - grained sandstones of the Dewey Lake Formation (Late Permian?) immediately overlie the evaporites which fill the Delaware Basin. They remain enigmatic even though they were initally described over 50 years ago (Lang, 1935). Questions abound concerning their depositional environment, age and tectonic setting. The only sedimentological study of the Dewey Lake was conducted by Miller (1955, 1966) over twenty years ago. He concluded that the sediment was transported by the wind and subsequently deposited in a shallow, saline body of water. Field work, associated with the present study, reveals that a fluvial setting is more likely. The Dewey Lake, therefore, provides a relatively rare opportunity to study an ancient fine - grained fluvial system.

A lack of fossil material in the Dewey Lake has fueled a fifty year old debate concerning its age. Many geologists believe that the Dewey Lake is unconformably overlain by the Middle to Late Triassic Santa Rosa Formation and hence Late Permian in age (Hills, 1942; Hills, 1984; King, 1942). Others, however, have raised doubts about the exact nature of the Dewey Lake / Santa Rosa contact (McGowen et al., 1979, 1983) and consequently suggest that the Dewey Lake could be Early Triassic in age. The current study utilizes data compiled from gamma ray logs to shed further light on this problem.

While questions concerning the age and depositional environment of the Dewey Lake Formation have been examined, the larger scale aspects of the problem (such as source and tectonic setting) have essentially been ignored. This study examines the tectonic framework of the Permo - Triassic boundary and attempts to place the Dewey Lake Formation within this regional picture.

The results of this study are divided into three major sections. The first contains a lithologic description of the Dewey Lake Formation, a discussion of its depositional environment and an examination of the regional picture obtained through the analysis of gamma ray logs. The second section consists of a summary of all data pertinent to the question of age. The third and final section examines the question of tectonic setting and broad stratigraphic relationships.

STUDY METHODS

A goal of this thesis was to more precisely delineate the depositional and tectonic setting of the Dewey Lake Formation. The following techniques were utilized to reach this goal: 1) a literature search, 2) a field analysis, and 3) a study of gamma ray logs. The literature review provided necessary background information while the field work provided the data needed to interpret the depositional environment of the Dewey Lake. The analysis of the gamma ray logs greatly increased the effective study area of the thesis and helped to place the Dewey Lake Formation within a larger tectonic framework.

The Dewey Lake and its probable stratigraphic equivalent, the Quartermaster Formation, extend throughout a wide region of southeastern New Mexico, west Texas and the Texas Panhandle (Figure 1). Areas of good exposure, however, are limited to the Palo Duro Canyon in the Texas Panhandle and the Maroon Cliffs in southeastern New Mexico. The western portion of the latter was examined in this study.

The field work in the Maroon Cliffs was completed in stages. The stratigraphic section was initially described utilizing such observations as color, lithology and

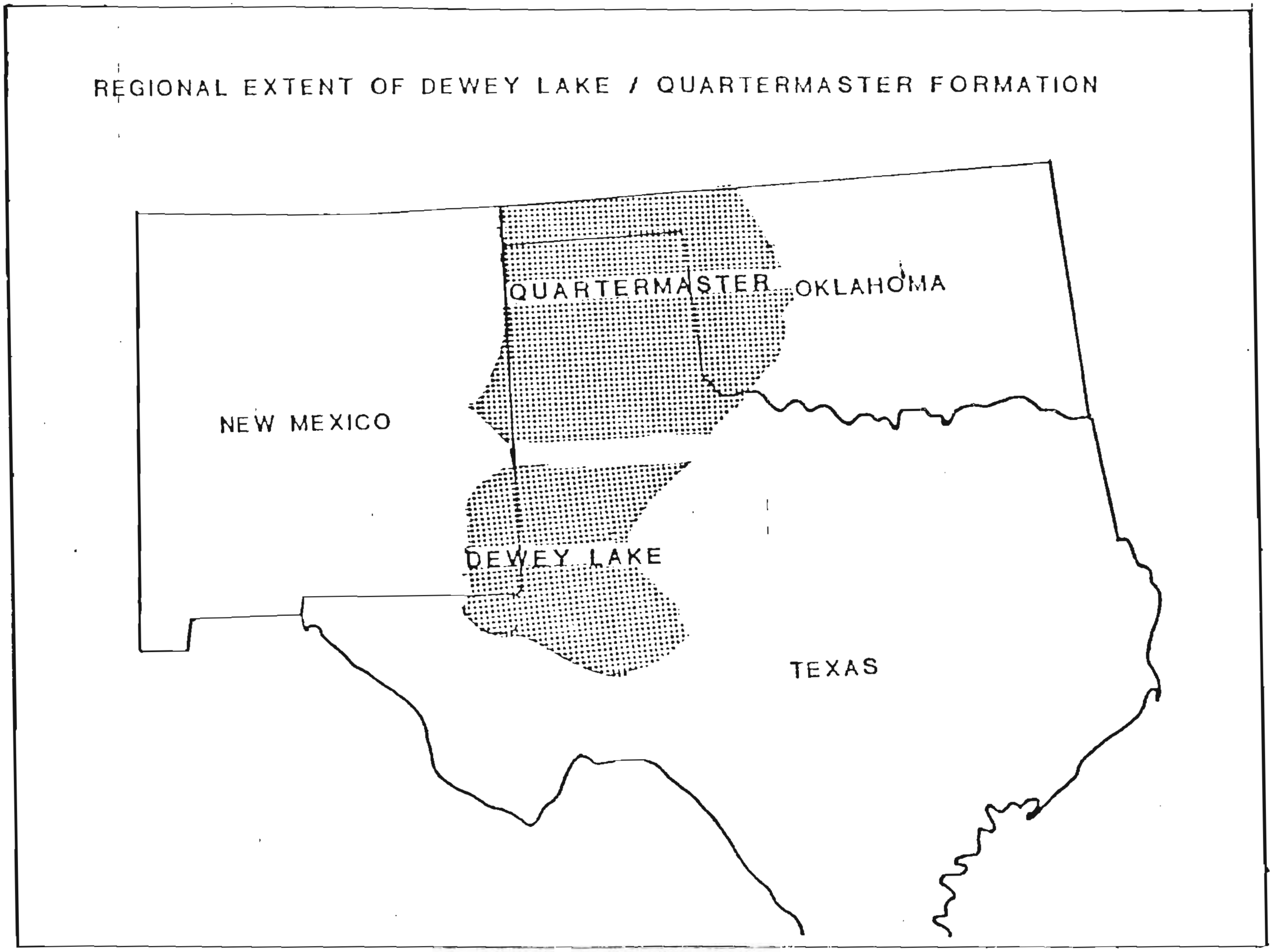


Figure 1 Regional extent of the Dewey Lake / Quartermaster Formation.

bedding. These characteristics were used to subdivide the strata into several distinct lithofacies. Detailed vertical and lateral sections were then created.

Approximately 600 natural gamma ray logs from Lea, Andrews, Martin, Howard, Ector, Glasscock, Midland, Upton, and Reagan Counties were examined in this study. The data from the logs in Lea, Andrews, and Ector Counties are presented in this thesis.

GEOLOGIC BACKGROUND

The stresses associated with the Late Paleozoic collision of North America and Gondwanaland uplifted the Central Basin Platform, thereby dividing the southern Tobosa Basin into the Delaware and Midland Basins (Galley, 1958) (Figure 2). Rapid subsidence of the Delaware Basin during the late Pennsylvanian and Permian created a topographic depression surrounded by shallow shelves (King, 1942). Growth of the Capitan reef around this margin decreased the quantity of fresh sea water entering the basin and as a result triggered the precipitation of evaporites (King, 1942). These evaporites eventually filled the basin (the Castile Formation) and covered most of west Texas, the Texas Panhandle and eastern New Mexico (the Salado and Rustler Formations). The silt and fine sand comprising the Dewey Lake (Latest Permian ?) were deposited above these evaporitic units.

It is generally believed that most of the Permian Basin was uplifted and eroded during the Early Triassic (Hills, 1942; Hills, 1984; King, 1942). Clastic deposition resumed with the influx of the coarser fluvial sediments of the Santa Rosa Formation (a redbed of Middle to Late Triassic age). The Santa Rosa is conformably

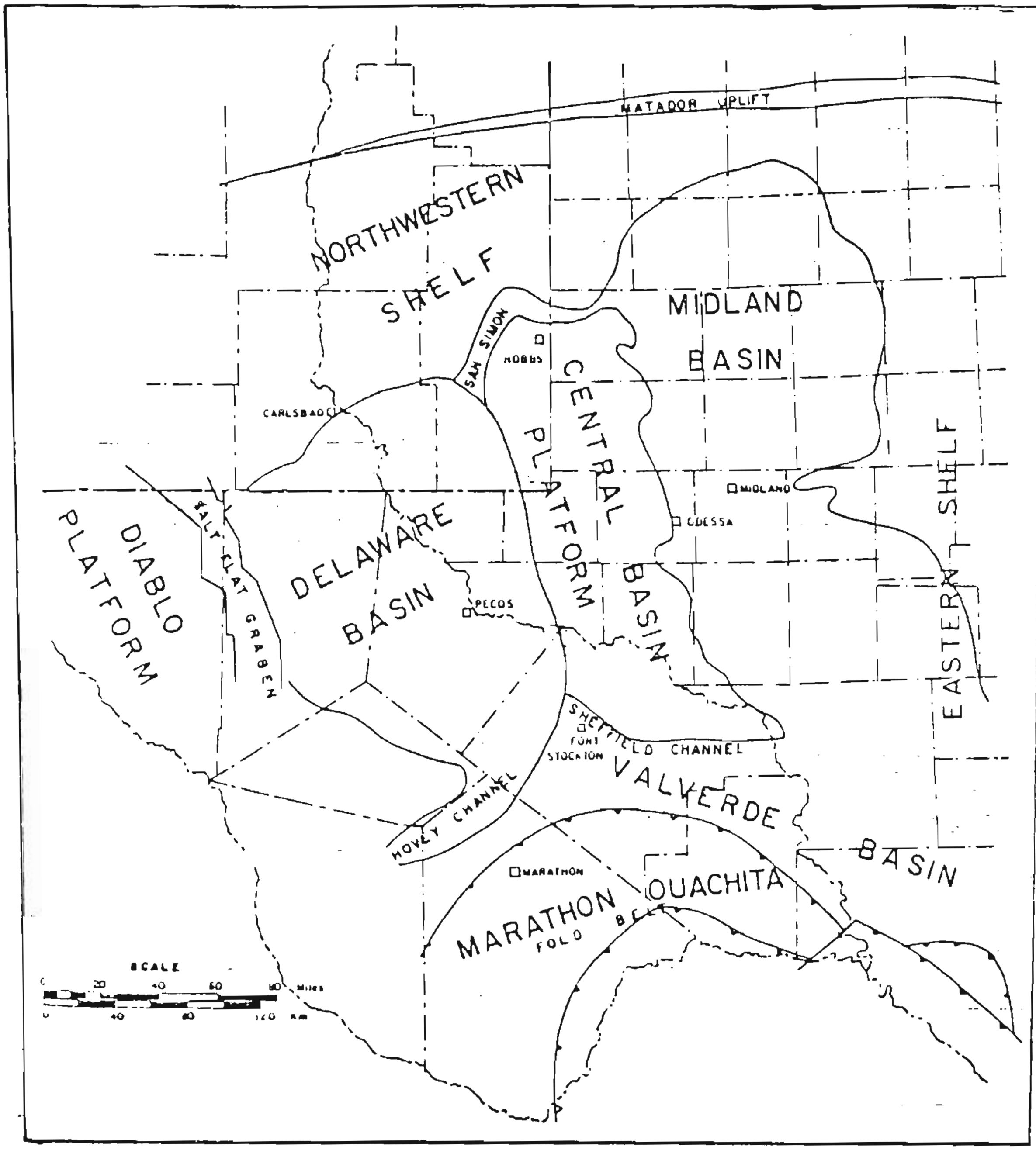


Figure 2 Tectonic framework of the Permian Basin region (from Hills, 1984).

overlain by the Chinle Formation, which is also a terrestrial redbed unit. The Santa Rosa and Chinle Formation comprise the Dockum Group.

THE DEPOSITIONAL ENVIRONMENT OF THE DEWEY LAKE FORMATION

Previous Work

Miller (1955, 1966) was the first person to speculate on the depositional environment of the Dewey Lake Formation. He theorized that the detritus was transported to the depositional basin by the wind and then "deposited in a broad, shallow, saline body of water which covered at least the eastern part of the Delaware basin".

Oriel et al. (1967) summarized the Dewey Lake data in their general overview of the paleotectonics of the Permian and followed Miller (1966) in interpreting the Dewey Lake as shallow marine.

Hills (1972) noted that the Dewey Lake contained many large (1.5 mm), well rounded and finely frosted grains and he too theorized that wind had played a prominent part in the deposition of the formation. He also observed that the Dewey Lake was regularly bedded with traces of soft gypsum and was, therefore, probably deposited in playa lakes.

McGowen et al. (1979), who studied the lower Dockum Group, stated that the Permian evaporites and clastics were deposited under arid conditions in restricted shallow hypersaline water bodies, tidal flats and sabkhas.

Outcrop Analysis

Outcrop Location

Dissolution of evaporites in the Salado and Rustler Formations has led to the subsidence of a large region twenty miles east of Carlsbad, New Mexico (Figure 3). This area, known as Nash Draw, is approximately 13 km (8 mi) long and up to 14 km (9 mi) wide. The Dewey Lake Formation is exposed along the northern rim of this draw, in an area called the Maroon Cliffs (Figure 3). The western segment of the region comprises the field area for this study. It is subdivided into two localities (A and B) which will be discussed separately.

Description of Locality A

This locality consists of two mutually perpendicular cliffs approximately .8 km (.5 mi) long: one trends approximately north - south (Plate 1) and the other trends approximately east - west. The area between the cliffs consists of a series of large northeast - southwest - trending arroyos. The sides of these arroyos, which are on the order of 304 m (1000 feet) long and 30 to 50 m (90

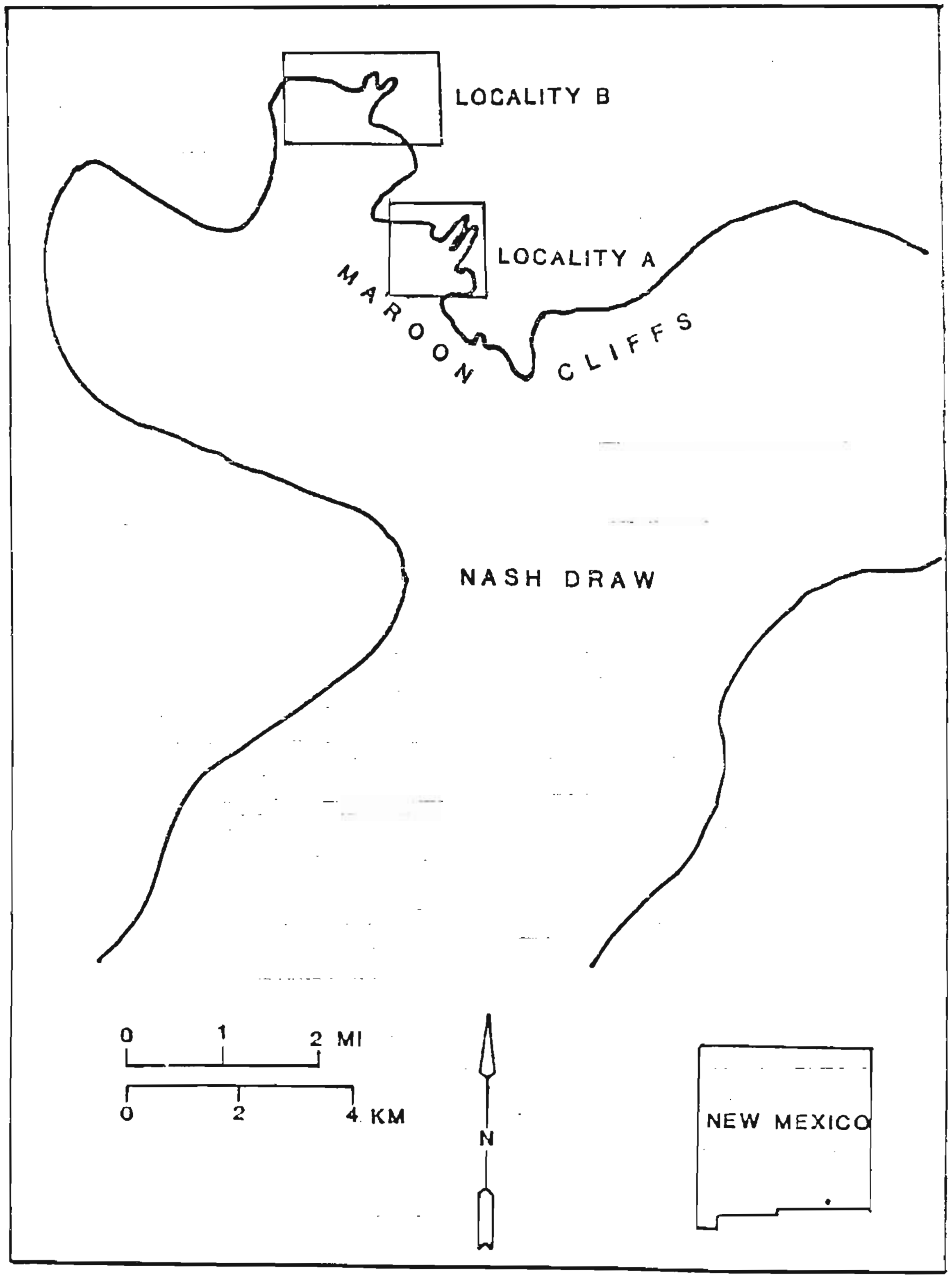


Figure 3 Location of field area.

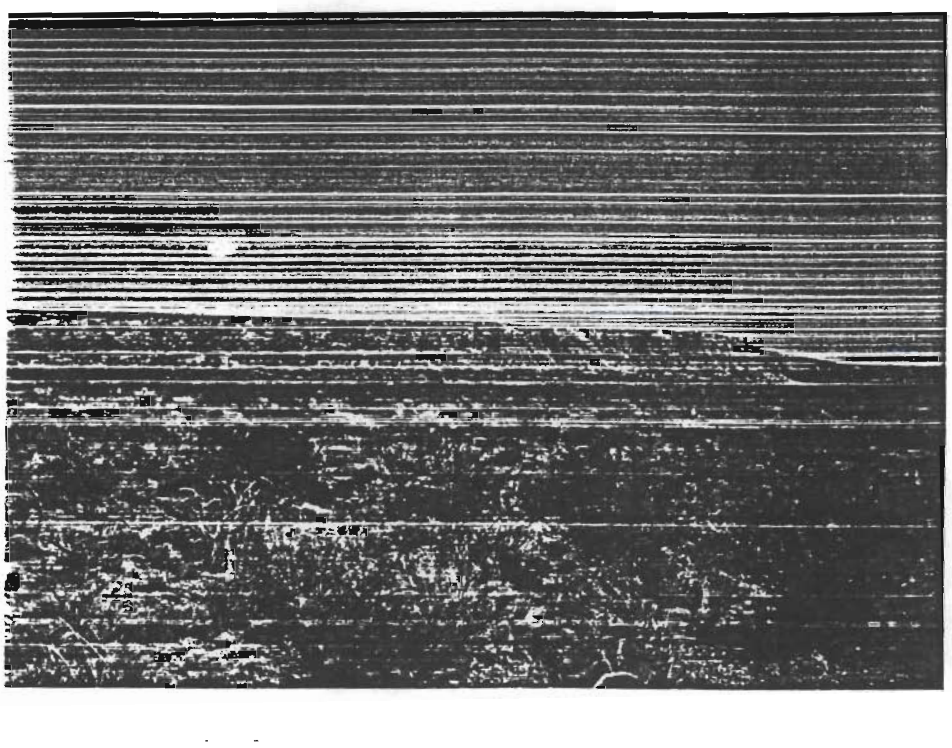


Plate 1 North - south trending cliffs. The distinct unit in the mid - section is Facies 1.

to 150 ft) wide, provide excellent exposures of the lateral relationships in the Dewey Lake.

The north - south - trending cliffs expose the lower portion of the stratigraphic section while the gullied region and the east - west - trending cliffs expose the middle to upper part. The total stratigraphic section is approximately 15 m (50 ft), or 10 percent of the Dewey Lake believed to exist in this region (based on well log data). The excellence of the lateral exposures in the cliff and gully regions compensates somewhat for the relatively thin nature of the section.

Facies Description

Facies 1 Horizontally laminated siltstone

This facies occurs only once, in the mid section of the north - south trending cliffs. The 1.8 m (6 ft) of coarse siltstone/fine sandstone, which comprise this unit, are much more resistant than either the underlying or overlying strata. It is, therefore, clearly visible, even from a distance of several km (Plate 1). Horizontal laminations, 2 - 5 mm (.08 to .2 in) thick, are present throughout the unit (Plate 2). The lower surface is planar and very sharp (Plate 3). Although this lower contact appears erosional, there are no reworked clasts from the underlying strata (Facies 6). The dimensions of Facies 1 are at least 1.2 km (.75 mi) in a north - south direction and 60 m (200 ft) in an east - west direction.

Facies 2 Structureless siltstone

Facies 2 is composed of dark red, coarse siltstone/very fine sandstone. The red color is, however, almost always covered by a brown clayey coating on the outcrop. This facies is poorly cemented and generally

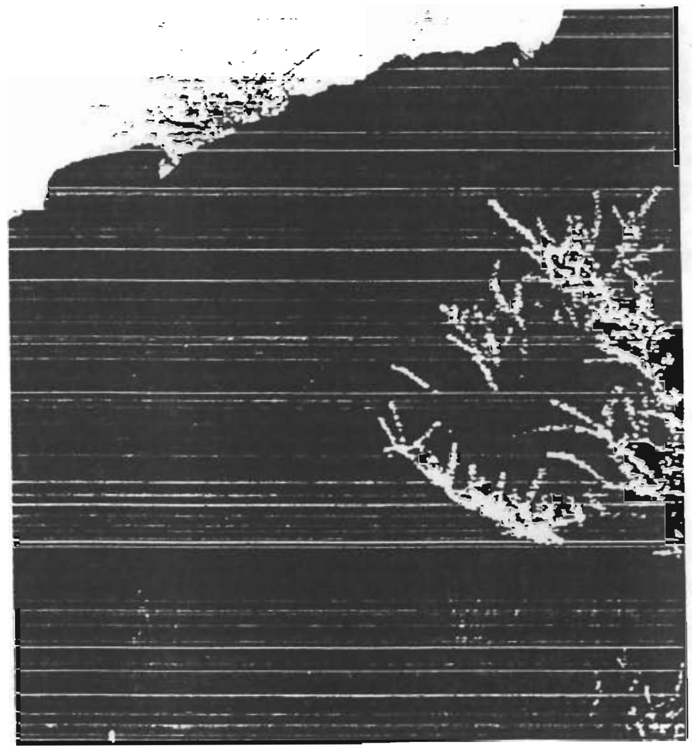


Plate 2 Facies 1 overlying Facies 6. The horizontal laminations, comprising Facies 1, are faintly visible in this picture.

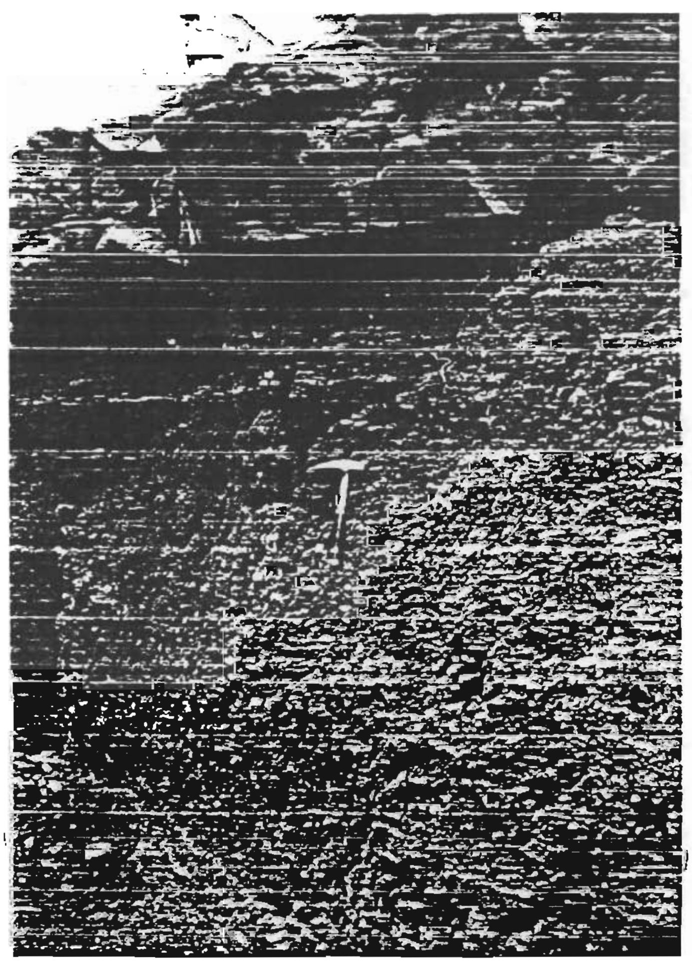


Plate 3 Closer view of the contact between Facies 1 and 6.

appears structureless (Plate 4). A few horizontal and cross laminations [approximately 1 mm (.04 in) thick] were faintly visible in a few places. The cross laminations appear to be contained in sets approximately 10 cm (4 in) thick. Claystone clasts, ranging in size from small flakes [1 - 2 mm (.04 to .08 in) long] to clasts several cm in diameter, are sometimes present. This facies has a distinctly erosional lower surface with relief, in places, of several tens of centimeters (Plate 5).

The structureless siltstone facies occurs in only one section of the stratigraphic section. It varies in thickness from approximately 10 cm (4 in) to 1.8 m (6 ft). In one instance a single cross laminated set [approximately 1 cm (.4 in) thick] was present near the upper boundary of a structureless siltstone unit (Plate 6). In most areas there appears to be only a single occurrence of the structureless siltstone (i.e. Plate 5); however, in one locality there are two superimposed siltstone beds separated either by a silty claystone (such as in Plate 6) or an erosional surface. The dimensions of Facies 2 are at least .8 km (.5 mi) north - south and a little under 1.7 km (1 mi) east - west.

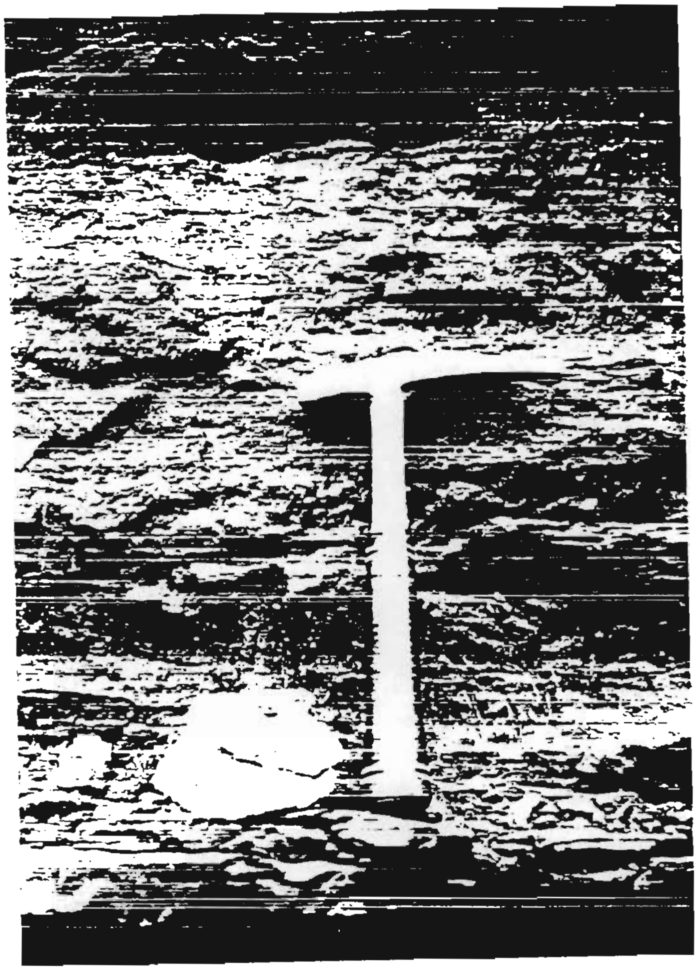


Plate 4 Picture of Facies 2 (under hammer head) showing its generally structureless nature.

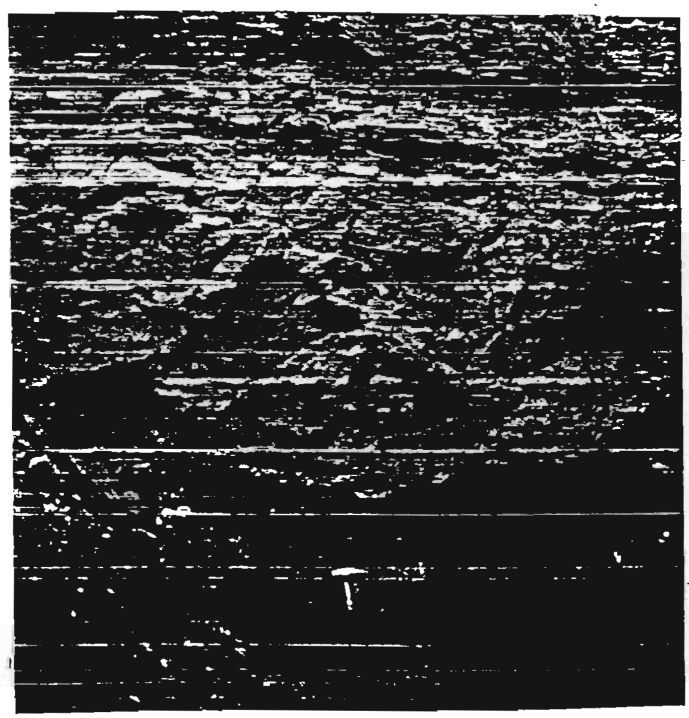


Plate 5 A much thicker occurrence of Facies 2 displaying a distinctly erosional lower surface [approximately 30 cm (1 ft) above hammer].

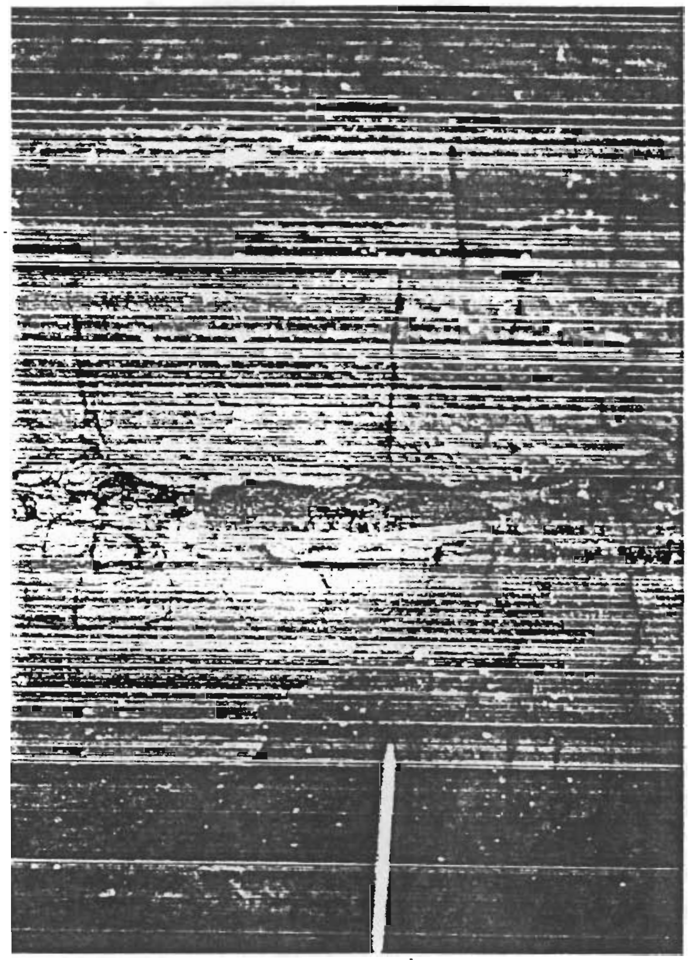


Plate 6 Thin ripple set [1 - 2 cm (.5 - 1 in)], approximately 10 cm (4 in) above pencil point, overlying Facies 2 and underlying a silty claystone bed. A second exposure of Facies 2 occurs above the silty claystone.

Facies 3 Horizontally laminated (siltstone / fine sandstone) channel fill

The horizontal laminations which comprise Facies 3 are either very thin [approximately 1 - 2 mm (.04 to .08 in)] (Plate 7) or relatively thick [approximately 5 mm (.2 in)]. A channel fill will consist of either one or the other. The laminations commonly parallel the sloping channel margins. Some of the channels contain abundant claystone clasts (up to several cm in diamter) (Plate 8) and clast lenses. Some of this claystone material could also represent uneroded claystone drapes. Although horizontal laminae dominant the channel fill, thin sets of cross laminae are also present (Plate 8). These are usually topped by a thin silty claystone bed (Plate 8).

The channels filled by Facies 3 vary from approximately 27.5 m (90 feet) in width and 1.2 m (4 feet) in maximum thickness to 6.1 m (20 feet) in width and .45 m (1.5 feet) in thickness. They exist either singularly or in nested and cross cutting relationships. All of the channels exposed in the gully region have axes which trend northwest - southeast.

Plate 7 Fine horizontal laminations of Facies 3.

Plate 8 Claystone clast and lense within Facies 3. Left side of picture shows a transition from horizontal laminations (point A) to cross laminations (point B) to silty claystone drape (point C).

Facies 4 Micro - cross laminated siltstone

Facies 4 is a reddish brown siltstone composed of very thin [approximately 1 mm, (.04 in)] cross laminations. Numerous exposures show sections either perpendicular or parallel to flow. Superimposed troughs (Plate 9) in a section perpendicular to flow vary from 1 - 3 cm (.4 to 1.2 in) in depth and from 20 - 30 cm (7.8 to 11.7 in) in width. An entire coset usually varies in thickness from .3 to .6 m (1 to 2 ft) and is overlain by a thin bed (few cms) of silty claystone. In most occurrences of Facies 4 there are 2 to 3 repetitions of trough cosets and silty claystone beds (Plate 10). Although the thin cross laminations comprising this facies cannot always be seen clearly, the facies can generally be identified by its unusual ribbed weathering surface (Plate 11).

Sections of this facies parallel to flow reveal a series of climbing cross laminated sets 2 - 2.5 cm (.78 to 1 in) thick and approximately 30 cm (12 in) long (Plate 12). The lower surface of each set is either planar or concave upward.

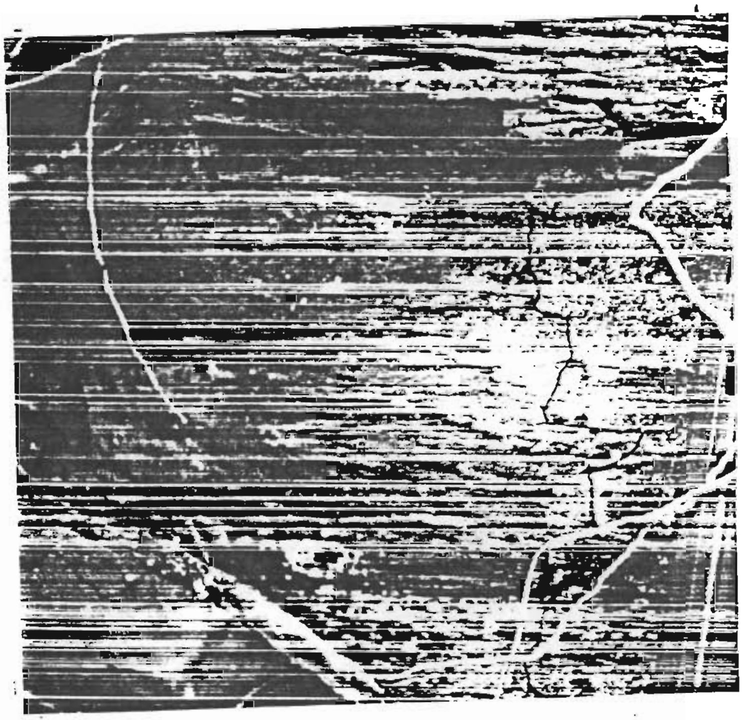


Plate 9 Superimposed troughs of Facies 4.

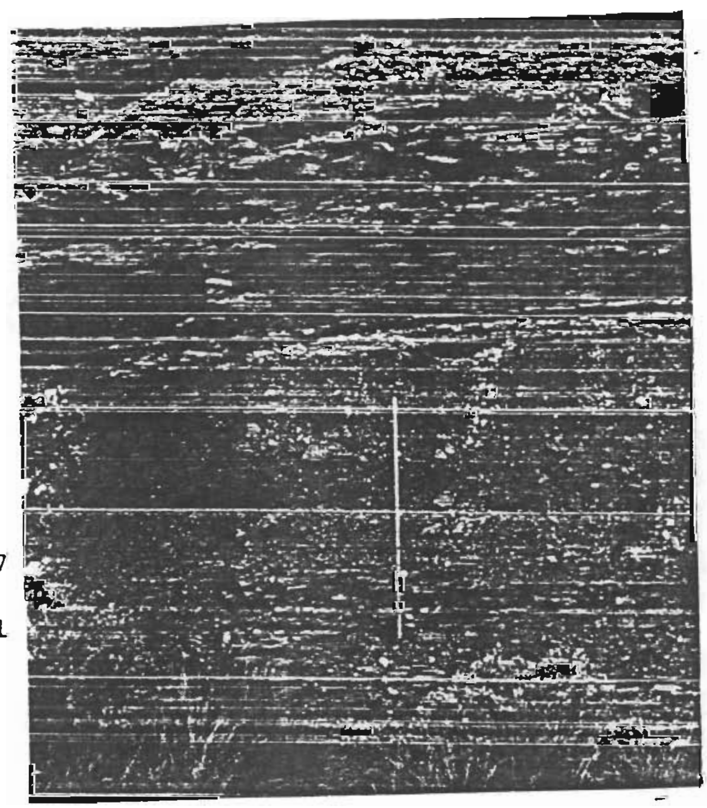


Plate 10 A portion of the stratigraphic section exposed in the Maroon Cliffs.

Plate 11 The unusual weathering style of Facies 4.

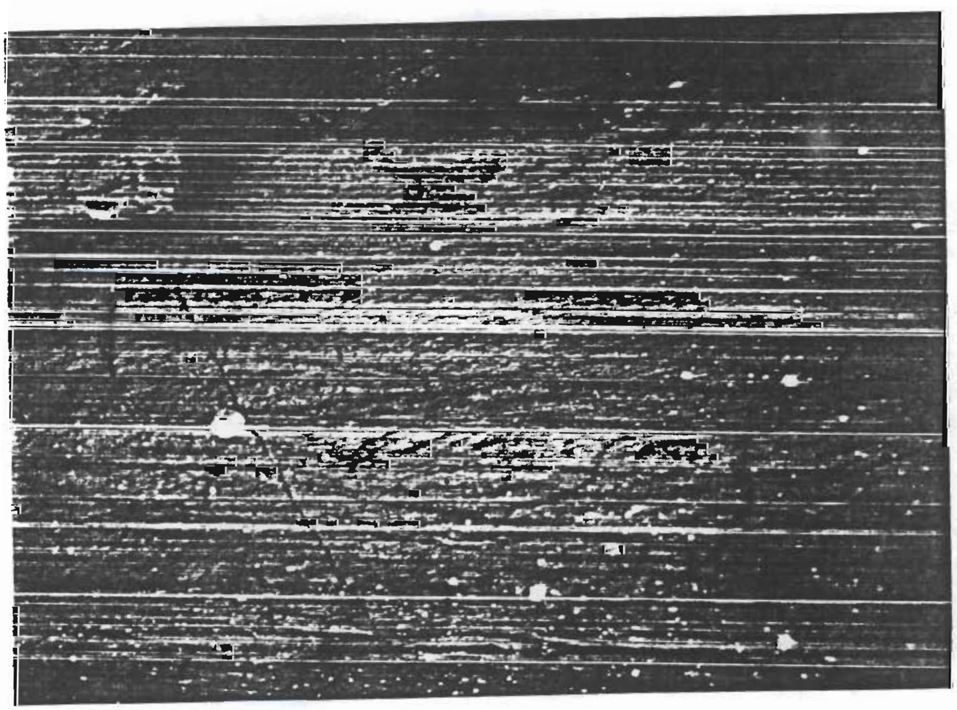


Plate 12 View of Facies 4 perpendicular to that shown in Plate 9.

Facies 5 Interbedded siltstone and silty claystone

This facies is composed of 1 to 10 cm (.4 to 4 in) thick interbeds of siltstone and silty claystone (Plate 13). Each siltstone and silty claystone bed can be thought of as comprising a couplet. The thickness of the beds within a couplet is approximately equivalent [i.e. if the siltstone bed is 5 cm (2 in) thick the associated silty claystone will also be approximately 5 cm (2 in) thick]. In good exposures of the facies it can be seen that the contact between the different lithologies is very sharp and that each bed can be traced for the extent of the exposure (at least several meters). The sharp contacts, the approximate thickness equivalence of the siltstones and silty claystones and the continuous nature of the beds all give this facies a very even platey appearance (Plate 14).

The siltstones are structureless, horizontally laminated or cross laminated, with laminae approximately 1 mm (.04 in) thick and sets .5 to 1 cm (.2 to .4 in) thick. The sets appear to be climbing. The upper surfaces of many of the siltstone beds are planar; however, others are covered by asymmetrical, slightly sinous and very low amplitude ripples (Plate 15). These

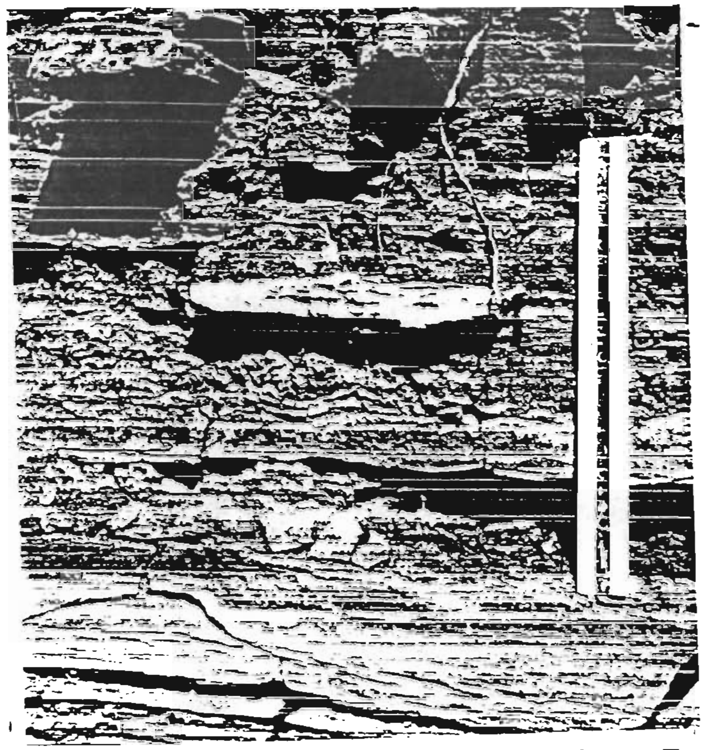


Plate 13 Interbedded siltstone and silty claystone of Facies 5.

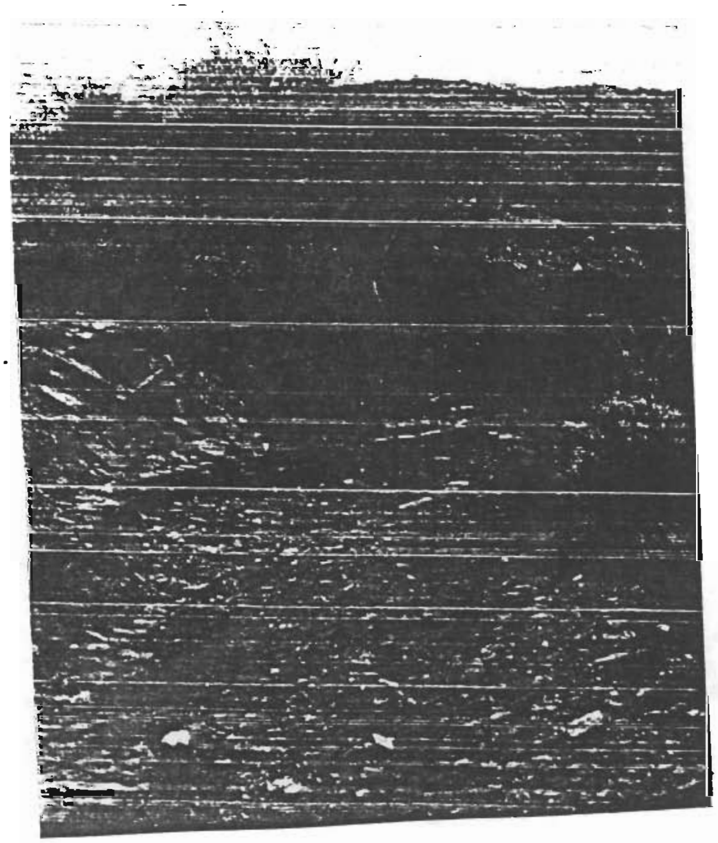


Plate 14 A distal view of Facies 5.

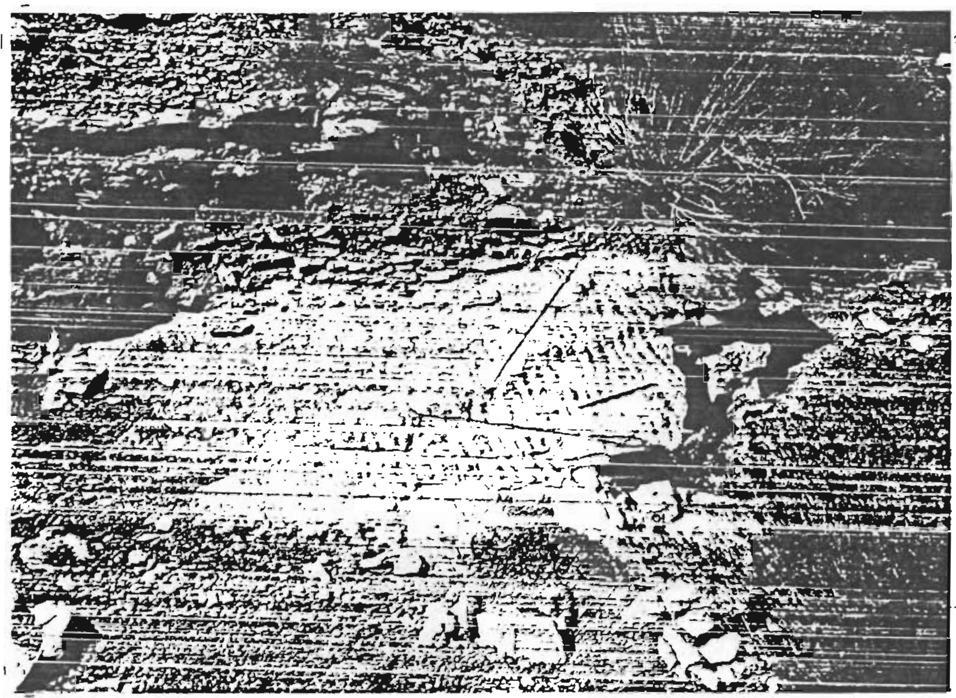


Plate 15 Ripples on the surface of a siltstone bed within Facies 5.

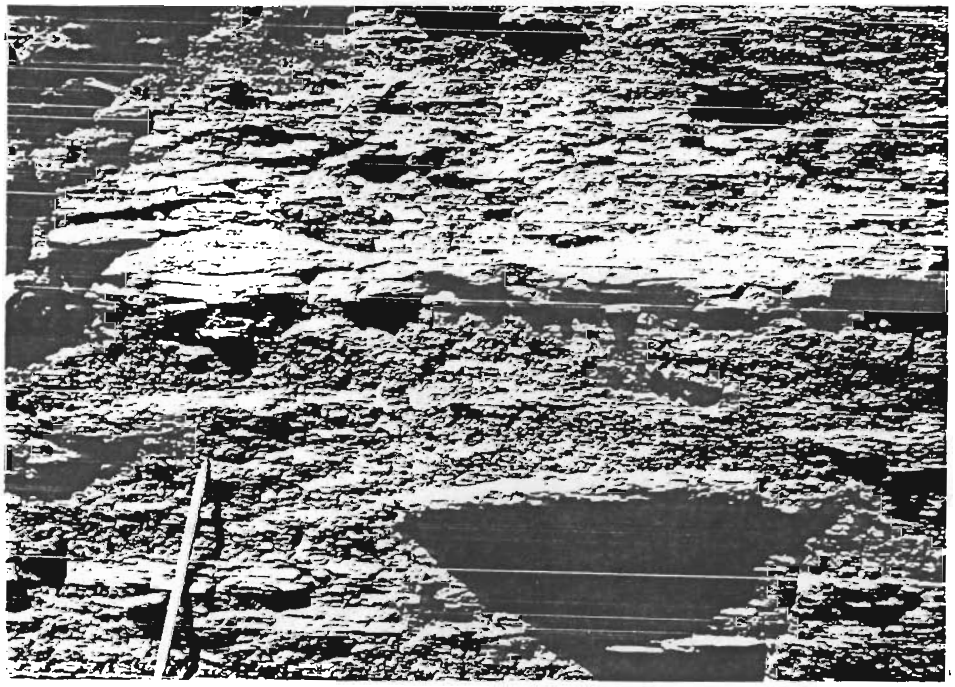


Plate 16 Examples of distinct ripple forms within Facies 5.

ripples have an amplitude of 2 - 3 mm (.08 to .12 in) and an average wavelength of 2.5 cm (1 in). They appear to have been formed be currents moving to the northwest. In one instance the siltstone beds had wavy surfaces and large distinct ripple forms were preserved. These ripples (Plate 16), with amplitudes of 2 - 4 cm (.8 to 1.5 in) and wavelengths of 15 cm (5.8 in), are much larger than those just described. Their distinct outline, within finer material, suggests that sometime after forming they were starved of silt sized sediment.

Load casts several cm wide and deep are present beneath some of the siltstone beds comprising Facies 5 (Plate 17). Other sole markings include casts of cubic crystals (probably halite) and burrows.

Two distinct types of burrows are present. The first is very regular, with a width of 1.5 cm (.6 in), a length of 10.5 cm (4.2 in) and a thickness of .5 cm (.2 in). The form is only slightly curved and lacks branches. The second type is straight to slightly sinuous, .5 to 1 cm wide (.2 to .4 in), and up to 22 cm (8.8 in) long. It contains few branches and the ones which are present occurr at right angles to the main track.

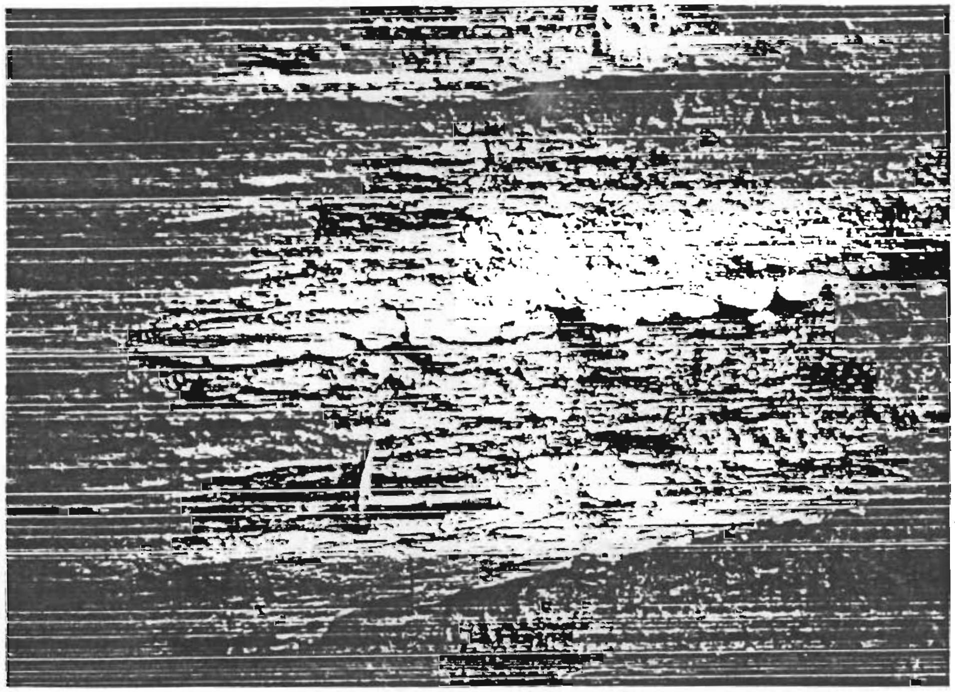


Plate 17 Examples of siltstone load casts within Facies 5.

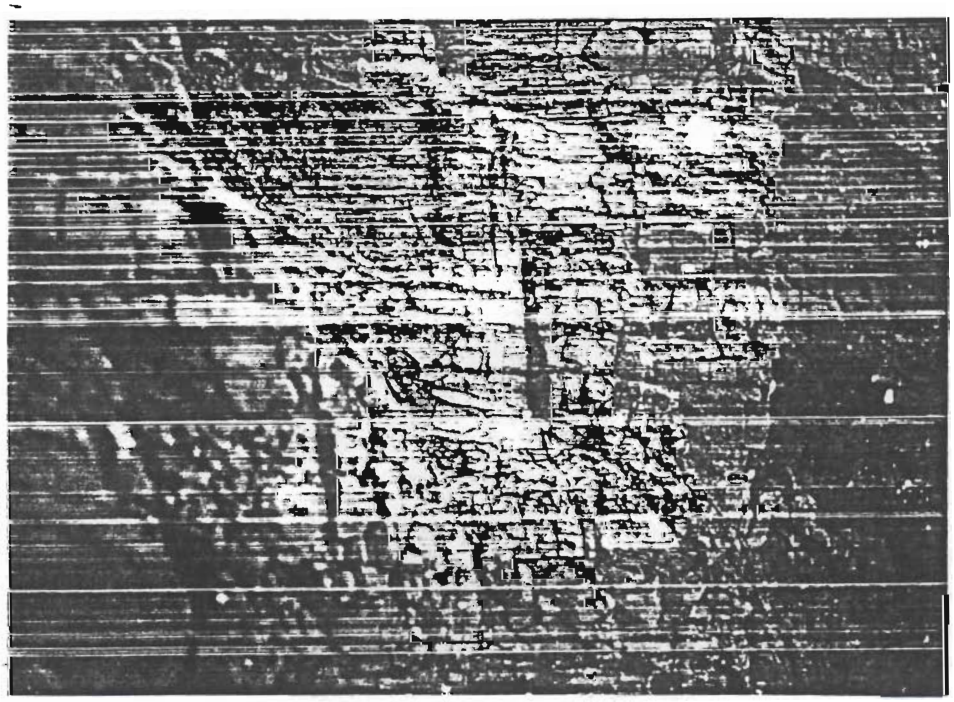


Plate 18 Thinly interlaminated siltstone and claystone of Facies 6.

Facies 6 Thinly interlaminated siltstone and claystone

Facies 6 consists of thin interbeds of siltstone and claystone (Plate 18). The siltstone beds range in thickness from 1 to 9 cm (.4 to 3.5 in) while the claystone laminae range from 1 to 2 mm (.04 to .08 in). The contact between the siltstone beds (which appear structureless) and the underlying claystone laminae is irregular. On a small scale the contact is convoluted with relief of a few mm while on a larger scale the contact is wavy with relief of approximately 1 cm (.4 in). It is believed that the convoluted contact could be due to the presence of numerous tiny load casts, while the larger scale wavy nature could be the result of differences in compaction. Both the claystone and siltstone beds continue for a distance of at least several meters and probably much further. They do, however, thicken and thin over this distance. Facies 6 characteristically weathers into 1 to 2 cm (.4 to .8 in) blocks (see Plates 2 and 3).

Facies 7 Silty claystone

Facies 7 is a structureless, reddish - brown, silty claystone. It is fissile and weathers into thin flakes, 1 - 2 mm (.04 to .08 in) thick. This facies is not particularly common. It first appears above the horizontally laminated siltstone of Facies 1. In another, stratigraphically higher, location it forms the lowest portion of a channel fill (this occurrence is described in more detail in the section entitled "Lateral Sections from Locality A").

Vertical Section from Locality A

A vertical stratigraphic section of the exposed Dewey Lake (Figure 4) begins with approximately 5 m (15 ft) of Facies 6 (not shown in its entirety in Figure 4). This is overlain, very sharply, by the horizontal laminae of Facies 1, which is succeeded by the silty claystone of Facies 7. This is, in turn, followed by 40 cm (15.6 in) of horizontally laminated siltstone. The very fine laminations comprising this unit suggest an affinity with Facies 3. It was, therefore, placed into this category even though it was not possible to determine if it was filling a channel. This facies was followed by a second appearance of Facies 7.

The next segment of the stratigraphic section is dominated by alternations of Facies 4 and 5. (The section from Facies 1 through the first appearance of Facies 4 is shown in Plate 10). This alternating pattern is eventually broken by the appearance of Facies 2 (structureless siltstone). The sequence above Facies 2 is laterally variable and will be described in the section entitled "Lateral Sections from Locality A".

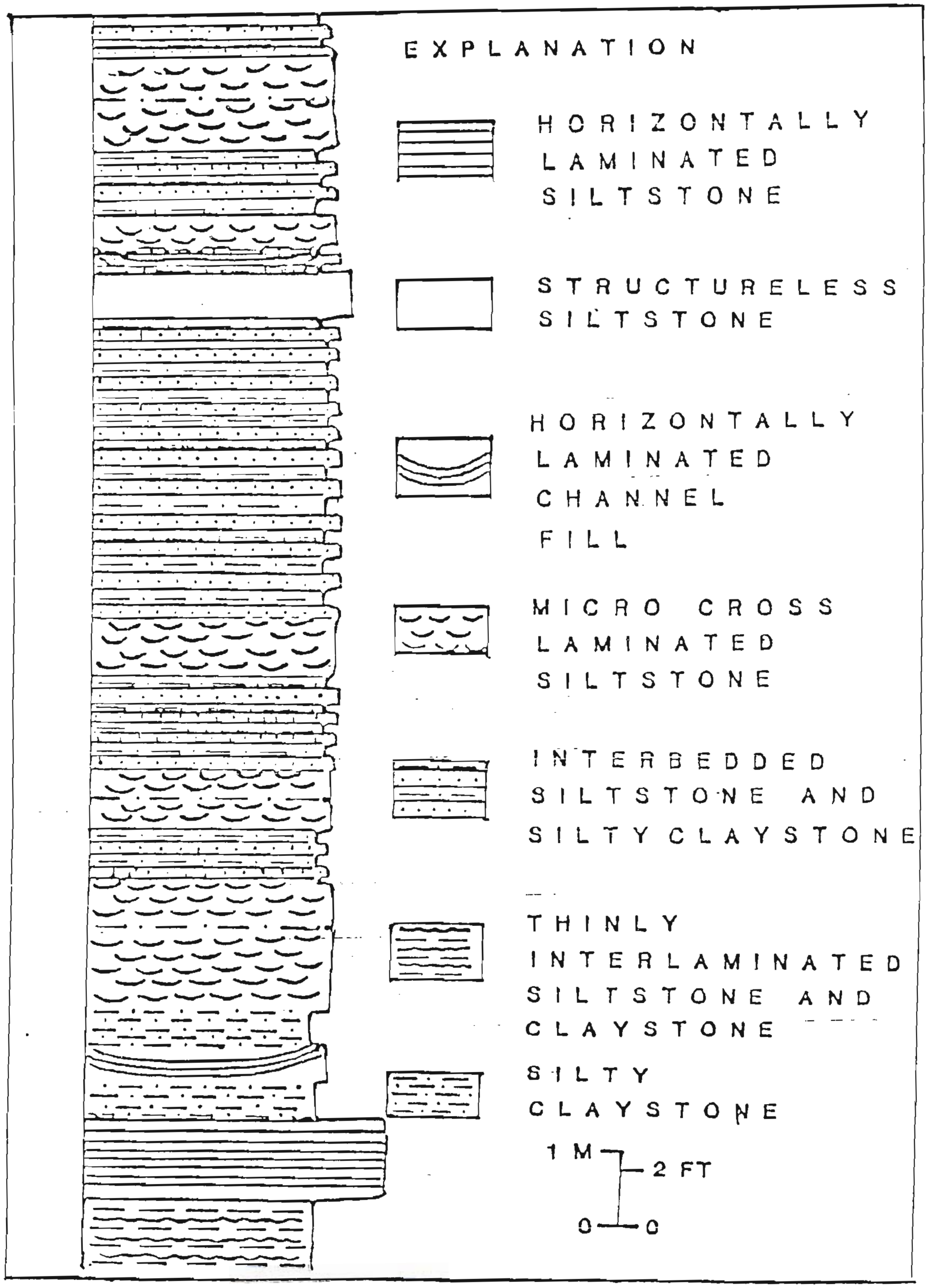


Figure 4 Partial stratigraphic section of the upper Dewey Lake Formation in Locality A.

Description of Locality B

The exposures in locality B are quite different from those in locality A. Instead of weathering into cliffs and numerous gullies this region is one of large amphitheater like structures separated by long and relatively narrow spurs. The data from locality B is limited and consists of a single vertical section.

Facies Description

Facies 8 Cross laminated fine to medium grained sandstone

The one facies which occurs in locality B and is not represented in locality A is cross laminated sandstone. The laminations are 1 to 2 mm thick and comprise either trough or tabular cross sets. The trough variety is relatively uncommon. The best exposure revealed that the sets are cross cutting and approximately .3 m (1 foot) thick (Plate 19). The tabular cross sets vary in thickness from a few cm up to .3 m (1 foot). In many places singular tabular cross sets overlie horizontally laminated sandstone. In other places (Figure 5) tabular

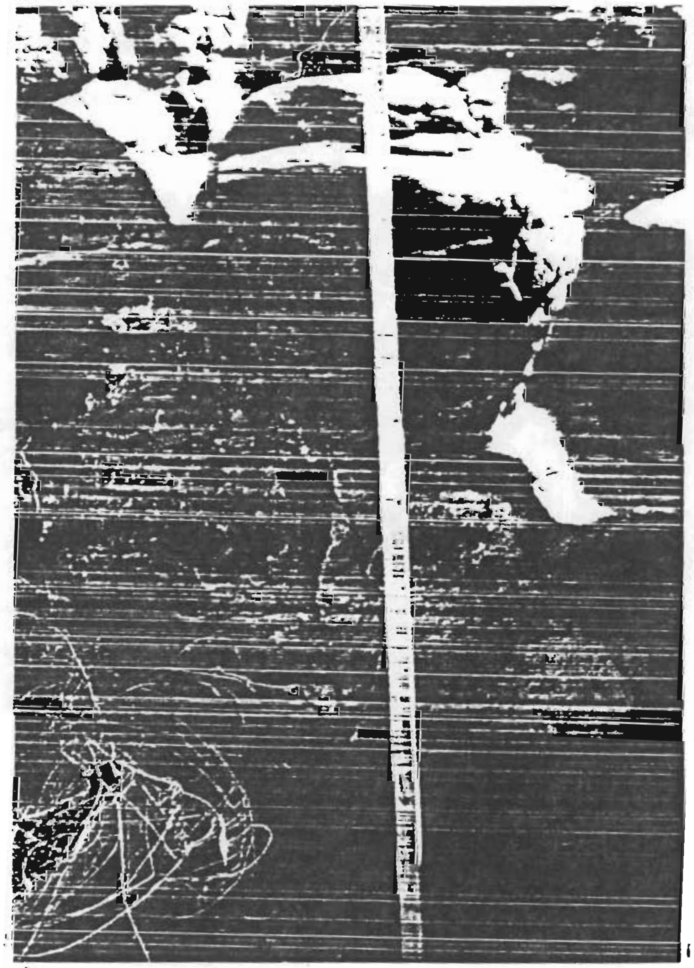


Plate 19 Trough cross laminations of Facies 8.

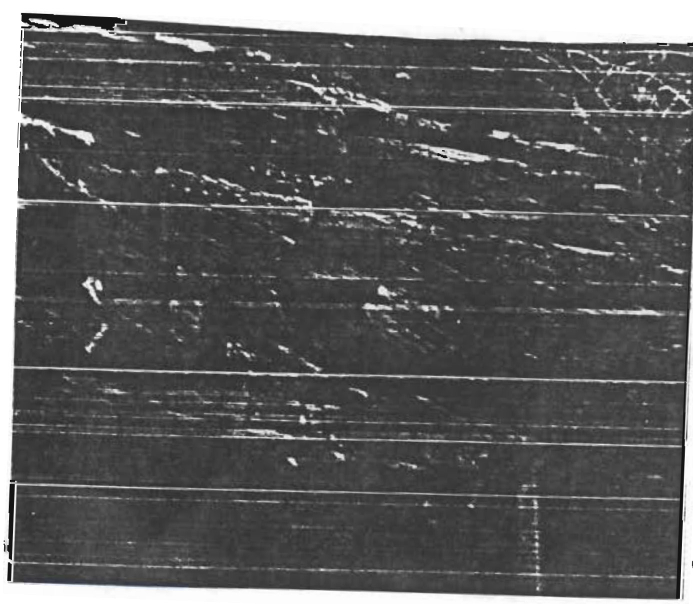


Plate 20 Tabular cross laminations of Facies 8.

cross sets overlie trough cross sets (Plate 20). Most of the cross lamination in Facies 8 indicate a northwesterly paleocurrent.

Vertical Section from Locality B

The vertical section from locality B can be easily divided into 2 parts: a lower, slightly coarser portion dominated by Facies 8 and a relatively fine - grained portion dominated by horizontal lamination (Facies 1 and 3) (Figure 5).

The lower segment begins with approximately 1.5 m (5 ft) of trough cross lamination (Facies 8). The cross cutting sets appear to be approximately .3 m (1 ft) thick (Plate 19). The cross lamination above consists of 2 distinct sets of tabular cross lamination (also Facies 8). Both sets are composed of laminae 2 - 4 mm (.08 - .16 in) thick; however, the lower set is twice as thick as the upper set [20 cm (8 in) vs 10 cm (4 in)] (Plate 20). The contact between the individual laminae and the set boundary is distinctly more tangential in the upper (i.e. smaller) set. A top view of these tabular cross sets (Plate 21) indicates a northwest current direction (i.e. $N30^{0}$ W to $N55^{0}$). These two sets are followed by

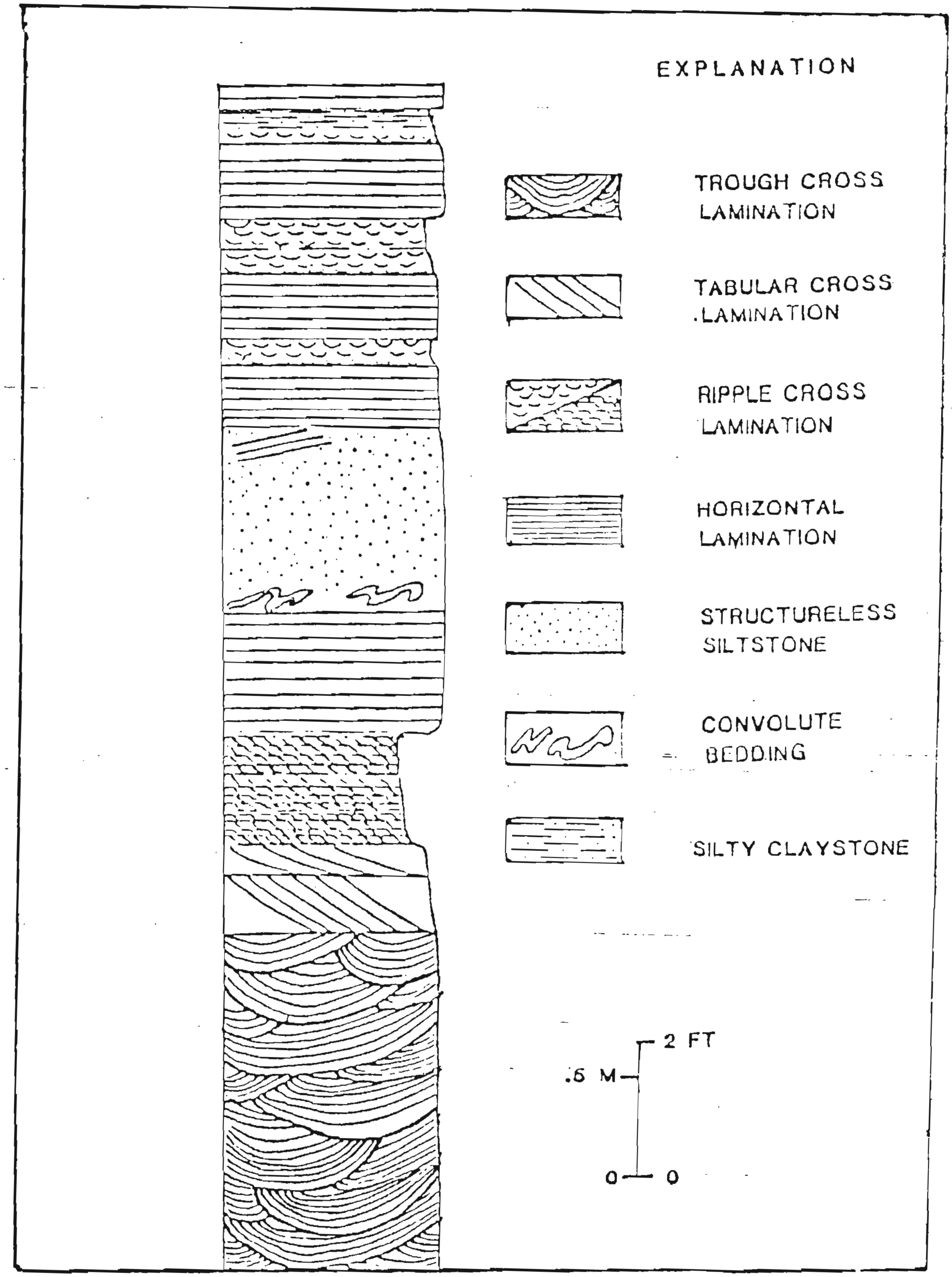


Figure 5 Partial stratigraphic section of the upper Dewey Lake Formation in Locality 8.

Plate 21 A top view of the tabular cross sets shown in Plate 20.

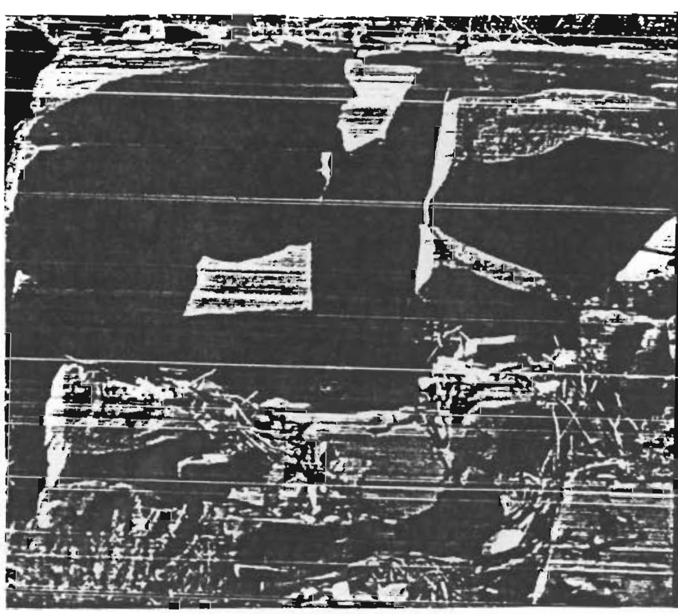


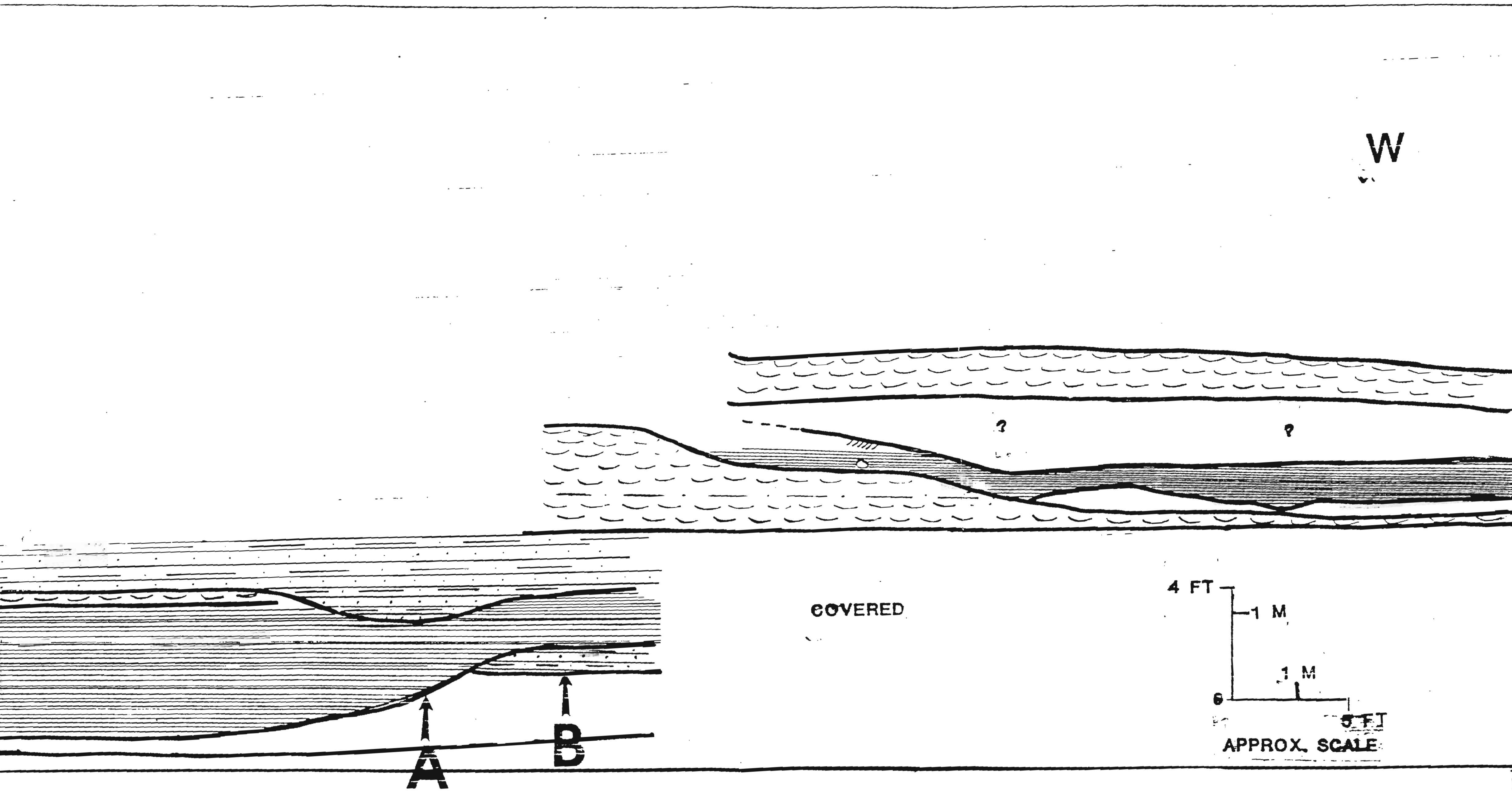
Plate 22 Single cross laminated set within Facies 1.

approximately .5 m (1.5 ft) of Facies 4 (i.e. cross laminated siltstone alternating with thin layers of silty claystone.

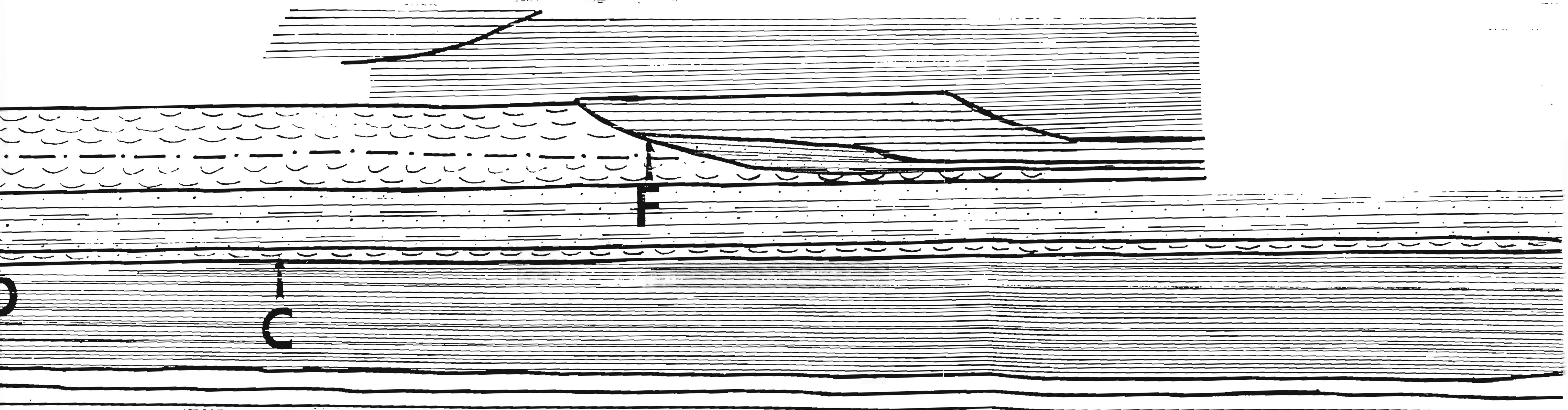
The upper segment begins with an erosional surface followed by approximately 1.5 m (5 ft) of horizontally laminated siltstone / fine sandstone (Facies 1). In some places the horizontal laminations are not visible, and the unit appears essentially structureless. Convoluted bedding is present approximately .6 m (2 ft) above the lower erosional surface. The .6 m (2 ft) above this convoluted zone are structureless, except for a single cross laminated set approximately 20 cm (8 in) thick (Plate 22). The cross laminae in this set dip to the southeast and are cut by a distinct planar surface. Horizontal laminae above this surface reach a thickness of .3 m (1 ft). Approximately 10 cm (4 in) of Facies 4 follows.

A second horizontally laminated siltstone/fine sandstone (Facies 1) [approximately 20 cm (8 in)] is present above the silty claystone. It is also followed by approximately 20 cm (8 in) of Facies 4 (micro - cross laminated siltstone). A third horizontally laminated siltstone, approximately .3 m (1 ft) thick, (Plate 23) (Facies 1) occurs near the top of the section. This unit,

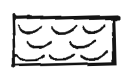
Plate 23 Horizontally laminated unit (Facies 1) near the top of the stratigraphic section.



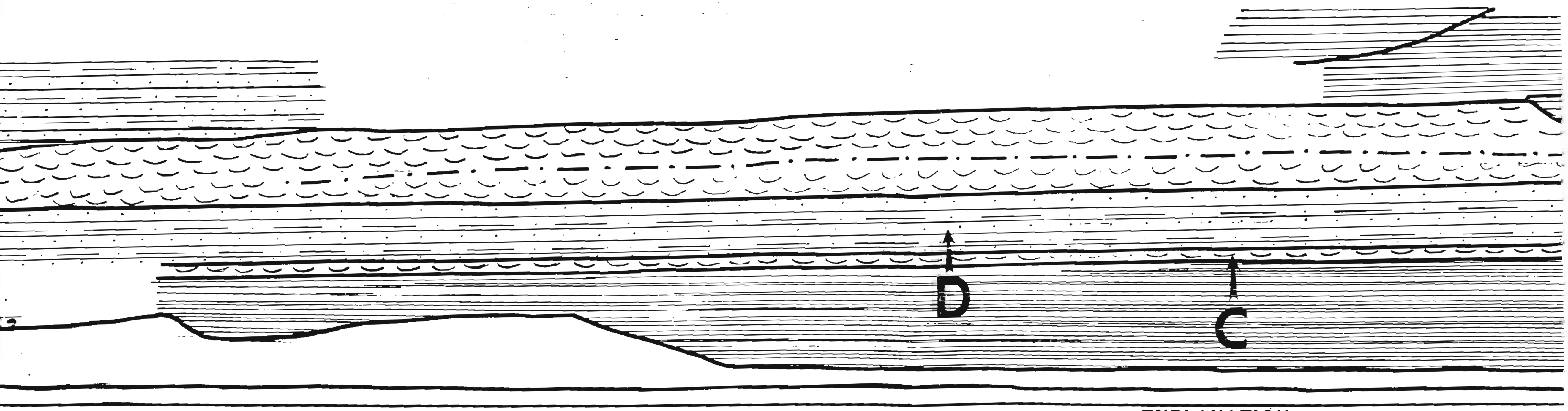
FACIES 5 INTERBEDDED SILTSTONE AND SILTY CLAYSTONE



EXPLANATION

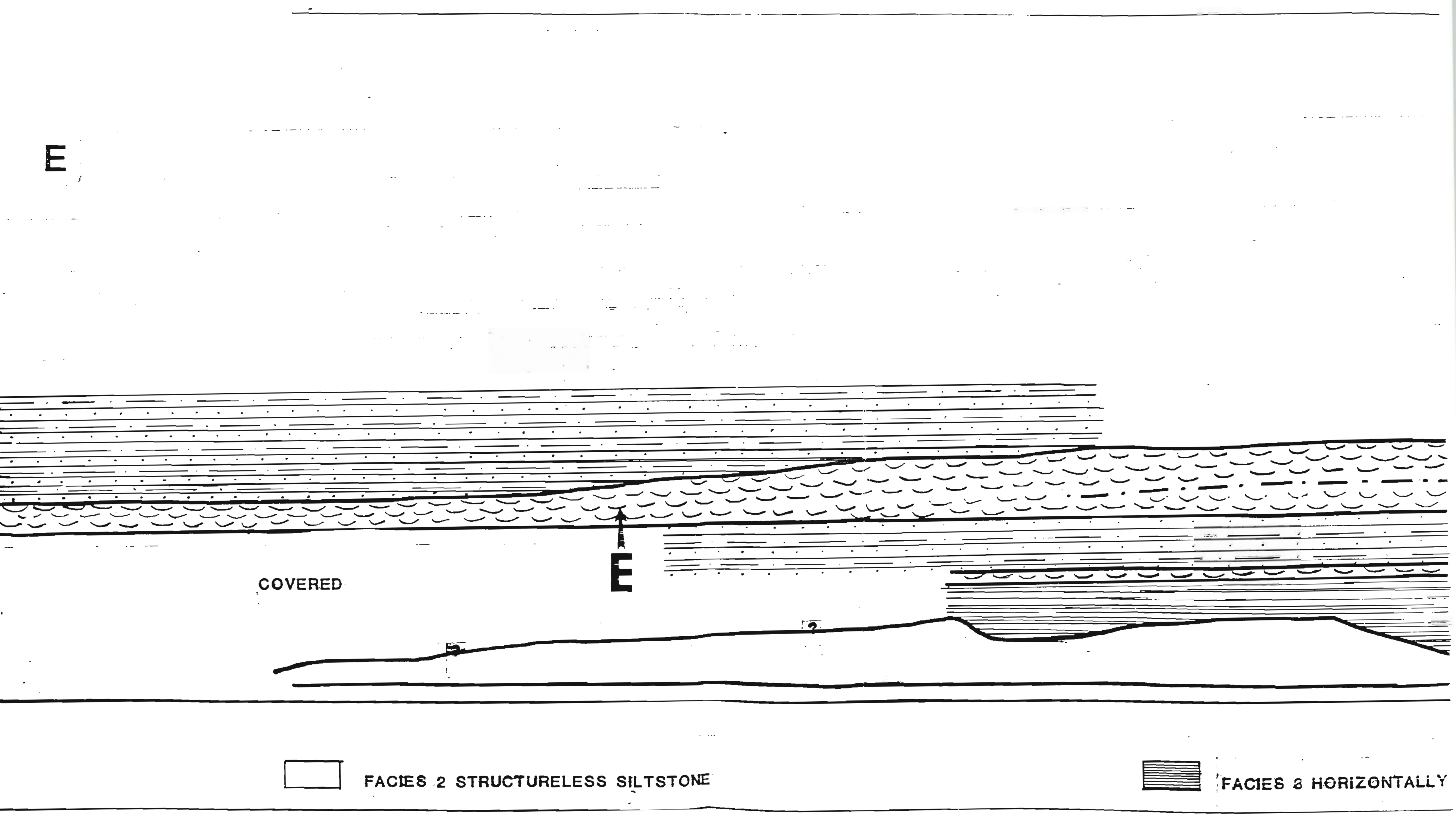


FACIES 4 MICRO CROSS LAMINATED SILTSTONE



EXPLANATION

FACIES 3 HORIZONTALLY LAMINATED CHANNEL FILL



igure 6 East -west cross of the Dewey Lake Formation.

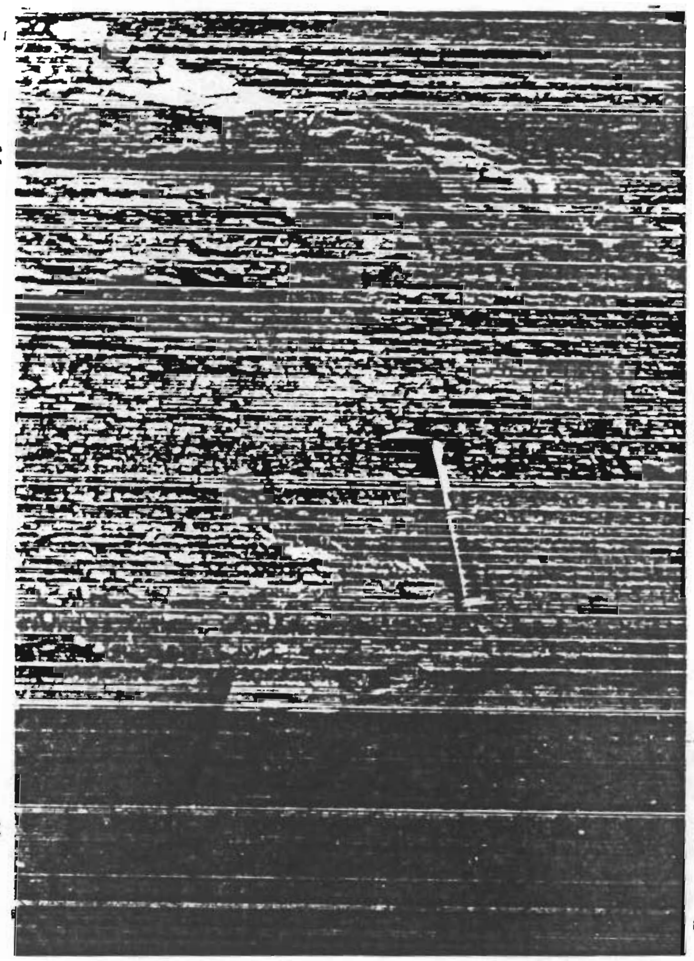


Plate 24 Erosional contact between Facies 2 and Facies 3 (Point A on Figure 6).

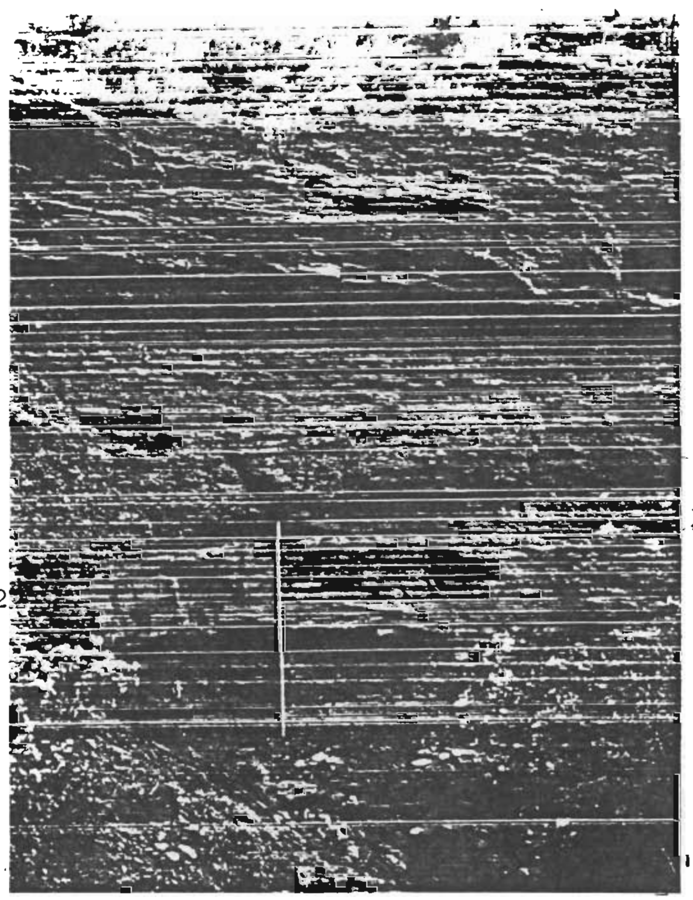


Plate 25 More distal view showing the presence of Facies 5 between Facies 2 and Facies 3 (Point B on Figure 6). Plate 24 was taken to the left of the Jacob's Staff.

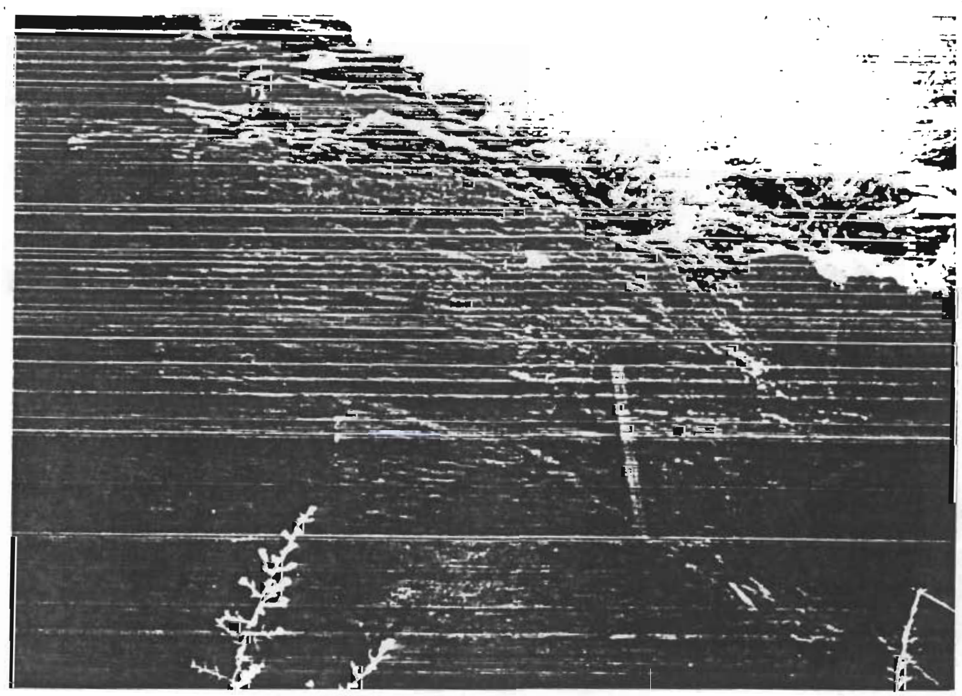


Plate 26 Left margin of a channel eroded into Facies 4 (Point F on Figure 6). Also visible are the initial fine grained channel fill and the overlying horizontally laminated siltstone.

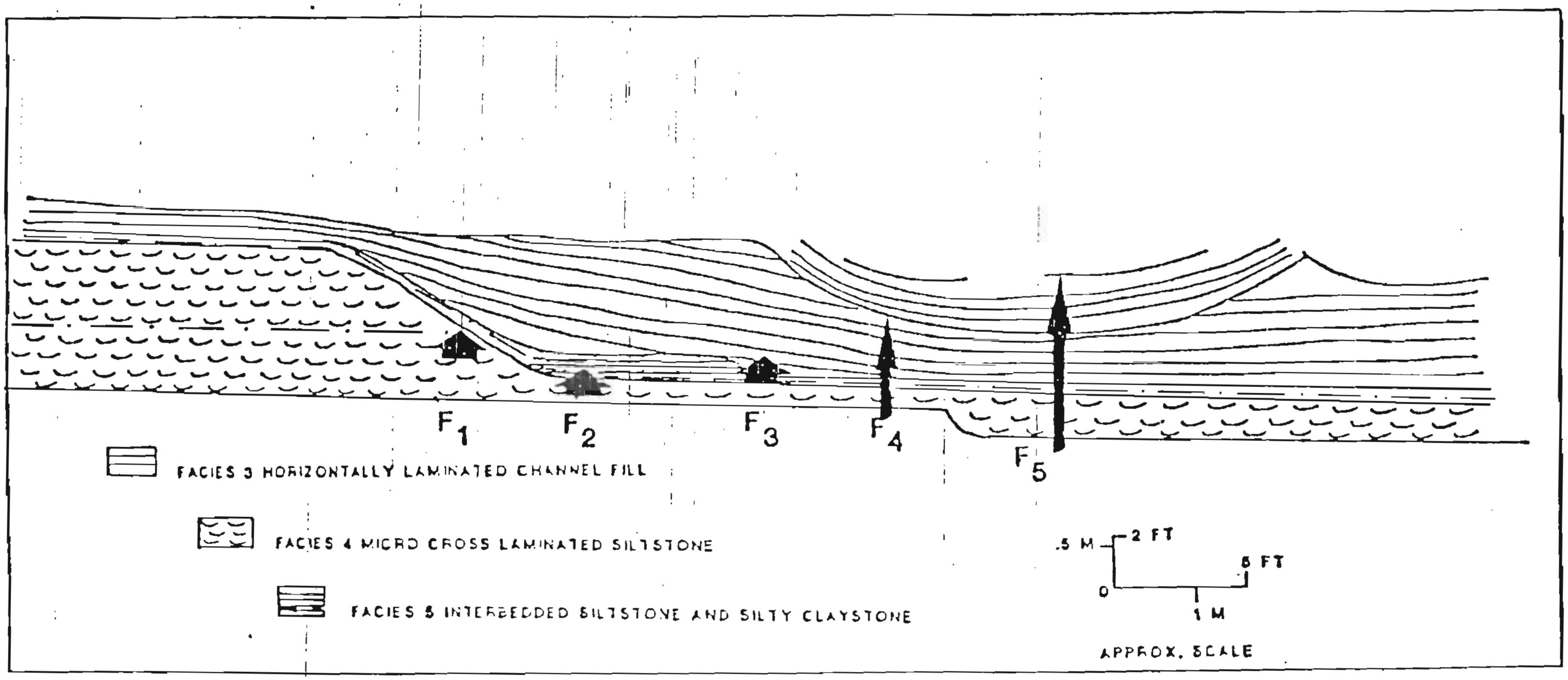


Figure 7 Example of nested channeling within Facies 3.

nested channeling which frequently occurs in Facies 3. There were apparently 4 distinct channel cutting and filling events within a distance of approximately 12 meters (40 ft). The first event eroded Facies 4 (Point F_1 in Figure 7). This channel was then filled to some extent by the relatively fine grained lithology of Facies 5 (Point F_2 in Figure 7, Plates 26 and 27). This filling was at some point re-excavated and replaced by the horizontal laminations of Facies 3 (Point F_3 in Figure 7, see Plate 27). A much smaller channel, approximately 6 m (20 ft) in width, was subsequently carved into this channel fill and was itself filled with the relatively thin lamination of Facies 3 (Point F_4 in Figure 7, Plate 28). Another, smaller, channel was then eroded into this fill (Point F_5 in Figure 14).

The western (right half of a second cross section (Figure 8) shows Facies 2 and Facies 3 separated by a .5 meter (1.5 ft) covered interval and a .6 to .9 m (2 to 3 ft) exposure of Facies 4 (Point A in Figure 8). Facies 2, in this location, is composed of two siltstone units separated by: an erosional surface (Point B in Figure 8), a thin silty claystone (Point C in Figure 8) or a .3 m (1 ft) interval of thinly interbedded siltstone, silty claystone and claystone (Point D in Figure 8). Small

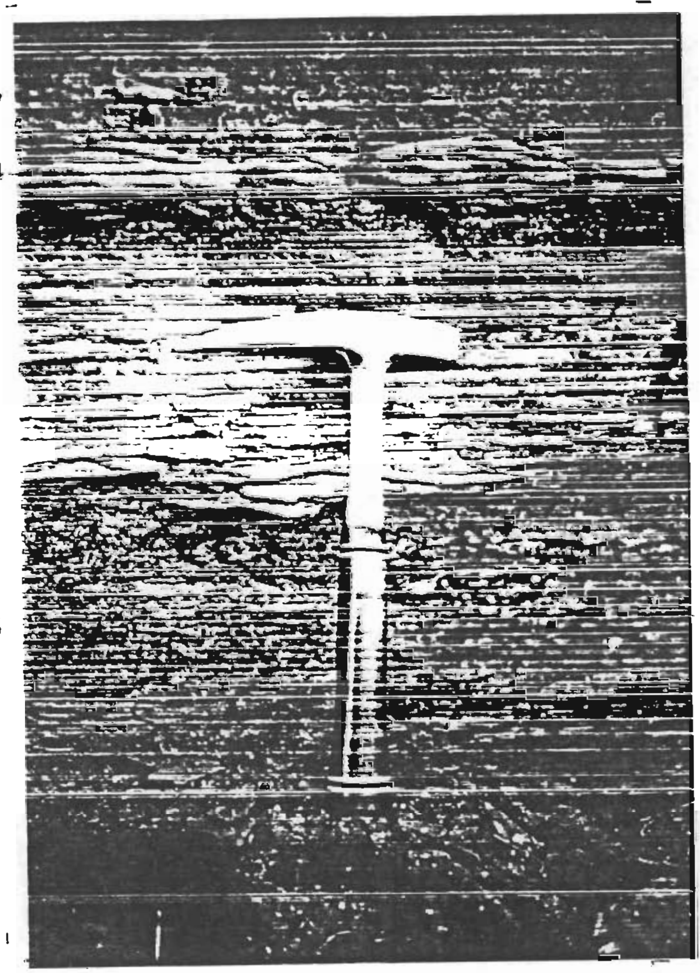


Plate 27 Close up of the fine grained channel fill and immediately overlying horizontally laminated siltstone. Upper half of the photograph shows a transition from horizontally laminated siltstone (Facies 3) to cross laminated siltstone (Facies 4) to silty claystone (Facies 7).

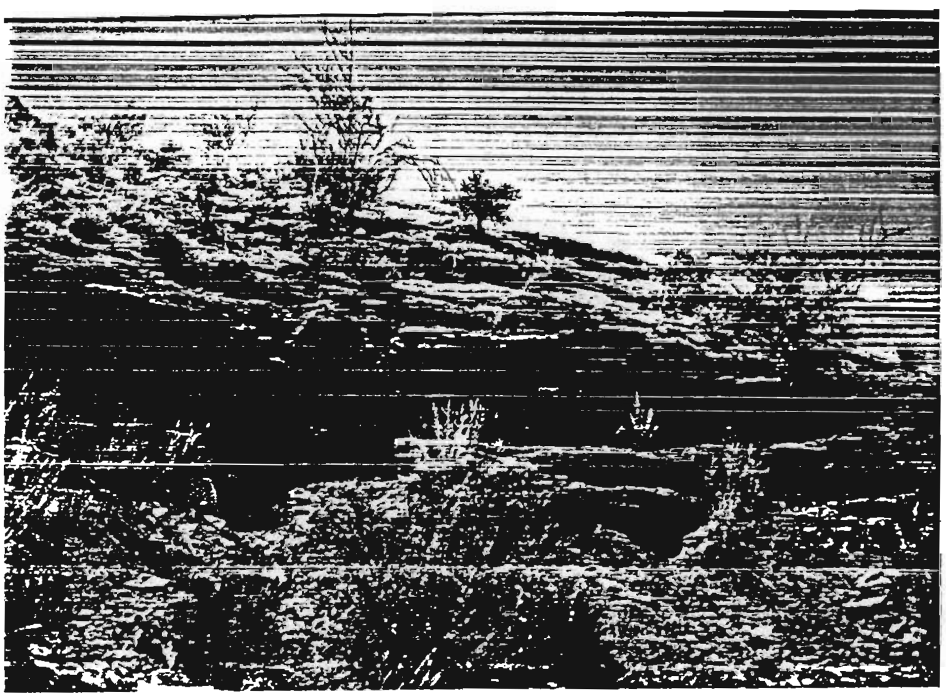
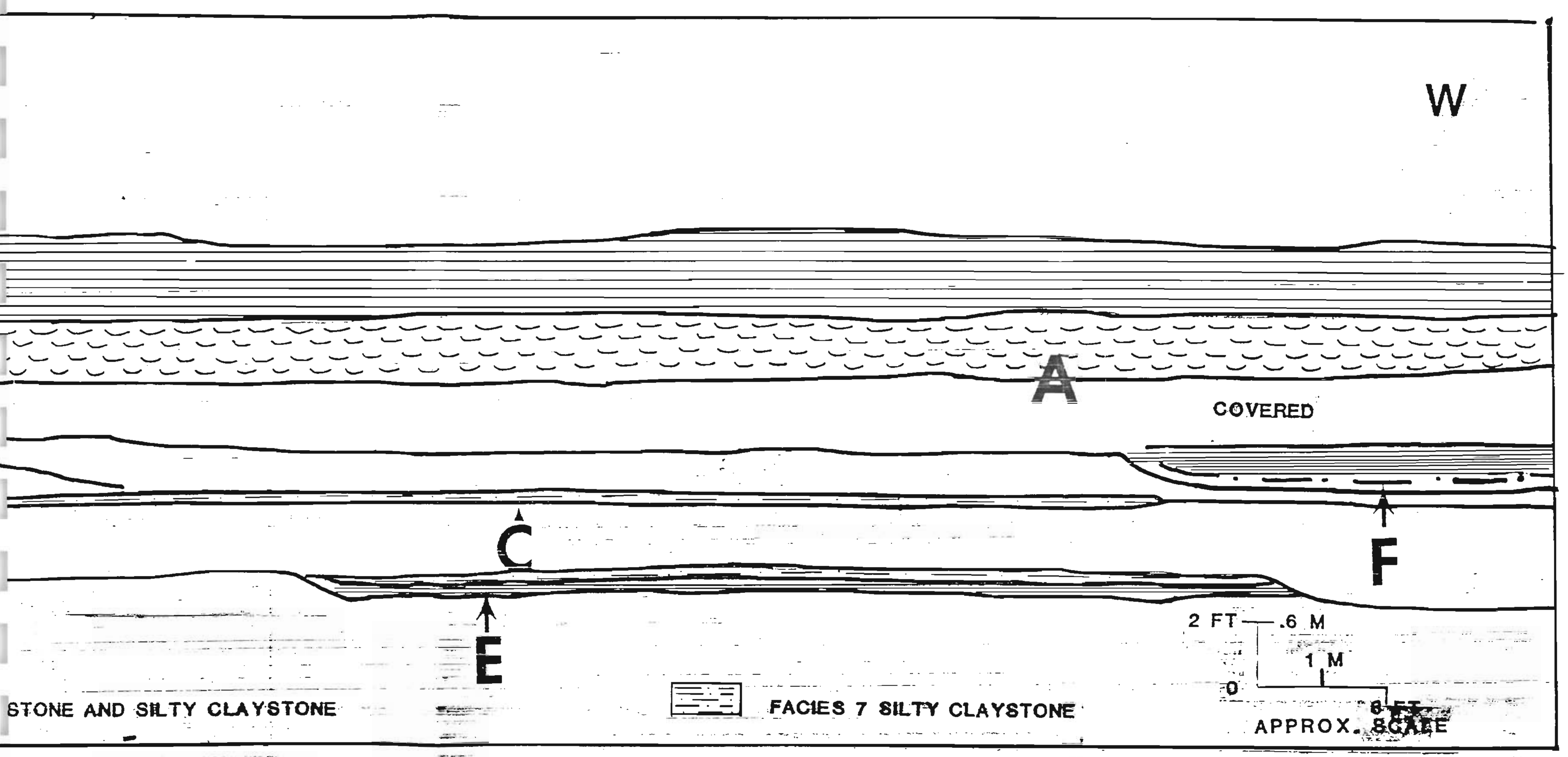


Plate 28 Channel [approximately 6 m (20 ft) in width] eroded into a previous channel fill (Point F_4 on Figure 7).



W
A
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.6 M
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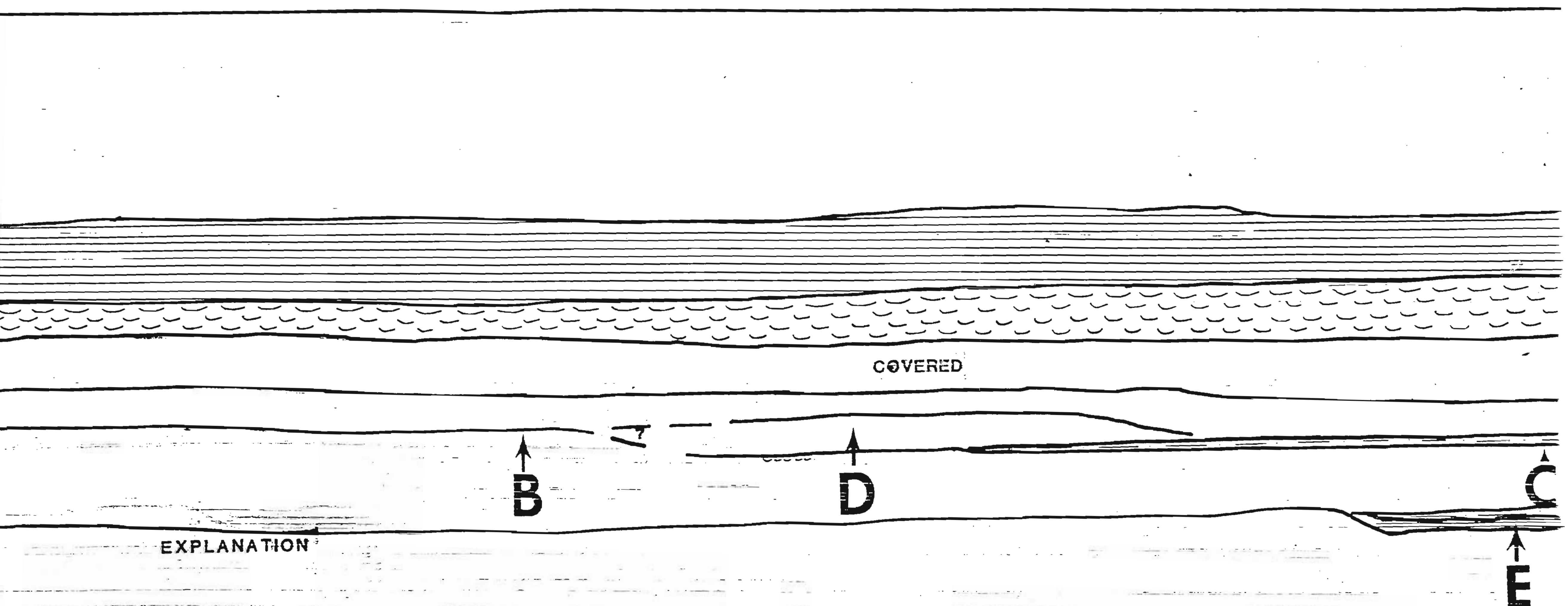
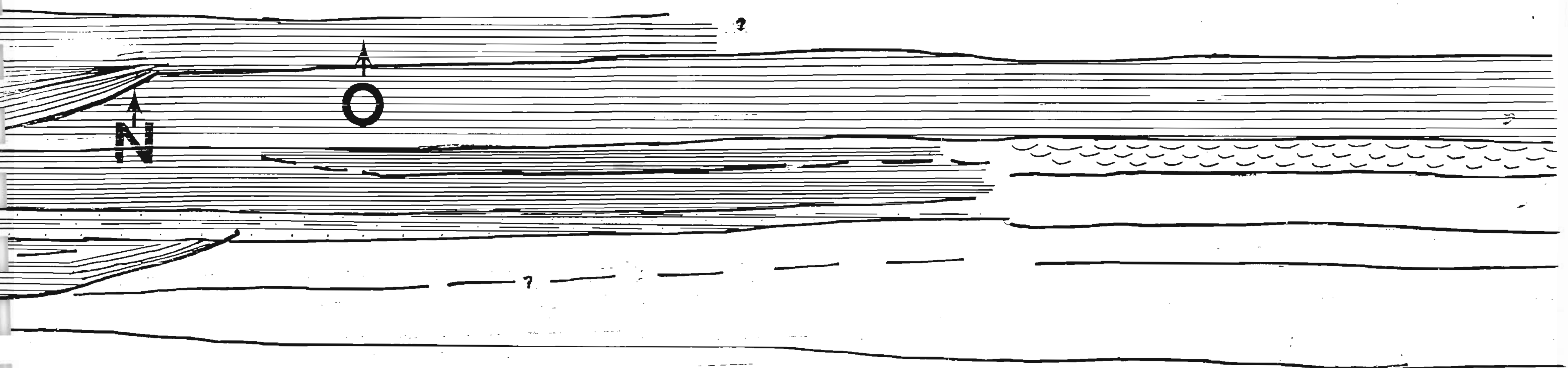
APPROX. SCALE
STONE AND SILTY CLAYSTONE
FACIES 7 SILTY CLAYSTONE



EXPLANATION

CROSS LAMINATED SILTSTONE

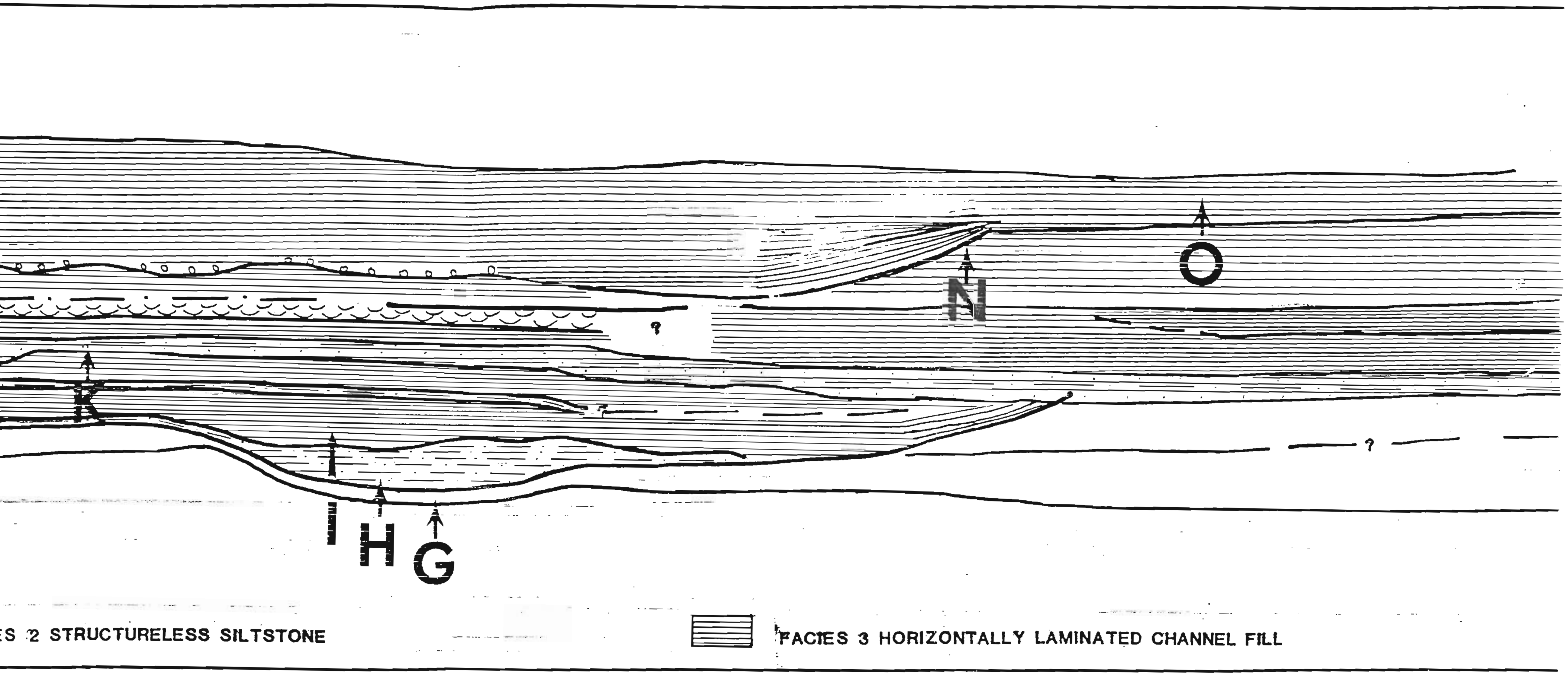
FACIES 5 INTERBEDDED SILTSTONE AND SILTY CLAYSTONE



EXPLANATION

ES 3 HORIZONTALLY LAMINATED CHANNEL FILL

FACIES 4 MICRO CROSS LAMINATED SILTSTONE



– west cross section of the Dewey Lake Formation.

channel fills underlie and overlie Facies 2 (Points E and F in Figure 8).

The eastern half of the section provides a striking example of the channalized nature of the Dewey Lake. The lower channel is approximately 24 m (80 ft) wide and 1.2 to 1.5 m (4 to 5 ft) deep at the center. It cuts out most of Facies 2 (Point G in Figure 8). This channel is interesting for two reasons. First it, like several others, has a distinctly stepped margin, seen most clearly on the left side. Second, it definitely had at least 3 distinct phases of filling. The first phase deposited silty clay in the deepest portion of the channel (Point H in Figure 8, silty claystone beneath hammer in Plate 29). The thin siltstone underlying the silty claystone in Plate 29 is the uneroded portion of Facies 2 (Point G on Figure 8). The draping of this silty claystone material onto the second step of the channel indicates that the stepped nature was in existence before this filling event. The second phase of filling deposited approximately .5 m (1.5 ft) of silt and 15 cm (6 in) of silty clay (Point I in Figure 8 and Plate 30, siltstone and silty claystone above hammer in Plate 29). This event appears to have almost filled the channel; however, it was probably still a shallow depression several inches deep. The third event

FACIES 3
(UNIT J ON
FIG. 8)

FACIES 7

FACIES 3
(UNIT I ON
FIG. 8)

FACIES 7
(UNIT H ON
FIG. 8)

FACIES 2
(UNIT G ON
FIG. 8)

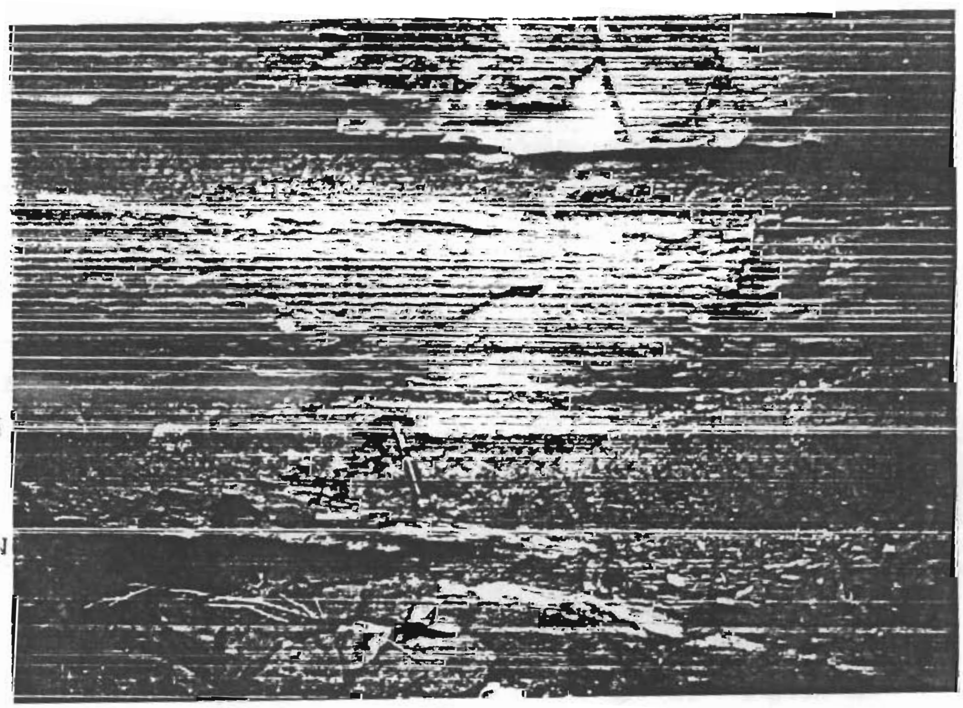
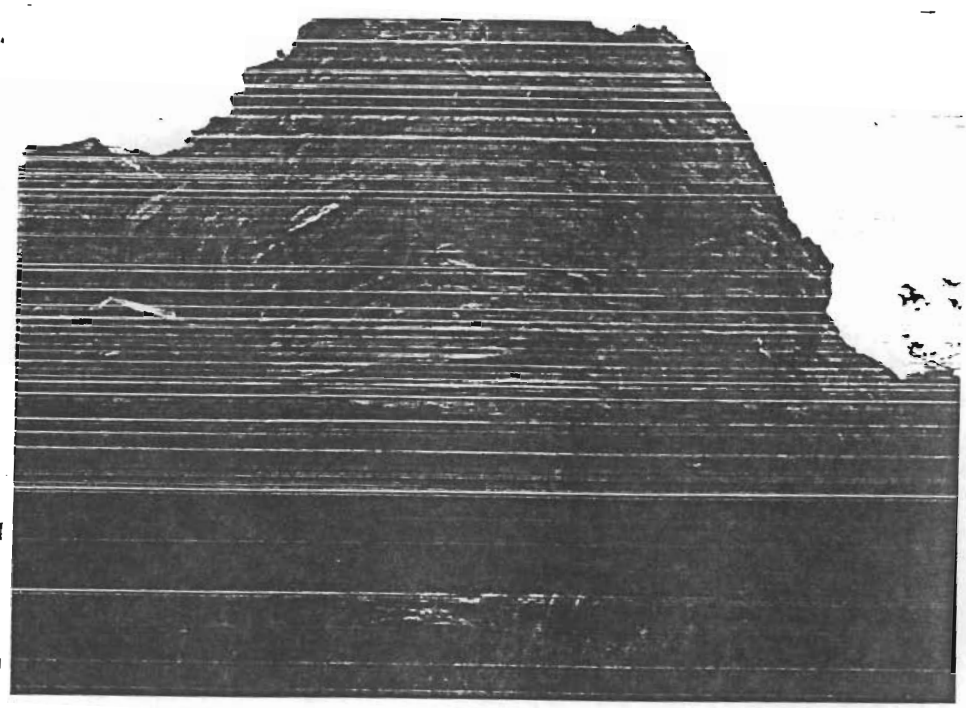


Plate 29 Channel eroded into Facies 2. See text for a detailed discussion of this plate.

FACIES 3
(UNIT J ON
FIG. 8).

FACIES 2
(UNIT G ON
FIG. 8)



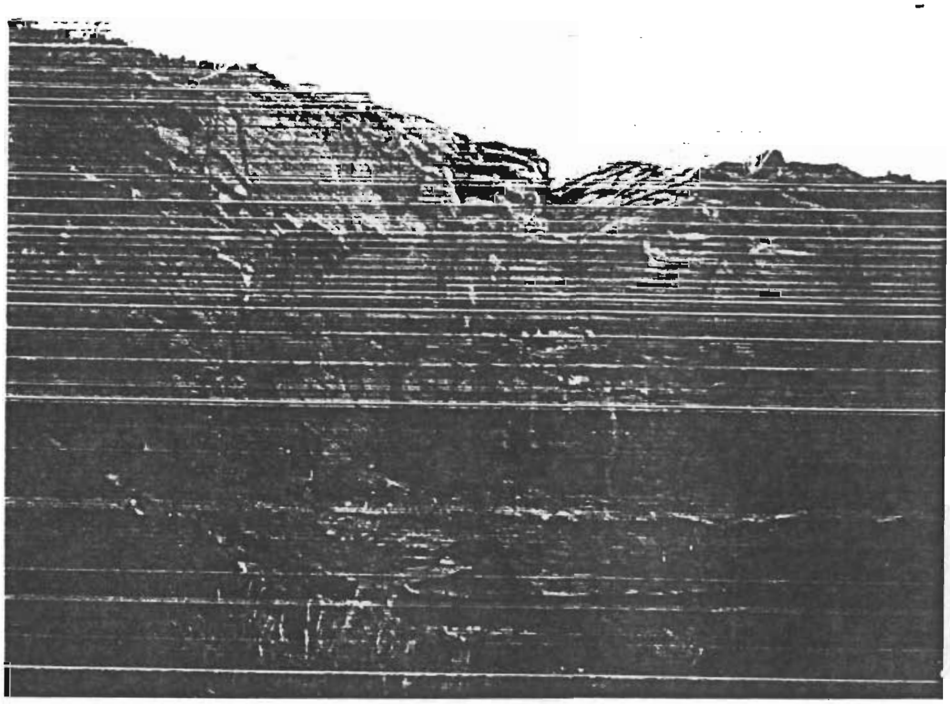
UNIT I ON FIG. 8

Plate 30 Left margin of channel shown in Plate 29. See text for a detailed discussion of this plate and its relationship to Plate 29.

filled the channel and deposited a "wing" to the east (Point J in Figure 8 and Plate 30, uppermost siltstone in Plate 29).

After the lower channel was filled, the area continued to aggrade. Several feet of interbedded silt and silty clay were deposited (i.e. Facies 5) (Point K in Figure 8 and Plate 31). After that 3 distinct beds of silt were deposited (Facies 3?). Each is .3 to .4 m (1 to 1.5 ft) thick and separated from the others by an erosional surface or a silty claystone bed (Point L in Figure 8, and Plate 31). The lower and upper units are composed of fine horizontal laminations while the middle unit consists of ripple lamination followed by convoluted bedding. These beds cannot be traced to the western portion of the exposure, therefore, their lateral extent in this direction is unknown.

The upper portion of the eastern half of this section exposes one of the largest channels in the Maroon Cliffs. It is 1.5 to 2.1 m (5 to 7 ft) deep and at least 15 m (50 ft) wide (Unit M in Figure 8 and Plate 31). The channel surface has a relief of several centimeters and contains numerous claystone clasts. The channel fill consists entirely of the fine horizontal laminae of Facies 3. Some laminations drape the right hand margin of the channel



FACIES 3
(UNIT M ON
FIG. 8)

UNIT L

FACIES 5
(UNIT K ON
FIG. 8)

FACIES 3
(UNIT J ON
FIG. 8)

Plate 31 Strata overlying the channel pictured in Plates 29 and 30.

(Point N in Figure 8). The channel fill overflows this margin and continues for an unknown distance (Point O in Figure 8).

A third east - west cross section of the Dewey Lake (Figure 9, Plate 32) displays a shallow channel (margin indicated by arrow) completely filled by horizontally laminated siltstone/fine sandstone. This channel fill overflows the margin to create a rapidly thinning wing - like structure. This "wing" eventually becomes incorporated into Facis 5. The inacessibility of this "wing" prevented the author from determining its bedding structure; however, it is very likely that it is composed predominantly of the micro - cross laminated siltstone of Facies 4.

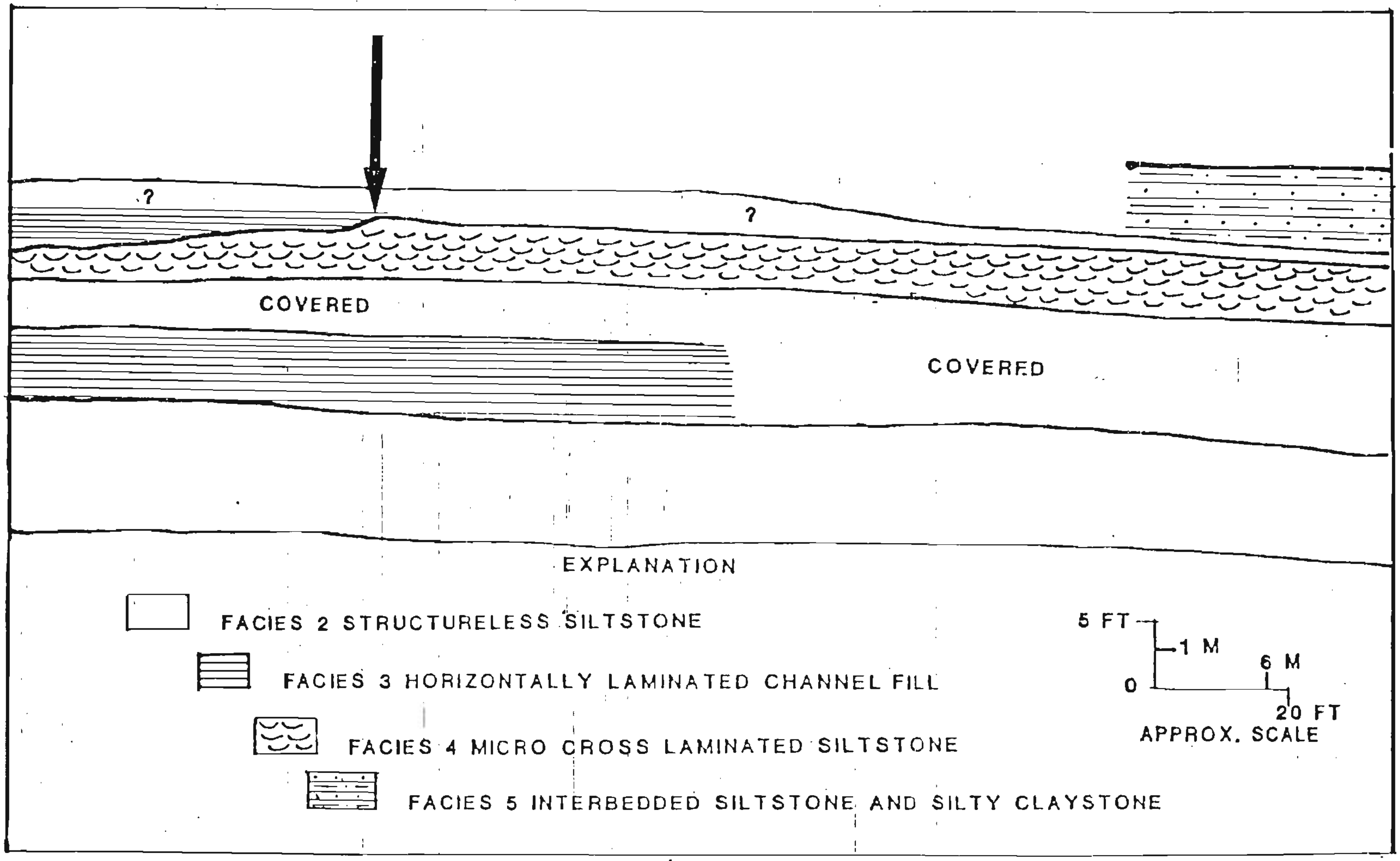


Figure 9 A third east - west cross section of the Dewey Lake Formation.

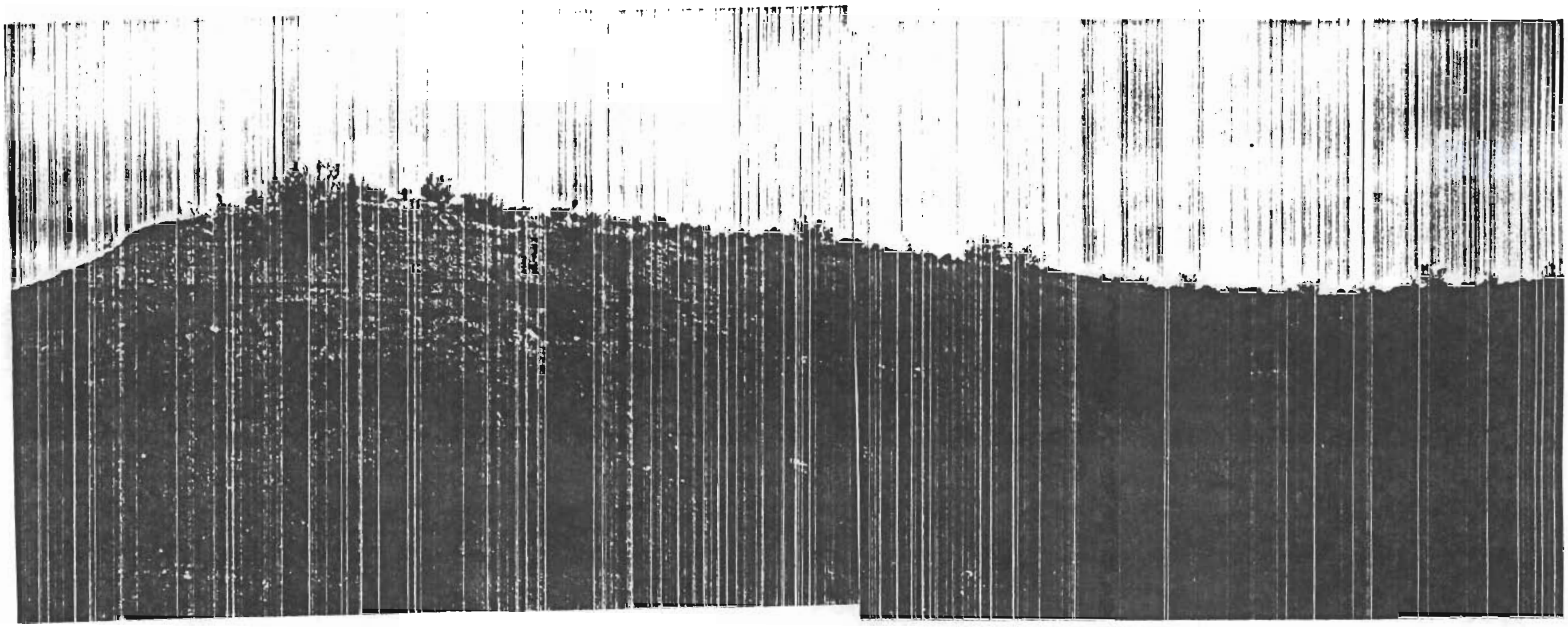


Plate 32 Section sketched in Figure 9. The arrow in this plate corresponds to the arrow in Figure 9.

Facies Analysis

Facies 1 and 3

The horizontal laminations comprising Facies 1 and 3 had been interpreted by Miller (1955, 1966) to represent varve - like sedimentation from a large body of water. The fact that in most cases these horizontal laminations appear to be filling channels effectively eliminates this hypothesis. Two other alternative are that the horizontal laminations were formed on a lower or upper stage plane bed. The silt to fine sand comprising most of the Dewey Lake rules out the former because it is not known to exist in sediment with a diameter less than .7 mm (Figure 10). We are, therefore, left with the conclusion that the horizontal laminations in Facies 1 and 3 were formed on an upper stage plane bed. This does not, however, automatically translate into extremely rapid velocity or high stream power. The transition, in relatively fine material, from ripples to upper plane bed occurs well within the dune subfield of slightly coarser sediment (Figure 10).

The single exposure of Facies 1 in locality A revealed horizontal laminations throughout; however, an exposure of

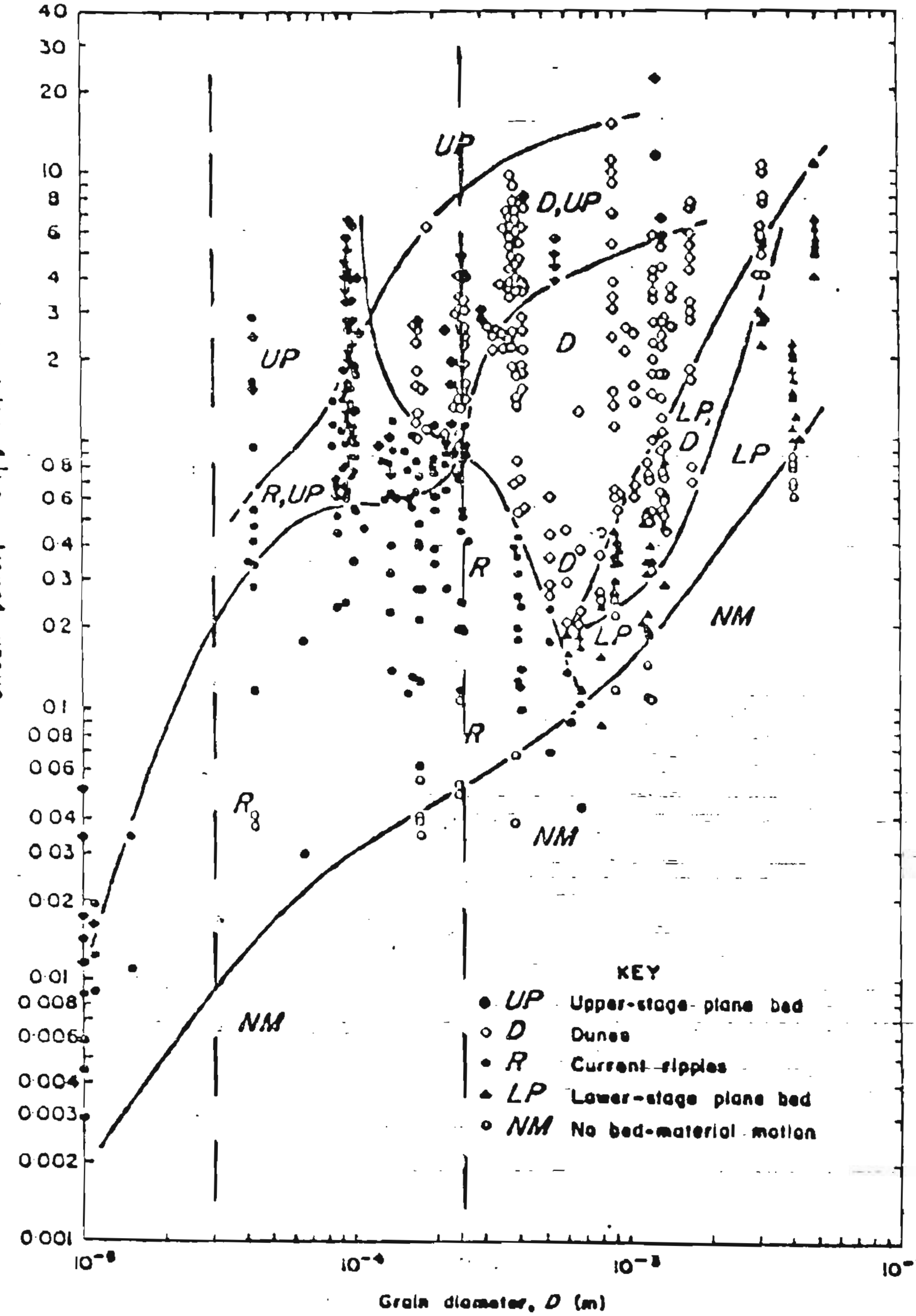


Figure 10 A stream power vs grain diameter bed form diagram (from Allen, 1982). The area between the dashed lines designates the grain size comprising the Dewey Lake in Locality A.

Facies 1 in locality B contained a single cross laminated set approximately 20 cm (8 in) thick (Plate 22). There is the possibility that this set is an example of antidune cross bedding.

Blatt, Middleton and Murray (1980) outline 3 characteristics which they believe are diagnostic of antidune cross bedding. They are: 1) the low dip of the cross laminae (less than 10 degrees) 2) the association with planar lamination formed in the upper flow regime and 3) the inclination of the cross laminae in a direction generally opposite to that of other paleocurrent indicators. The set in Plate 22 appears to meet all three of these qualifications: 1) the dip of the laminae within the set is certainly much lower than the angle of repose for fine sand, 2) the set is clearly associated with horizontal / planar lamination (i.e. immediately above) which are believed to have been deposited in the upper flow regime, and 3) the cross laminae appear to dip to the southeast, which is the opposite of the northwest current direction indicated by the tabular cross beds a few feet below.

If the segment containing the cross set does represent high velocity conditions it could explain two observations: the relatively structureless nature of the unit and the convolute bedding at its lower boundary. Flume experiments indicate that the antidune cross bedding is very faint (Middleton, 1965) (Figure 11). Middleton (1965) stated that "It seems very probable that after diagenesis many of the faintly cross laminated units would appear completely massive". This could be the reason that approximately .6 m (2 ft) of the siltstone at the base of the upper section appears structureless. The convolute bedding in this unit is restricted to that region immediately below the structureless portion (see Figure 5). A rapid increase in flow velocity could have been the cause of the shear which disturbed the bedding.

The horizontal laminations comprising Facies 3 were likely deposited in channalized flows. Facies 1, however, does not appear to contain channeling of any sort. This could indicate that the flow which deposited Facies 1 was unchannalized or that it was deposited in an extremely large channel, the margins of which are not exposed. I believe that the latter is more likely.

Facies 2

Facies 2 generally appears structureless; however, there are faint suggestions of horizontal and cross

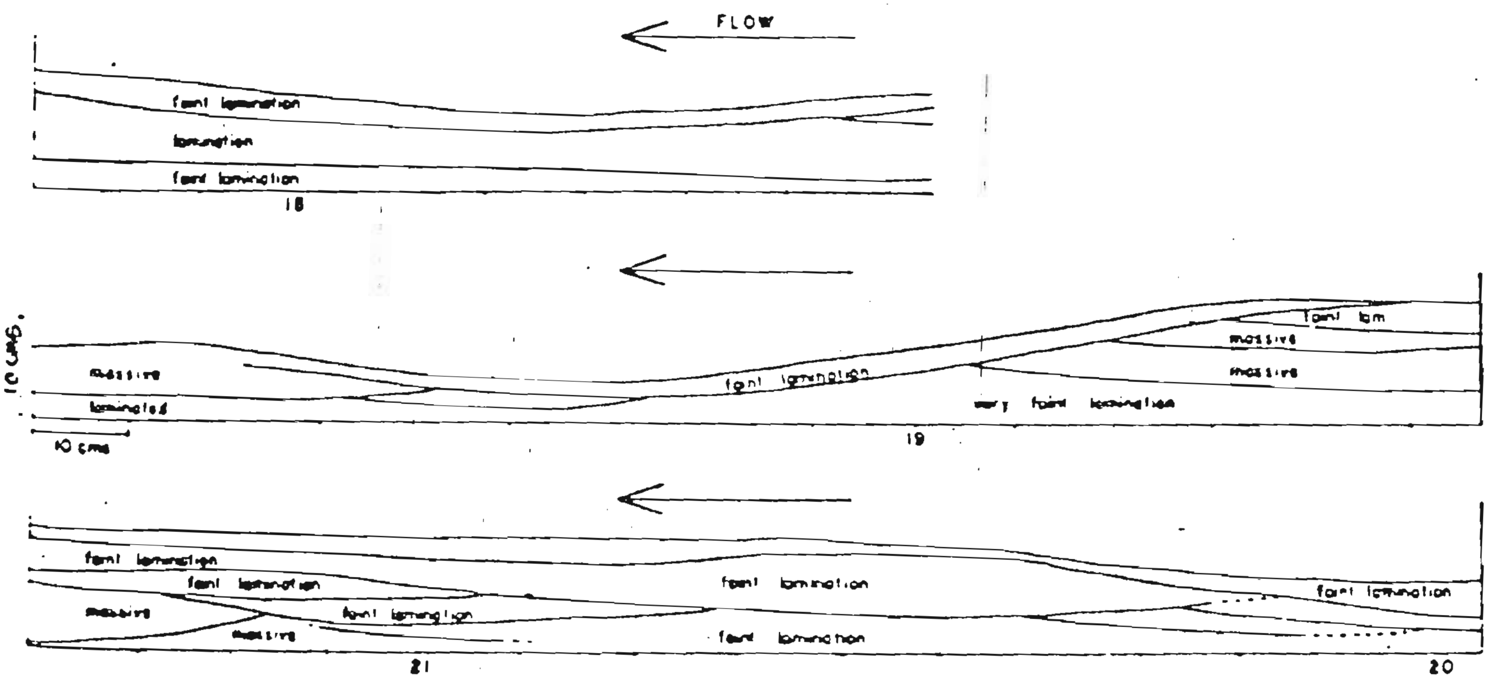


Figure 11 Sketch of antidune lamination from a flume experiment (from Middleton, 1965). The numbers along the bottom of the sketch indicate the distance in meters from the flume entrance.

laminations [sets appear to be approximately 10 cm (4 in) thick]. The generally structureless appearance of Facies 2 could be the result of rapid deposition (there are, however, other possible causes), while the presence of faint cross lamination indicates that the sediment size was just large enough to allow the formation of small dunes (Figure 10). The existence of both cross and horizontal laminations suggests a flow velocity/stream power near the boundary of dunes and upper flow regime plane beds (Figure 10).

Facies 4

The cross laminations within Facies 4 appear to be very similar, if not identical to the micro - cross laminations described by Hamblin (1961) from the Freda Formation (Precambrian) of northern Michigan. He believed that they formed on a floodplain through the migration and climb of cuspate shaped ripples. Observations from the Dewey Lake Formation support that conclusion.

Facies 5

The interbedded siltstone and silty claystone of Facies 5 suggest an environment which experienced periodic impulses of energy. This pattern, and a relatiely intimate relationship with Facies 4, indicates that Facies 5 was also deposited in a floodplain setting. The fact that the siltstone half of the couplet is rather thin while the silty claystone half is rather thick, as compared to Facies 4, suggests that it is representative of a more distal portion of the floodplain than Facies 4.

Facies 6

Facies 6 (interbedded siltstone and claystone) differs from the other facies in that its relatively high and low energy deposits are interlaminated on a very fine scale. This suggests that the environment was one which periodically received only minute pulses of evergy, possibly in the form of very thin sheet floods.

Facies 7

The fine grained nature of Facies 7 and the fact that it was seen filling a portion of a channel suggests that it was probably deposited from slow moving or ponded water.

Facies 8

The cross laminations which comprise Facies 8 are obviously a reflection of the slightly larger sediment size. The transition of trough cross lamination to tabular cross lamination (Figure 5) is indicative of decreasing flow velocity (Harms et al, 1975). The overall reduction in tabular set size from 20 cm (8 in) to 10 cm (4 in) (Figure 5) suggests that the reduction in flow velocity was accompanied by a decrease in flow depth. This evidence combined with the observation that single sets of tabular cross lamination were often seen overlying horizontally laminated sandstone suggests that Facies 8 was deposited in flows which were experiencing a decrease in both velocity and depth. The sequences within Facies 8 could, therefore, reflect a waning flood or possibly the migration of some type of point bar. The context of Facies 8 suggests that the former is more likely (see following two sections).

Comparison of the Dewey Lake Formation to Known Fluvial Models

The three fluvial models in use today are: meandering, anastomosing and braided. The meandering model is based upon the fact that the flow of water through a channel causes erosion of the outer bank and deposition on the inner bank or point bar. A decrease in water depth and velocity across the point bar results in a gradual reduction of both sediment and bedform size (Walker and Cant, 1984). The subsequent movement of the point bar, as the channel shifts, causes the finer sediment to overlie relatively coarse sediment. It is this lateral migration which creates the fining upward sequences that are associated with the meandering model (Walker and Cant, 1984). Sometimes the former gradually sloping surfaces of the point bars are preserved. These are termed lateral accretion surfaces or epsilon cross beds (Walker and Cant, 1984).

The Dewey Lake Formation appears to lack many of the charactistics commonly associated with the meandering model. The majority of the exposures in the Maroon Cliffs lack any type of obvious fining upward sequences or lateral accretion surfaces. The only exception is the relatively infrequent occurrence, in locality B, of Facies

8. I believe, however, that a more probable interpretation of Facies 8 is a waning flood deposit. The channel morphology displayed in the Dewey Lake (i.e. broad and shallow with laterally thinning wings) is also indicative of depositional processes quite different from those associated with the meandering model.

An anastomosing river is "an interconnected network of low gradient, relatively deep and narrow, straight to sinuous channels with stable bands composed of fine grained sediment (silt/clay) and vegetation" (Smith and Smith, 1980). These rivers would in the geologic record consist of "thick vertically accreted sand bodies bounded by wetland facies" (Walker and Cant, 1984). The anastomosing model does not appear to be applicable to the Dewey Lake Formation because it (the Dewey Lake) lacks these thick vertical sections of channel and overbank deposits.

The braided model is much more variable than either the meandering or anastomosing models. It has, in fact, been divided into 6 relatively distinct submodels (Miall, 1978). The Dewey Lake, with its abundant horizontal and ripple lamination, is most comparable to the Bijou Creek model. The Bijou Creek, located in Colorado, is an ephemeral stream subject to high velocity flood events. McKee et al. (1967) examined the deposits resulting from a

1965 flood and thereby provided the data for the model. They indicate that although the region studied was outside the channel, it was not a typical floodplain deposit. They state that

> Because the flow across the floodplain was essentially a downstream continuation of main - channel flow the resulting deposits were not characteristic of either typical channel deposits or of more normal floodplain deposits formed by the lateral spilling over channel banks.

It appears, therefore, that the Bijou Creek model is based upon a relatively unusual occurrence of a high velocity unchannelized flow.

The sedimentary structures in these sand sheets, which averaged .75 to 1 m (2 to 3 ft) in thickness, consisted of: 1) horizontal lamination, 2) climbing ripple lamination, 3) low angle forset bedding, and 4) convolute lamination. McKee et al. (1967) interpreted the horizontal lamination to be the result of "relatively high velocity currents of the upper flow regime". They believed that the climbing ripple laminae represented "a rate of water movement far below that of strcng floodwaters" and that they "commonly develop during the waning phase of a large flood." The low angle forset bedding occurred along the outer margin of the sand sheet, where the water velocity was reduced. The convolute bedding was interpreted by McKee et al. (1967) to have "developed during a late stage of the flood when current velocities had slowed down materially and sediment was in the condition of quicksand."

Although the sedimentary structures in the Bijou Creek appear to essentially mirror those found in the Dewey Lake, there are at least two differences between these units. First, the sediment transported by the Bijou Creek ranges from fine to coarse sand while most of the sediment comprising the Dewey Lake ranges from silt to fine sand. The transition to the upper flow regime occurs at much lower stream power in the finer grain sizes comprising the Dewey Lake (Figure 10). This suggests that the stream power represented by the horizontal lamination in the Dewey Lake could be significantly lower than that of the Bijou Creek. The second difference between these units is that the flow which deposited the horizontally laminated sand at Bijou Creek was apparently unchannelized; however, most of the horizontal lamination in the Dewey Lake appears to be filling channels.

Obviously, these differences indicate that the Bijou Creek is not a perfect model for the Dewey Lake Formation. The question then becomes, do these differences outweigh the overall similarity in the sedimentary structures and negate the general concept of a depositional system dominated by ephemeral flood events.

The Depositional Environment

The Dewey Lake Formation possesses a number of the characteristics found by other workers to be indicative of deposition in an ephemeral fluvial system. Turnbridge (1981, 1984) described parallel laminated sand in the Trentishoe Formation which filled channels and comprised thickly and thinly bedded sandsheets. He interpreted the channels to have been cut and deepened at high stage followed by relatively rapid infilling. He stated "Each channel fill may be regarded as a product of a single flood event with vertical infilling of shallow channels leading to the incision of new courses". Turnbridge (1984) interpreted the sandsheets to be laterally extensive unconfined flood deposits and indicated that "This facies represents a degeneration of channel flow into flood sheets analogous to many major flood events."

Turnbridge (1981) compiled (from his own work and the literature) a number of criteria which he believes are useful in the recognition of sandy high energy flood sedimentation. These criteria are shown below. [Turnbridge (1981) presented this information in paragraph form. I have, for convenience, listed the criteria numerically]

1) Parallel laminations are often the main, or only sedimentary structure found.

2) There is an absence of reactivation surfaces.

3) Rapidly declining flows may leave little trace of lower flow regime conditions.

4) Silt or mud drapes may be deposited at the final stage of the flood.

5) Individual deposits from ephemeral - flow events are on the order of 1 m thick, either filling channel forms if stream flood deposits or forming extensive sheets if unconfined.

6) Deposits at the lateral margin of sheet floods may thin and consists of interfingering sands and silts.

7) Vertical sequences will consist of multistorey sandstones consisting essentially of parallel laminated sands separated by erosion surfaces. Lateral - distal sequences may be represented by alternating sands and silts.

The Dewey Lake Formation appears to meet all of these criteria. Parallel laminations are the dominant sedimentary structure and there appears to be an absence of reactivation surfaces (criteria 1 and 2). There are several instances in the Maroon Cliffs where flow velocities appear to have dropped so rapidly that little or no time was spent in the lower flow regime (criterion 3) (i.e. the apparent absence of a feature is, however, not a particularly strong criteria because the possibility exists that it was initially present but subsequently eroded). Perhaps the best example of a possible rapid drop in flow velocity is the transition (in locality A) from Facies 1 (horizontally laminated siltstone) to Facies 7 (silty claystone). Numerous silty clay drapes in the Dewey Lake (i.e. thin silty claystone beds in Facies 4 and silty claystone portions of Facies 5) fulfill criterion number 4. Although not all of the "flood deposits" in the Dewey Lake are 1 meter thick [as indicated by Turnbridge (1981) in criterion number 5] there are several which reach and even exceed this value (i.e. Facies 1 and the large channel in the upper portion of Figure 8). The interbedded siltstone and silty claystone of Facies 5 would appear to satisfy criteria number 6 and there are numerous examples in the lateral sections which satisfy criterion number 7.

The Trentishoe Formation has a number of sedimentological features in common with the Dewey Lake Formation; however, it is the Beaufort Group (Stear, 1983) of South Africa, which appears to have similar morphologic characteristics. The channel sandstones in the Beaufort Group consist of a main or central body and lateral wings (Bersier, 1958, cited in Stear, 1983) (Figure 12). The central body is believed to be a channel fill, while the wings are thought to be thin overbank deposits (Williams, 1975, cited in Stear, 1983). Stear (1983) stated that

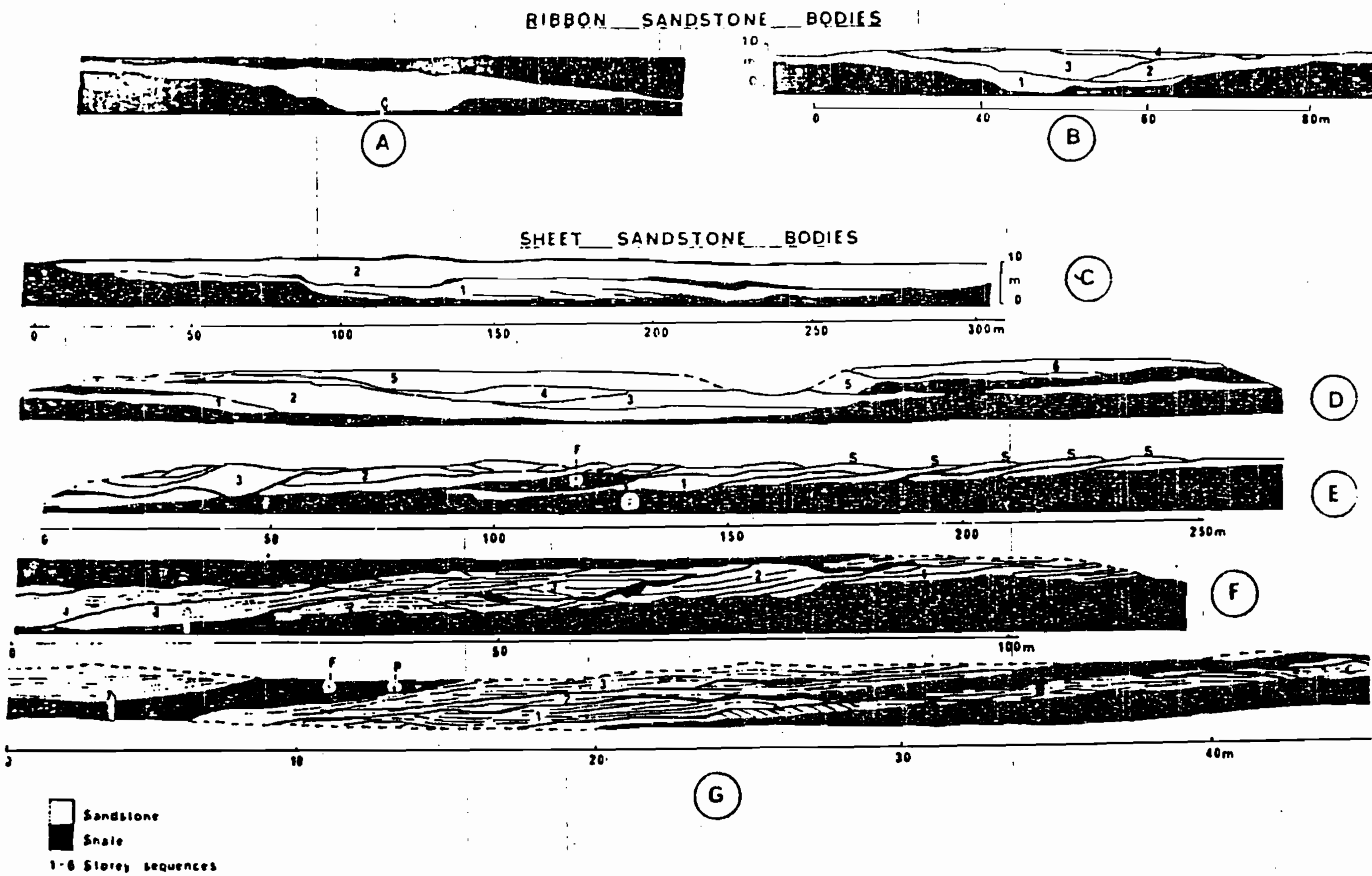


Figure 12 Example of ribbon and sheet sandstone bodies from the Beaufort Group (from Stear, 1983).

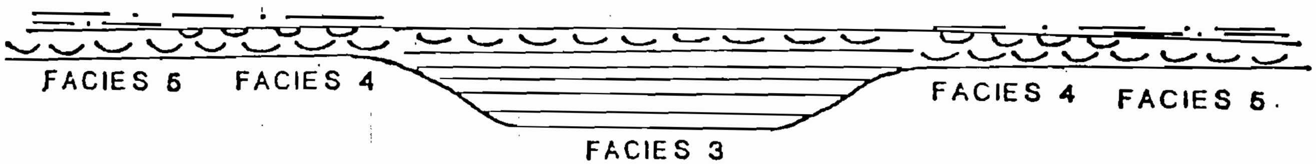
"Channelization was probably the initial form of flow but was accompanied in most cases by extensive sheet flooding outside the channels". He believed that "The morphology of channel and overbank splay sandstone bodies illustrates some of the diagnostic features of ancient fine - grained fluvial deposits in the ephemeral stream facies model".

The Dewey Lake Formation appears to fulfill both the sedimentologic and morphologic criteria for relatively fine grained ephemeral systems. Its depositional environment is, therefore, envisioned to have been a broad, arid and relatively featureless fluvial plain. Sediment from a major southeastern source was periodically eroded, transported and re - deposited by flash floods which swept through the area. Transport of the sediment across the plain was not continuous but instead occurred only sporadically. The relatively limited areal extent of each flood (both in a lateral and down current sense) meant that sediment transported by one flood might not be moved again for tens or even hundreds of years.

Facies Model

The depositional environment of the Dewey Lake is believed to have been a large and arid fluvial plain. Desert flash floods, caused by sudden downpours, would rush across some portion of the plain and carve broad shallow channels into the unconsolidated sediment. These channels would be filled, during the course of the flood, with horizontally laminated silt and fine sand (Facies 3) (Figure 13). The water would eventually flood onto the surrounding plain, experience a reduction in velocity and shape the sediment into cusp - shaped ripples (Facies 4) (Figure 13). Further away from the channel the velocity would be even slower. Only a small quantity of silt / fine sand would reach these more distal regions; the material which did would ultimately form the siltstone portion of Facies 5 (Figure 13). As the flood waned, silty clay would be draped over the entire region. It would be fairly thin close to the channel (forming the thin silty claystone units in Facies 4) but thicken substantially in the more distal areas (forming the silty claystone portion of Facies 5) (Figure 13). The overlap of thousands of these channels (both large and small) could easily create the fluvial architecture seen in the Dewey Lake Formation (Figure 14).

A FACIES MODEL FOR THE DEWEY LAKE FORMATION



EXPLANATION

FACIES 3 HORIZONTALLY LAMINATED CHANNEL FILL

FACIES 4 MICRO CROSS LAMINATED SILTSTONE

FACIES 5 INTERBEDDED SILTSTONE AND SILTY CLAYSTONE

Figure 13 A facies model for the Dewey Lake Formation.

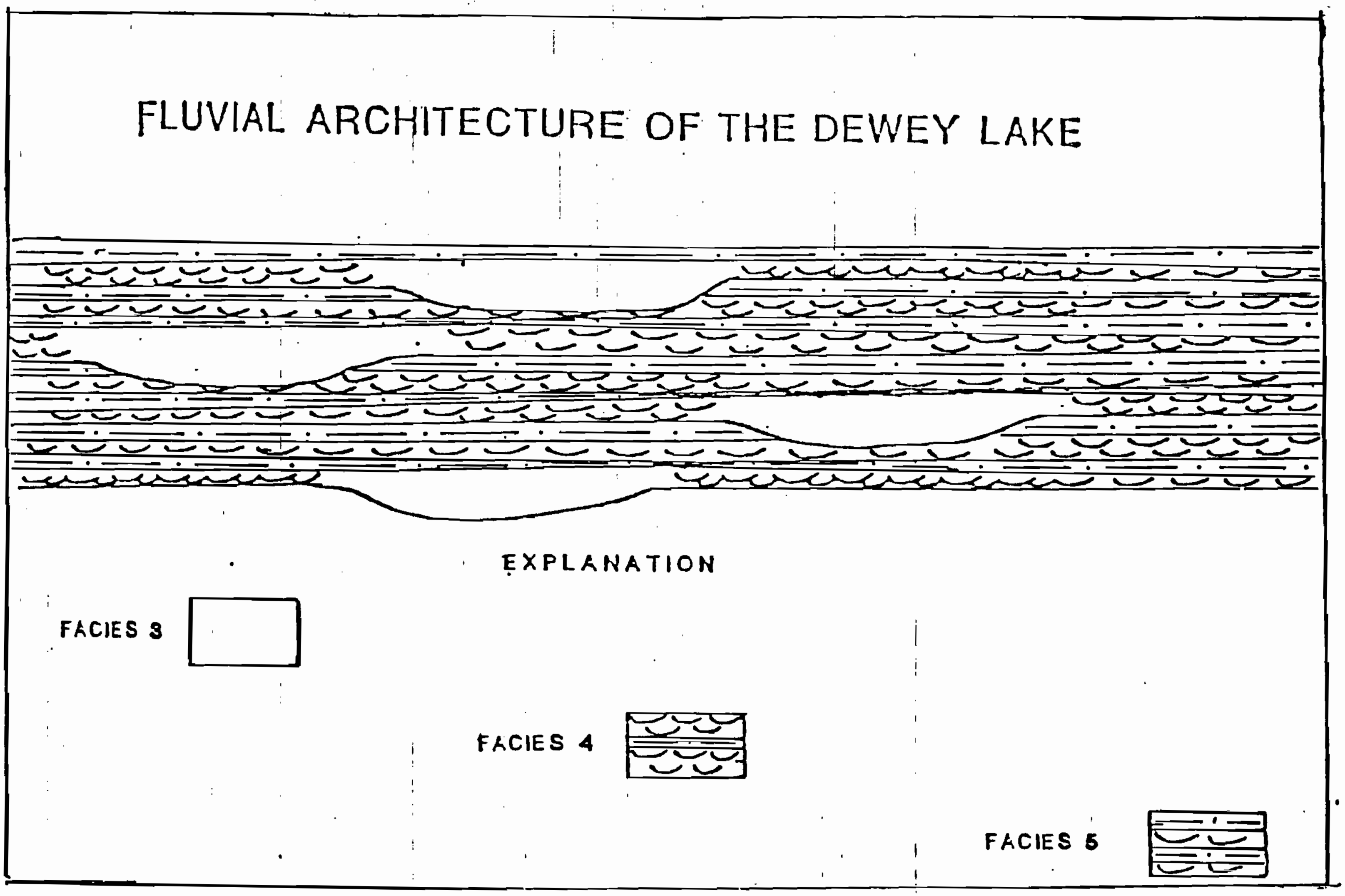


Figure 14 Fluvial architecture of the Dewey Lake Formation.

The model just outlined utilizes Facies 3, 4 and 5. It is necessary at this point to discuss how the other facies might fit into such a model. Facies 1 is believed to be a very thick and extensive channel fill. It would, therefore, on a much larger scale be equivalent to Facies 3. Facies 2 appears to be some type of channel fill. The fact that it lacks the horizontal lamination, so visible in other channel fills, suggests that the depositional conditions were somehow different. The thinly interlaminated siltstone and claystone of Facies 6 probably represent the very distal portions of flood sheets while the silty claystone of Facies 7 represents either an unusually thick drape (i.e. when it overlies Facies 1) or fine grained channel fill. Facies 8 is interpreted as a waning flood deposit which formed in sediment coarse enough to permit the formation of cross lamination.

Analysis of Gamma Ray Logs

The field exposures of the Dewey Lake Formation are fairly limited. In order to gain a more regional perspective on the unit it was necessary to utilize well logs. Approximately 600 gamma ray logs were examined from the region outlined in Figure 15; however, only that data from Lea County, New Mexico and Andrews and Ector Counties, Texas will be presented in this thesis. Plate 33 shows the location of all of the interpreted logs from Lea, Andrews and Ector Counties. The appendix provides the full name and precise location of each of these logs.

Description of Gamma Ray Units

The gamma ray signature above the Rustler Formation can be divided into four distinct segments (Figure 16). These units can be recognized on most logs throughout the study region (Figure 17).

Unit A is that segment immediately above the Rustler Formation (Figure 16). The gamma signature for this unit, which varies in thickness from 0 to 200 m (0 to 600 ft) is very irregular. Viewed as a whole it appears to show a very gradual fining upward trend. The upper boundary of

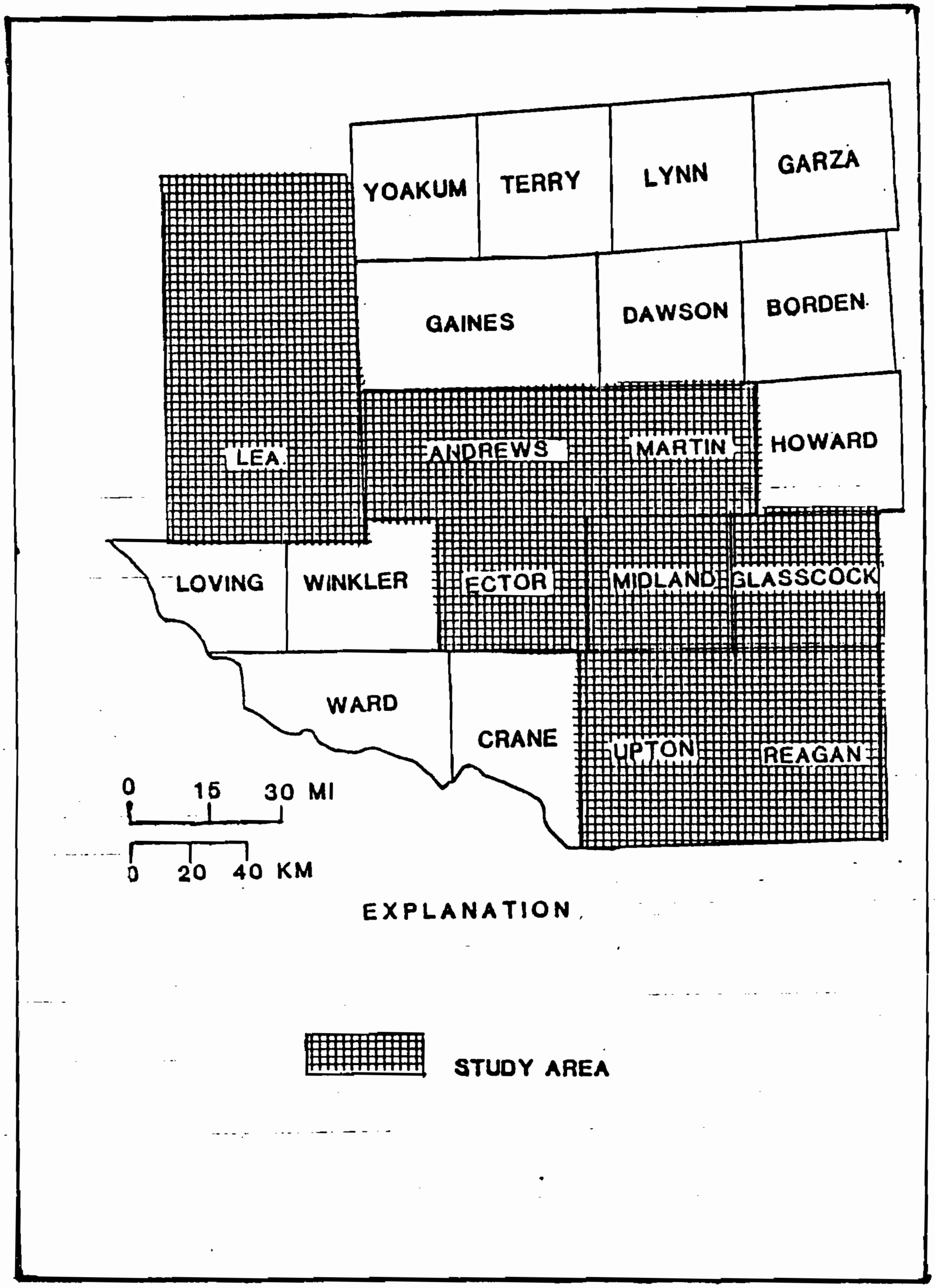


Figure 15 Well log study area.

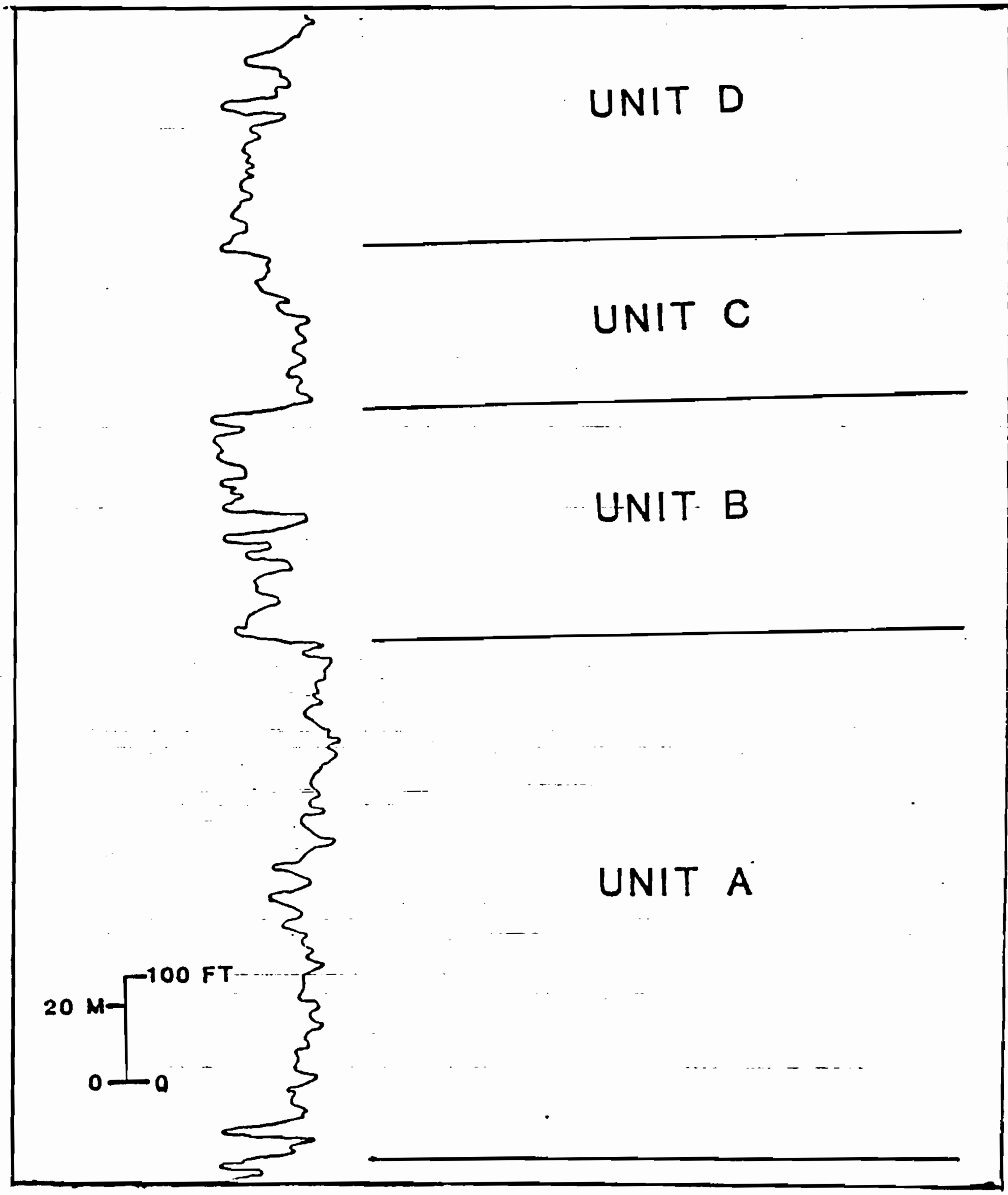


Figure 16 Gamma ray log segments above the Rustler Formation.

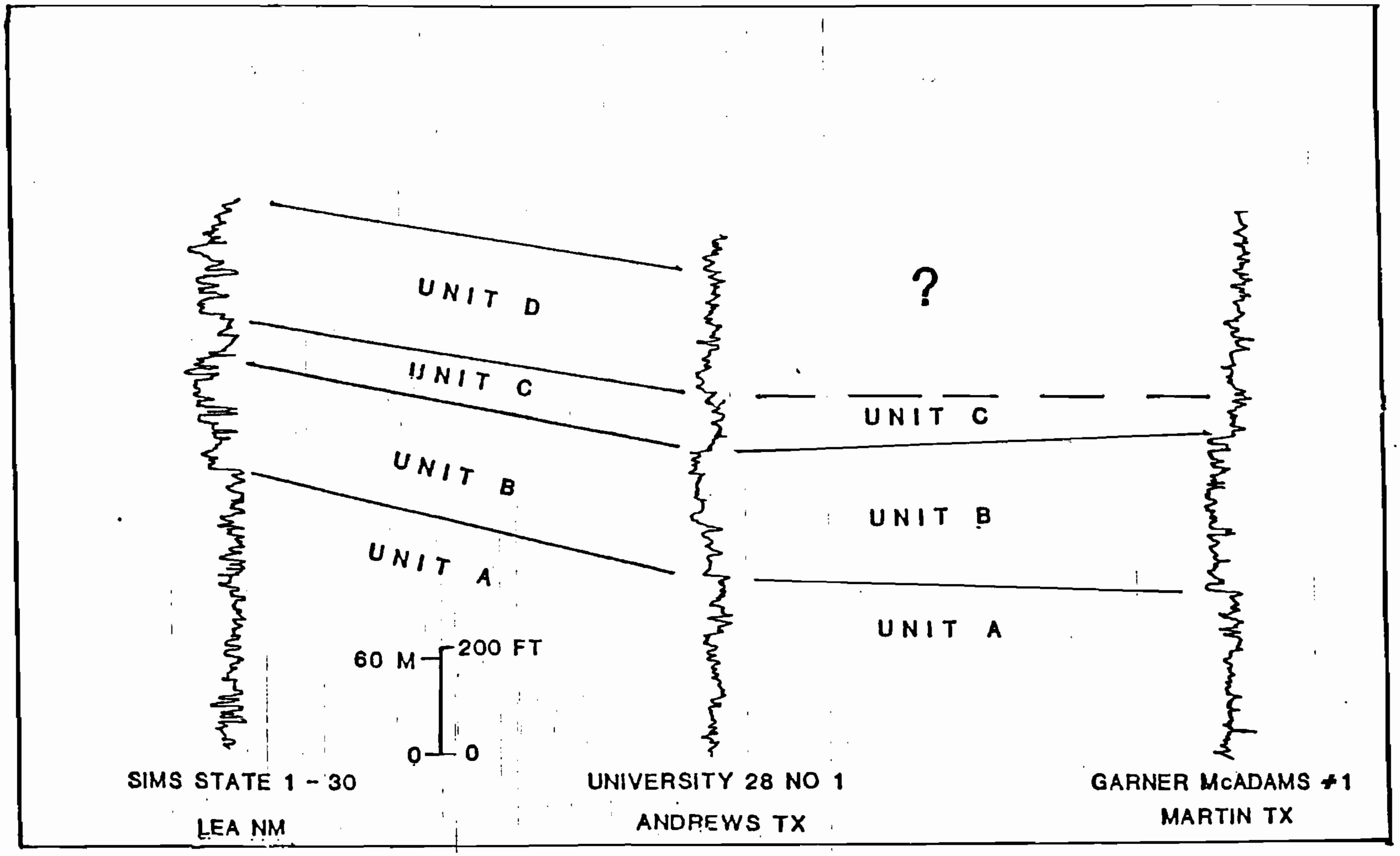


Figure 17 Gamma ray logs from Lea, Andrews and Martin Counties.

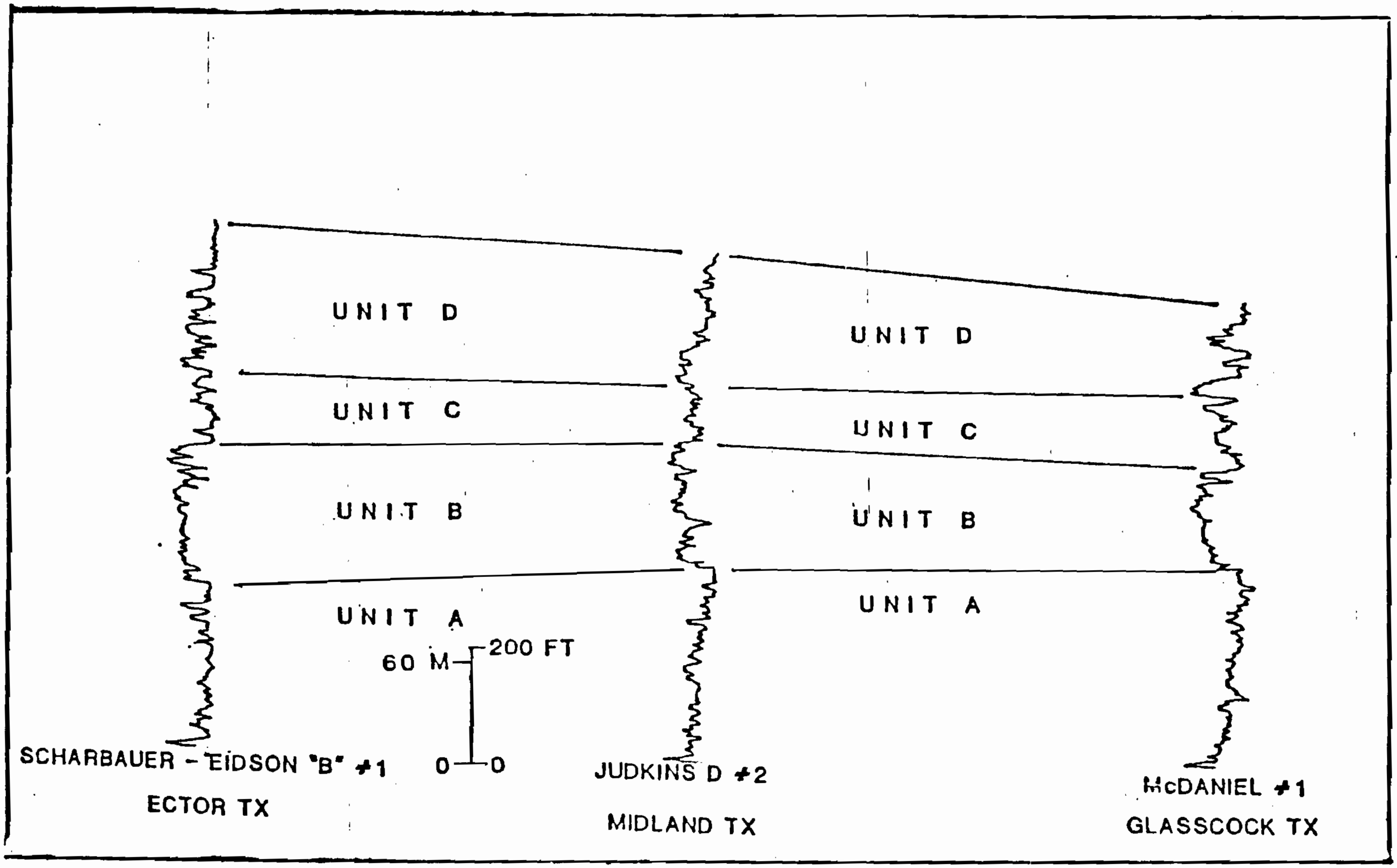


Figure 17 (Con't) Gamma ray logs from Ector, Midland and Glasscock Counties.

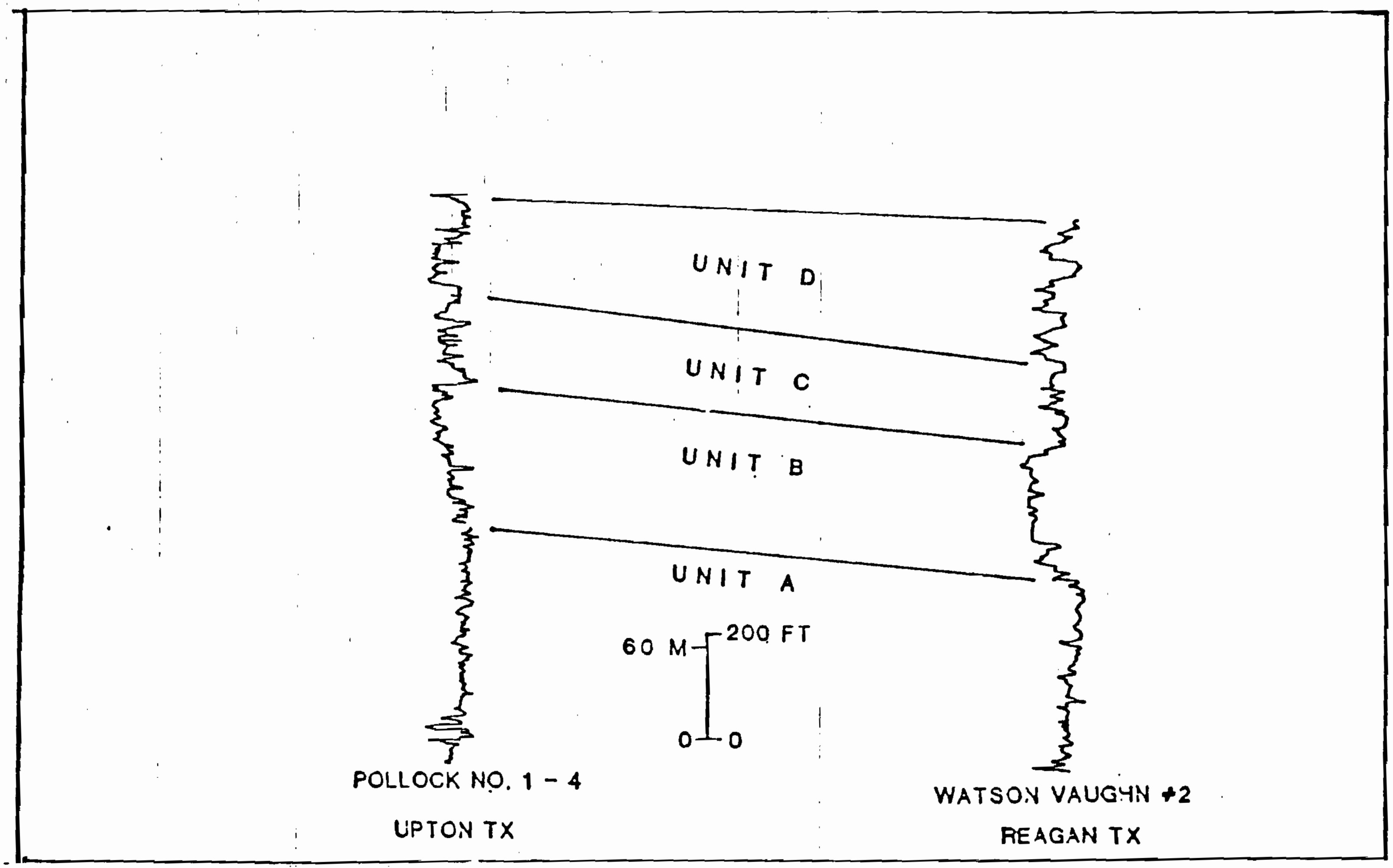


Figure 17 (Con't) Gamma ray logs from Upton and Reagan Counties.

this unit is the point at which the entire log signature shifts to the left. This shift is easily identifiable on almost every log in the study region.

Unit B extends from the top of Unit A up to the point at which there is a significant increase in the gamma readings (Figures 16 and 17). This unit, which varies in thickness from 50 to approximately 133 m (150 to approximately 400 ft) has a very distinct log signature and can easily be recongized on most logs in the region. It is most easily pictured as consisting of a low gamma baseline with one or more thin, high gamma spikes.

Unit C is the high gamma segment located between Units B and D. It varies in thickness from less than 33 to 100 m (100 to 300 ft) and is quite variable internally. Sometimes it has relatively little gamma variation (Figure 17); however, in other logs the upper and lower sections of the unit give high gamma readings while the central portion contains one or more zones of relatively low gamma.

Unit D is the relatively low gamma segment above Unit C. It varies in thickness from less than 33 m (100 ft) to a little over 100 m (300 ft) and is internally quite variable. On some logs there is little gamma variation; however, on others there are several relatively large swings in the radiation values.

Identification of Gamma Ray Units

Page and Adams (1940) described the Dewey Lake Formation from the well cuttings of Penn's Habenstreit No. 1, located in Glasscock County (Blk 36, Twp 3S, section 47). This well is bracketed by two well logs utilized in this study: TXL C #1 and W. H. Clark #1 (Figure 18). The two hundred and sixty feet of red siltstone and fine sandstone described by Page and Adams in Penn's Habenstreit No. 1 coincides fairly well with the 123 m (396 ft) and 104 m (313 ft) of Unit A present in TXL C #1 and W. H. Clark #1 (Figure 19). The approximate thickness equivalence combined with its stratigraphic position above the Rustler suggests that Unit A is the Dewey Lake Formation.

No one (to the author's knowledge) has ever attempted a correlation of the gamma ray units in southeastern and northeastern New Mexico. It is generally assumed that it is not possible. However, comparison of gamma ray logs from Lea and Quay Counties, New Mexico (Figure 20) reveals that gamma ray units can, in fact, be correlated very easily from north to south. Unit B appears to be equivalent to the Santa Rosa Formation while Units C and D appear to be the Lower Shale and Cuervo Sandstone Members of the Chinle Formation.

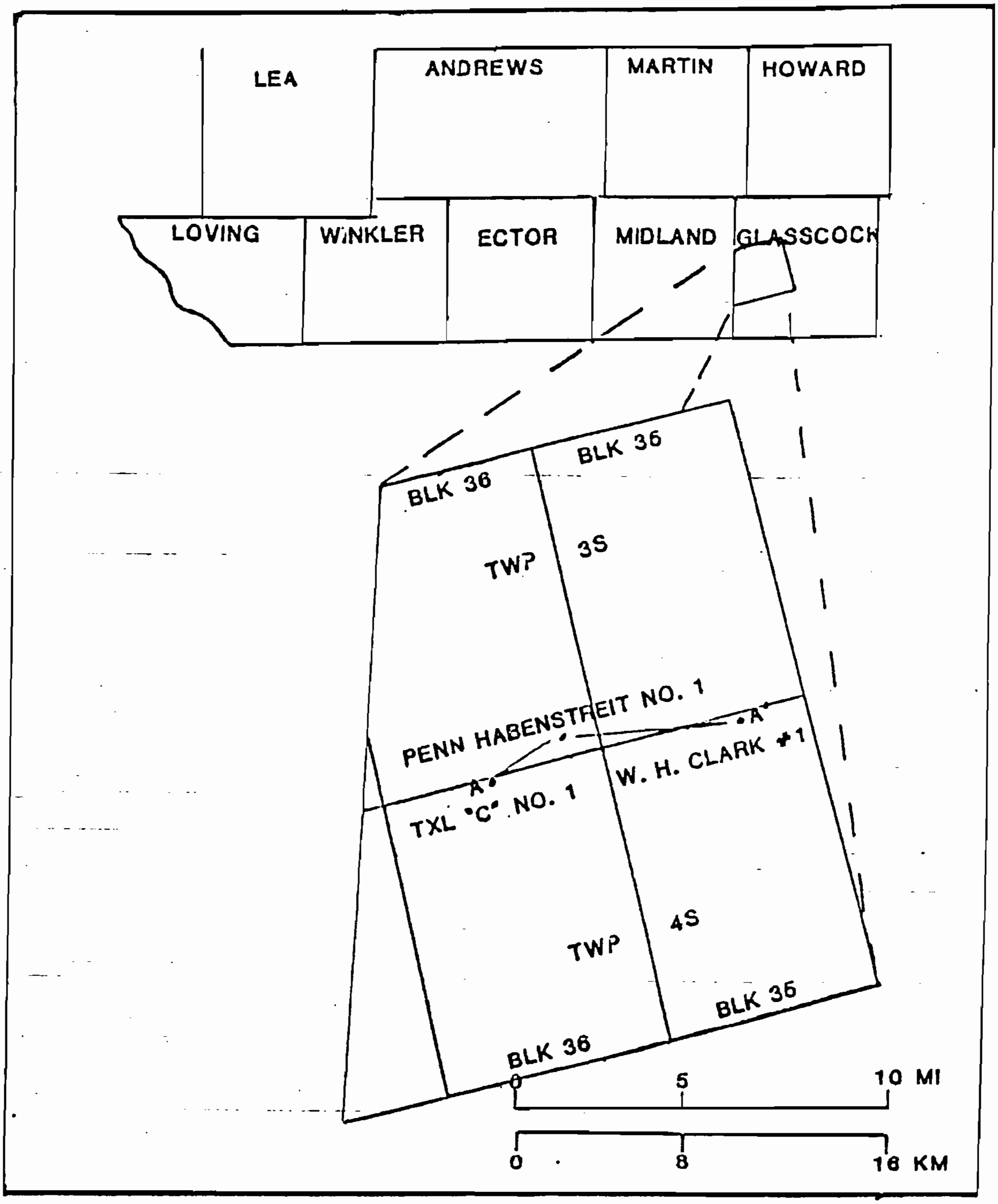


Figure 18 Location of Penn Habenstreit No. 1 with respect to Txl "C" No. 1 and W. H. Clark #1.

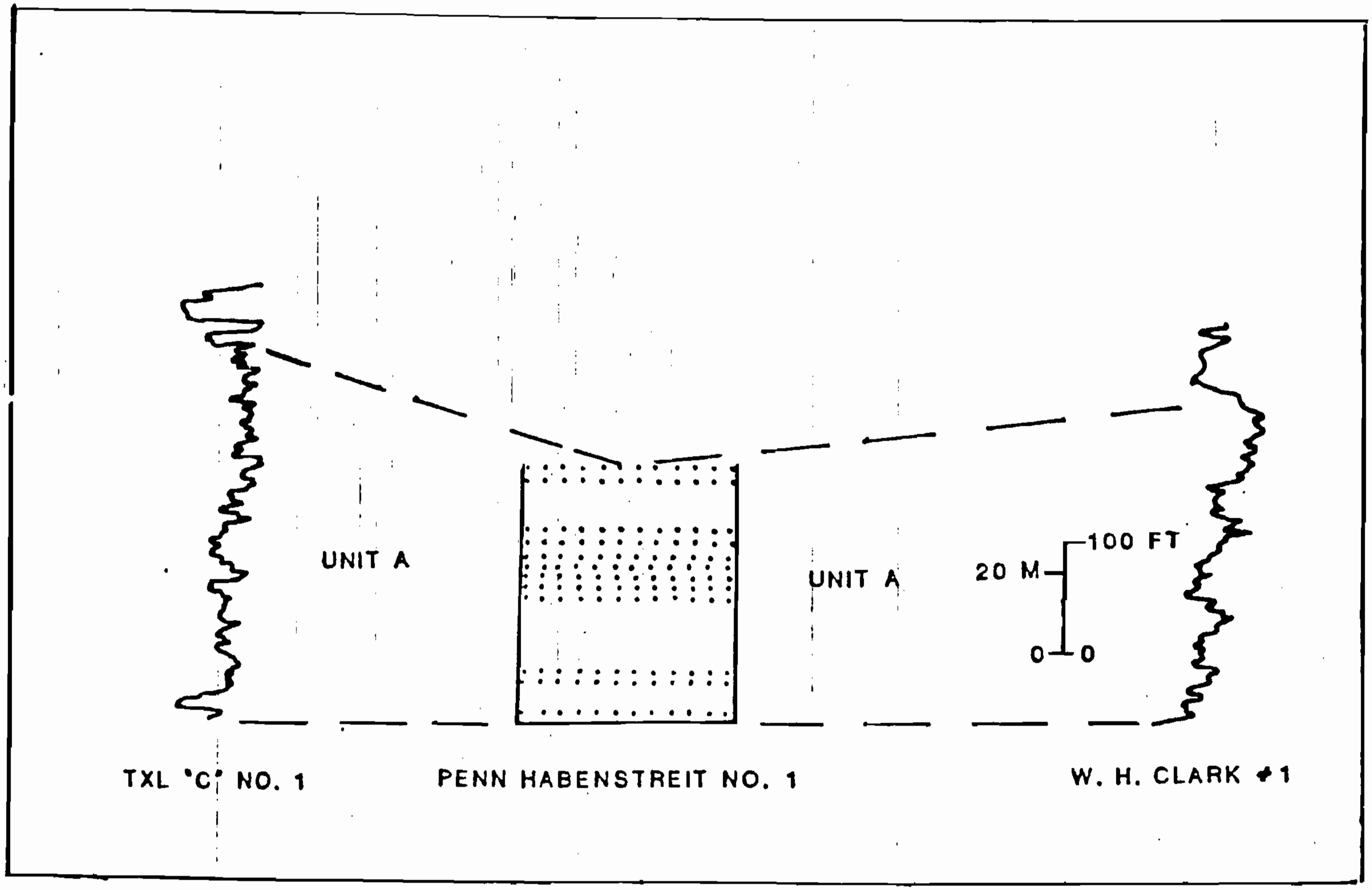


Figure 19 Cross section indicated in Figure 18. Stippled pattern in Penn Habenstreit section represents siltstone/fine sandstone. Blank spaces represent gaps in the well log.

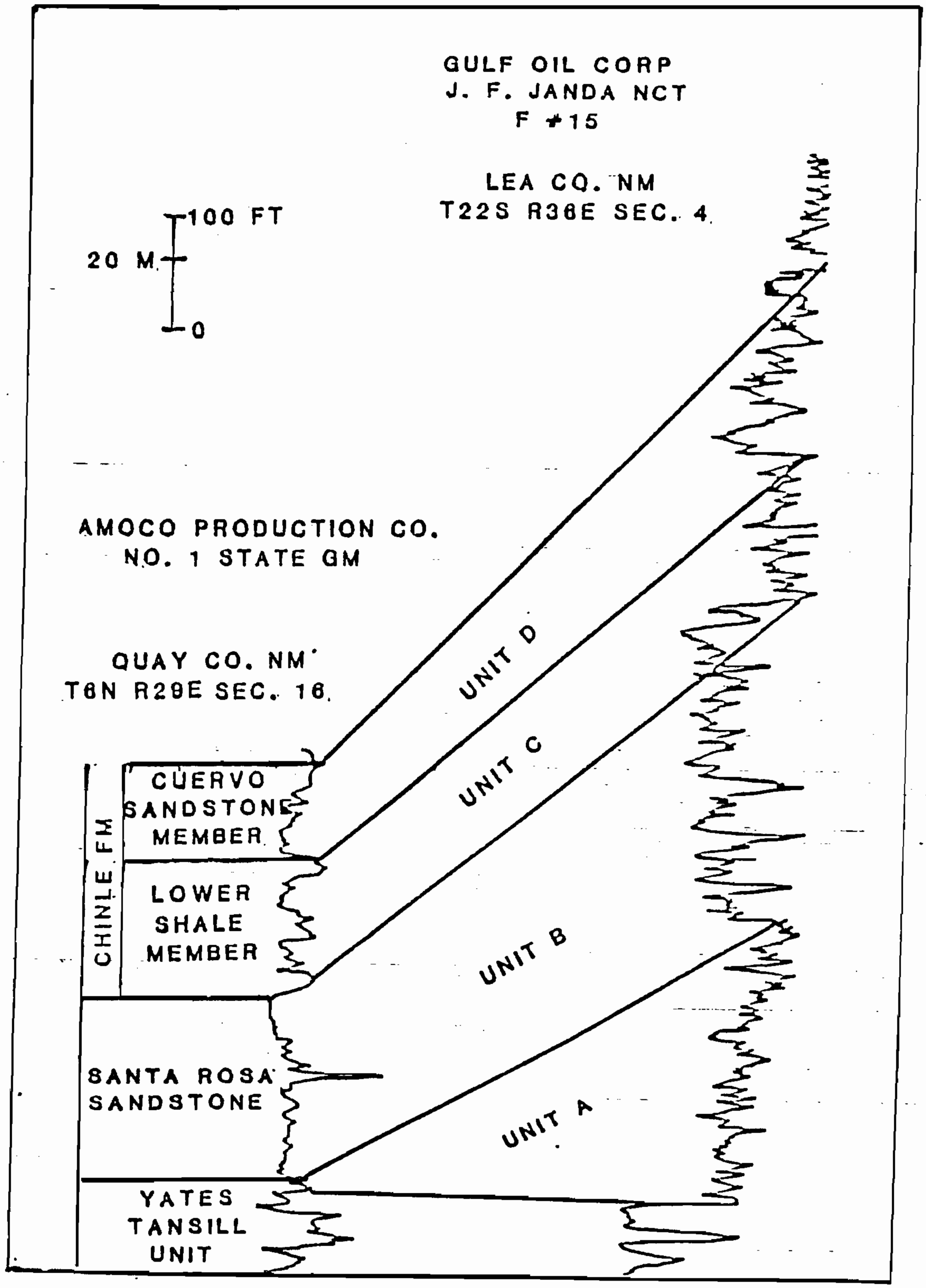


Figure 20 Comparison of gamma ray logs from Lea and Quay Counties New Mexico. Quay County log from Broadhead (1985).

The Santa Rosa Formation has been subdivided informally into 4 members: the lower sandstone, the middle sandstone, the middle mudstone and the upper mudstone (Gorman and Robeck, 1946, cited in Lucas et al., 1985). The lower sandstone was described by Gorman and Robeck (1946) as a "friable, purplish red, salt and pepper - textured, fine grained, platey to thin bedded, micaceous, silty sandstone". The middle sandstone is, according to Gorman and Robeck (1946), "a gray to brown, medium - to coarse grained, platey to massive - bedded sandstone that weathers into fretted blocks". Lucas et al. (1985) indicate that this unit also contains isolated, subrounded quartz pebbles about 1 cm in diameter and a basal conglomerate of quartz, limestone and petrified wood fragments". The middle mudstone is described by Gorman and Robeck (1946) as "red to grey shale that frequently is arenaceous in its basal portion". The uppermost unit in the Santa Rosa Formation is

> a brown to grey, dense, fine - grained, calcareous, platey to massive sandstone that weathers into rounded surfaces with ribbed cupholes (Gorman and Robeck, 1946).

A middle - Triassic (Anisian) amphibian (capitosaurid labyrinthodont <u>Eocyclotosaurus</u> sp.) was found in the lower sandstone member of the Santa Rosa (Lucas and Morales, 1985), thereby indicating that it is at least Middle - Triassic in age. Ash (1972) dated plant fossils recovered from the middle mudstone member as Norian (Late Triassic).

The lower shale member of the Chinle was described by Broadhead (1984) as being

> composed primarily of moderate reddish brown (10 R 4/6) to moderate reddish - orange argillaceous, calcareous mudstone. It also contains minor amounts of greenish gray to bluish - gray mudstone and some laterally discontinuous beds of fine - to very fine- grained sandstone. Casts of plant stems are common in the red mudstones.

The Cuervo Member is summarized by Lucas et al. (1985) as a "laterally persistent complex of sand bodies and intercalated mudrock in the middle part of the Chinle Formation throughout east - central New Mexico". They go on to state that "in addition to sandstone, significant amounts of mudstone, conglomerate and siltstone are included in the Cuervo".

Analysis of the Dewey Lake Formation

The early Ochoan was a time of evaporite precipitation with very little clastic deposition. This situation changed with the influx of the Dewey Lake siltstones, which in many places reach thicknesses of 200 m (600 ft) (Figure 21). This clastic influx was probably the result

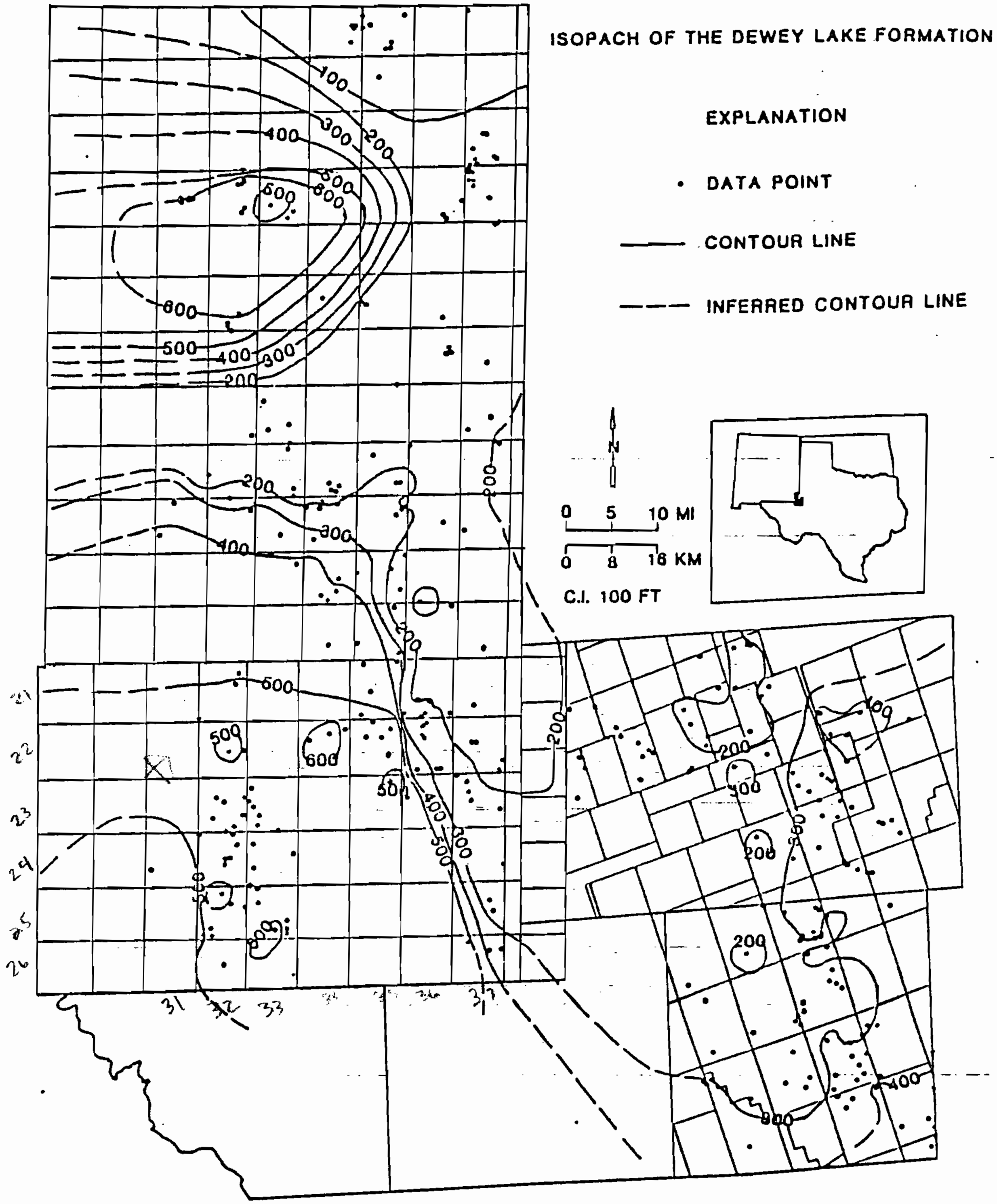


Figure 21 Isopach map of the Dewey Lake Formation.

of a significant uplift in the source region. (Outcrop data suggest that this area was located to the south - southeast.) Progressive erosion of this uplift could explain the very gradual fining upward trend in the Dewey Lake.

The shift of the log signature at the top of Unit A reflects an influx of the coarser material comprising the Santa Rosa Formation. It is theorized that this influx was caused by a second significant uplift of the source region. It appears, therefore, that both the lower and upper boundaries of the Dewey Lake could reflect major tectonic events (i.e. uplifts) and as a result maybe essentially isochronous surfaces.

An isopach of the Dewey Lake (i.e. Unit A) (Figure 21) displays a relatively thick region in southwestern Lea County and a relatively thin region in southeastern Lea County, Andrews County and Ector County. The thin region appears to correspond to the early to middle - Permian Central Basin Platform while the thicker area to the west appears to correlate with the northeastern Delaware Basin (Figure 2). Northern Lea County was a stable shelf in the early to middle Permian; however, Figure 21 suggests that at least a small portion of this region was subsiding rapidly during the deposition of the Dewey Lake.

The closely spaced contour lines in the southeastern portion of Lea County closely parallel the fault zone which had previously separated the Delaware Basin and Central Basin Platform (Figure 22). A structure contour map of the Rustler - Dewey Lake contact (Figure 23) does show approximately 100 m (300 ft) of offset, which Holt and Powers (1988) have attributed to faulting. This boundary fault was apparently reactivated during the time of Dewey Lake deposition. A structure contour map of the upper Dewey Lake contact shows little to no offset (Figure 24), indicating that fault movement had essentially ceased after the deposition of the Dewey Lake. This theory is supported by the fact that the thickness of the Santa Rosa (i.e. Unit B) remains essentially constant through this area. These observations suggest that the Delaware Basin / Central Basin Platform tectonic regime was active during the deposition of the Dewey Lake Formation.

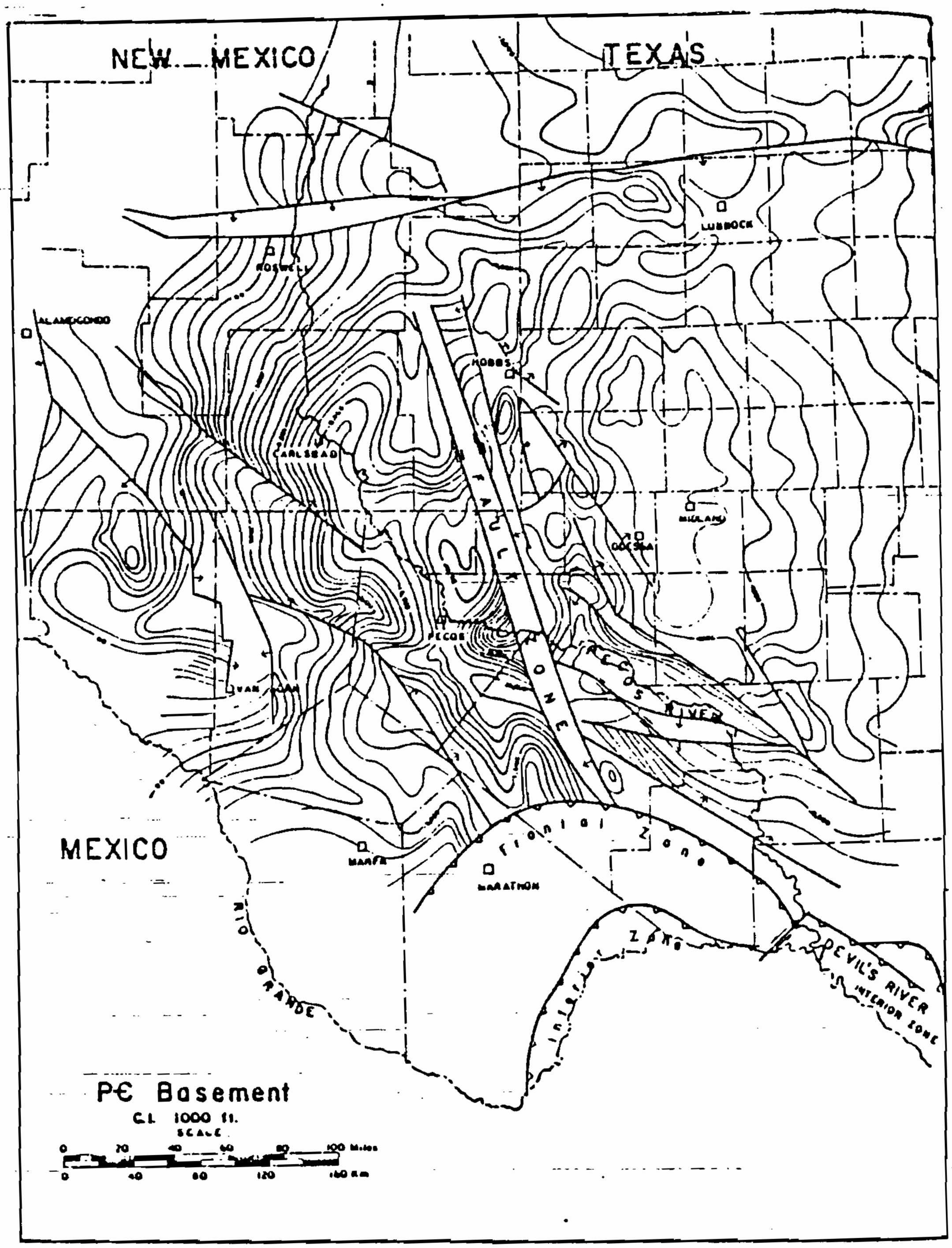


Figure 22 Structure contour map of the Precambrian basement in the Permian Basin (from Hills, 1984).

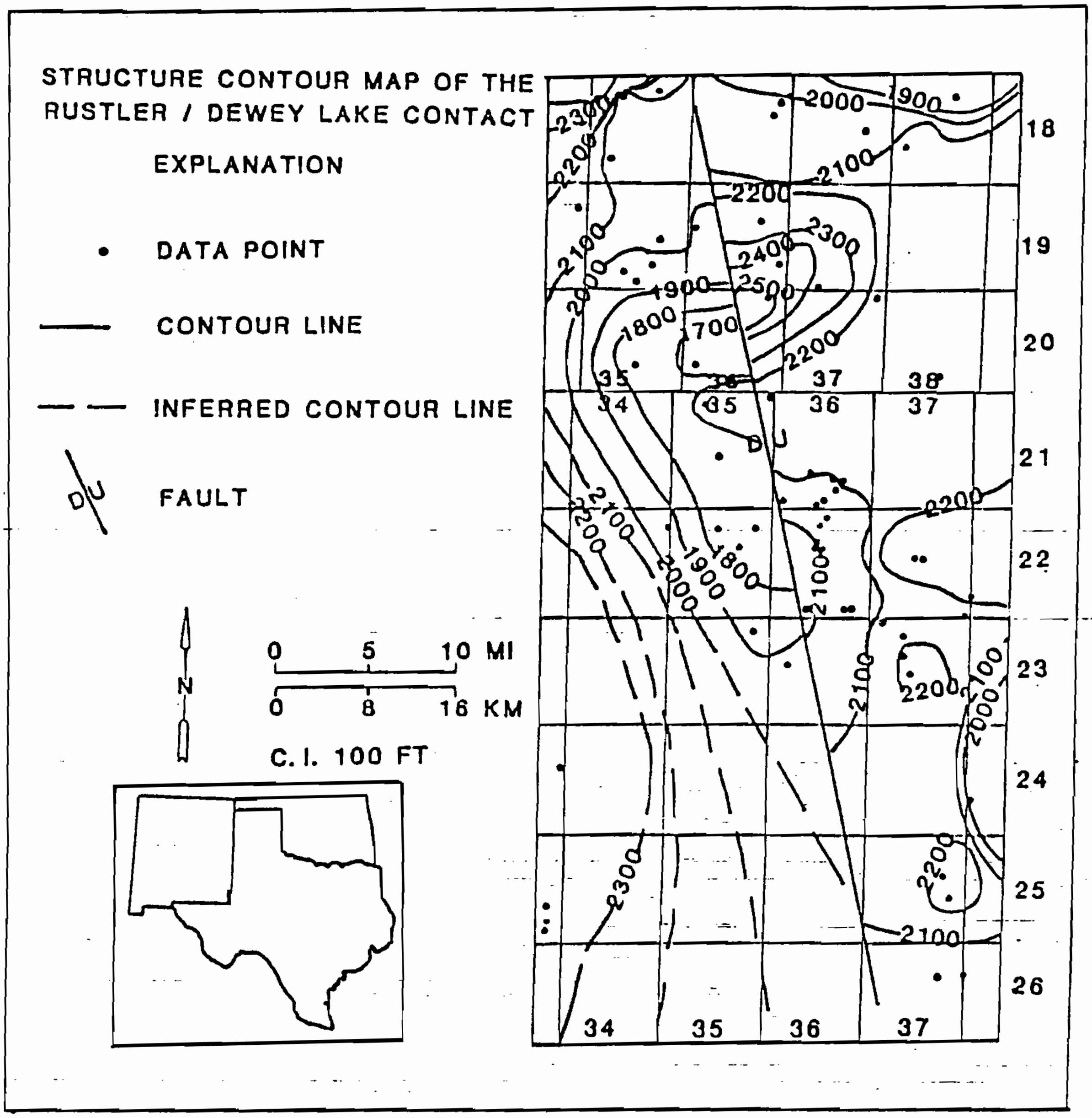


Figure 23 Structure contour map of the Rustler / Dewey Lake contact in southeastern Lea County, New Mexico.

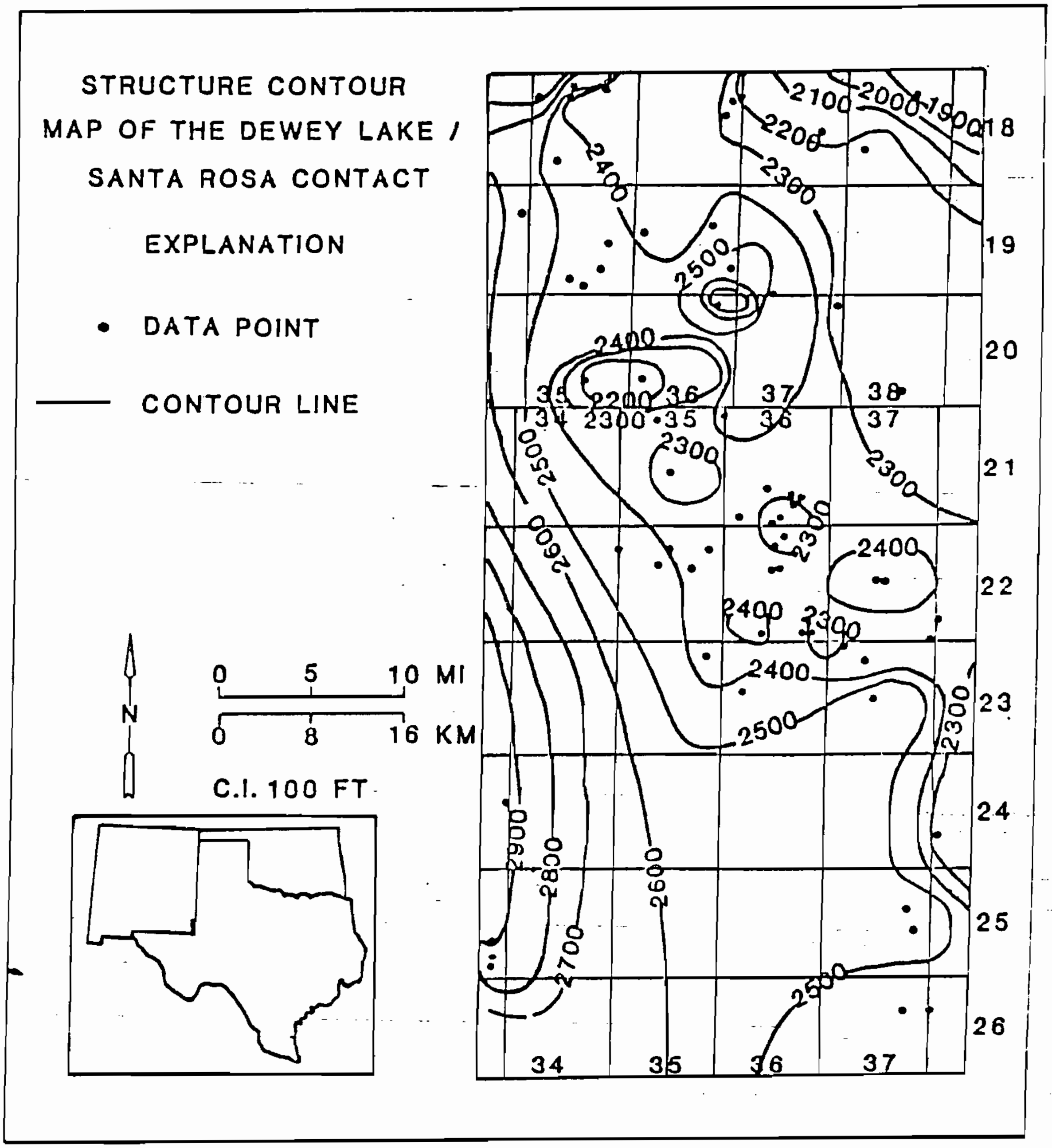


Figure 24 Structure contour map of the Dewey Lake / Santa Rosa contact in southeastern Lea County, New Mexico.

Interpretation and Environmental Significance of Low Gamma Zones

Two low gamma zones are clearly visible in the upper portion of the Dewey Lake (Unit A) from T21S R35E s32 (Figure 25). They are approximately 2.5 m (8 ft) thick and 3.3 m (10 ft) apart.

The most likely explanation for these low gamma zones is that they represent 2.5 m (8 ft) of very clean siltstone. The lack of fine clayey material would significantly decrease the gamma reading. Field observations in the Maroon Cliffs of Nash Draw (see outcrop analysis section) indicate that this is a plausible hypothesis. Both Facies 1 and 2, which represent essentially pure siltstone, reach thicknesses of 2 to 2.5 m (6 to 8 ft). It has previously been theorized that these facies represent the deposit of a single flood event; therefore, it appears likely that each of these low gamma zones also represents sedimentation from a single event.

The gamma lows can be recognized in logs from T21S R35E to T23S R36E (Figure 26). A southeast - northwest cross section through this region (Figure 27) shows that the thickness of the zones decreases to the northwest. If

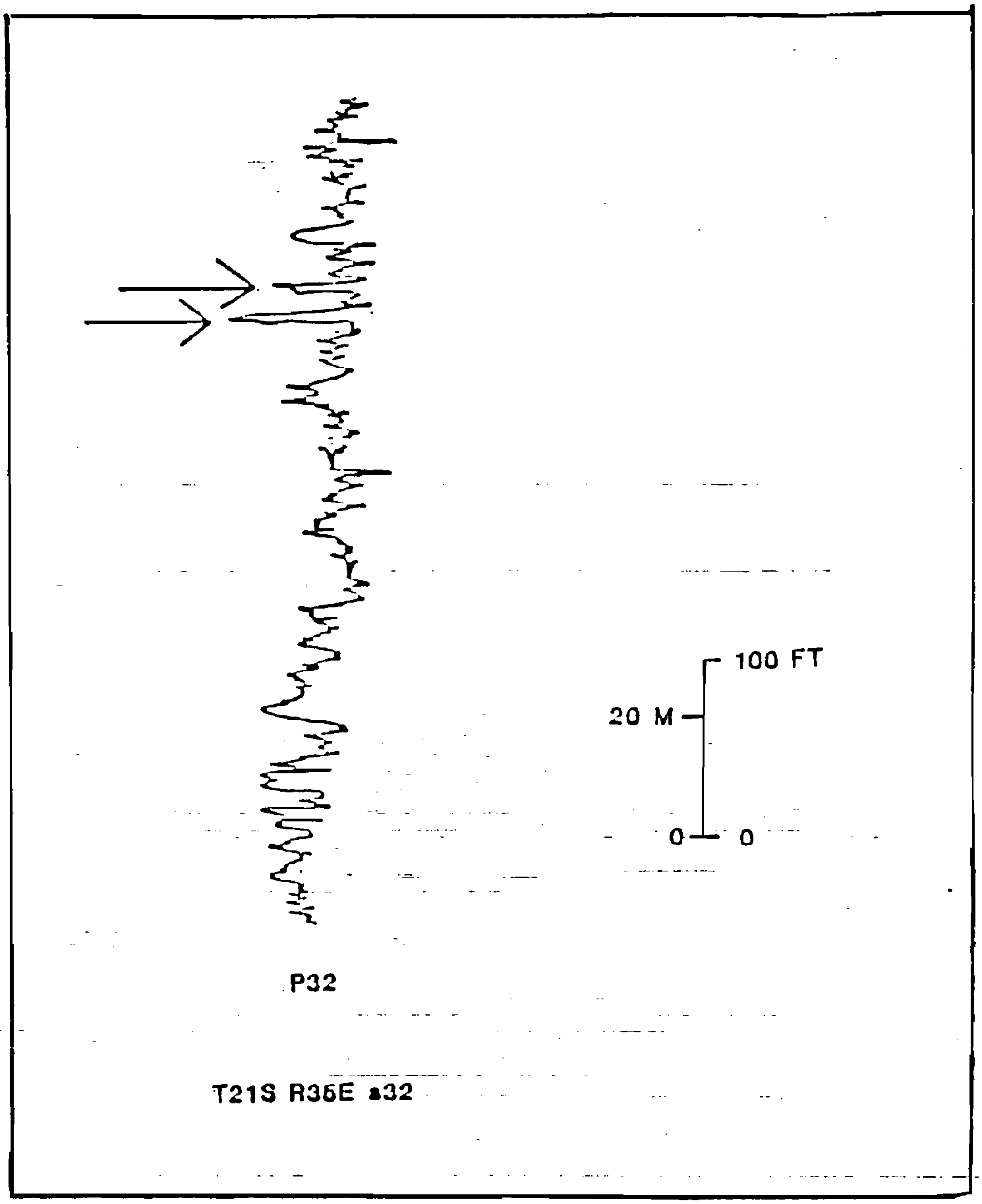


Figure 25 Gamma ray log of the Dewey Lake Formation showing two distinct low gamma zones. The log is from Resler and Sheldon Phillips State "C" No. 2 located in T21S R35E s32 of Lea County, New Mexico.

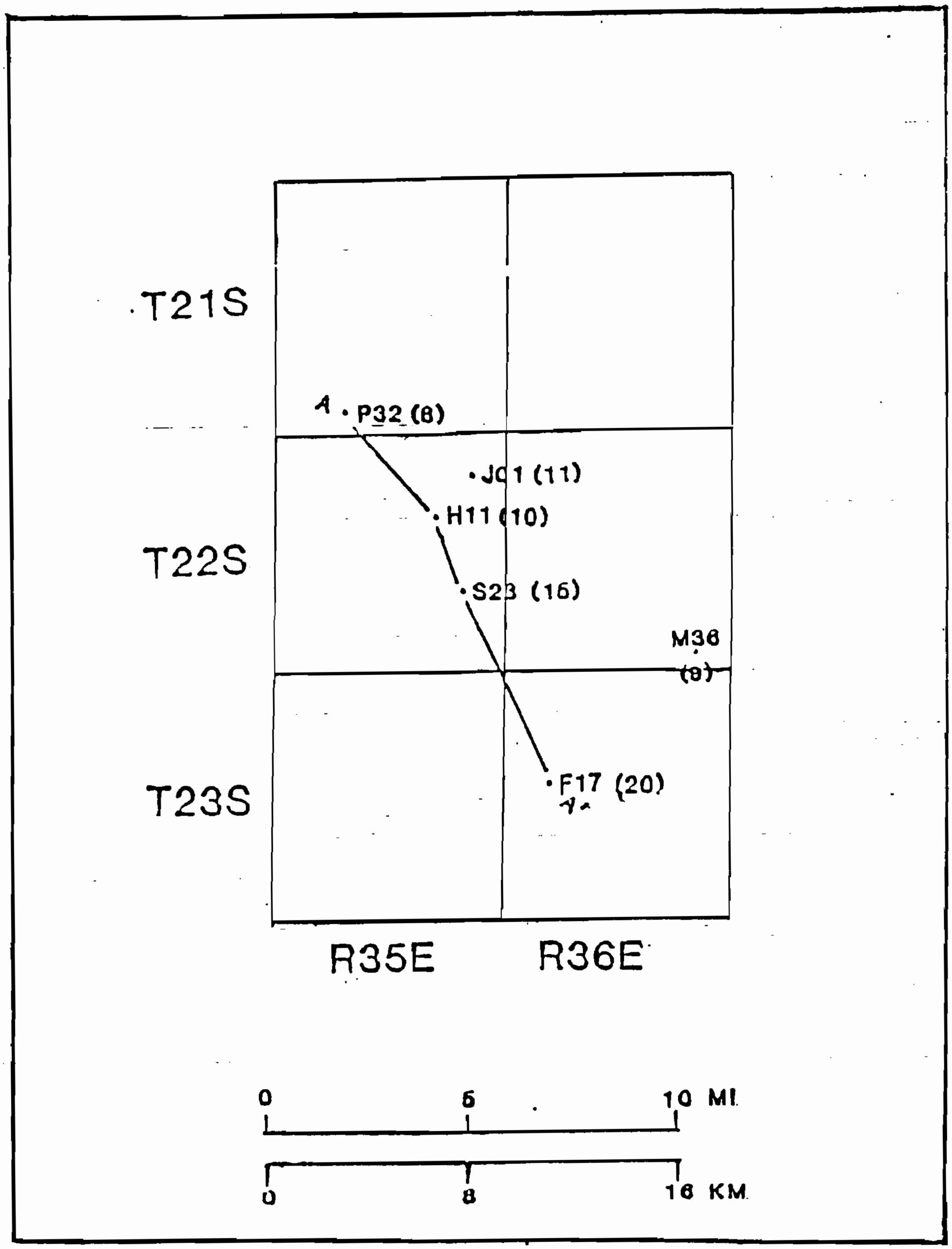


Figure 26 Plot of 6 gamma ray logs which contain the two low gamma zones. The number in parantheses indicates the thickness (in ft.) of the lower zone.

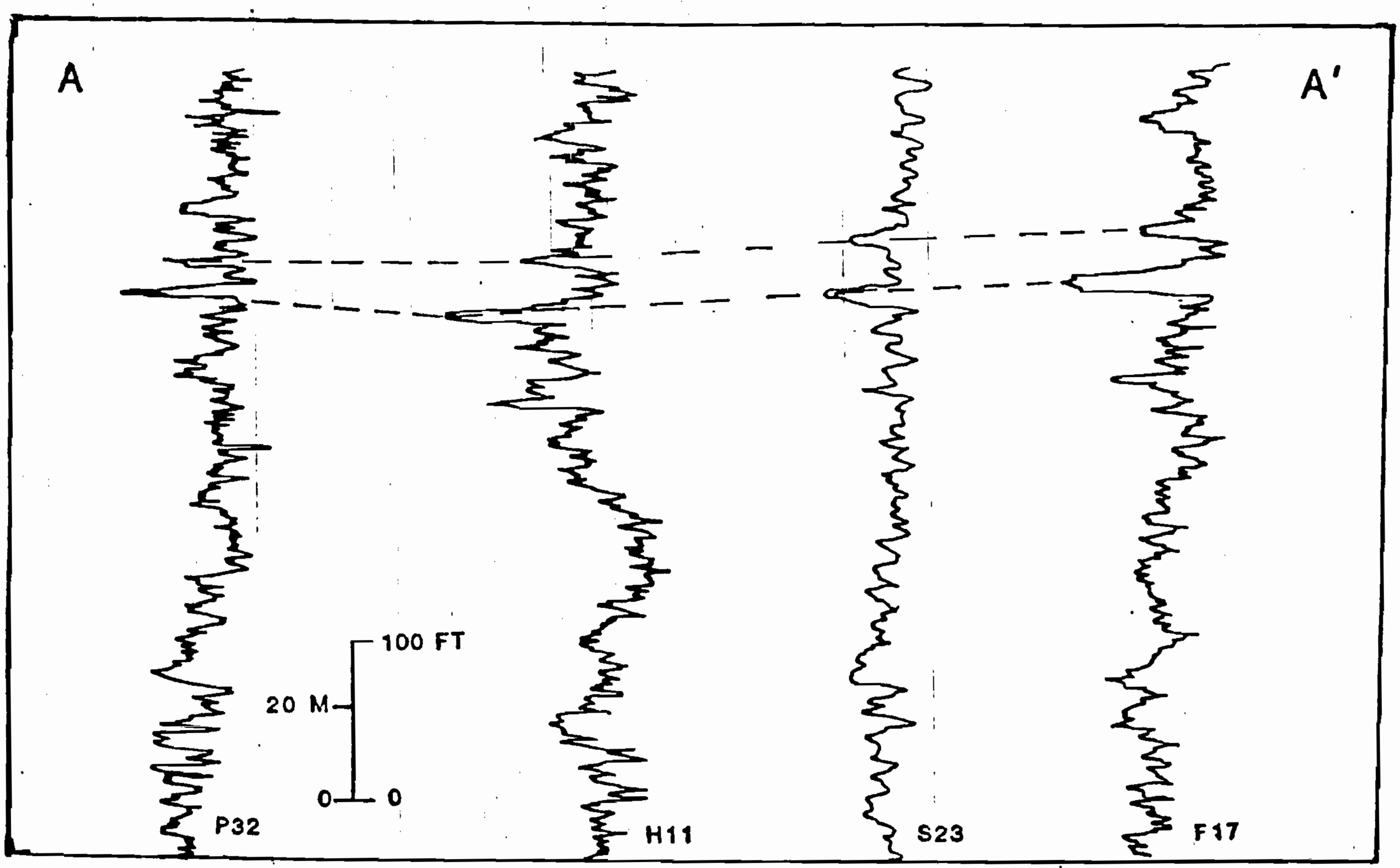


Figure 27 Cross section A - A' shown in Figure 26. P32 is Phillips State No. 2 located in T21S R35E s32. H11 is Hall State F #9 located in T22S R35E s11. S23 is State "AN" #1 located in T22S R35E s23. F17 is the Farney A-17 No. 3 located in T23S R36E s17.

one assumes a generally northwest paleocurrent this decrease could reflect a gradual waning of flood deposition. The fact that these two zones can be recognized in all the well logs plotted in Figure 26 suggests that a region at least 6.4 km (4 mi) wide and 16 km (10 mi) long was probably flooded during a single storm.

These low gamma zones are fairly rare in the Dewey Lake Formation. The reason that they are so obvious when they do occur is that they represent unusually thick occurrences of pure siltstone. This and their continuity over several miles, suggests that they are the result of fairly large and infrequent flooding events.

Conclusions

Field observations in the Maroon Cliffs of New Mexico indicate that the Dewey Lake Formation was deposited on a very extensive fluvial plain, covering much of west Texas, the Texas Panhandle, eastern New Mexico and western Oklahoma. Sediment, derived from a source to the south / southeast, was transported to the northwest. Movement of material across this plain was, however, sporadic occuring only during flash floods. The largest of these could apparently flood and deposit sediment over an area of several miles.

An isopach map of the Dewey Lake Formation (compiled from gamma ray logs in Lea, Ector and Andrews Counties) clearly reveals the western portion of the Central Basin Platform and the northeastern corner of the Delaware Basin. This suggests that the tectonic regime initiated during the Ouachita Orogeny was active during the deposition of the Dewey Lake Formation.

THE AGE OF THE DEWEY LAKE FORMATION

Introduction

The redbeds examined in this study were initially described over 50 years ago. A complete absence of fossil material in the beds prevented the geologists of the 1930's and 40's from determining a definitive age. The controversey surrounding this problem has never really abated and there is, to this day, some question as to the correct age of the Dewey Lake (i.e. is it Late Permian or Early Triassic).

A detailed analysis of this problem clearly indicates that there is little or no data to support the claim that the Dewey Lake is entirely Late Permian in age. The evidence which does exist (both previously and as a result of the current study) suggests that although the deposition of the silt and fine sand comprising the Dewey Lake might have begun in the latest Permian it probably continued throughout the Early Triassic.

Previous Work

The work of Lang (1935,1937,1947); Page and Adams (1940) and Adams (1944)

Lang (1935) was the first person to describe the redbeds above the Rustler Formation. He obtained his description from two wells drilled in central Loving County, Texas. The Means well (drilled in 1921) was located in the SE corner of section 23 Block C-26 and the Eldridge Core Test (drilled in 1926) was located NE of section 22 Block C-26. He indicated that in these wells Triassic redbeds were present from the surface to a depth of 66±3 m (200±10 ft), and that a "series of fine sandy to earthy red beds polka dotted with green reduction spots and usually veined with thin secondary selenite fillings" were present down to a depth of 183 m (550 ft). Because Lang believed that these same red beds were exposed in Pierce Canyon (SE of Loving, N.M.) he gave them the name Pierce Canyon Redbeds. It was later realized that at least some of the redbeds in Pierce Canyon are the Pleistocene - aged Gatuna Formation (Miller, 1966). The name Pierce Canyon has since been officially abandoned by the U.S.G.S. Lang (1935) did not indicate what criteria he used to differentiate the Triassic beds from the underlying Pierce Canyon.

By 1937 Lang appeared to have changed has mind concerning the Permian age of the Pierce Canyon RedBeds. In a paper published that year (Lang, 1937) he stated "Also, the Triassic, which rests on the Rustler east of the Pecos Valley is . . . ." He also utilized the Table shown in Figure 28. Both of these examples suggest that he now believed the Pierce Canyon Redbeds were Triassic in age.

The fact that the Pierce Canyon Redbeds in the Delaware Basin were now considered Triassic is important. Page and Adams (1940) described the redbeds above the Rustler in the Midland Basin. They considered them to be Permian in age because

> they rest conformably on the Rustler, commonly have an anhydrite cement, are well indurated, are similar in appearance and mineral content to the underlying Permian sands and are separated from the overlying beds by an unconformity that is commonly marked by a zone of bleaching.

Page and Adams (1940) indicated that these beds had previously been classified as Pierce Canyon but stated that "when it was redefined to exclude all Permian beds a new name became necessary". The name they chose was the Dewey Lake Formation.

We now have two groups of redbeds, each overlying the

TABLE II

COMPARISON OF THE ROCKS EXPOSED ON THE WEST AND EAST SIDES OF THE PECOS RIVER IN THE VICINITY OF ARTESIA NEW MEXICO

West Side of Pecos Valley or Sacramento Cuesta	*East Side of Pecos Valley to the Llano Estacado*
Cretaceous } Sierra Blanca basin (Capitan Mountains)	
Triassic } Sierra Blanca basin (Capitan Mountains)	Triassic
	Rustler..............poor exposures
	Salado..............not exposed
	Castile..............not exposed
Chalk Bluff (remnants)	Chalk Bluff..........exposed
San Andres	San Andres } In subsurface
Hondo	Hondo } In subsurface
Yeso	Yeso } In subsurface
Abo } In subsurface or on the bajada slope	Abo } In subsurface
Magdalena } In subsurface or on the bajada slope	Magdalena } In subsurface

Figure 28 Langs's comparison of strata on the west and east sides of the Pecos River (from Lang, 1937).

Rustler, which have been assigned different names and ages. In the Delaware Basin an unconformity is thought to exist between the Permian Rustler Formation and the Triassic Pierce Canyon (Lang, 1937). In the Midland Basin the Rustler - Dewey Lake contact is thought to be conformable but there is believed to be an unconformity between the Permian Dewey Lake and the Triassic Tecovas Formation (Page and Adams, 1940).

This very complicated problem became even more complex in 1944 when Adams (1944) stated that

> Most of the Redbeds of the Delaware basin previously classed as Permian (Lang, 1935) belong in the Triassic Pierce Canyon formation. Uppermost Permian redbeds, present in a few localities are assigned to the Dewey Lake formation.

He went on to state that

> The outcropping Pierce Canyon redbeds of the Pecos Valley are similar lithologically to the post-Dewey Lake redbeds of the southern Permian basin and to the Quartermaster of the Panhandle. They occupy the same position with respect to the Upper Triassic Santa Rosa Sandstone and judged by the sections encountered in thousands of intervening wells form a continuous stratigraphic unit. Regionally these redbeds overlap a wide range of Permian formations. In some localities the basal unconformity is overlooked and they are classed as Permian. They are made up largely of reworked Permian sediments with admixtures of new minerals, including coarse rounded, but unfrosted red quartz grains.

Because Page and Adams (1940) placed the Tecovas Formation above the Dewey Lake and below the Santa Rosa in the Midland Basin, it (the Tecovas) was probably the formation to which Adams was referring to when he wrote "post Dewey Lake Red Beds of the southern Permian Basin". This correlation is supported by the similarity in the description of the post Dewey Lake redbeds and the Tecovas Formation in Page and Adams (1940). Adams (1944) was apparently correlating the Pierce Canyon of the Delaware Basin with the Tecovas Formation of the Midland Basin which he believed (Page and Adams, 1940) to be late Triassic in age.

Apparently the belief at this time was that at least two distinct redbed formations existed above the Rustler Formation. One was Permian in age (the Dewey Lake), abundant in the Midland Basin but "limited to structural lows along the east and south edges of the Delaware Basin" (Adams, 1940). The other was considered Late Triassic in age (the Pierce Canyon in the Delaware Basin and the Tecovas in the Midland Basin) and had an unconformable contact with the Rustler or Dewey Lake below and a conformable contact with the Upper Triassic Santa Rosa above (Figure 29).

Lang (1947) did not distinguish two pre - Santa Rosa redbed units in the Pecos Valley region. He believed that

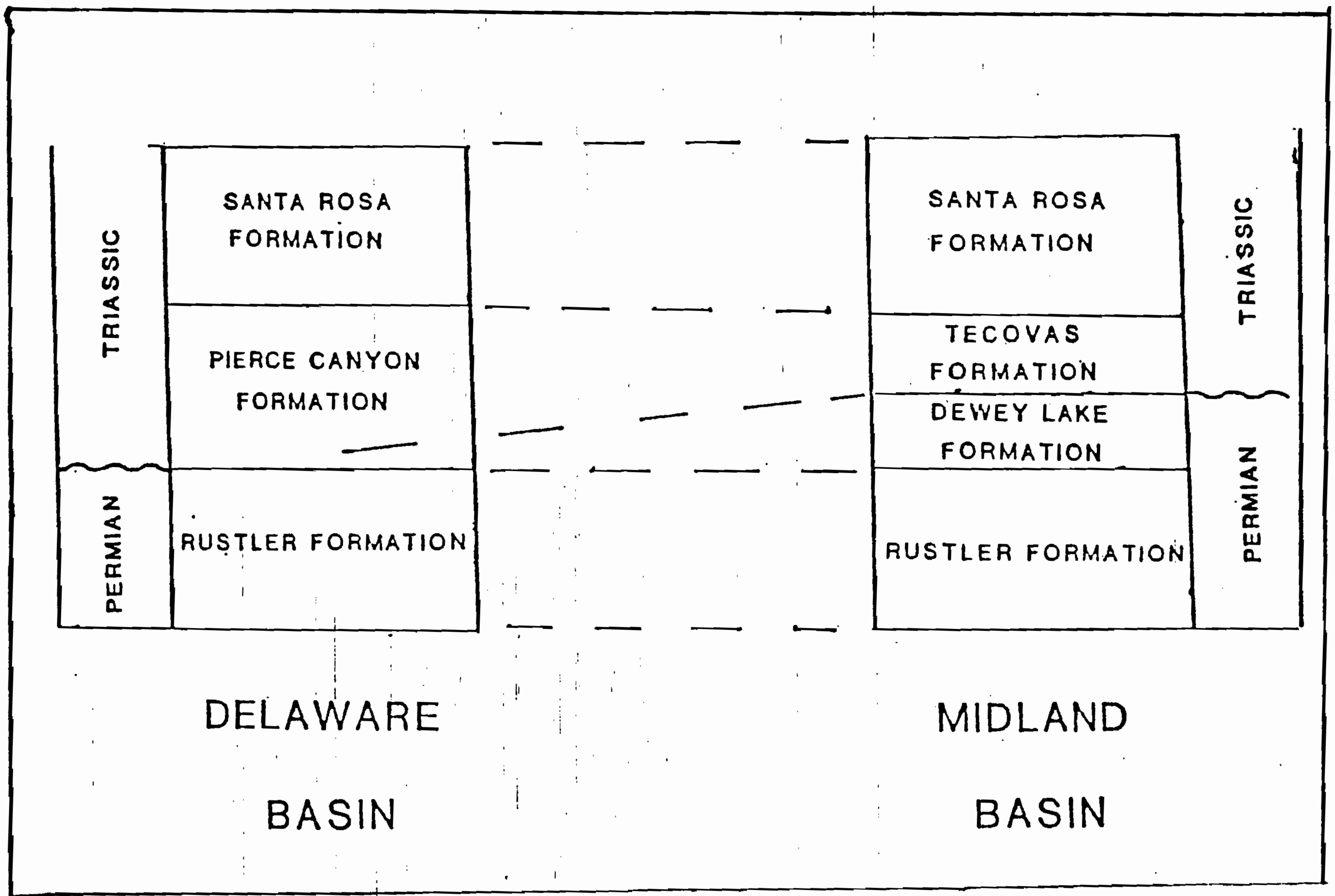


Figure 29 Apparent stratigraphic correlation, between the Delaware and Midland Basins, proposed by geologists in the 1940's.

the Santa Rosa was "Upper (?) Triassic in age" and underlain by

> another sequence of fine-grained, evenly bedded sandstone and siltstone described as the Pierce Canyon redbeds of the Dockum Group, and also considered to be Upper (?) Triassic in age, although no critical fossil evidence has ever been found in them.

And even more importantly Lang (1947) stated that

> Field investigations however, have disclosed that the Santa Rosa sandstone grades into the Pierce Canyon redbeds and that they are, in part, contemporaneous in origin.

Lang (1947), therefore, did not agree with the existence of a separate Late Permian Dewey Lake Formation in the Pecos Valley area. He did, however, agree that the Pierce Canyon Redbeds were more closely associated with the Late Triassic than the Permian.

The work of Miller (1955, 1966)

Miller (1955, 1966) published the first and possibly only petrologic study of the Pierce Canyon Redbeds. As a result of this study he determined that the Pierce Canyon was composed predominantly of quartz, othoclase and microcline, with much smaller quantities of numerous other materials (Miller, 1955, 1966). Miller theorized that the predominant source for the Pierce Canyon detritus was a "single, plutonic igneous source with a composition close to that of granite" most likely located in northern Coahuila, Mexico, south of the Marathon fold belt. He also theorized that relatively minor sources for the detritus were a volcanic terrane possibly located in the Marathon Fold Belt and a metamorphic terrane of unknown location.

Miller (1955, 1966) also compared the petrology of several redbed formations in the region. Two important conclusions were: 1) that the Pierce Canyon Redbeds of the Delaware Basin and the Dewey Lake Formation were equivalent petrologically and hence the same formation (this and the fact that the type section of the Pierce Canyon Redbeds was found to contain the Pleistocene Gatuna Formation led to the abandonment of the name Pierce Canyon) and 2) that the Pierce Canyon Redbeds/Dewey Lake Formation were more similar petrologically to the clastics in the Rustler Formation (Late Permian) than to the Santa Rosa Sandstone or Tecovas Formation (Late Triassic). As a result he proposed that the Pierce Canyon/Dewey Lake strata were Late Permian and not Triassic in age.

The well log analysis completed in the present study supports Miller's conclusion that the Dewey Lake Formation (defined by Page and Adams in 1940) is physically equivalent to the redbeds in the Pecos Valley, which were originally named the Pierce Canyon.

An important advance in provenance studies has been the realization that sandstone composition is dependent on the grain size examined (Basu, 1976). Miller (1955, 1966) did not have the benefit of this knowledge when he conducted his petrologic comparison of the Rustler, Pierce Canyon (now Dewey Lake), Tecovas and Santa Rosa Formations. As a result he compared populations of different grain sizes. Miller's petrologic argument concerning the age of the Dewey Lake is, therefore, invalid.

The present study supports the belief that the redbeds exposed in the Pecos Valley region are physically equivalent to the Dewey Lake in Glasscock County, Texas. This leads immediately to the problem of conflicting age assignments. Page and Adams (1940) believed that the Dewey Lake in R. R. Penn's Habenstreit well was Late Permian in age; however, the geologists of the 1930's and 1940's (except Lang, 1935) all appeared to agree that the redbeds exposed in the Pecos Valley area (then known as the Pierce Canyon, now known as the Dewey Lake) were Triassic in age.

The work of McGowen et. al. (1979, 1983)

Confusion still surrounds the relationship of the various redbeds in the Permian Basin. McGowen et al. (1983), in their study of the Dockum Group, noted that although the contact between the Permian and Triassic is generally unconformable, there are places where "the contact is gradational and that sedimentation was probably continuous from Permian into Triassic". This observation once again raises the question of the correct age of the Dewey Lake. For as McGowen et al. (1979) stated

> If this (continual deposition) is so then where are the Lower and Middle Triassic deposits? They are perhaps hidden in such Upper Permian deposits as Pierce Canyon Redbeds (Lang, 1935) and Dewey Lake Redbeds (Page and Adams, 1940)".

The work of Fracasso and Kolker (1985)

Fracasso and Kolker (1985) discovered two thin ash beds in the Quartermaster Formation of the Texas Panhandle (probable Dewey Lake equivalent). The lower ash bed, recognized in all 5 locations studied, ranges in stratigraphic position from 4 - 20 m (13 - 66 feet) above the top of the uppermost Alibates (Rustler equivalent) while the second bed, located in only 3 localities was approximately 130 meters (390 feet) above the top of the

Alibates. The lower ash bed (composed of subhedral to euhedral phenocrysts of sanidine, quartz, biotite, apatite, zircon, and iron - titanium oxides in a clay matrix) was dated using K/Ar methods and found to be 251 ± 4 and 261 ± 9 million years old. These dates are very close to the Permian - Triassic boundary and could [with the uncertainty in this boundary 248 ± 20 my (Harland et al, 1982)] be considered either late Permian or early Triassic. The fact that this ash bed occurs very low in the secion (i.e. 4 to 20 meters above the Alibates) and gives a reading so close to the Permian - Triassic boundary suggests that even if the strata enclosing the ash bed is placed within the Late Permian it is very likely that the Quartermaster section above extends into the Triassic.

The Quartermaster Formation is believed by most workers to be equivalent to the Dewey Lake Formation (Fracasso and Kolker, 1985). This correlation is supported by 1) the apparent similarity in lithologic and sedimentologic characteristics and 2) the general equivalence in stratigraphic position (i.e. above a gypsiferous unit and beneath the Dockum Group). The correlation of these two units suggests that the Dewey Lake Formation also spans the Permian - Triassic boundary.

Implications of the Present Study

It has already been noted that the isopach of the Dewey Lake Formation (in Lea, Andrews and Ector Counties) delineates what appears to be the western portion of the Central Basin Platform and the northeastern corner of the Delaware Basin (Figure 21). The structure contour of the Rustler - Dewey Lake contact in eastern Lea County reveals that the major fault zone separating the basin from the platform was active during, or immediately following, the deposition of the Dewey Lake.

The relative movement on this fault was east side up - west side down. It is necessary, however, to determine the actual movement which occurred (i.e. did the east side actually move up or did the west side move down) because this will provide some insight into the age of the Dewey Lake.

If the east side (i.e. Central Basin Platform) was uplifted, the relatively thin nature of the Dewey Lake in this region could be due to erosion. The relatively thick region to the west would be the result of the redeposition of this eroded material. A very important implication of this hypothesis is that a significant lapse of time would have had to occur between the initial deposition of the

Dewey Lake (i.e. that which occurred prior to fault movement) and the influx of the coarser material comprising the Santa Rosa.

If, on the other hand, the west side actually subsided, it is quite possible that the Central Basin Platform was never actually eroded but instead received less sediment because it was relatively more stable (i.e. not subsiding as rapidly as the region to the west). If this was the case, it implies that the thickness variations in the Dewey Lake are a direct reflection of subsidence rates. The important implication of this hypothesis is that little or no time need have elapsed between the deposition of the Dewey Lake and Santa Rosa Formations.

Several observations suggest that the second hypothesis is the most likely. First, if the additional sediment in the Delaware Basin was eroded from the Central Basin Platform the predominant paleocurrent direction should be to the west. Outcrop data, which is admittedly limited, suggests a north to northwest paleocurrent direction. A second observation in support of a gradually subsiding Central Basin Platform involves the internal gamma ray signature of the Dewey Lake Formation. In many localities it appears to be composed of several fining upward segments ranging in thickness from approximately 6 m (18 ft) to well over 33 m (100 ft) (Figure 30). The relatively thin nature of these segments, combined with the fact that they are not visible throughout the entire study area, suggests that they are the result of a depositional process, the precise nature of which is unknown at this time.

If the Central Basin Platform was eroded, the gamma ray logs in that region should be missing segments while the gamma ray logs in the basin should contain extra segments. If, on the other hand, both the basin and platform were subsiding (at unequal rates) they should contain an equivalent number of segments. These segments would, however, be substantially thicker in the basin.

A cross section through the area of interest (Figure 31) reveals the presence of three segments in each gamma log. The fact that two of the three segments thicken significantly toward the west appears to support the concept that the Central Basin Platform was not eroded but that the Delaware Basin subsided more rapidly to receive more sediment.

A slowly subsiding Central Basin Platform is also suggested by the tectonic context of the Late Permian. Uplift of both the Central Basin and Diablo Platforms is believed to have been the result of compressional forces

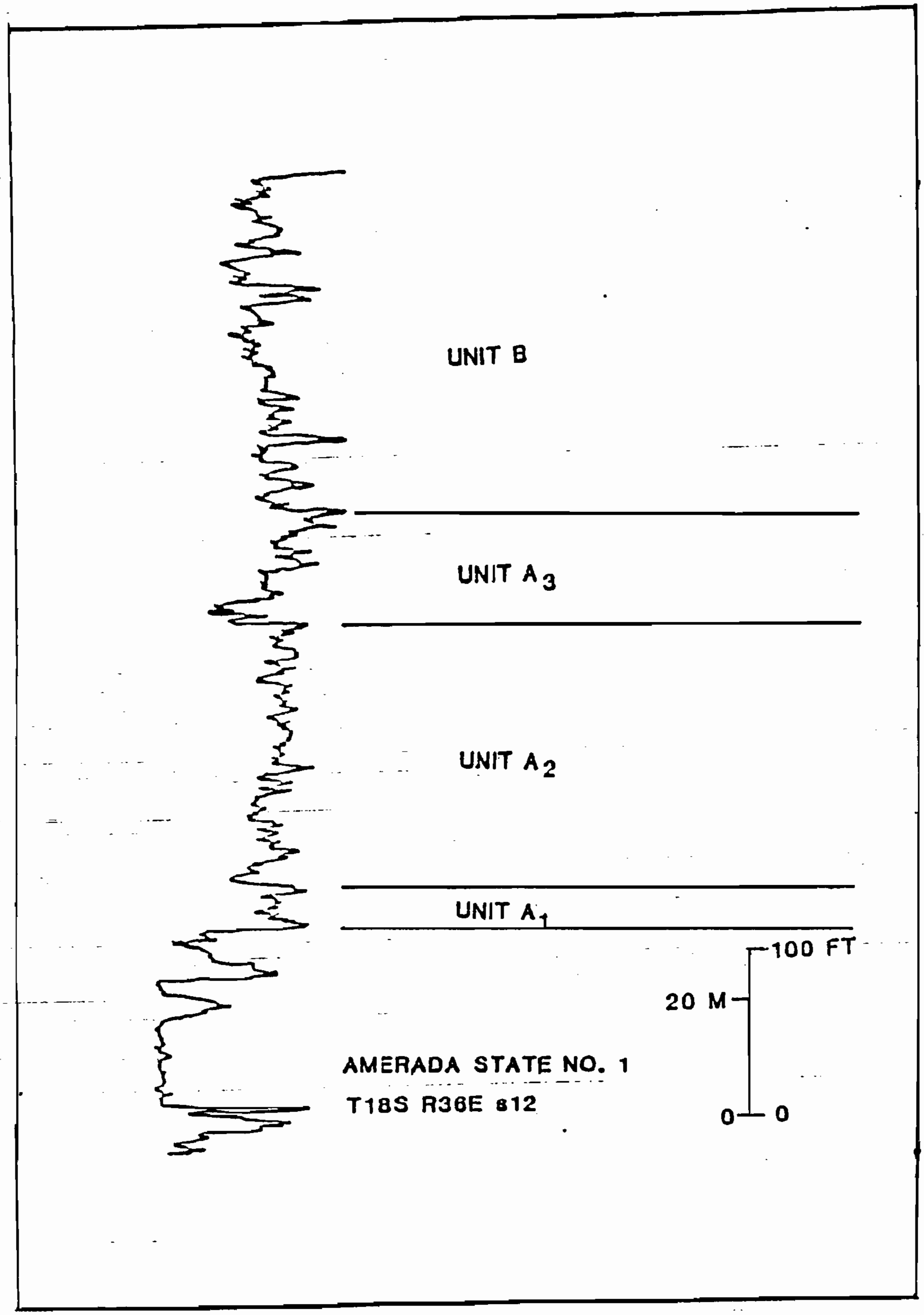


Figure 30 Gamma ray units A_1, A_2, and A_3.

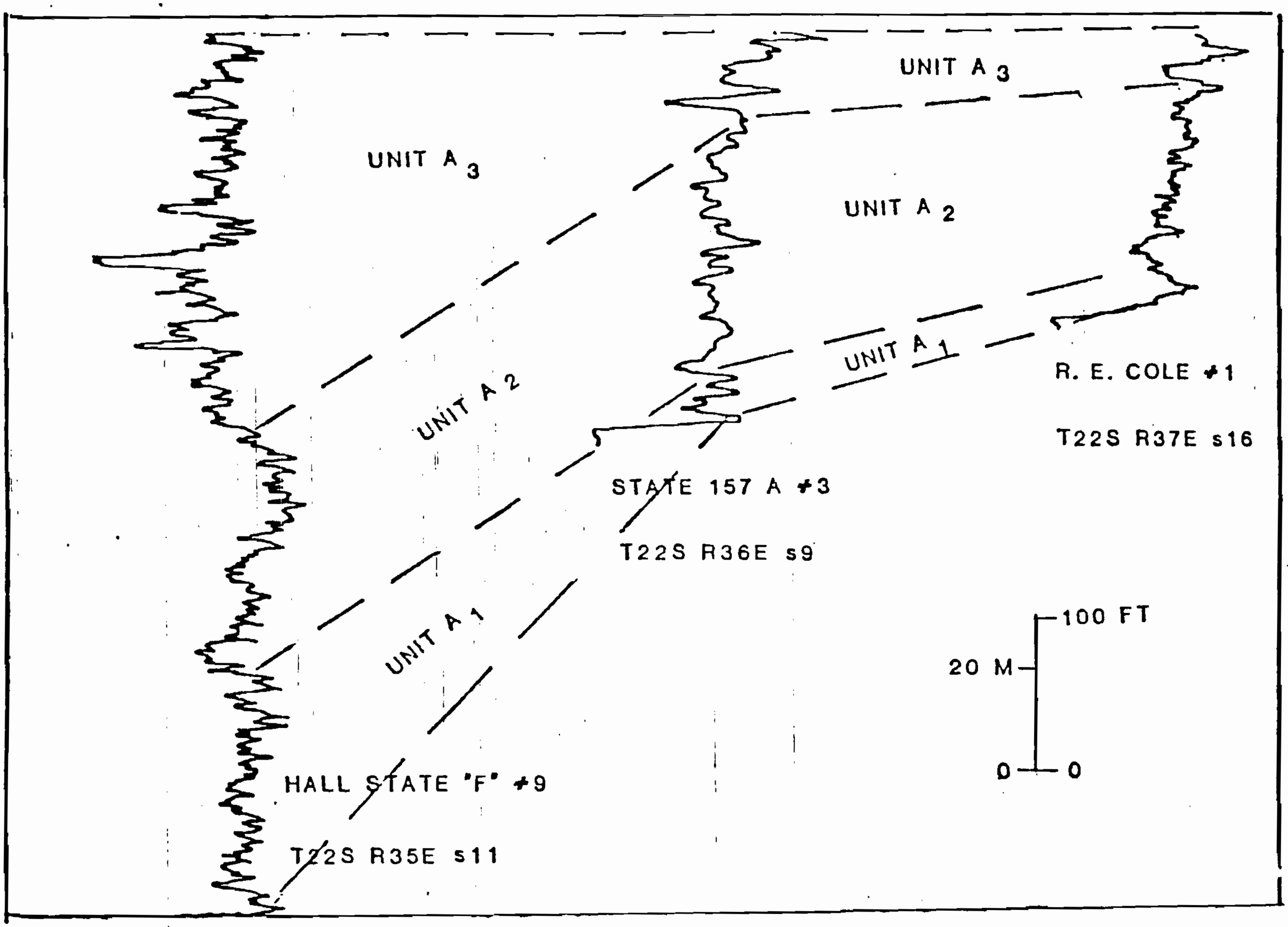


Figure 31 Cross section from T22S R35E to T22S R37E showing the draping of A_1, A_2, and A_3 onto the Central Basin Platform.

associated with the collision of North and South America (Walper, 1977). Uplift of these regions occurred predominantly during the Pennsylvanian and early Permian (i.e. Wolfcampian), when the compressional forces were at their maximum. When these forces subsided, uplift ceased and was replaced by subsidence. Ammon (1981) made this point quite clearly when he stated

> Starting with Leonardian time, west Texas began to subside regionally with deposition replacing erosion on the Diablo, Central Basin and other range - platform highlands indicating the end of compression from the south.

It is unlikely that west Texas experienced a renewed suge of compressional force during the Late Permian, therefore, the Central Basin Platform was probably subsiding as it had been since the Leonardian.

The argument could be made that the uplift which supplied the Dewey Lake was caused by compressional forces and if a compressional stress regime did exist it could have resulted in a renewed uplift of the Central Basin Platform. I, however, consider it unlikely that the proposed uplift (located to the south - southeast) was a result of compressional forces (see Tectonic Framework Chapter for a discussion of this topic).

The Dewey Lake - Santa Rosa Contact

It has always been thought that the contact between the Dewey Lake and the Santa Rosa was unconformable. If, however, the thickness variations in the Dewey Lake are the result of differing subsidence rates (as hypothesized in the previous section), there is no reason to believe that a significant period of time had elapsed between the deposition of the Dewey Lake and Santa Rosa Formations. A regional post - Dewey Lake pre - Santa Rosa uplift (i.e. one affecting the entire region, not just the Central Basin Platfrom) is unlikely because the isopach map clearly delineates the Central Basin Platform and Delaware Basin. If uplift and erosion of this area had occurred it probably would have destroyed (or at least diminished) the isopachic signature of these two tecgonic features.

The concept of continuous sedimentation from the Dewey Lake through the Dockum Group is not new. McGowen et. al. (1983) believed that "within the Midland Basin sedimentation was continuous from Late Permain through Triassic time". The similarity between the well logs in the Midland Basin and those in other portions of the study region indicates that nothing unusual occurred in the Midland area. If sedimentation was continuous in that basin it is very likely that it was continuous throughout the entire region.

A scour surface, in Nash Draw, containing siltstone and claystone clasts has been used to suggest that presence of an erosional unconformity. Detailed study of the Dewey Lake Formation suggests, however, that scour and erosional surfaces are an intricate part of the environment in which the Dewey Lake was deposited. Scour surfaces also appear to be an important part of the depositional environment of the Lower Dockum Group (McGowen et al., 1979, 1983). The controversy surrounding the presence or absence of this erosional surface appears to support the concept that it represents channel scouring and not a regional erosional surface.

Conclusions

A vertebrate fossil found in the lower sandstone member of the Santa Rosa has been dated as early Middle Triassic (Lucas and Morales, 1985). If the Dewey Lake - Santa Rosa contact is conformable it suggests that Dewey Lake sedimentation continued through the Early Triassic. This lends support to the concept that although Dewey Lake deposition might have begun in the Permian it did not conclude until well into the Triassic. The available evidence, therefore, appears to suggest that the Permian / Triassic boundary is located somewhere within the lower portion of the Dewey Lake. The discussion of the Tectonic Framework, which follows, is based upon the assumption that the Dewey Lake Formation is latest Permian to Early Triassic in age.

THE TECTONIC FRAMEWORK OF THE DEWEY LAKE FORMATION

The late Permian - early Triassic influx of silt and fine sand into the Permian Basin reflects a significant uplift in the source region. A general northwest paleocurrent in the Dewey Lake suggests that this source area was located to the south / southeast. There is, in fact, stratigraphic evidence which clearly indicates that a large region of central Texas (comprising the Ouachita / Marathon thrust belt and foredeep basins) was uplifted and eroded during the Early and Middle Mesozoic (Figure 32).

Throughout most of the Marfa Basin (point A on Figure 32) there is an erosional unconformity separating strata of Early Permian and Cretaceous age (Ammon, 1981). This same general relationship is seen in the Val Verde (Sanders et al., 1983) and Fort Worth Basins (Cheney and Goss, 1952) (Points B and C on Figure 32). Vitrinite reflectance on material in the Ellenburger Limestone (in the Val Verde Basin) indicates that a minimum of 2666 to 3333 m (8,000 to 10,000 ft) of material was eroded prior to the deposition of Cretaceous strata (Sanders et al., 1983). If the erosion in the rest of the region was of the same magnitude it suggests that a tremendous quantity of sediment was removed during the latest Permian (?), Triassic and Jurassic.

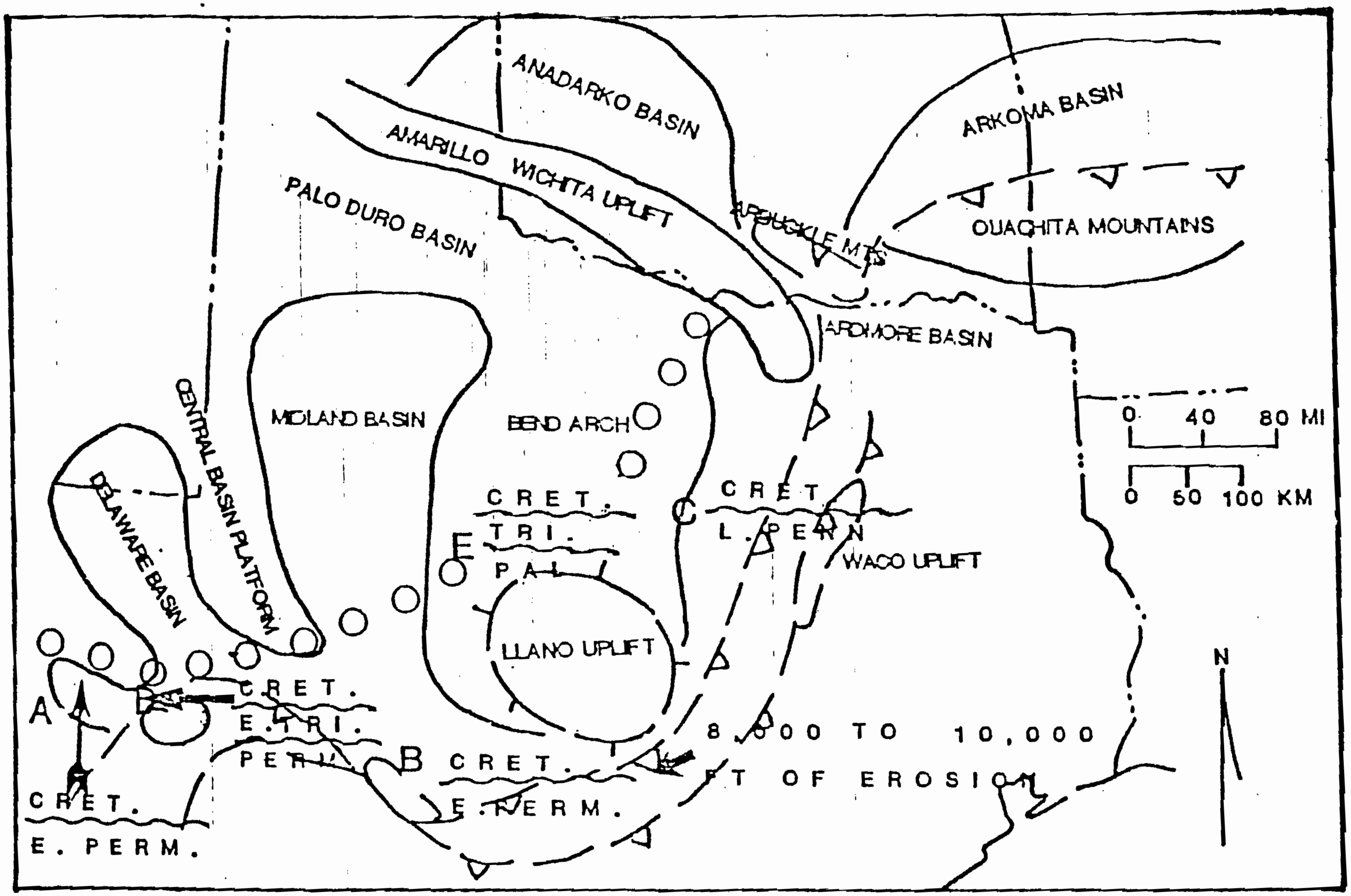


Figure 32 Nature and extent of the Permian / Cretaceous unconformity in central and west Texas. See text for a detailed discussion of this figure.

Stratigraphic relationships in the Glass Mountains (Point D on Figure 32) and north of the Llano Uplift (Point E on Figure 32) are more complex. In the Glass Mountains Permian strata are unconformably overlain by approximately 500 feet of interbedded calcareous conglomerate and red shale known as the Bissett Formation (King, 1927). It has been dated, using vertebrate and plant fossils, as Early Triassic (King, 1935). Sometime after its deposition the Bissett Formation was uplifted and tilted to the northwest (King, 1935). In the Early Cretaceous it was covered by the sands of the Trinity Group.

The stratigraphic section north of the Llano Uplift is very similar to that in the Glass Mountains. Paleozoic strata is unconformably overlain by a conglomerate of hard limestone, dolomite and chert in a matrix of coarse sand (Gawloski, 1983). The age of this unit, known as the Sycamore Formation, has been controversial, however, most workers now appear to agree on a Triassic age (Gawloski, 1983). The Sycamore Formation, like the Bissett, is overlain by strata of Early Cretaceous age. Gawloski (1983) has interpreted both the Bissett and Sycamore Formations to be proximal alluvial fan deposits.

The broad regional uplift in central Texas appears to have also extended into northern Chihuahua (Figure 33). Brown and Dyer (1987) indicate that "In northwestern

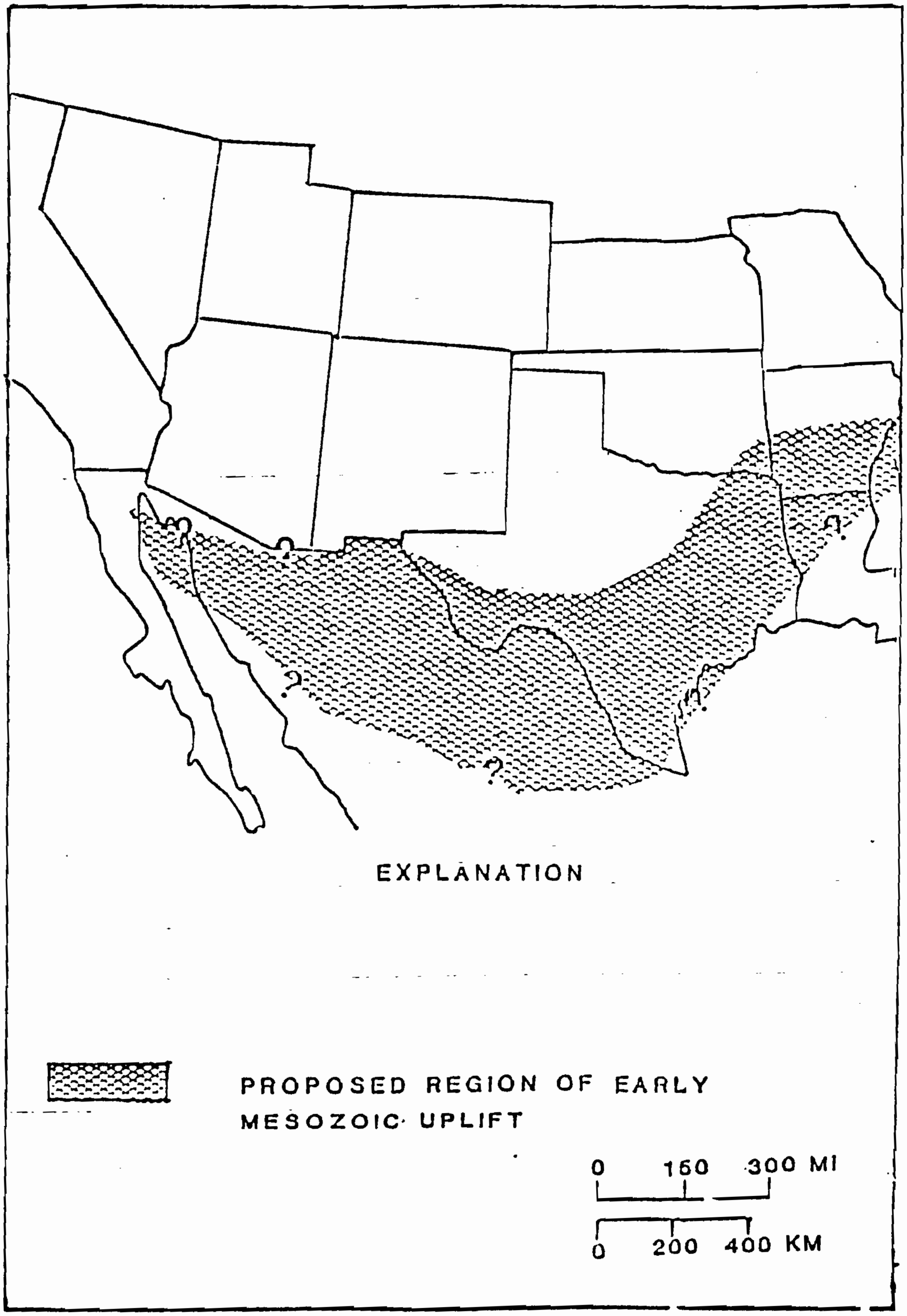


Figure 33 Proposed extent of Early Mesozoic uplift.

Chihuahua a pronounced unconformity separates Lower Permian from Lower Cretaceous rocks".

The stratigraphic relationships in the Glass Mountains suggests that the uplift of the Ouachita / Marathon region occurred in at least two phases. The first, in the Early Triassic, supplied the Bissett and Sycamore Formations. The second, which occurred some time after the Early Triassic, is reflected by the uplift and tilting of the Bissett Formation. It is believed that the initial (i.e. Early Triassic) uplift supplied the silt and fine sand comprising the Dewey Lake Formation (Figure 34). There is a possibility that the second (post Early Triassic) uplift supplied the relatively coarse material of the Santa Rosa Formation (Middle to Late Triassic).

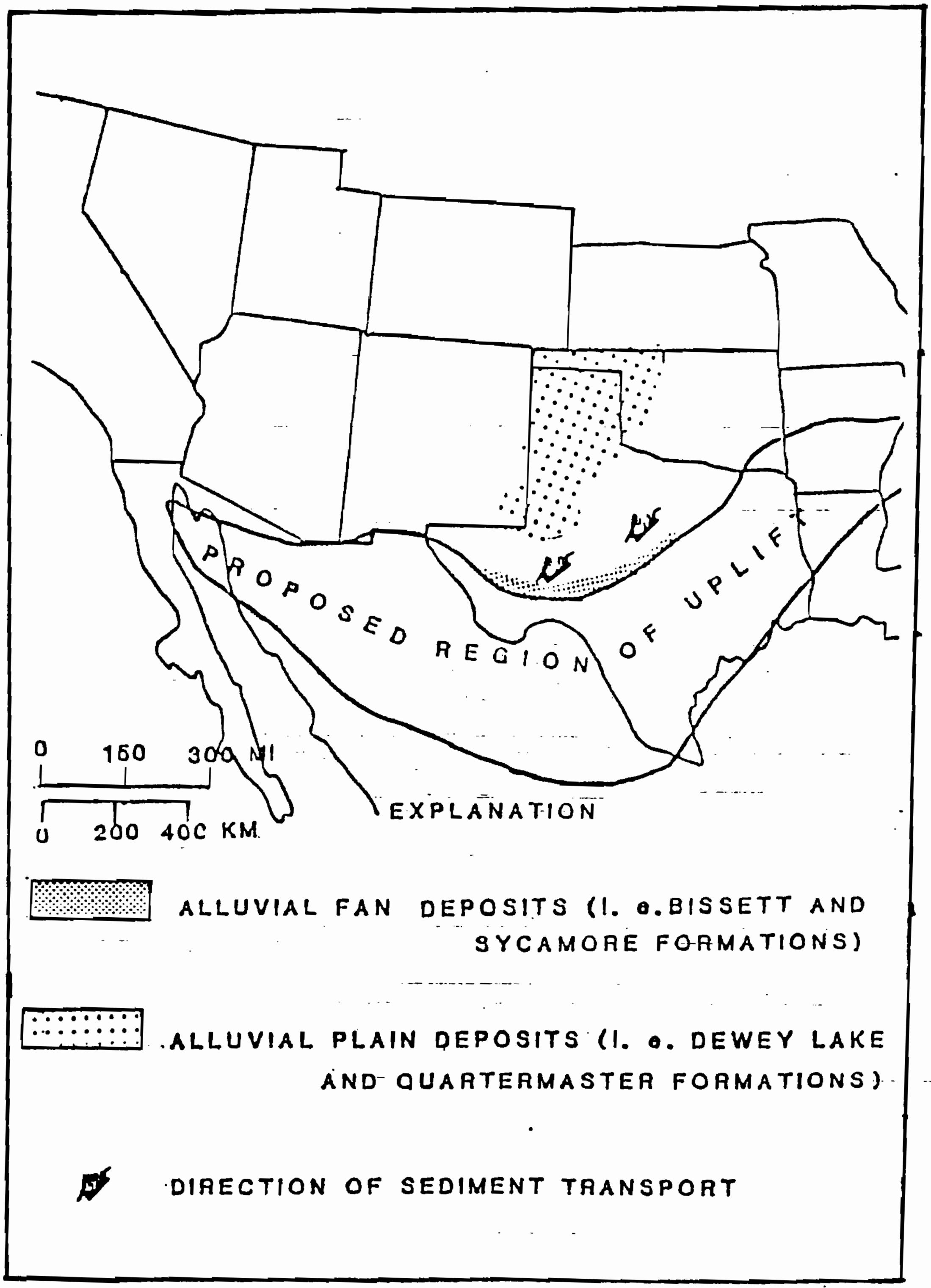


Figure 34 Proposed tectonic setting of the Dewey Lake and Quartermaster Formations.

Origin of Uplift

The Early to Middle Mesozoic uplift of the Ouachita region appears to overlap the rift grabens which began to form in the Late Triassic (Traverse, 1987) (Figure 35). The close geographic and temporal relationship of this uplift to rift features suggests that it was in some way associated with the rifting process. I would like to propose that it originated as a pre - rift bulge.

The uplift in northern Mexico could have had the same origin. Stewart and Roldan (1986) speculate that the 3 km thick Barranca Group (middle section dated as Late Triassic) of Sonora, Mexico was deposited in a rift basin. They state that

> "The rift basins of northern Mexico occur in a broad zone that was the site of subsequent transform faulting during the opening of the Gulf of Mexico. The rift basins may be analogous to those of the Upper Triassic and Lower Jurassic Newark Supergoup of the eastern United States . . . ."

The presence of these rift basins so far from the actual rifting center suggests that they could represent a failed arm of the Late Triassic rift system.

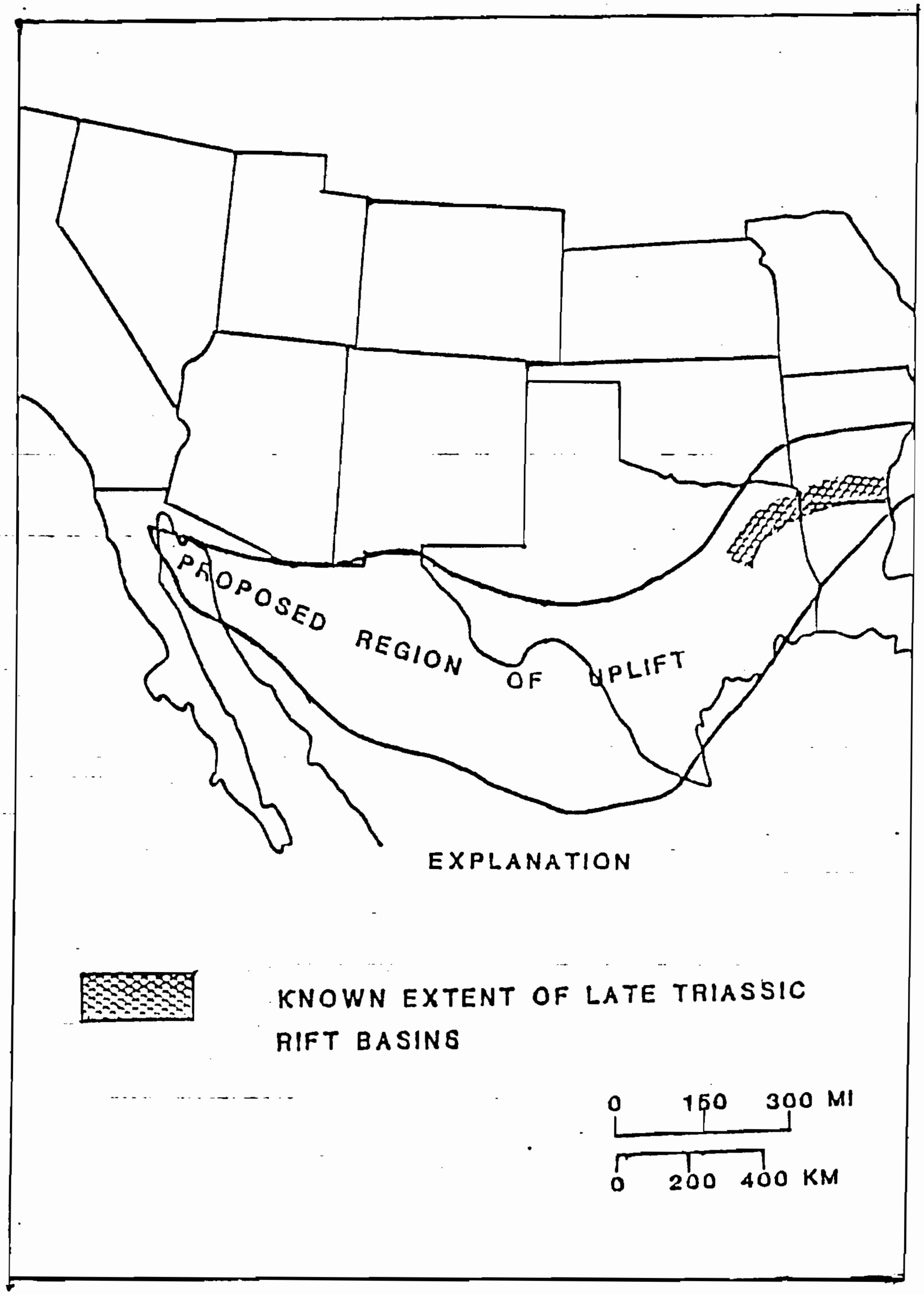


Figure 35 Location of Late Triassic rift grabens with respect to the proposed region of Early Mesozoic uplift. Location of rift grabens from Traverse (1987).

Summary of Tectonic Framework

The end of the Permian was apparently a time of transition for the Permian Basin. Evaporite precipitation ended and a dramatic influx of clastic and volcanic detritus began (i.e. the Dewey Lake Formation, the Santa Rosa Formation and the Chinle Formation). Most of the clastic material was apparently derived from a large upwarp centered on the Late Paleozoic Ouachita/ Marathon thrust belt and its numerous foredeep basins. The timing and location of this uplift suggests that it could have originated as a pre - rift bulge.

Alluvial fans formed along the northern edge of the upwarp (Bissett and Sycamore Formations) while a much larger alluvial plain stretched to the north - northwest (Dewey Lake and Quartermaster Formations). Stratigraphic relationships in the Glass Mountains suggest that the uplift of the source region occurred in at least two distinct phases: the first occurred in the Early Triassic and supplied the Dewey Lake and Quartermaster Formations, the second occurred sometime after the Early Triassic and is theorized to have supplied the much coarser material comprising the Santa Rosa Formation.

THE RELATIONSHIP BETWEEN THE MOENKOPI AND DEWEY LAKE FORMATIONS

The broad nature of the Early to Middle Mesozoic uplift (Figure 33) suggests that the alluvial plain to the north probably extended significantly beyond west Texas and the Texas Panhandle. The western portion of this alluvial plain is quite possibly represented by the eastern redbed facies of the Moenkopi Formation (Figure 36).

Numerous observations support the hypothesis that the Dewey Lake and redbed facies of the Moenkopi are components of a single laterally extensive lithologic unit (Figure 37). First, they both appear to lie very close to the Permian / Triassic boundary (see Stewart et al., 1972 for a discussion of the age of the Moenkopi Fm) and to be composed predominantly of siltstone and fine sandstone. Second, an apparent similarity in their sedimentological features and bedding structures suggests that they could have been deposited in the same depositional environment. (See McKee, 1954 and Stewart el al., 1972 for a description of the Moenkopi Formation). Third, the Dewey Lake and Moenkopi Formations represent an approximately simultaneous influx of clastic material, after a period of

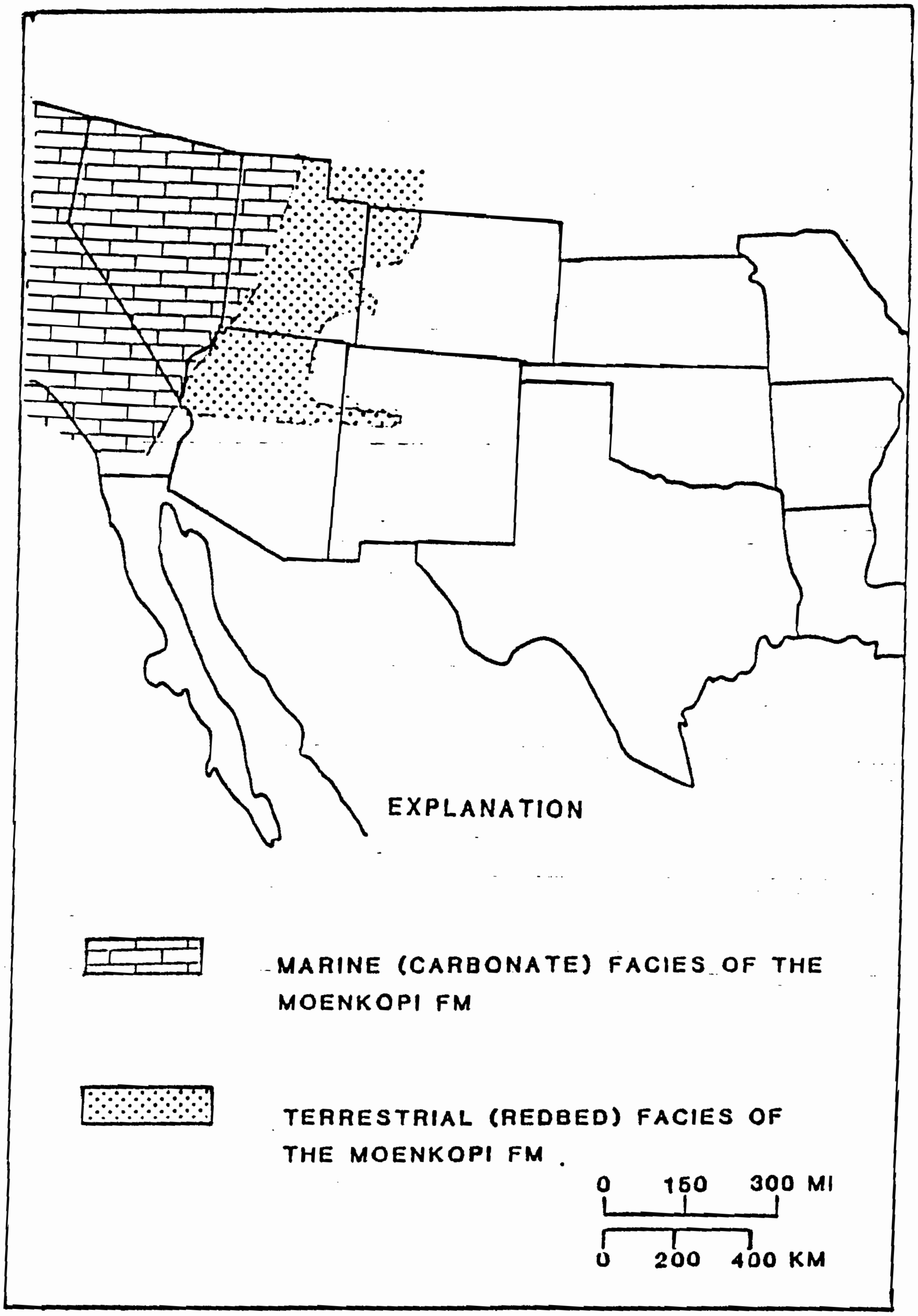


Figure 36 Approximate geographic extent of the marine and terrestrial facies of the Moenkopi Formation (from Stewart et al., 1972).

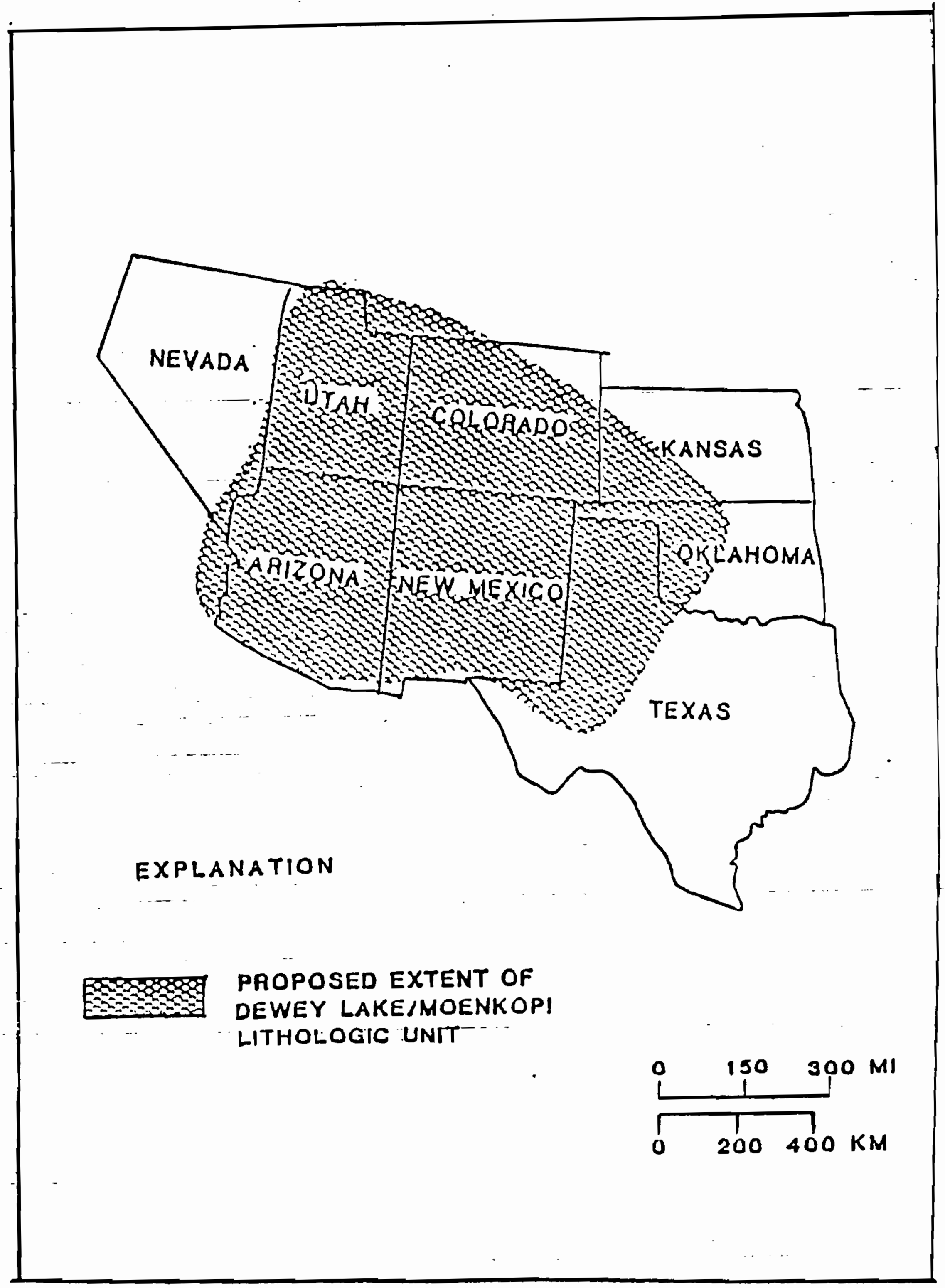


Figure 37 Proposed extent of the Dewey Lake / Moenkopi lithologic unit.

little or no clastic deposition. This supports the concept that they are reflecting the same tectonic event. And fourth, the Moenkopi, like the Dewey Lake, has a dominantly northwestern paleoslope and a southern source.

The source for the Moenkopi Formation had previously been thought to be the Mogollon Highland in central and southern Arizona (Stewart et. al., 1972); however, the recognition of the Moenkopi Formation in southeastern California (Walker, 1987), a Moenkopi equivalent (i.e. the Buckskin Formation) in west central Arizona (Reynolds et al., 1987) and a questionable Early Triassic unit (i.e. the Mount Wrightson Formation) in southeastern Arizona (Drewes, 1971) suggest that southern Arizona was the site of deposition, not erosion, during the Early Triassic. A much more likely source for the Moenkopi Formation is northern Mexico, a region which apparently experienced extensive Early Mesozoic uplift and erosion.

One reason that these two formations had not previously been correlated (besides an assumed difference in age) was the belief that the Moenkopi Formation depositionally thinned and eventually pinched out to the east (Stewart et. al., 1972) (Figure 38). This eastern boundary is, however, somewhat questionable. Although Stewart et. al., (1972) drew the eastern boundary at

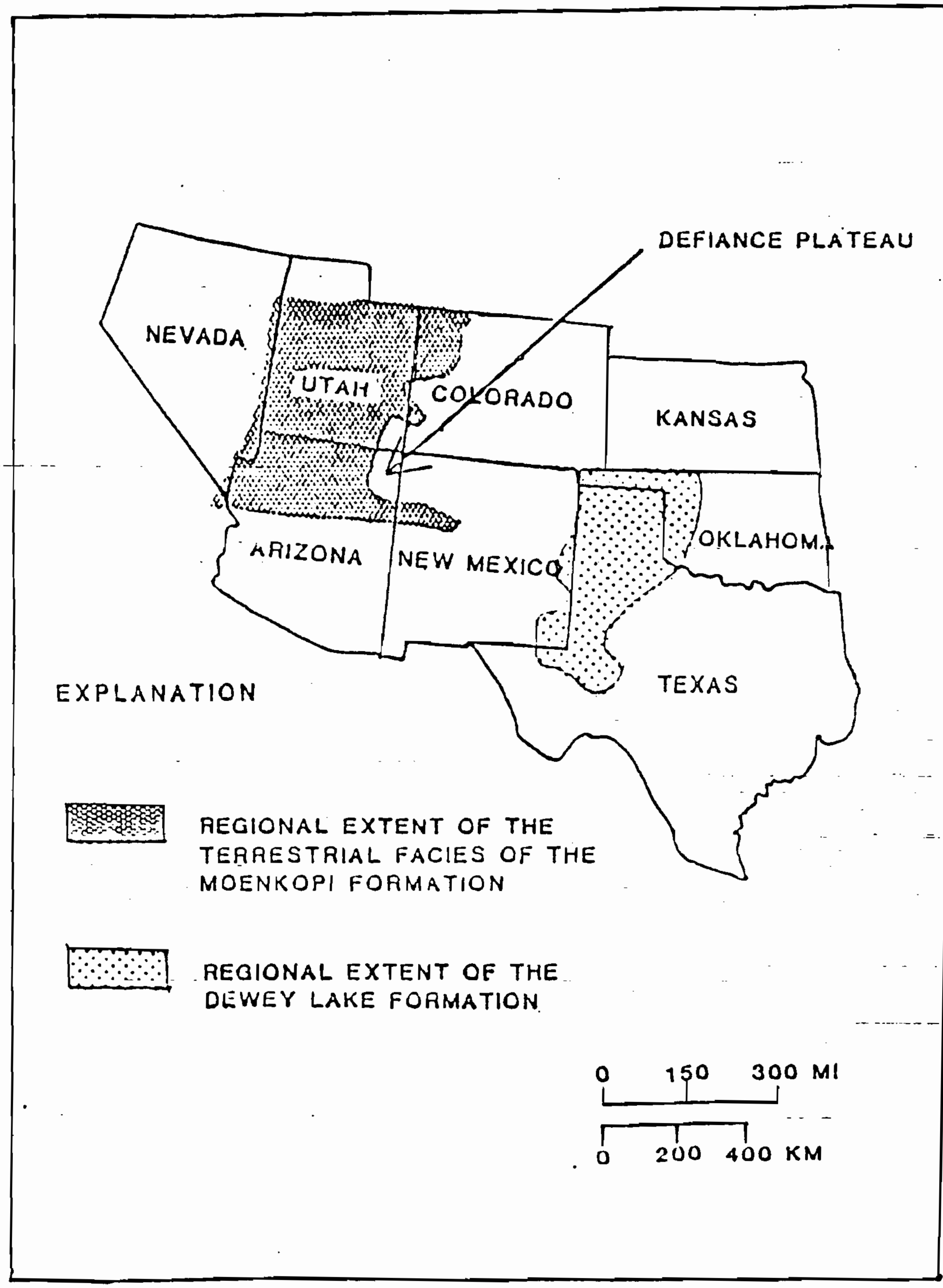


Figure 38 Regional extent of the Dewey Lake Formation and the redbed facies of the Moenkopi Formation.

Socorro, New Mexico they specifically state that "The east limit of the formation in New Mexico is not known". Stratigraphic problems in northeastern Arizona (the Defiance Uplift) (Peirce, 1964, 1967) and problems delineating the Permo - Triassic boundary in southwestern Utah (Baars, 1987) suggest that the Moenkopi Formation might also extend a significant distance beyond the generally accepted limit in those regions.

None of the data, available at this time, appears to directly contradict the hypothesis that the Dewey Lake, Quartermaster and Moenkopi Formations were deposited on an extensive alluvial plain whose predominant sediment source was a broad uplift (pre - rift bulge ?) located in central Texas and northern Mexico (Figure 39).

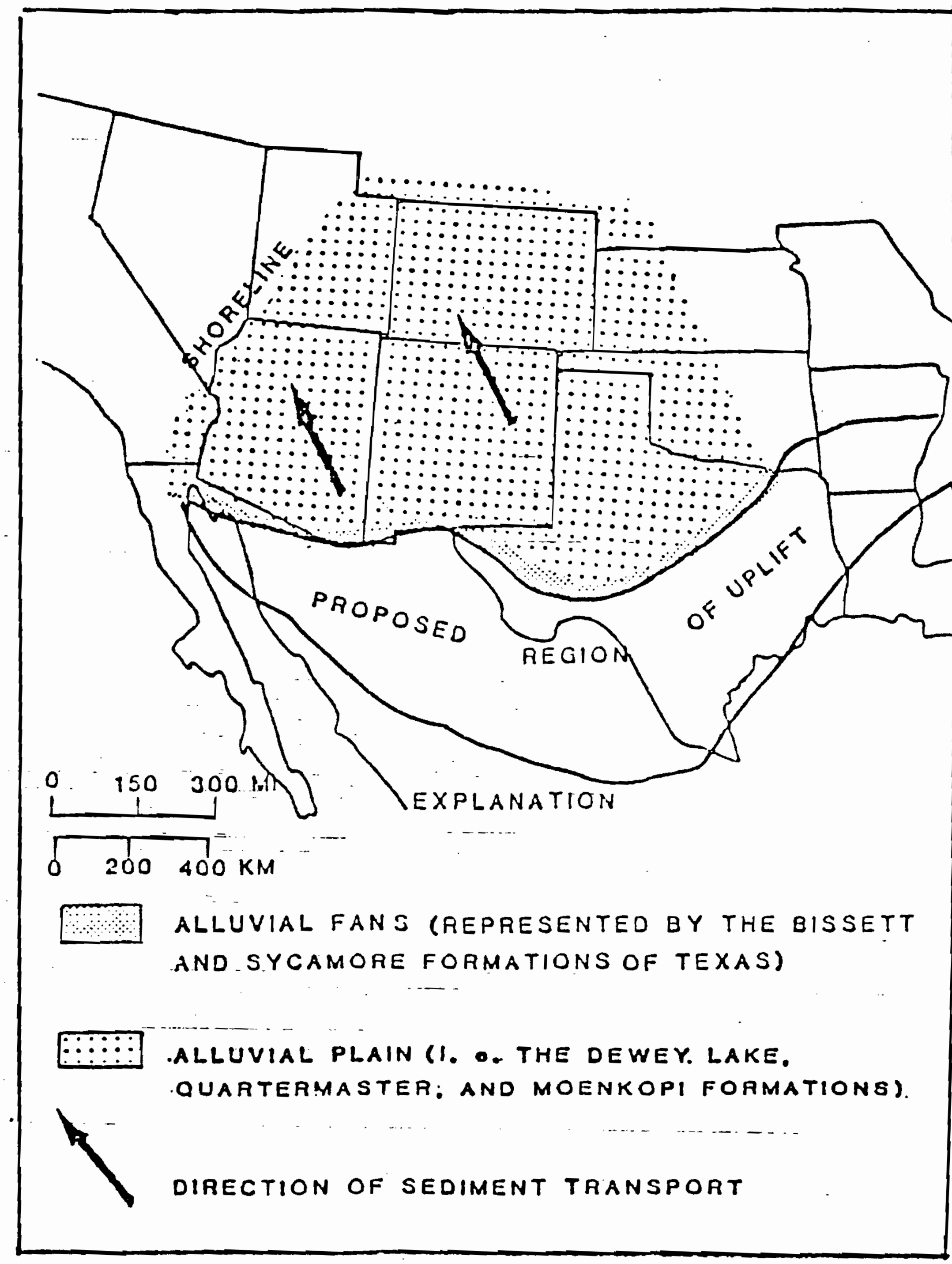


Figure 39 Proposed tectonic and paleogeographic setting of the Early Triassic.

IMPLICATIONS OF THE HYPOTHESIS

A major rift related uplift in central Texas and northern Mexico helps to explain the broad lithologic similarities in the Triassic section of the southwestern U.S. (these lithologic similarities are discussed by Lucas et al., 1985). The pulsaic uplift of a pre - rift bulge could be the ultimate cause for both the initial influx of silt and fine sand (i.e. the Dewey Lake and Moenkopi Formations) and the later influx of much coarser material (i.e. the Santa Rosa Formation and Shinarump Conglomerate). The overlying volcanic detritus, comprising the Petrified Forest Member and lower and upper shale membes of the Chinle, can also be placed within this tectonic framework if the assumption is made that the rift zone eventually progressed to the point of extensive volcanic activity.

AVENUES FOR FURTHER STUDY

The preceeding discussion and analysis is based, in part, upon the hypothesis that the Dewey Lake and Moenkopi Formations are lithologically and chronologically equivalent. Several avenues of study which might help to support or disprove this hypothesis are listed below:

1. A detailed comparison of the sedimentological features in the Dewey Lake and Moenkopi Formations might help to determine if they were, in fact, deposited in similar depositional environments.

2. Numerous paleomagnetic studies have been completed on the Moenkopi Formation (Helsey, 1969; Helsey and Steiner, 1974), while none have been attempted on the Dewey Lake. A comparison paleomagnetic study of the Dewey Lake Formation could help to more precisely delineate its age.

3. Ash beds have, to this date, only been found in the Texas Panhandle (i.e. the Quartermaster Fm). If ash beds could be located in the Delaware or Midland Basins they would provide additional data on the age of the Dewey Lake.

4. Continued work on the Permian - Triassic boundary in the four corners region could help to more precisely outline the eastern extent of the Moenkopi Formation.

5. A well log study encompassing west Texas, the Texas Panhandle, New Mexico and Oklahome would more precisely delineate the actual extent of the Dewey Lake Formation. A gamma ray log from Quay County, New Mexico (Figure 20) suggests that the Dewey Lake could be present in northeastern New Mexico but misidentified as a segment in the Yates - Tansill unit. Lithologic descriptions from northeastern New Mexico, summarized by Lucas et al., (1985), suggest that on the outcrop the Dewey Lake could be misidentified as the lower sandstone member of the Santa Rosa Formation.

SUMMARY AND CONCLUSIONS

Broad, winged channels filled with thin, horizontal laminations dominate the Dewey Lake Formation. The lateral interfingering and vertical stacking of these channels creates an unusual depositional architecture not seen in either the typical meandering, anastomosing or braided fluvial models. It, however, is not unique. Similar sedimentologic and morphologic characteristics have been noted in other formations and interpreted to represent a fluvial system dominated by ephemeral flood events. The depositional environment of the Dewey Lake is, therefore, envisioned to be a large, arid to semi - arid fluvial plain, which experienced infrequent and localized flash floods. As the flood waters rushed across some portion of the plain they would carve and quickly fill broad, shallow channels. Later floods would erode and fill other channels to create the interfingering and stacked architecture now exposed in the Dewey Lake Formation.

An isopach map of the Dewey Lake (compiled through gamma ray logs) in Lea, Ector and Andrews Counties appears to delineate the Central Basin Platform and eastern Delaware Basin. This suggests that the thickness variations in the Dewey Lake are not due to pre - Santa Rosa uplift and erosion but to the differential subsidence rates of the Central Basin Platform and Delaware Basin. If this is the case, little or no time need have elapsed between the deposition of the Dewey Lake and the overlying Santa Rosa Formation (dated as Middle to Late Triassic in northeastern New Mexico). A conformable relationship between these two units dictates that Dewey Lake deposition must have extended into the Early Triassic.

Stratigraphic relationships (i.e. an unconformity between the Early Permian and the Cretaceous) indicate that a large portion of northern Mexico and central Texas was uplifted and eroded during the Early Mesozoic. The timing and location of this uplift strongly suggest that it supplied the coarse clasts comprising the Bissett and Sycamore Formations and the much finer material comprising the Dewey Lake and Quartermaster Formations. A close geographic and temporal association between this uplift and Late Triassic rift grabens indicate that it could have originated as a pre - rift bulge.

A closer examination of the Early Triassic paleogeography reveals that the Dewey Lake and Quatermaster Formations represent only the eastern portion of what was apparently a much more extensive alluvial plain. The remainder of the plain is believed to be represented by the redbed facies of the Moenkopi Formation (Early Triassic). Apparent similarities in age, stratigraphic position, lithology and paleoslope all support the concept that the Dewey Lake and Moenkopi Formations were once part of the same depositional system.

APPENDIX

This appendix gives the name and precise location of all the gamma ray logs shown in Plate 33. Also provided are the log datum and depths to pertinent formations. The abbreviations are explained below:

T.R. = Top of the Rustler Formation
T.A. = Top of the Dewey Lake Formation
T.B. = Top of the Santa Rosa Formation
T.C. = Top of the Lower Shale Member of the Chinle Formation

LEA COUNTY, NEW MEXICO
T9S, R35E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M11	Jack Markham 1 (Magnolia Pet)	s11,660fsl,660fel	4140	2195	2185	1805	1560
B12	T.Betembaugh 1 (Magnolia Pet)	s12,660fsl,660fwl	4130	2190	2162	1840	1370
Y13	Fed. Yeckle #1 (J.R. Sharp)	s13,660fnl,660fwl	4132	2190	2160	1865	1670
B26	Cont. Barnes No. 1 (Vickers Pet. Inc)	s26,660fnl,1980fel	4117	2178	2140	1950	1700

T9S, R36E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C01	Cox Fed. #1 (Magnolia Pet)	s1,660fsl,660fwl	4058	2220	2190	1840	1610
F06	Walker Fed. 1 - H (Magnolia Pet. Comp)	s6,660fsl,660fwl	4136	2272	2210	1960	1630
W08	Walker Fed. #1 (Magnolia Pet)	s8,660fsl,660fwl	4099	2175	2140	1930	1578
W17	Fed. Warren 1 (Forest Oil)	s17,660fnl,660fwl	4097	2172	N.P.	1930	1685
W18	Fed. Warren 2 (Forest Oil)	s18,660fnl,660fwl	4109	2180	?	?	?
S22	Santa Fe D #1 (Magnolia Pet)	s22,660fsl,660fwl of SE/4	4055	2190	2100	1928	1572
D27	Dessie Sawyer #1 (Mid Cont. Pet. Comp)	s27,1980fsl,1980fwl	4039	2215	2160	?	?
S33	U.D.Sawyer #1 (Skelly Oil Comp)	s33,660fnl,660fel	4043	2248	2200	1957	?

T9S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F07	Byler-Fed. #1 (Magnolia Pet. Comp)	s7,660fnl,660fwl	?	2271	2200	?	?

T10S, R36E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S09	State C.A. #1 (Amerada Pet.)	s9,660fsl,660fel	4030	2205	2130	1930	1555

T11S R33E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S35	State B.T.C. No. 5 (Amerada Pet. Comp)	s35,1980fsl,1980fwl	4263	1700	1280	?	?

T11S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
E16	State EC #3 (Amerada Pet.)	s16,1980fnl,1980fel	3910	2310	2190	1970	?
S16	State #16-1 (Gordon M. Cone)	s16,1980fnl,1980fwl	3969	2304	2165	1990	1705
S20	State #1-20 (Great Western Drlg)	s20,660fsl,660fwl	3928	2278	2160	1880	1650
E27	Elliott No. 1 (Los Nietos Oil)	s27,660fsl,660fel	3901	2340	2240	1980	1740
F27	Fed. Elliott #1 (D.D. Feldman Oil & Gas)	s27,660fsl,1980fel	3898	2310	2225	1970	?
N29	A. M. Nelson 1 (Ne-O-Tex Corp)	s29,1979fwl,330fsl	3906	2318	2200	1938	1582
M32	Markham State No. 2 (Ralph Lowe)	s32,1980fsl,1980fel	3894	2255	2132	1950	1668
S32	Markham State No. 1 (Ralph Lowe)	s32,660fsl,1980fel	3890	2310	2176	1955	1690
W31	Wallace 31 #1 (Ralph Lowe)	s31,1980fsl,660fel	3893	2288	2141	1970	?

T12S, R32E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S14	W.C. Speed #2 ((Superior Oil)	s14,330fsl,1650fwl	4349	1486	?	?	?
M15	Magnolia Speed No. 1 (Great Western Drlg Co).	s15,660fsl,660fel	4358	1416	820	?	?
S15	Ella Speed #1 (Amerada Pet)	s15,660fsl,660fwl	4371	1447	?	?	?
B22	#1 State "BA" NCT 8 (The TExas Co.)	s22,660fnl,660fel	4356	1455	835	690	?
F22	Fed. 3-22 (Amer. Republics Corp)	s22,1980fnl,660fwl	4369	1430	?	?	?
N23	N. M. D #1 (Magnolia Pet)	s23,660fnl,660fwl	4355	1460	840	?	?

T12S, R33E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S02	State B.T.D. #1 (Amerada Pet. Comp)	s02,660fsl,1980fwl	4250	1710	1108	800	650
C10	A.T. Caudle #1 (Amerada Pet. Corp)	s10,1980fnl,660fel	?	1670	1065	?	?

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S11	J.E.Simmons etal #1 (Amerada Pet. Corp)	s11,660fnl,660fwl	4252	1703	1090	?	?
S23	State B.T.E. #1 (Amerada Pet. Corp)	s23,660fsl,1980fwl	4254	1709	1090	?	?
R26	Birdie C. Roach (Amerada Pet. Corp)	s26,1980fsl,660fwl	4249	1665	1015	?	?

T12S, R34E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
L20	Lowe State #1 (Murphy H. Baxter)	s20,660fsl,1980fel	4195	1882	1328	?	?
R26	Ranger #11 (Phillips Pet)	s26,1978fnl,1978fwl	4161	1985	N.P.	1670	1428
S34	State AZ #2 (Pan Amer. Corp)	s34,660fnl,1980fel	4169	1960	?	?	?

T12S, R35E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
W26	West Tatum Unit #1 (Skelly Oil Comp)	s26,660fsl,1980fwl	4050	2125	1500	1290	962

T12S, R37E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
W24	L. Wingard #7 (Stanolind Oil & Gas)	s24,1980fnl,990fel	3887	2200	2097	1805	1610
F27	M.A. Foster #1 (Skelly Oil)	s27,990fsl,330fel	3900	2265	2127	1892	1722
M35	Midhurst #2 (Nearburg & Ingram)	s35,1880fnl,1880fwl	3894	2210	2095	1920	1750

T12S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
A05	W.F. Adamson #1 (Ralph Lowe)	s5,660fnl,660fwl	3884	2250	2115	?	?
K05	Kendrick Estate #3 (Sinclair Oil & Gas)	s5,1980fnl,660fel	3866	2252	2130	1885	?
A06	Wallace #2-A (Ralph Lowe)	s6,330fnl,1650fel	?	2290	2180	1930	?
W06	Wallace #3 (Ralph Lowe)	s6,1980fnl,1980fel	3889	2230	2100	?	?
Z07	Z Taylor No. 1 (Sunray Mid Cont Oil)	s7,660fnl,1980fel	3886	2254	2125	1860	1600

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
H08	G. Hall #2 (Sunray Mid. Cont Oil)	s8,1980fsl,1980fwl	3880	2272	2150	1950	?
M08	M.M. Harris 2 (Warren Pet. Corp)	s8,660fnl,660fwl	?	2263	2140	1928	1630
W08	M.M. Harris 4 (Warren Pet. Corp)	s8,1980fnl,1980fwl	3871	2290	2173	1965	1795
G22	Field-Greathouse 1 (Mobil Oil)	s22,cen. NW/4 NW/4	3823	2248	2108	1895	1620
H35	H.H. Harris 1 (The Texas Comp)	s35,330fsl,1980fwl	3805	2242	2086	1910	1800
		T13S, R38E					
L02	Lipscomb State 1 (Operators Service Comp)	s2,330fnl,990fwl	3805	2263	2142	?	?
		T14S, R33E					
S23	State "S.J." 1 (Amerada Pet Corp)	s23,sw/4 of sw/4	4210	1594	900	?	?
B28	State of N.M. "BU" No. 2 (The Texas Comp)	s28,660fsl,660fel	4216	1520	987	820	?
S33	J.E. Stevens #4 (Amerada Pet. Corp)	s33,1980fnl,660fel	4212	1507	985	?	?
S34	M. Saunders #1 (Gulf Oil Corp)	s34,660fsl,1980fwl	4207	1518	925	638	350
		T14S, R35E					
S17	State #1-17 (Union Oil Comp of Cal)	s17,660fnl,660fel	4057	2036	1602	1390	1280
		T14S, R36E					
A17	Austin #1 (Phillips Pet)	s17,660fsl,660fwl	3981	2095	1965	?	?
A19	Austin State #1 (Cherry Brothers & Cabot Corp)	s19,1980fnl,1980fwl	4004	2075	1960	1790	1590
		T14S, R37E					
S26	Skelton #5 (Shell Oil)	s26,2310fnl,430fwl	3827	2130	2010	1700	1480

T15S, R36E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S35	State Aw #4 (Cities Service Oil)	s35,1980fsl,660fel	3864	2040	1880	1558	?

T15S, R37E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
D11	Denton #1 (McAlester Fuel)	s11,660fsl,1980fel	3799	2074	1950	1720	1545
D13	Dickenson #1 (Atlantic Ref)	s13,660fnl,660fwl	3721	2142	1980	?	?
M14	P. McClure A 1 (McAlester Fuel Comp)	s14,1650fnl,2310fel	3799	2140	1996	1818	1680

T15S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S22	C.S. Stone #3 (Sinclair Oil & Gas)	s22,1980fnl,1980fwl	3721	2240	2055	1860	1755

T16S, R33E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
N25	N. M. A #2 (Phillips Pet)	s25,1983fel,661fsl	4166	1500	1385	1148	985

T16S, R34E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S08	State W.M. #1 (Shell Oil)	s8,1980fnl,660fwl	4140	1570	1450	1240	915
K23	Northeast Kemnitz #5 (Elk Oil Comp)	s23,1980fsl,660fwl	4089	1671	1545	1370	?
S29	State Western A-3 (Tenn. Gas & Transmission)	s29,1980fnl,1980fel	4132	1545	1430	1205	?
S35	Shell State 1 (Carper Drilling)	s35,660fsl,1980fwl	4061	1191	1032	?	?

T16S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
R22	United Royalty #1 (Midwest Oil)	s22,660fnl,660fel	3720	2128	1945	1680	?
A29	Austin Cook #1 (Gulf Oil Corp)	s29,2310fnl,980fwl	3754	2082	1921	1705	1590
E35	Rose Eaves #1 (Amerada Pet Corp)	s35,660fsl,1980fwl	3712	2102	1900	?	?

T17S, R33E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
P19	Phillips State 4B (Zapata Pet Corp)	s19,660fnl,660fel	4127	1329	1225	985	?
C34	Carper Wyatt Fed #4 (James P. Vanigan)	s34,990fsl,1700fwl	4057	1470	1222	1010	?

T17S, R34E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
O02	Ohio State "B" No. 2 (S.P. Yates)	s2,2348fnl,660fwl	4063	1645	1527	1315	?
B26	Bridges State #95 (Socony Mobil)	s26,860fsl,660fel	4016	1527	1403	1145	987
H35	Hale #9 (Phillips Pet. Comp)	s35,1785fel,1980fsl	4026	1510	1357	1135	940

T17S, R35E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S26	Santa Fe No 89 (Phillips Pet)	s26,2310fnl,330fwl	3931	1635	1495	1260	?
S27	Santa Fe No 90 (Phillips Pet)	s27,330fsl,660fel	3949	1580	1441	1260	?
S28	Santa Fe #108 (Phillips Pet)	s28,990fnl,431fel	3951	1635	1502	1270	?
S34	Santa Fe #65 (Phillips Pet)	s34,987fnl,1980fel	3939	1618	1470	1270	?

T17S, R36E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
N09	N.M. State P#3 (Humble Oil & Refining)	s9,660fnl,660fwl	3886	1886	1768	1570	1375
S25	Spencer #1 (J.C. Williamson)	s25,660fnl,1980fwl	3816	1926	1700	1480	?
M26	Monsanto State G #1 (Monsanto Chem Comp)	s26,1980fel,660fnl	3834	2012	1763	?	?

T17S, R37E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C06	Caylor #6 (Sunray Oil Comp)	s6,1980fnl,902fwl	3827	1982	1860	1600	?

T17S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
E02	Rose Eaves A 1 (Amerada Pet)	s2,1980fel,660fnl	3710	2140	1932	?	?

T18S, R32E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F04	Fed #2 (B.M. Jackson)	s4,1650fnl,990fel	3885	1158	818	625	555
Y20	Young Fed #5 (John M Beard)	s20,2310fsl,990fwl	3751	1017	580	390	285

T18S, R33E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
B12	British Amer. State No. 2 (P. W. Miller Drlg)	s12,660fnl,1980fel	4104	1753	1430	?	?

T18S, R34E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
L06	Lea No. 17 (Phillips Pet)	s6,989fnl,330fwl	4098	1631	1395	1185	1135
S22	State V-22 #2 (Cont. Oil)	s22,1980fsl,1980fwl	4023	1820	1452	1150	?
M33	Marathon State #1 (Tom Brown Drlg)	s33,330fsl,1980fwl	3957	1712	1318	1128	1050

T18S, R35E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F03	Santa Fe No. 114 (Phillips Pet)	s3,2310fsl,330fel	3920	1745	1522	1300	?
V04	Vac Edge Unit 2 (Standard Oil)	s4,1980fnl,660fwl	3961	1600	1420	1225	1105
V05	Vac Edge Unit #19 (Standard Oil of Tx)	s5,990fsl,990fel	3598	1598	1395	1195	1065
W06	State Warren Acct 2 #9 (The Ohio Oil Comp)	s6,330fsl,913fwl	3991	1512	1290	1075	?
C29	Carper Luthy 1 (Carper Drilling)	s29,1980fnl,660fwl	3948	1855	1532	1285	1180

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
		T18S, R36E					
C01	Catron "B" No. 2 (Cactus Drilling)	s1,1980fsl,1980fel	3789	1825	1632	1322	?
J11	State JJ #1 (John M. Kelly)	s11,660fsl,660fel	3816	1811	1518	1300	?
A12	Amerada State No. 1 (Cactus Drilling)	s12,660fnl,1980fwl	3783	1782	1520	1300	?
		T18S, R37E					
B14	State WH "B" #2 (Amerada Pet)	s14,1650fsl,2310fwl	3698	1643	1525	1300	?
		T18S, R38E					
S03	Saunders #1 (O.D. Alsabrook)	s3,1980fsl,1980fel	3660	1965	1765	1520	?
M19	McKinley A-19 #1 (Shell Oil)	s19,2310fsl,1650fel	3664	1520	1400	1200	?
		T19S, R34E					
U12	U.S. Smelting State #1 (Carper Drlg)	s12,660fnl,660fwl	3974	1855	1420	1220	1130
		T19S, R35E					
S14	State AU #1 (Atlantic Refining)	s14,660fsl,660fwl	3815	1805	1410	1210	1125
A27	Allen Estate A #1 (Shell Oil)	s27,1980fnl,660fel	3723	1760	1318	1100	990
G28	State G #1 (Cabot Carbon Comp)	s28,1980fsl,660fwl	3743	1752	1294	1078	1005
L33	Lea State BG #8 (Gulf Oil)	s33,1980fnl,660fel	3703	1779	1286	1072	985
		T19S, R36E					
S01	State "B" #1 (Pan Amer Pet)	s1,330fel,1980fnl	?	1480	1330	1120	1040

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
N11	N.M. State "AO" #1 (Humble Oil & Ref)	s11,660fsl,1980fwl	3759	1472	1272	1060	900
S18	Sunray Bryan #1 (Tom Brown Drlg)	s18,1980fnl,1980fwl	3744	1777	1419	1200	?
T25	State "T" No. 4 (Amerada Pet. Corp)	s25,NE/4 of NW/4	3702	1230	1110	?	?
	T19S, R37E						
L32	May Love Unit #1 (Amerada Pet. Corp)	s32,1980fel,1980fsl	3580	1220	1150	900	780
	T20S, R35E						
P28	Phillips State No. 1 (W.H. Black)	s28,660fnl,660fel	3701	1972	1550	1230	1160
	T20S, R36E						
S02	State "A" No. 2 (Superior Oil)	s2,660fnl,1980fel	3603	1005	865	640	570
S30	Sims State 1-30 (Union Oil of Cal)	s30,660fnl,660fwl	3662	1985	1470	1260	1180
	T20S, R37E						
N01	N.M. State "AG" No. 6 (Humble Oil & Ref)	s1,990fnl,1650fwl	3604	1465	1321	1135	1010
	T20S, R38E						
W27	Warren Unit "BT" No. 26 (Cont. Oil Comp)	s27,660fsl,660fwl	3542	1425	1288	1050	?
	T21S, R32E						
F01	Fed #1 (Kimball Prod Co)	s1,660fsl,1980fwl	3792	1550	1115	840	?
F11	Fed 1 (Gackle Drilling)	s11,SE/4 of SE/4	3861	1565	988	820	690

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
A31	AEC #7 (Union Carbide)	s31,2040fnl,2040fel	3662	670	122	?	?
		T21S, R35E					
S01	State WE "F" #3 (Amerada Pet)	s1,660fnl,660fel	3564	1455	1120	870	?
N04	N.M. State "F" #1 (British Amer Oil)	s4,660fwl,1902fnl	3638	1757	1320	1105	990
C16	Cosden Pet State D #1 (Cosden Pet)	s16,660fsl,660fel	3603	1825	1385	1100	900
P32	Phillips State "C" No. 2 (Resler & Sheldon)	s32,660fel,1650fnl	?	1802	1270	1050	900
		T21S, R36E					
R21	Arnott Ramsey "C" No. 5 (Gulf Oil)	s21,SE/4 of SW/4	3593	1425	1241	970	868
G26	N.M. State "G" #14 (Humble Oil & Ref)	s26,1980fnl,1980fwl	3550	1397	1212	?	?
R27	W.A. Ramsay A #42 (Gulf Oil)	s27,1980fel,650fnl	3568	1472	1255	1000	870
W27	W.A. Ramsey #39 (Gulf Oil)	s27,1980fsl,510fel	3545	1486	1263	1000	895
R31	Rector A #1 (Late Oil Comp)	s31,1980fel,1980fnl	3635	1580	1255	990	828
R33	Arnott Ramsey NCT-D #12 (Gulf Oil)	s33,1980fsl,1980fel	3581	1560	1330	1040	960
R34	W.A. Ramsey NCT #38 (Gulf Oil)	s34,1980fnl,660fwl	3580	1556	1320	1050	960
		T21S, R37E					
C28	J.N. Carson C#9 (Gulf Oil)	s28,2085fsl,765fel	?	1168	1040	770	685

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M31	N.T. Mattern No. B-12 (Gulf Oil)	s31,660fsl,1980fnl	?	1150	994	770	658
		T22S, R32E					
B13	B & H Fed 1 (Ray Smith Drlg)	s13,660fsl,660fel	3644	860	358	?	?
R14	#2 Red Tank (Carper Drilling)	s14,660fsl,1980fwl	?	950	453	?	?
		T22S, R34E					
N01	N.M. State BS #1 (Humble Oil & Refining)	s1,1980fsl,660fel	3640	1728	1225	960	810
N08	N.M. State "AE" No. 1 (Sunray Mid Cont)	s8,660fsl,1980fel	?	1600	986	765	630
A10	Allison Fed. No. 1 (Hudson & Hudson)	s10,1980fwl,660fel	2573	1690	1052	820	695
		T22S, R35E					
J01	Jalmat Deep 1 (The British Amer Oil Comp)	s1,660fsl,660fwl	3611	1822	1295	1070	?
D03	Donegan State No. 1 (Western Drlg Co)	s3,660fnl,660fwl	?	1856	1305	1070	950
S04	Skelly State No. 1 "U" (Ashman & Hilliard)	s4,660fsl,660fel	3611	1860	1278	1050	930
H09	Humble State #1 (Hudson & Hudson)	s9,1980fsl,1980fwl	?	1810	1230	1010	865
H11	Hall State "F" #9 (British Amer Oil)	s11,990fwl,660fsl	3610	1878	1300	1050	875
S23	State "An" 1 (Atlantic Refining)	s23,330fel,1980fsl	?	1755	1200	950	825
		T22S, R36E					
L03	Harry Leonard NCT-D No. 10 (Gulf Oil)	s3,1980fnl,1980fwl	3571	1562	1298	1050	908

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
J04	J.F. Janada F #15 (Gulf Oil)	s4,1980fsl,660fel	3587	1568	1322	1060	940
S09	State 157 A #4 (Sinclair Oil & Gas)	s9,1980fsl,660fel	3552	1460	1204	950	800
T09	State 157 A #3 (Sinclair Oil & Gas)	s9,660fsl,660fel	3540	1420	1162	918	818
R10	Record #2 (Western Nat. Gas)	s10,560fsl,660fwl	3560	1470	1212	975	870
S33	J.L. Selby #2 (The Atlantic Ref. Co)	s33,1980fnl,1830fwl	3498	1360	1000	760	642
A35	State A-35 "A" No. 1 (Continental Oil)	s35, Loc. ?	3469	1393	1149	900	785
M36	State McDonald 1-B No. 11 (Ohio Oil Co)	s36,2310fnl,330fwl	3469	1420	1181	930	820

T22S, R37E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
W15	E.W. Walden #4 (Amerada Pet Corp)	s15,NW/4 of SW/4	3410	1120	938	?	?
C16	R.E. Cole #1 (E.P Campbell)	s16,2310fsl,1650fel	3405	1130	945	665	570
S36	State BD 36 #1 (Aztec Oil & Gas)	s36,1980fsl,1980fel	3316	1190	1005	760	650

T22S, R38E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
D30	Gulf Drinkard #2 (Western Oil Fields Inc)	s30,990fsl,330fwl	3337	1120	952	678	580

T23S, R32E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C09	Cont Fed #1-9 (McBee Oil Comp)	s9,1980fel,660fsl	3699	1140	585	?	?
F15	Fed Cont 1-15 (John Trigg)	s15,1980fnl,1980fel	3722	1176	640	?	?
C24	Conoco Fields Fed #1 (H.L. Johnson)	s24,1650fsl,330fel	3720	1225	697	450	?
C28	Cont. Fed No.1 (Max Wilson)	s28,660fnl,1980fwl	3687	1180	650	?	?
F34	Fed "K" No. 1 (The Pure Oil Comp)	s34,1980fsl,330fel	3630	1170	630	?	?
J35	Fed. James No. 1 (P.M. Drilling Co)	s35,660fnl,660fel	3675	1220	590	350	?

T23S, R33E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S06	Shell Fed #1-6 (Hudson & Hudson)	s6,330fsl,330fel	3704	1260	731	500	330
F07	Fed. 7 well #1 (Hudson & Hudson)	s7,660fsl,660fwl	3722	1270	740	500	390
T17	Texaco State No. 1 (P.M. Oil Comp)	s17,660fsl,660fwl	3715	1270	730	505	340
S18	Skelly State #1 (Tenneco Oil)	s18,660fnl,1980fel	3726	1290	750	?	?
M19	I. J. Johnson 19-1 (Cont. Oil)	s19,660fsl,660fwl	3720	1230	700	470	?
L20	Levick Fed #1 (Cont. Oil Comp)	s20,660fsl,660fel	3701	1280	710	?	?
H32	Humble State 1-32 (El Cinco Prod)	s32,660fnl,1980fel	3683	1268	715	?	?
S35	State 1-35 (George L. Buckles)	s35,660fsl,660fwl	?	1310	738	558	?

T23S, R35E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M01	Malco Fed. No. 1 (?)	s1,330fwl,2310fsl	3494	1655	1172	850	710

T23S, R36E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F17	Farney A-17 No. 3 (Continental Oil)	s17,1650fnl,990fwl	3468	1545	1025	750	625

T23S, R37E

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
H04	Hughes A-1 #6 (Samedan Oil Co)	s4,1980fsl,660fwl	3324	1142	935	700	535
K06	King "B" #5 (Ralph Lowe)	s6,330fnl,330fel	3383	1261	1040	790	650
H09	Harrison B-10 (Skelly Oil Comp)	s9,1980fsl,1980fwl	3317	1090	890	650	455
S16	#3 State of N.M. "BZ" NCT-8 (The Texas Comp)	s16,1980fsl,1980fel	3317	1045	795	570	460
O24	Ohio State #1 (?)	s24,660fel,660fsl	?	1356	1105	835	758

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
		T24S R31E					
P20	Poker Lake #40 (David Fasken)	s20,660fsl,1980fwl	3490	530	175	?	?
		T24S, R32E					
O02	Ohio State #1 (P.M. Drilling)	s2,1980fnl,660fel	3631	1172	558	?	?
B06	Bondurant Fed No. 1 (Curtis Hankamer)	s6,1980fel,660fnl	3584	890	354	?	?
H12	Hanagan Fed 3 (Curtis Hankamer)	s12,1980fnl,660fwl	3605	1130	590	?	?
J14	Jennings Fed 4 (Tenneco Oil Comp)	s14,1980fsl,1980fwl	3591	1130	513	?	?
H15	Fed. Hanagan "B" #3 (Gulf Oil Corp)	s15,660fel,1980fsl	3591	1108	505	?	?
S22	U.S. Smelting USA #4 (Tenneco Oil Comp)	s22,2310fnl,1650fel	3604	1065	495	?	?
		T24S, R33E					
N08	N.M. State A.G. 1 (Sunray Mid Cont. Oil)	s8,660fnl,660fwl	3637	1265	645	?	?
H13	Holland #1 (Lyard Bennett)	s13,1980fnl,660fel	3598	1245	673	440	?
S20	State "BB" 20 No. 1 (Cont. Oil Co)	s20,660fsl,1980fwl	3540	1140	560	?	?
C31	Cont. State 1 (Albert Gackle)	s31,1980fsl,660fel	3524	1065	500	?	?
		T24S, R38E					
H30	Hair #2 (Ralph Lowe)	s30,535fnl,2310fwl	3156	1200	909	?	?
		T25S, R32E					
C03	Cotton Draw Unit No. 9 (Texaco Inc.)	s3,1650fsl,1980fel	3486	810	365	?	?
C11	Cont. Fed #1 (Westatco Pet)	s11,SW of SE	3410	838	312	?	?

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S28	J.D. Sena U.S.A. No. 1 (Tenneco Oil Comp)	s28,2310fsl,1650fwl	3374	900	350	?	?
C32	Conoco State No. 1 (R.C. Graham)	s32,1980fnl,1980fwl	3307	1080	590	?	?
J33	Jennings Fed 33-1 (Hill & Meeker)	s33,2310fnl,2310fwl	3351	1040	450	?	?
		T25S, R33E					
B05	Bass Fed #1 (Hill & Meeker)	s5,660fnl,660fel	3478	1108	529	?	?
A08	Anne Bass Fed. #1 (Santana Pet)	s8,1980fsl,660fel	3456	1065	462	245	?
B18	#1 Bass Fed (Sam H. Jolliffe)	s18,660fnl,660fwl	3497	988	428	?	?
P24	Perry Fed #1 (R.B. Farris)	s24,660fsl,660fwl	3349	1045	446	?	?
P25	Pan Amer Fed 1 (King Resources)	s25,1980fsl,660fwl	3342	1050	460	260	?
D27	Harry Dickson #1 (Robert A Dean)	s27,660fsl,660fel	3320	1021	562	220	?
S36	State #1-36 (Ashmum & Hilliard)	s36,660fnl,660fwl	3346	1040	450	?	?
		T25S, R37E					
F14	Fed "A" #1 (Johnson & French)	s14,330fel,560fnl	3123	865	578	300	?
W24	Wimberly #4 (Western Nat. Gas)	s24,1980fnl,990fwl	3087	790	560	?	?
		T26S, R32E					
C05	Conoco Bradley #1 (Fred Pool)	s5,660fnl,1980fwl	3282	1388	819	?	?
B15	Ben Fed. #1 (Brown & Krag)	s15,NE/4 SE/4	3177	600	55	?	?
		T26S, R37E					
F04	Farnsworth #6 (Jal Oil Comp)	s4,990fsl,990fwl	?	982	480	?	?

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
L11	U.S.A. Leonard Oil No. 1 (Stanolind Oil & Gas)	s11,660fsl,660fel	3013	930	531	?	?
		T26S, R38E					
F07	Fed Lowe 1 (Forest Oil Comp)	s7,1980fsl,660fwl	3032	970	590	?	?

ECTOR COUNTY, TEXAS
T1N, B41

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F34	D. Fasken AG #1 (Stanolind Oil & Gas)	s34,1980fnl,1980fel	2955	1850	1476	1250	1185

T1N, B42

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C46	NCU #528 (Pan Amer Pet)	s46,1841fwl,885fnl	3068	1898	1609	1360	1255

T1N, B43

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C04	W.F. Cowden A #8 (Stanolind Oil & Gas)	s4,660fnl,660fwl	3125	1575	1311	1090	982
H09	O.B. Holt A/C 2 #8 (Texas Pacific Coal & Oil)	s9,1980fnl,2080fwl	3058	1740	1447	1215	1110
C15	North Cowden 12-8 (Pan Amer)	s15,660fnl,660fwl	3100	1610	1282	1085	1018
C18	North Cowden 535 (Pan Amer)	s18,2459fel,1713fsl	?	1910	1610	1345	1210
H19	O.B. Holt A/C 1 #9 (Texas Pacific Oil)	s19,440fnl,440fel	3071	1870	1558	1324	1200
H25	Hugh Corrigan #9 (Sinclair Oil & Gas)	s25,1320fsl,1320fwl	3022	1770	1495	1270	1150
C26	North Cowden Unit 538 (Pan Amer Pet)	s26,1300fnl,2700fwl	?	1805	1500	1260	1170
N27	N. Cowden Blk 21 No. 11 (Stanolind Oil & Gas)	s27,1980fnl,660fwl	3057	1770	1410	1245	1142
C28	North Cowden No. 532 (Pan Amer Pet)	s28,2141fsl,330fel	3076	1654	1385	1100	1039
C35	North Cowden Unit 561 (Pan Amer Pet)	s35,on NL,2600fel	3062	1781	1500	1265	1178
M36	Midland Natl Bank 3 (Cont Oil Comp)	s36,440fnl,440fwl	?	1750	1480	1235	1155

T1N, B44

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S21	Scharbauer "MO" #6 (Pan Amer Pet)	s21,330fsl,1300fel	3174	1545	1350	1082	965

T1N, B45

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
K39	Klok B-39 No. 2 (Cont Oil)	s39,660fsl,1980fel	3321	1470	1255	1015	930

T1S, B43

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S01	R.W. Smith A #2 (Tidewater Oil)	s1,2200fnl,1330fwl	3071	1738	1398	1248	1158
C03	North Cowden #533 (Pan Amer Pet)	s3,2620fsl,20fwl	3091	1748	1430	1233	1105
U11	Unit Blk 31 #10 (Tidewater Oil)	s11,660fnl, ?	3058	1812	1550	1282	1192
C13	North Cowden Coop #1 (Pan Amer)	s13,42fsl,149fwl	3048	1790	1535	1280	1196
C23	Rhodes Cowden 306-W (Cities Service Oil)	s23,10fsl,2630fwl	?	1774	1492	1245	1160
C25	Rhodes Cowden 645W (Cities Service)	s25,10fsl,2630fel	?	1772	1498	1232	1125
R25	Rhodes Cowden 646W (Cities Service)	s25,2647fnl,124fwl	3035	1796	1512	1252	1165
J31	J.L. Johnson No. 1 (Stanolind Oil & Gas)	s31,660fsl,660fel	3048	1614	1330	1092	1018
J32	J.L. Johnson No. 2 (Stanolind Oil & Gas)	s32,330fnl,422fwl	3046	1670	1402	1135	1039
J42	Johnson No. 16 (Eastland Oil Comp)	s42,995fnl,167fwl	3071	1570	1295	1051	965
J43	J.L. Johnson No. 1 (Paul Moss)	s43,660fnl,333fwl	3055	1560	1295	1055	970

T1S, B44

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
J37	J.L. Johnson "S" No. 3 (Eastland Oil)	s37,2322fsl,2310fel	3091	1545	1280	1040	930
C42	J.T. Cross #5 (Pan Amer)	s42,660fnl,830fel	3217	1528	1323	1017	900

T1S, B45

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
B10	Blk 30, Tract 3 well 3 (Sun Oil)	s10,440fnl,440fwl	3083	1786	1518	1248	1120
P40	Parker "A" SA #12 (J.C. Barnes Oil)	s40,1882fsl,690fwl	?	1405	1143	920	802

T2S, B41

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
R41	Dora Roberts A2 No. 1 (Forest Oil)	s41,660fel,660fnl	2861	1625	1292	1002	880

T2S, B42

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F08	H.C. Foster B No. 4 (Tennessee Prod Co)	s8,1665fsl,330fwl	2952	1661	1371	1130	1030
J16	Tenneco Jutkins No. 1 (Tenneco Jutkins)	s16,330fnl,330fwl	2948	1708	1390	1120	1005
F18	South Foster Unit 134	s18,330fwl,2232fsl	2942	1675	1376	1135	1048
M43	Paul Moss No. 33 HW (Forest Oil)	s43,1331fsl,2640fwl	2924	1630	1280	970	873

T2S, B43

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
Q09	Cowden Q-1 (Cities Service Oil)	s9,1980fwl,660fsl	2975	1647	1317	1050	965
C14	E.F. Cowden "B" #62 (Pan Amer Pet)	s14,1320fsl,150fwl	2969	1642	1347	1071	970
C23	E.F. Cowden "A" #92 (Pan Amer Pet)	s23,190fnl,2220fel	?	1651	1350	1080	972

T1S, B44

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
J37	J.L. Johnson "S" No. 3 (Eastland Oil)	s37,2322fsl,2310fel	3091	1545	1280	1040	930
C42	J.T. Cross #5 (Pan Amer)	s42,660fnl,830fel	3217	1528	1323	1017	900

T1S, B45

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
B10	Blk 30, Tract 3 well 3 (Sun Oil)	s10,440fnl,440fwl	3083	1786	1518	1248	1120
P40	Parker "A" SA #12 (J.C. Barnes Oil)	s40,1882fsl,690fwl	?	1405	1143	920	802

T2S, B41

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
R41	Dora Roberts A2 No. 1 (Forest Oil)	s41,660fel,660fnl	2861	1625	1292	1002	880

T2S, B42

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F08	H.C. Foster B No. 4 (Tennessee Prod Co)	s8,1665fsl,330fwl	2952	1661	1371	1130	1030
J16	Tenneco Jutkins No. 1 (Tenneco Jutkins)	s16,330fnl,330fwl	2948	1708	1390	1120	1005
F18	South Foster Unit 134	s18,330fwl,2232fsl	2942	1675	1376	1135	1048
M43	Paul Moss No. 33 HW (Forest Oil)	s43,1331fsl,2640fwl	2924	1630	1280	970	873

T2S, B43

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
Q09	Cowden Q-1 (Cities Service Oil)	s9,1980fwl,660fsl	2975	1647	1317	1050	965
C14	E.F. Cowden "B" #62 (Pan Amer Pet)	s14,1320fsl,150fwl	2969	1642	1347	1071	970
C23	E.F. Cowden "A" #92 (Pan Amer Pet)	s23,190fnl,2220fel	?	1651	1350	1080	972

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F25	South Foster #127 (Pan Amer Pet)	s25,580fel,1320fsl	?	1585	1270	1025	940
C26	#98-A-E.F. Cowden (Pan Amer Pet)	s26,1387fwl,2640fsl	?	1580	1220	1005	855
C32	E.P. Cowden E #1 (Stanolind Oil & Gas)	s32,660fsl,660fel	3014	1616	1302	1020	895
A35	Frank V Addis #4 (Pan Amer Pet)	s35,1985fel,2150fsl	2954	1565	1290	998	810
M38	Paul Moss #105 (Forest Oil)	s38,660fel,760fsl	2966	1578	1231	1015	920
C44	Cross "D" No. 1 (Cities Service)	s44,w 1/2	3062	1674	1355	1080	1012
G46	Moss Grayburg S.A. No. 1 (Cities Service Comp)	s46,1320fnl,150fel	2974	1602	1278	1000	?

T2S, B44

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C11	Cowden #C-8 (Shell Oil)	s11,1440fsl,1890fwl	3071	1450	1165	920	845
M28	Moss "E" #8 (Cities Service)	s28,660fsl,1980fwl	3127	1380	1120	873	790
C36	E.F. Cowden No. 3 (H. Garrett Oil)	s36,330fwl,1650fnl	3039	1582	1284	1048	960
P38	Paul Moss #2 (Argo Oil)	s38,330fnl,1650fwl	3084	1604	1310	1080	980

T2S, B45

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
N25	Nelson #2 (H.L. Brown)	s25,1980fnl,1980fwl	2994	1140	860	652	559

T3S, B42

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C13	E.W. Cowden No. 1 (J.C. Williamson)	s13,660fsl,660fel	2869	1716	1279	1028	870
F32	H.S. Foster No. 1 (Mohawk Pet Corp)	s32,660fsl,660fwl	2956	1875	1385	1100	?

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C38	Cowden #1 (Sam Ares Et Al)	s38,660fnl,660fwl	2935	1880	1431	1120	?
T47	T.X.L. #3-47 (J.C. Willaimson)	s47,990fnl,1650fel	?	1832	1435	1100	1042
		T3S, B43					
M01	Paul Moss No. 9 (Carlton Beal & Assoc)	s1,2519fel,1283fsl	2933	1684	1240	965	887
S05	T.X.L. S #1 (Cities Service)	s5,1988fnl,1980fwl	?	1704	1369	1100	1020
F08	Foster E - 2 (Cities Service)	s8,672fel,1988fsl	3034	1680	1320	1080	1012
F09	Foster No. 2 (Cities Service)	s9,1980fel,660fnl	3043	1700	1350	1065	970
		T4S, B42					
P02	Peck "A" #1 (Chester Tyra)	s2,330fnl,1980fel	2907	1795	1358	1058	908
S10	Slator No. 1-10 (Tyra & Hood)	s10,330fnl,2310fwl	2922	1829	1352	1158	?
		Blk B-8					
E10	Scharbauer -Eidson A-1 (Chamber & Kennedy)	s10,660fsl,510fel	3025	1189	880	640	495
S10	Scharbauer -Eidson B #1 (Chamber & Kennedy)	s10,1980fsl,660fel	3029	1190	888	635	500
		Blk B-15					
W01	Willie "D" #1 (Chamber & Kennedy)	s1,1980fsl,660fel	3045	1220	930	660	560
C02	Chambers & Kennedy #1 Royal (Chamber & Kennedy)	s2,660fnl,660fwl	3025	1188	885	625	508
		Blk B-16					
C08	#2 - "C" Connell (Midhurst Oil Co)	s8,2000fel,960fnl	?	928	595	?	?

ANDREWS COUNTY, TEXAS
T1N, Blk 41

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M42	Midland Farms "V" #4 (Stanolind Oil & Gas)	s42,660fsl,660fwl	?	1832	1505	1270	1150
F43	David Fasken #A4 (Anderson Prichard)	s43,660fnl,1980fel	3030	1835	1508	1275	1160

T1N, Blk 42

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M07	Midland Farms "S" No. 6 (Stanolind Oil & Gas)	s7,660fnl,1980fwl	3070	1820	1521	1280	?
F09	David Fasken No. D-4 (Stanolind Oil & Gas)	s9,1980fnl,1980fwl	3074	1820	1598	1289	1200

T2N, Blk 41

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F02	Fasken No. 1H-2-1 (Anderson Pritchard)	s2,1980fnwl,660fsl	?	1907	1550	1330	1242
F14	Fasken No. 1 (Hissom Drilling)	s14,660fnl,660fel	?	1972	1625	1390	1150
I19	Inex Fasken No. 1 (F. Kirk Johnson)	s19,1980fel,660fnl	3001	1940	1605	1380	?
D20	David Fasken "A" No. 1 (Ambassador Oil)	s20,467fsl,467fel of SW/2	3029	1950	1603	1230	1148

T2N, Blk 42

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M16	Midland Farms K-7 (Stanolind Oil)	s16,66fsl,660fwl	?	1835	1505	1290	1195

T3N, Blk 40

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F12	Fasken FB #2 (Magnolia Pet)	s12,330fnl,330fwl	3006	2080	1730	1480	1395

Blk 1

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
U01	University Blk 1 H 1 (White Eagle Oil)	s1,684fsl,1993fel	3104	1958	1620	1425	1347
B03	Buffalo Univ A #1 (Ralph Pembrook)	s3,560fnl,2288fel	3152	1925	1575	1360	1145
U10	University #3 (Carlton Beal & Assoc)	s10,330fsl,2295fwl	?	1870	1546	1312	1190
T13	State of TX Tract 9 well 1 (Grover McGurdy)	s13,2060fsl,660fwl	3110	1855	1490	1292	1220
U28	University 28 No. 1 (Signal Oil & Gas)	s28,1980fnl,660fel	3142	1830	1496	1270	1160

Blk 2

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
D09	Univ. "D.W." #2 (Pan Amer)	s9,993fnl,467fel of E/2 of sec	3099	1905	1595	1375	1248

Blk 3

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
T01	Texas Univ UV #1 (Phillips Pet Co)	s1,1980fnl,660fwl	3065	2130	1689	1480	1348
T08	Texas S #1 (Skelly Oil)	s8,w/2	3122	2140	1710	1477	1370
M16	R.M. Means 1-C H 1 (The Sharples Oil Corp)	S16,1980FNL,660FEL	3102	2148	1730	1475	1300
M18	Means C #1 (Gen. Amer Oil)	s18,660fsl,660fwl	3102	2120	1725	1508	1410
O27	Frank Orson NCT 1 #1 (The Tx Corp)	s27,330fwl,660fnl	3096	2115	1715	1505	1370

Blk 4

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
U31	University 4-31 #4 (Hanley Co)	s31,1980fel,660fsl	3132	2074	1640	1420	1310
T32	State of Texas "CB" #1 (The Texas Co)	s32,1980fsl,660fel	3098	2076	1685	1420	1300

Blk 9

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F08	Fuhrman-Mascho 78 (Pan Amer Pet)	s8,660fnl,1980fel of SE/4	3208	1903	1708	1408	1305
U35	University #1-W (Swell Oil Comp)	s35,2310fnl,330fel	3133	1870	1545	1264	1184

Blk 13

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
A11	University A #1 (Southern Minerals Corp)	s11,1980fel,660fnl	3266	1792	1609	1385	1252
K14	University KK #1 (Gulf Oil)	s14,330fsl,330fel	3282	1850	1652	1430	1290
T36	University T #3 (Phillips Pet)	s36,1989fsl,661fel	3279	1682	1518	1245	1132
D46	University "DZ" No. 7 (Pan Amer)	s46,1980fsl,1980fwl	3256	1760	1552	1322	1242
U46	University "DZ" No. 6 (Pan Amer)	s46,660fsl,1984fwl	3252	1738	1528	1380	?

Blk 13

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
U01	Univ 143 #4 (Sinclair Oil & Gas)	S1,660fsl,1980fwl	3181	1650	1458	1220	111
U25	University C-25-1 (Continental Oil)	s25,1980fnl,1980fwl	?	1845	1585	1397	1328

Blk A-19

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C05	Clefa A #1 (Phillips Pet Co)	s5,660fwl,1316fsl	3111	2005	1622	1400	1210

Blk A-33

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
W02	Williamson #1 (Caroline Hunt Sands)	s2,660fnl,1980fwl	3281	1882	1662	1460	?

Blk A-34

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C01	Crews "C" #3 (Cities Service Oil Comp)	s1,660fwl,1980fsl	3194	1880	1678	1462	1375
C02	E.R. Crews Mast "A" No. 2 (Texas Pacific Coal & Oil)	s2,660fsl,660fel	3194	1845	1655	1425	1230
H03	Home Stake #1 (Ralph Lowe)	s3,1986fsl,661fel	3227	1850	1620	1430	1170
C10	Elizabeth Crews Mast #1 (B.B.M. Drilling)	s10,660fnl,1980fwl	3188	1909	1737	1475	?
F24	Nola Fisher #1 (Jay H. Floyd)	s24,660fsl,660fwl	3205	1822	1641	1495	?

Blk A-35

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
G06	Gardner #2 (McWrath & Smith)	s6,1980fsl,1980fel	3196	1862	1632	1390	1280
G07	Mollie Groom No. 12 (Gulf Oil)	s7,660fnl,1980fel	3182	1889	1682	1440	1350

Blk A-36

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
S23	Shafter Unit #14 (Mobil Oil)	s23,660fnl,660fwl	3230	1860	1703	1400	?

Blk A-37

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
C06	Chesley #1 (Stanolind Oil & Gas)	s6,1980fnl,1980fwl	3408	1648	1412	1248	?
T24	V. Thomas #1 (Buffalo OIl Comp)	s24,1980fnl,660fel	3383	1675	1470	1265	1170

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ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M03	R. McWhorter No. 1 (Richardson & Bass)	s3,1980fnl,1980fwl	3428	1690	1472	1220	1140

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ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
M09	Mitchell #1 (Lanphere & May)	s9,1980fnl,660fwl	3192	1980	1650	1410	1300
M13	F.T. McCollam & Means #2 (Cont Oil Comp)	s13,1980fsl,660fwl	3117	1980	1615	1370	1278
P16	J.E. Parker Fee #1 (Texaco Inc)	s16,467fsl,467fwl	3158	1945	1578	1350	1248
G22	Grady #1 (W.E. Brady Oil)	s22,660fsl,660fwl	3159	1890	1532	1305	1205
M24	McCollum & Weibush #5 (Cont Oil)	s24,1982fsl,1992fel	3111	1960	1630	1387	1255
W24	McCullum Weibush #4 (Cont Oil Comp)	s24,1996fwl,660fnl	3113	1986	1625	1395	1300

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ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
L12	Shafter Lake Unit 164 (Mobil Oil)	s12,660fnl,660fwl	3203	1665	1342	1240	1140
S16	San Andrews Unit No. 189 (Mobil Oil Corp)	s16,546fwl,1948fnl	3212	1935	1704	1432	1306

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ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
G03	Grossman & Vance #1 (B.A. Ray)	s3,1980fnl,660fwl	3353	1685	1462	1270	1172
B07	Bryant Link No. 1 (Hill,Meeker & Aldrich)	s7,NW/4 of SE/4	3306	1710	1445	1305	1210
E09	E.T. Brooks No. 6 (Stanolind Oil & Gas)	s9,SW/4 of SE/4	3269	1672	1460	1240	1200
L15	Lotus B - 1G (J.C. Williamson)	s15,1980fnl,1980fel	3286	1748	1482	1305	1200
L16	Lotus "A" No 1 (Stanolind Oil & Gas)	s16,crn of SE of NE	3241	1660	1357	1225	1120
B22	Bradford #1 (E.M. Craig Jr)	s22,1980fsl,1980fel	3340	1798	1591	1330	1195

Blk A-49

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
F12	Ferguson #1 (Humble Oil & Ref)	s12,660fnl,660fwl	3394	1640	1420	1170	1050

Blk A-50

ID	Name	Location	Datum	T.R.	T.A.	T.B.	T.C.
N01	North Blk 12 Unit 2 (Continental Oil)	s1,660fsl,660fel	3422	1668	1450	1182	1110
M14	Magnolia Morgan #1 (Ralph Lowe)	s14,660fnl,1980fwl	3323	1570	1360	1115	955

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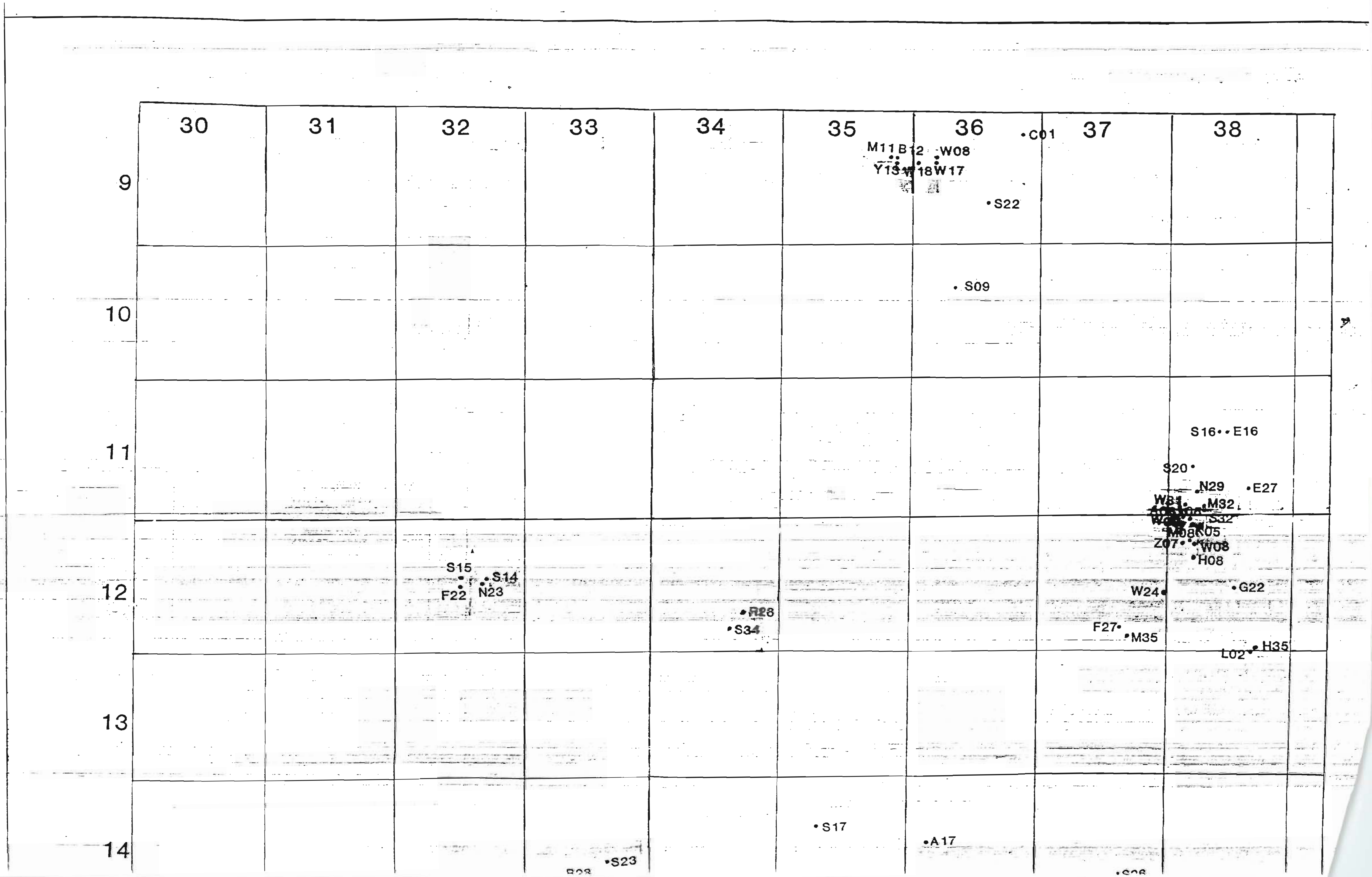

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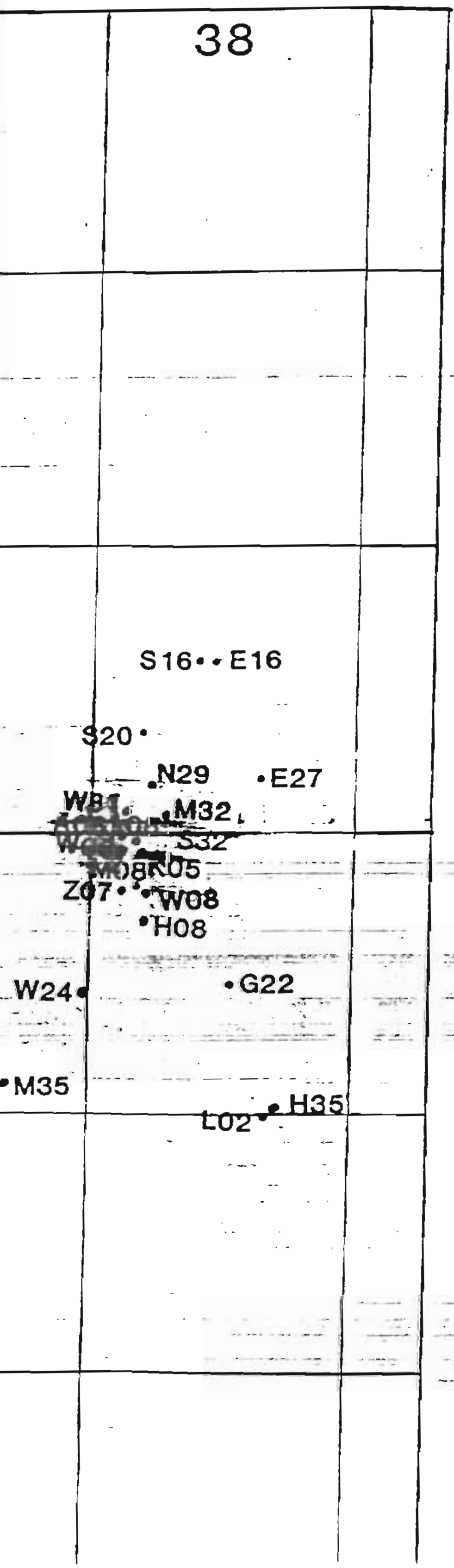

PLATE WELL LOCATION BASE MAP

EXPLANATION

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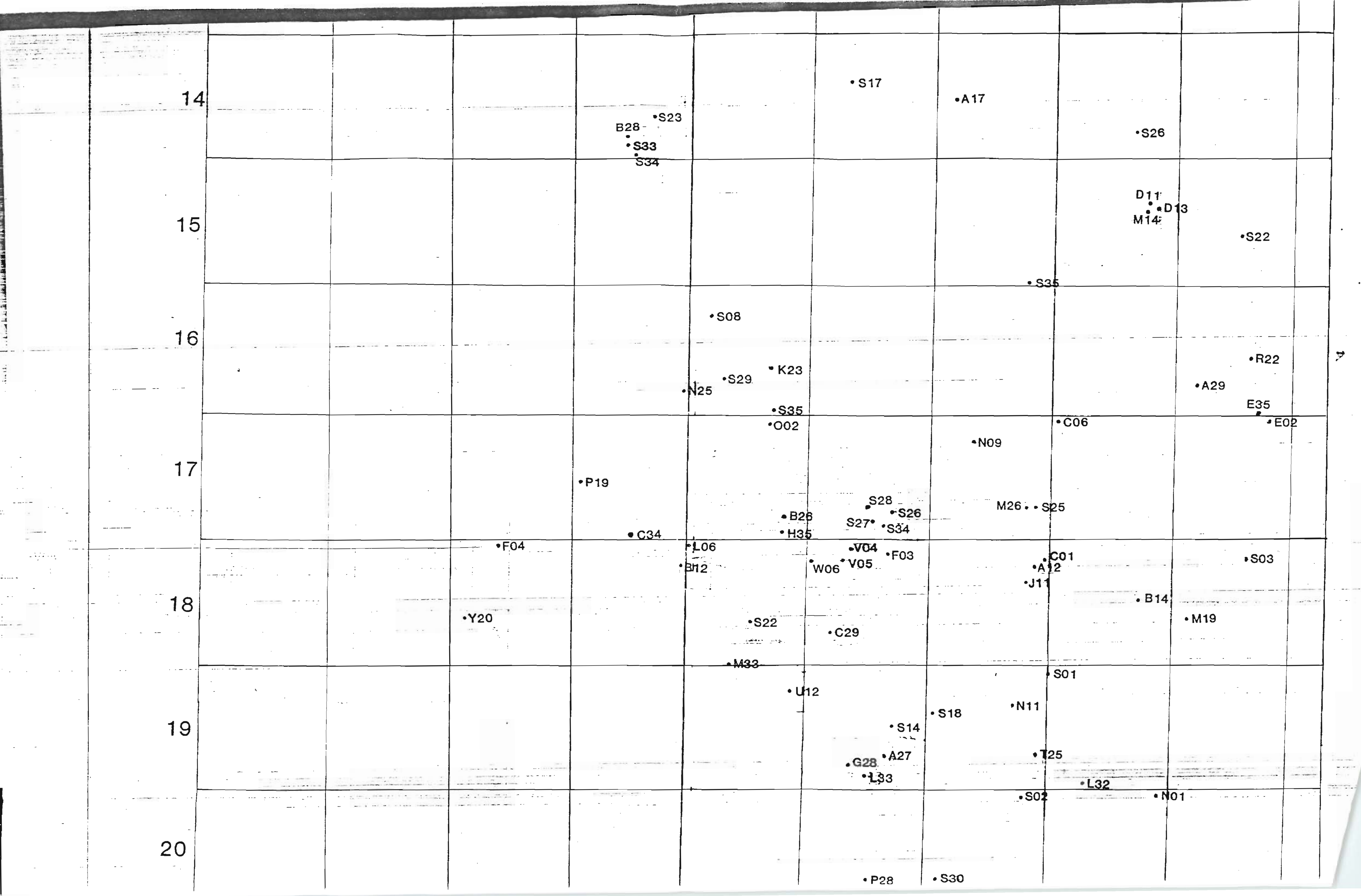
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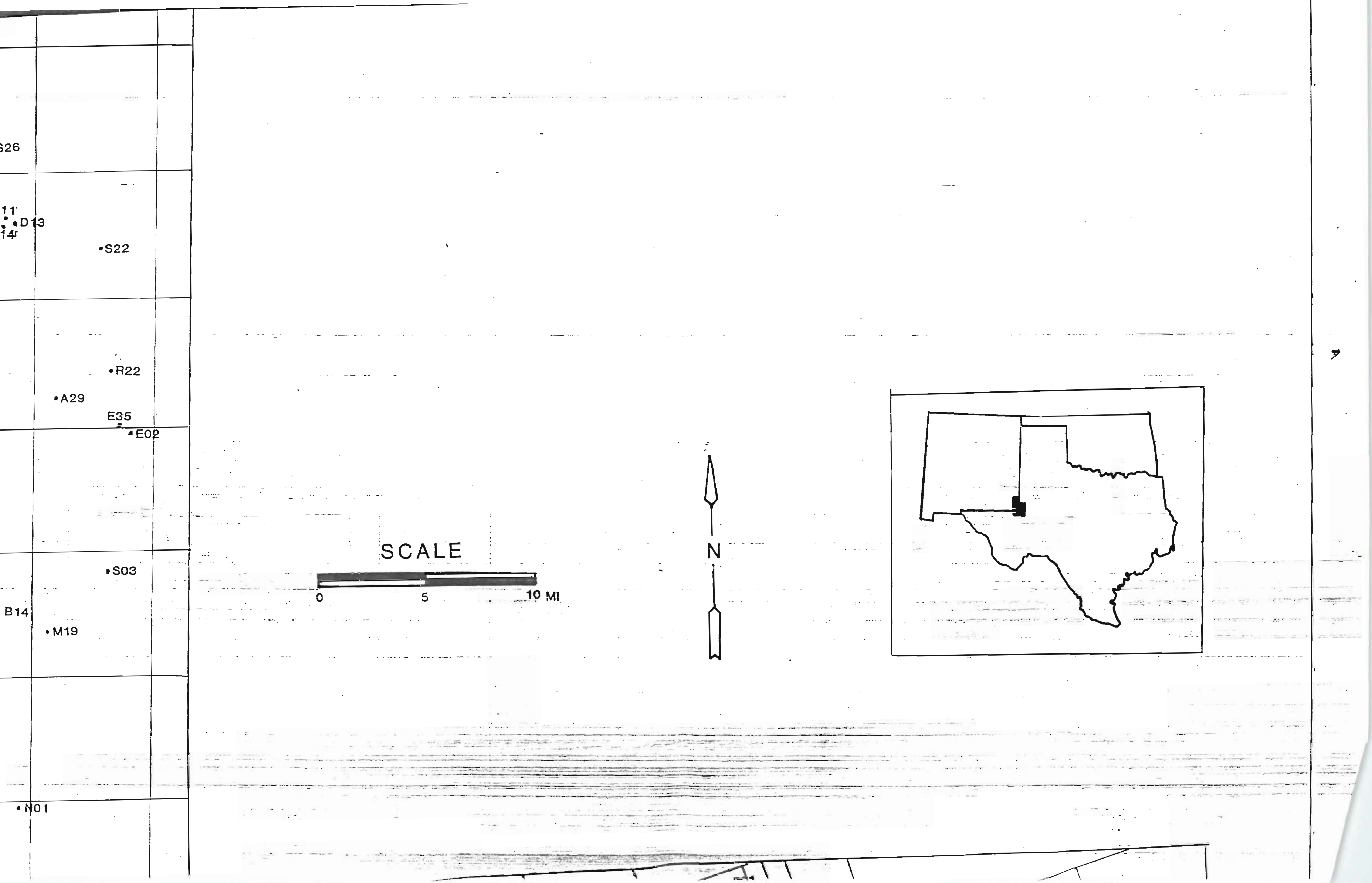

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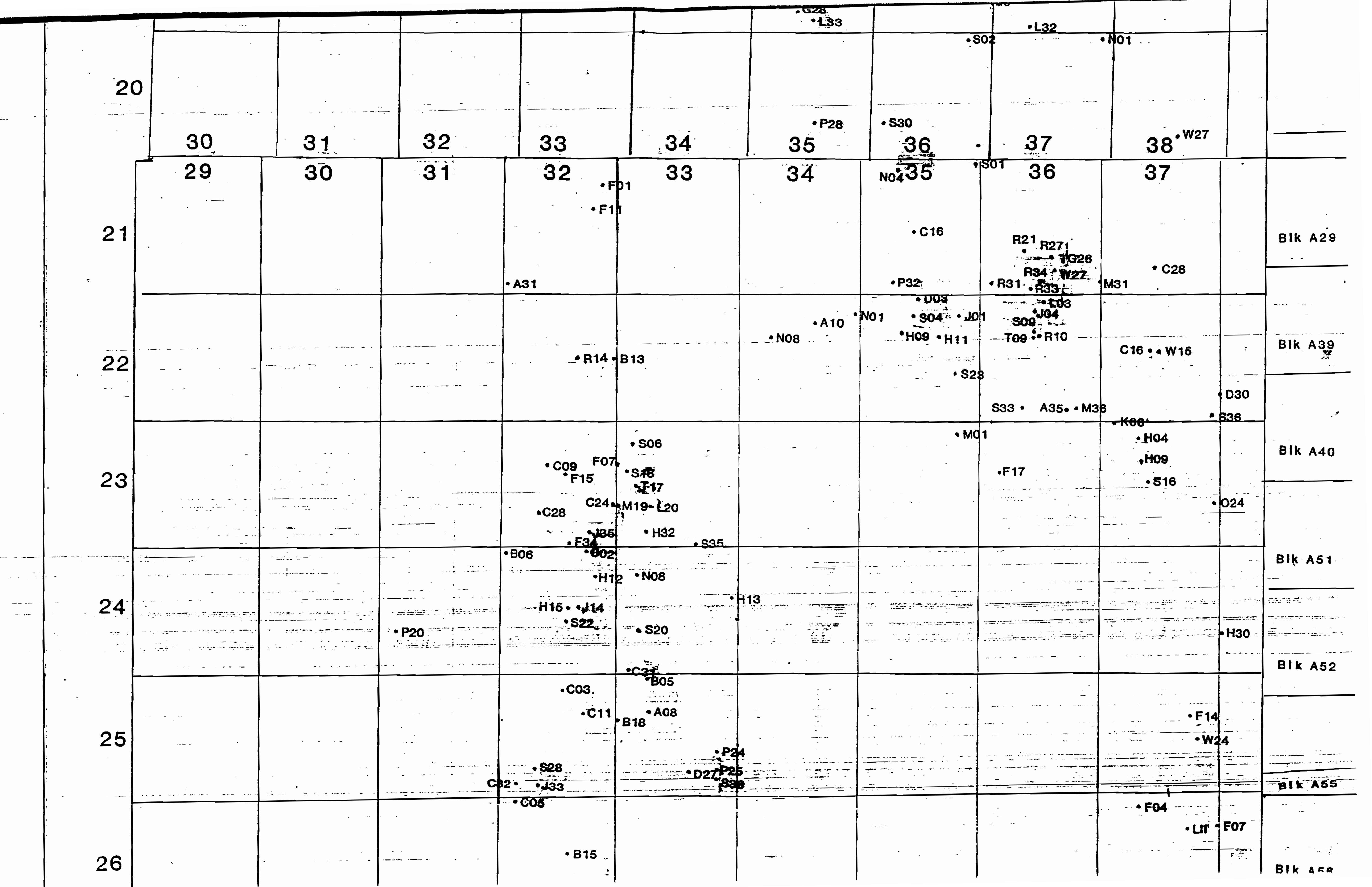

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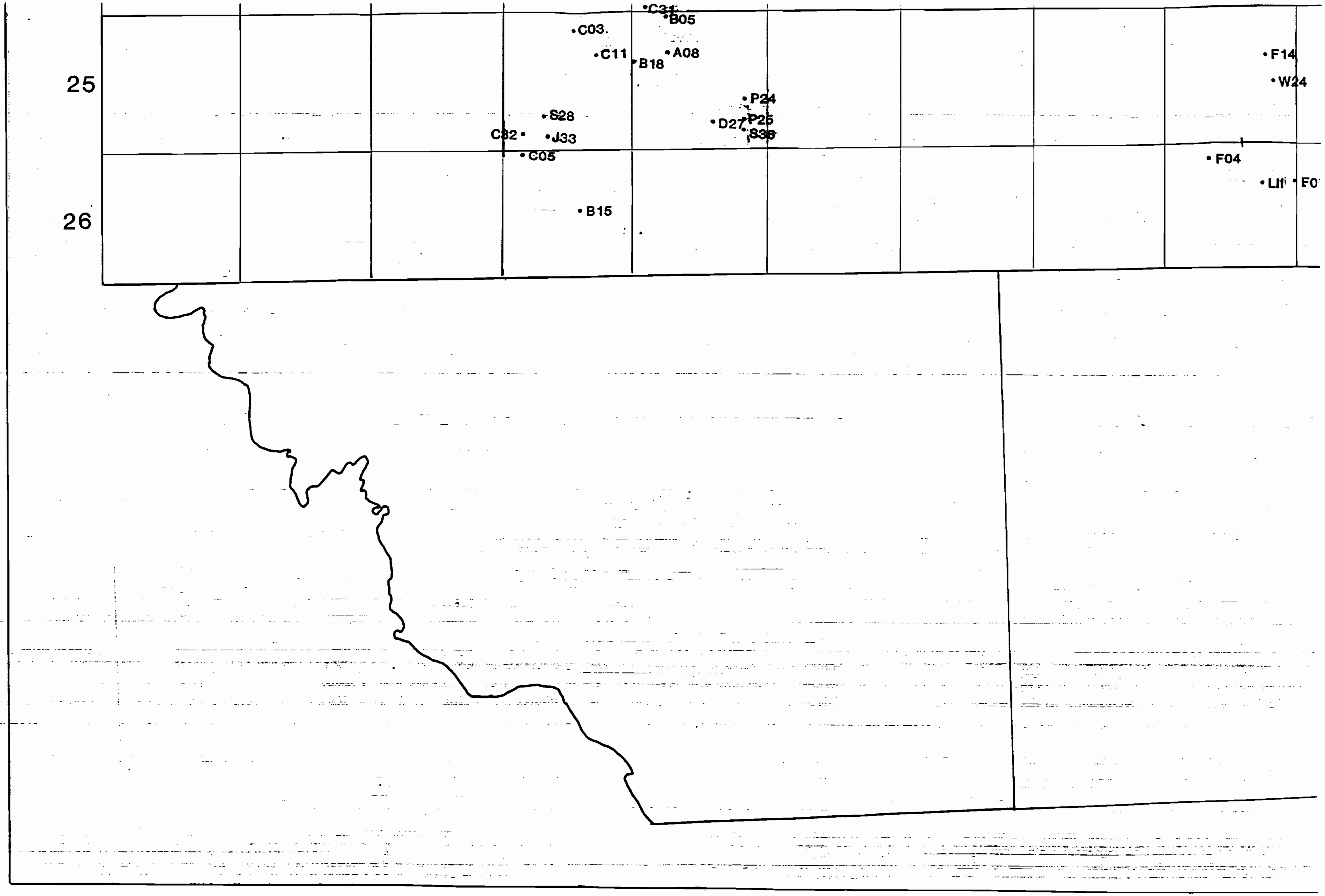
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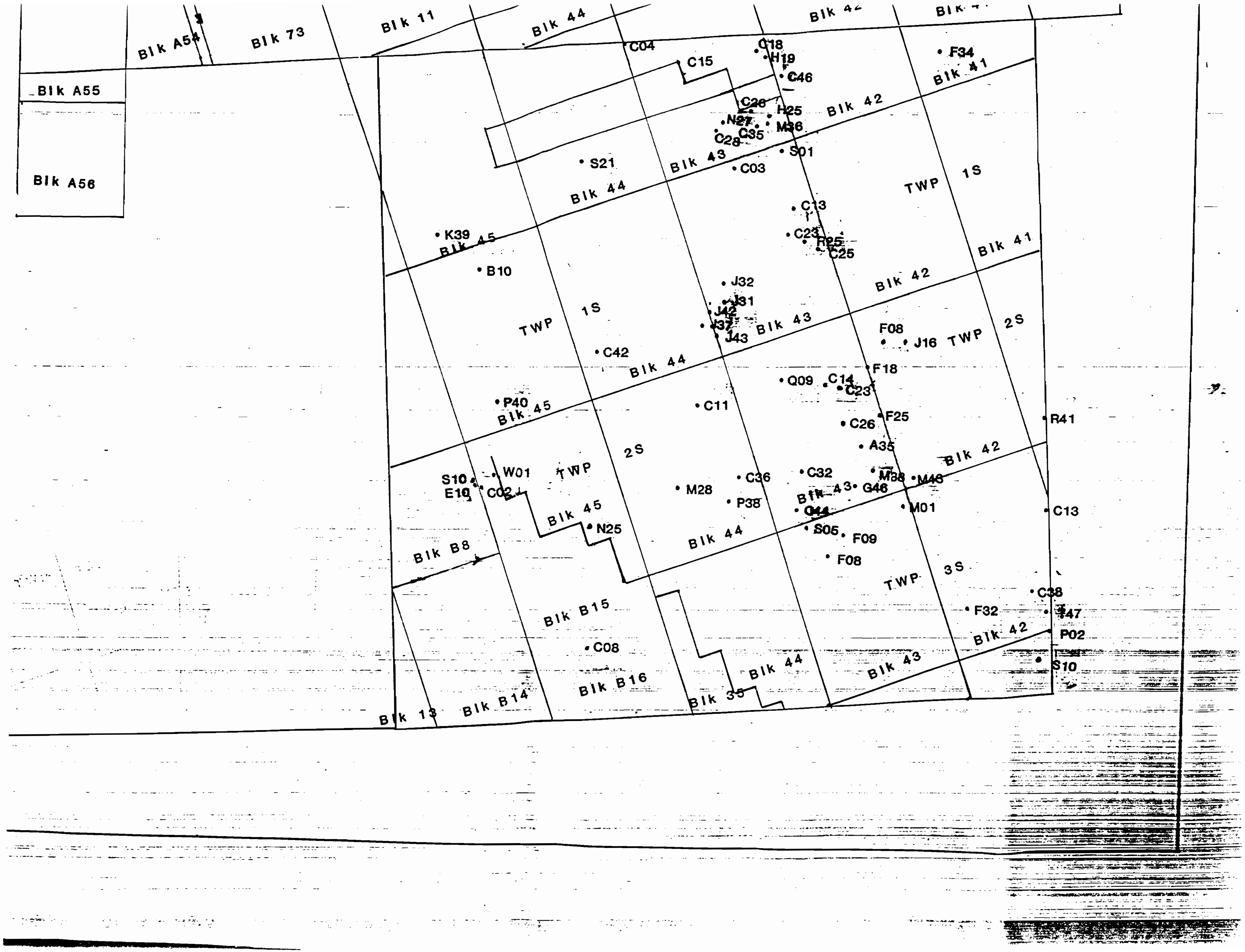

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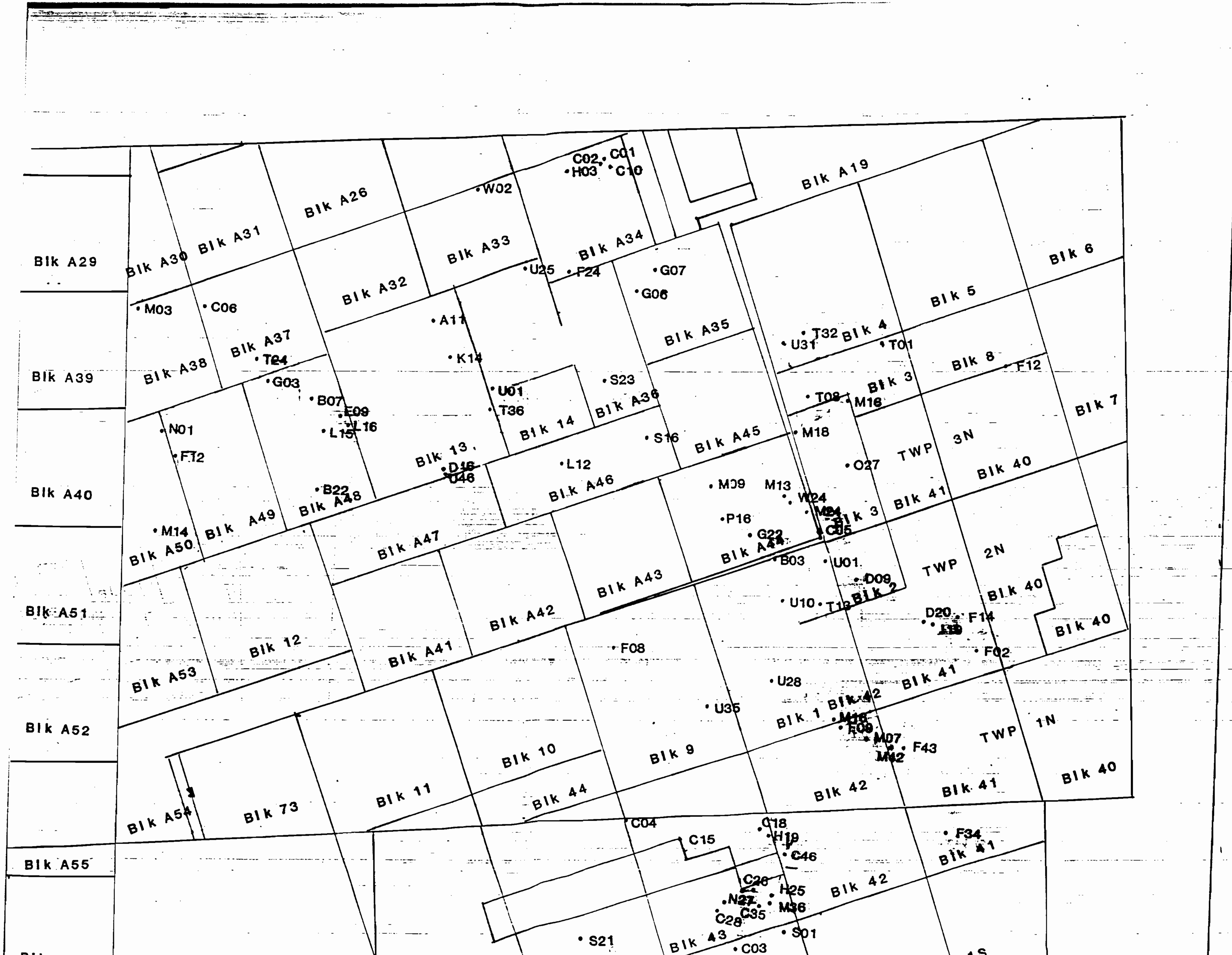
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