SUBSURFACE INVESTIGATION OF
THE NELLIE BLY FORMATION
IN CREEK AND OKFUSKEE
COUNTIES, OKLAHOMA

BY

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CHAPTER I

ABSTRACT

The Pennsylvanian Missourian Series Nellie Bly Formation is a regressive clastic unit bounded above and below by transgressive limestones. The Nellie Bly Formation is composed primarily of shales with siltstone and sandstones occurring in lesser quantities. A subsurface study was conducted across parts of Creek and Okfuskee Counties, Oklahoma so as to get a better understanding of the distribution, geometry and stratigraphic relation of the principal lithologies of the Nellie Bly Formation. Electric well logs were analyzed and then used in the construction of subsurface maps and cross sections. Two structural contour maps, two total interval thickness isopach maps, one net sandstone isolith, and one sandstone to shale ratio map were constructed to illustrate the distribution and geometry of the Nellie Bly Formation. Five subsurface cross sections, two north to south and three east to west, were constructed to illustrate the stratigraphic changes of the formation across the study area, as well as to illustrate the stratigraphic relationship between the Nellie Bly Formation and the other formations of the Skiatook Group within the Missourian

Series.

Information gathered from these electric well logs, subsurface maps and cross sections indicate the Nellie Bly Formation, in Creek and Okfuskee Counties, Oklahoma, can be divided into three distinct depositional areas. There is a northern area in which fairly significant amounts of sand were deposited and the Nellie Bly Formation locally thickens up to approximately 420 feet. These locally thick areas trend southwesterly across portions of T19N R9E, T19N R8E, T18N R7E, T18N R8E and T17N R7E, Creek County, Oklahoma. This trend of locally thick deposits outlines what appears to be a single lobe of a high constructive lobate delta. This lobe appears to have prograded in a northerly direction across the study area.

There is a central area in which large amounts of shale, muds and little or no sand were deposited. The thickness of the Nellie Bly in this central area ranges from 240 to 300 feet. This central area spans across portions of T18N R8E, T18N R9E, T18N R10E, T17N R7E, T17N R8E, T17N R9E, T16N R7E and T16N R8E, Creek County, Oklahoma. This area appears to have been deposited in an interdeltaic environment between a northern lobe and more southern lobe of a high constructive lobate delta.

Finally, there is a southern area in which significant amounts of sand were deposited and the Nellie Bly thickens, locally up to approximately 440 feet. These locally thick areas trend northeasterly across portions of T12N R7E, T13N

R7E, Okfuskee County, Oklahoma and across portions of T14N R7E, T14N R8E, T15N R8E and T16N R8E, Creek County, Oklahoma. This trend of locally thick deposits outlines what appears to be a second lobe of a high constructive lobate delta. This lobe appears to have prograded in a northerly direction across the study area.

Based upon the serrate electric log patterns and the subsurface geometry exhibited by the Nellie Bly Formation in the study area, it appears that the Nellie Bly Formation was deposited in a high constructive lobate deltaic environment.

CHAPTER II

INTRODUCTION

Purpose of Study

The purpose of this investigation was to study the Nellie Bly Formation in the shallow subsurface adjacent to the outcrop zone to gain a better understanding of the distribution, geometry, and stratigraphic relationships of the formation and its constituent lithologies. Interpretation of well logs, subsurface mapping, and cross sections were all incorporated into this investigation and contributed greatly to this understanding. Through analysis of the distribution, geometry, and stratigraphic relationships of the formation in the shallow subsurface, valuable insight to the depositional history and depositional environments of the Nellie Bly Formation was attained.

Location

The study encompasses portions of Creek and Okfuskee Counties in north-central Oklahoma. The Nellie Bly Formation crops out in a northeasterly to southwesterly trend across the two counties. The Nellie Bly Formation is present in the subsurface in the western half of Creek

County, Oklahoma, and in the western one-third of Okfuskee County, Oklahoma (Figure 1). The subsurface investigation area involves approximately 820 square miles.

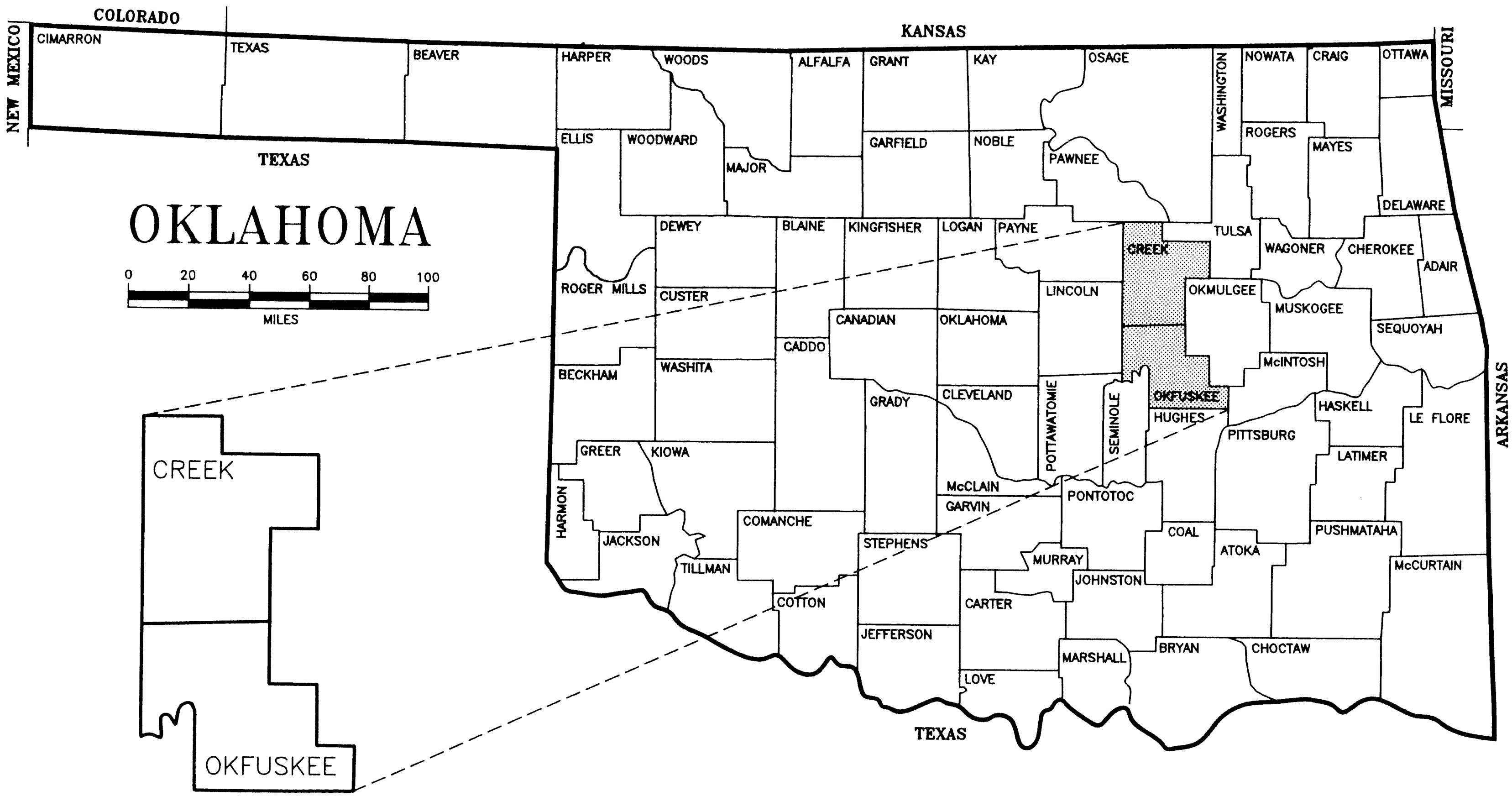


Figure 1. Location Map of Study Area

Previous Investigations

The Nellie Bly Formation was first defined by D.W. Ohern (1914). Its type section is located along Nellie Bly Creek, which is located southwest of the town of Ramona, Oklahoma in Sections 28, 29, 31 and 32 of T24N R13E, Washington County, Oklahoma. Ohern described the Nellie Bly Formation as the interval between the base of the Dewey Limestone and the top of the Hogshooter Limestone. In his original description, Ohern indicated that the Nellie Bly Formation is composed of alternating shales and hard gray to brown sandstones. These sandstones range from a few inches to several feet in thickness.

C.N. Gould (1925) studied and described the Nellie Bly Formation in north-central Oklahoma and published the first map of the formation.

A.K. Miller and L.M. Cline (1934) performed the first major paleontological study of the Nellie Bly Formation. Fossils from an outcrop west of the town of Sand Springs, Oklahoma were described in great detail in their study.

M.C. Oakes (1940, 1952, 1959) studied and mapped the Nellie Bly Formation in Washington, Tulsa and Creek Counties, Oklahoma for the Oklahoma Geological Survey. In his county report he identified three large mappable shale units and four mappable sandstones.

E.R. Ries (1954) studied and mapped the Nellie Bly Formation in Okfuskee County, Oklahoma for the Oklahoma Geological Survey. In his report he identified seven mappable shale units and six mappable sandstones which are traceable across the county. He also identified fifteen separate species of fossils including three types of brachiopods, ten types of Pelecypods and one type of gastropod.

H.D. Miser (1954) mapped the Nellie Bly Formation on the Oklahoma State Geological Map.

CHAPTER III

GEOLOGIC SETTING

Stratigraphic Framework of the Missourian Series Skiatook Group

A significant portion of the stratigraphic record of north-central Oklahoma is composed of rocks which are Pennsylvanian in age. To deal with this large volume of rock geologists have subdivided the Pennsylvanian System into five series. These five series are:

Virgilian Series (youngest rocks)
Missourian Series
Desmoinesian Series
Atokan Series
Morrowan Series (oldest rocks)

The series relevant to this particular study is the Missourian Series. The Missourian Series can be further divided into two rock stratigraphic groups. These two groups are:

Ochelata Group (younger)
Skiatook Group (older)

This investigation will confine itself to the Skiatook Group. The formations which comprise the Skiatook Group (Plate 1) include the:

Dewey Limestone (youngest)
Nellie Bly Formation
Hogshooter Limestone
Coffeyville Formation
Checkerboard Limestone
Seminole Formation (oldest)

Seminole Formation

The Seminole Formation, first described by J.A. Taff (1901), ranges from 250 to 330 feet in thickness in the study area and is comprised mostly of shales with lesser amounts of sandstone and conglomerate. These rock units range from grayish green to yellowish brown in color. The type locality for the Seminole Formation is in the southeastern corner of Seminole County, Oklahoma. The upper twenty feet of the Seminole Formation correlates with the Hepler Sandstone and overlying shale in southern Kansas (Oakes, 1959).

Checkerboard Limestone

The Checkerboard Limestone, described by C.N. Gould (1925), is a massive, dark and fossiliferous limestone. It ranges from two to seven feet in thickness and tends to thicken in a southerly direction in the study area. The type locality of the Checkerboard Limestone is along Checkerboard Creek, T15N R11E, Creek County, Oklahoma. The Checkerboard Limestone typically exhibits a very high resistivity reading on electric logs. The Checkerboard Limestone is the same Checkerboard Limestone as identified in Kansas, and correlates with the Dewey Limestone to the south of the study area (Oakes, 1959).

Coffeyville Formation

The Coffeyville Formation, as described by F.C. Scrader and E. Haworth (1905), ranges from 245 to 450 feet in thickness in the study area. The Coffeyville Formation consists of silty to clayey shales containing lenticular sandstones and sandy shales which are generally yellow to brown in color.

The type locality for the Coffeyville Formation is near Coffeyville, Kansas. The Coffeyville Formation correlates to the section between the Checkerboard Limestone and the Dennis Formation in Kansas, and to the lower part of the Francis Formation south of the study area (Oakes, 1959).

Hogshooter Limestone

The Hogshooter Limestone (Ohern, 1910), is 5 to 40 feet in thickness in the study area. The Hogshooter Limestone consists of a gray, crystalline, fossiliferous limestone which grades into sandstone and shales south of the study area. The type locality of the Hogshooter Limestone is along Hogshooter Creek, T26N R14E, Washington County, Oklahoma. The Hogshooter Limestone is composed of four members. These members are:

Winterset Limestone Member
Stark Shale Member
Canville Limestone Member
Lost City Limestone

Only the Winterset Limestone Member and the Stark Shale Member are present across the study area. The Canville Limestone Member and the Lost City Limestone are depositional variations of each other and are not present in the study area, but can be recognized locally north and east of the study area (Bennison, 1979). Other than localized thick areas of up to 60 feet, there is very little variation in the thickness of the Hogshooter Limestone, which maintains an average thickness of 25 to 30 feet across the study area. There appears to be no major accumulations of the Hogshooter Limestone in the study area that might indicate any form of carbonate build-up which could be used in defining a shelf edge. The Hogshooter Limestone usually exhibits a low negative spontaneous potential and a very high resistivity on electric logs. The Hogshooter Limestone is equivalent to the Dennis Formation in Kansas, and correlates to the middle shale of the Francis Formation south of the study area (Oakes, 1959).

Nellie Bly Formation

The Nellie Bly Formation ranges in thickness from 220 feet, in the northern portions of T18N R11E, Creek County, Oklahoma, to 460 feet in portions of T12N R7E, Okfuskee County, Oklahoma. The Nellie Bly Formation is composed predominantly of shales with interbedded sandstones, and is locally fossiliferous. However, the fossils are poorly preserved. The type locality of the Nellie Bly Formation is along Nellie Bly Creek, T24N R13E, Washington County, Oklahoma (Oakes, 1959).

The Nellie Bly in the study area has been divided into several mappable units. In Creek County, Oklahoma, the Nellie Bly Formation is divided into three mappable shales and five mappable sandstones (Oakes, 1959) (Figure 2). The three mappable shales of the Nellie Bly Formation in Creek County, Oklahoma, are identified as the lower, middle and upper shales. These three shales are separated by and interfinger with the five mappable sandstones, which have been labeled numerically.

The lower shale is a silty shale, approximately 50 feet thick, which contains sandstone #1 in portions of T14N. This shale also interfingers with the lower tongue of sandstone #2 in portions of T17N and T18N and conformably overlies the Hogshooter Limestone. Sandstone #2 is composed of resistant and nonresistant sandstone and very sandy shales. This sandstone separates into a lower, middle and upper tongues in portions of T17N and T18N. The upper tongue is approximately 30 feet thick, the middle tongue is approximately 115 feet thick and the lower tongue is approximately 10 feet thick. The middle and lower tongues interfinger with the lower Nellie Bly shale in portions of T17N and T18N.

The middle shale unit of the Nellie Bly Formation is composed primarily of silty to sandy shales and ranges in

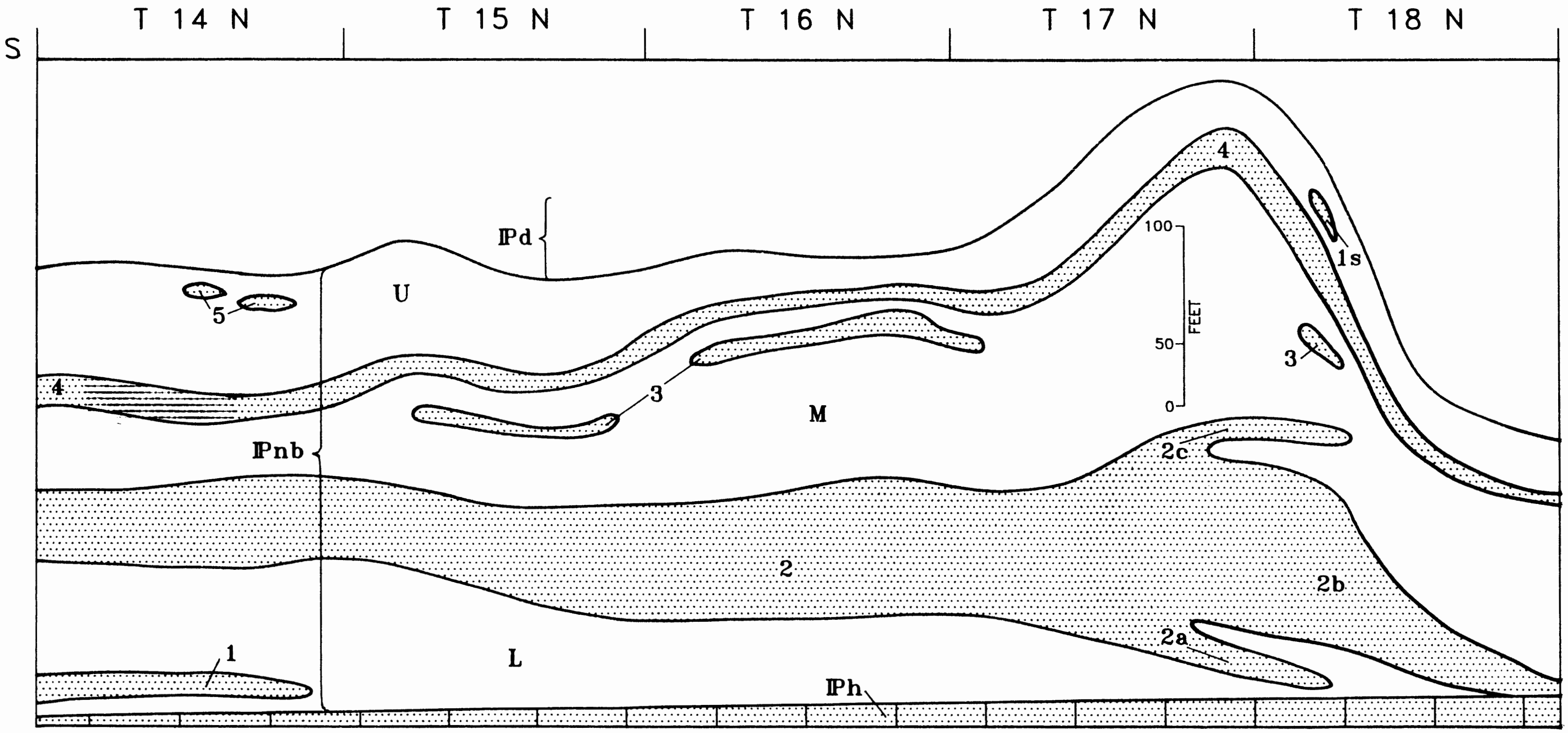


Figure 2. Nellie Bly Formation in Creek County
(M. C. Oakes, 1959)

thickness from 115 to 150 feet. This middle shale locally contains sandstone lenses which are not part of the same rock body, but have been grouped together and classified as sandstone #3. These sandstone lenses can be identified in portions of T15N, T16N, T17N and T18N. In T18N the middle shale interfingers with the upper sandstone tongue of sandstone #2. Sandstone #4 rests directly above the middle shale. This sandstone crops out entirely across Creek County, Oklahoma and ranges in thickness from 10 to 45 feet.

The upper shale of the Nellie Bly Formation rests above sandstone #4. The upper shale ranges in thickness from 40 to 110 feet and locally contains minor calcareous sandstone lenses. These calcareous sandstone lenses are grouped together and classified as sandstone #5. Sandstone #5 can be identified in portions of T14N. The upper shale of the Nellie Bly Formation in Creek County, Oklahoma is conformably overlain by the Dewey Limestone.

The Nellie Bly Formation in Okfuskee County, Oklahoma can be divided into seven mappable shales and six mappable sandstones (Ries, 1954). The mappable units have been identified numerically in ascending order, 1 to 13. Unit #1 is a yellowish brown shale which is approximately 16 feet thick and rests comformably upon the Hogshooter Limestone. Unit #2 directly overlies Unit #1 and is composed of a light brown sandstone which ranges in thickness from 4 to 12 feet. Unit #3 is a greenish yellow to yellowish brown shale which overlies Unit #2 and ranges in thickness from 70 to 90 feet. Unit #4 is a thin light brown sandstone that ranges in thickness from 3 to 10 feet. Overlying Unit #4 is a thick yellowish brown shale. This shale, Unit #5, ranges in thickness from 60 to 90 feet. Unit #6 is a light brown sandstone which ranges in thickness from 18 to 80 feet and overlies the shale of Unit #5. Unit #7 is a yellowish brown shale that ranges in thickness from 20 to 80 feet. Unit #8 is a thin light brown sandstone that ranges in thickness from 5 to 10 feet and overlies Unit #7. Overlying Unit #8 is a yellowish brown shale classified as Unit #9. This unit ranges in thickness from 30 to 90 feet. Unit #10 overlies the shale of Unit #9. This unit is composed of a thin light brown sandstone which ranges in thickness from 3 to 15 feet. Unit #11 is a thin yellowish brown shale which ranges in thickness from 5 to 25 feet and overlies Unit #10. Unit #12 is a light brown sandstone which ranges in thickness from 20 to 50 feet. The uppermost unit of the Nellie Bly Formation in Okfuskee County, Oklahoma is a greenish yellow shale classified as Unit #13. This unit ranges in thickness from 60 to 90 feet and rests above Unit #12 and is conformably overlain by the Dewey Limestone.

The Nellie Bly Formation is stratigraphically equivalent to the section between the top of the Dennis Formation and the base of the Drum Limestone, occupied by the Cherryvale Shale, in southern Kansas, and correlates to the upper half of the Francis Formation south of the study area (Oakes, 1959).

Dewey Limestone

The Dewey Limestone, described by D.W. Ohern (1910), ranges from 2 to 20 feet in thickness in the study area. The Dewey Limestone consists of a bluish-gray, semicrystalline limestone which is locally shaley and sandy. The type locality of the Dewey Limestone in the rock quarry of the Dewey Portland Cement Company, Dewey Oklahoma. Other than small variations in the thicknesses, no major limestone build ups, which might be used to define a shelf edge, were noted in the study area. The Dewey Limestone typically exhibits a low negative spontaneous potential and a very high resistivity on electric logs. The Dewey Limestone correlates to the Cement City Member of the Drum Limestone in Kansas and to a portion of the Hilltop Formation south of the study area (Oakes, 1959).

Tectonic Framework and Paleogeography

The study area is located in the south-central portion of the northeastern Oklahoma Platform. This Platform is bounded on the east by the Ozark Uplift, on the west by the Nemaha Ridge, on the south by the Arbuckle Uplift and on the southeast by the Arkoma Basin (Figure 3). These geologic provinces were all created and or influenced by Pennsylvanian tectonic activity.

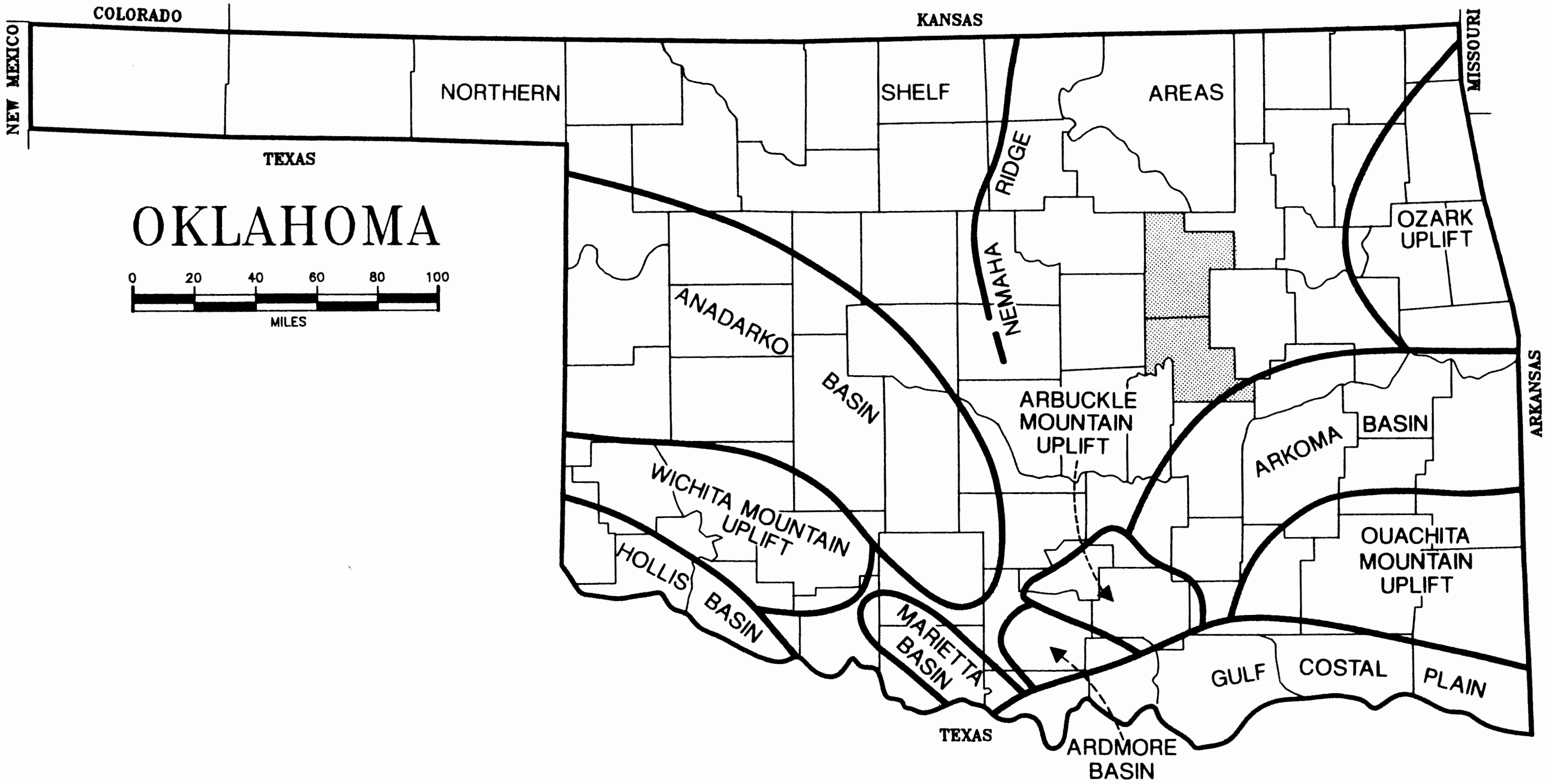


Figure 3. Geologic Provinces of Oklahoma
(Modified from Arbenz, 1956)

The south-central portion of the continent underwent major tectonic changes in the early part of the Pennsylvanian Period. These tectonic changes subsequently influenced the geology and the geography of what is now Oklahoma. During the Morrowan and Atokan epochs the North American Plate was colliding with the South American Plate. This collision resulted in the Ouachita Foldbelt and an increased subsidence of the Arkoma Basin (Rascoe and Adler, 1983). Most sediments deposited in the Arkoma Basin and on its northern shelf at this time were derived from a northerly source area (Figure 4). With the continued uplift of the Ouachita Foldbelt, a change of source area for sediments was noted during the latest part of the Desmoinesian Epoch (Figure 5). Early Desmoinesian sediments are characterized as having a northerly source area whereas the late Desmoinesian sediments were derived from a southerly source area, namely the Ouachita Foldbelt (Rascoe and Adler, 1983). This southerly source of sediments continued for the remainder of the Pennsylvanian Period.

The Missourian Epoch is characterized by a marine transgression onto the shelf with minor periods of regression (Figure 6). The result of these transgressive/regressive cycles were described in detail by Heckel (1977) and Brown (1990). Heckel described these cyclic deposits of carbonates and shales as cyclothems. The Missourian Epoch is represented by eight limestone-

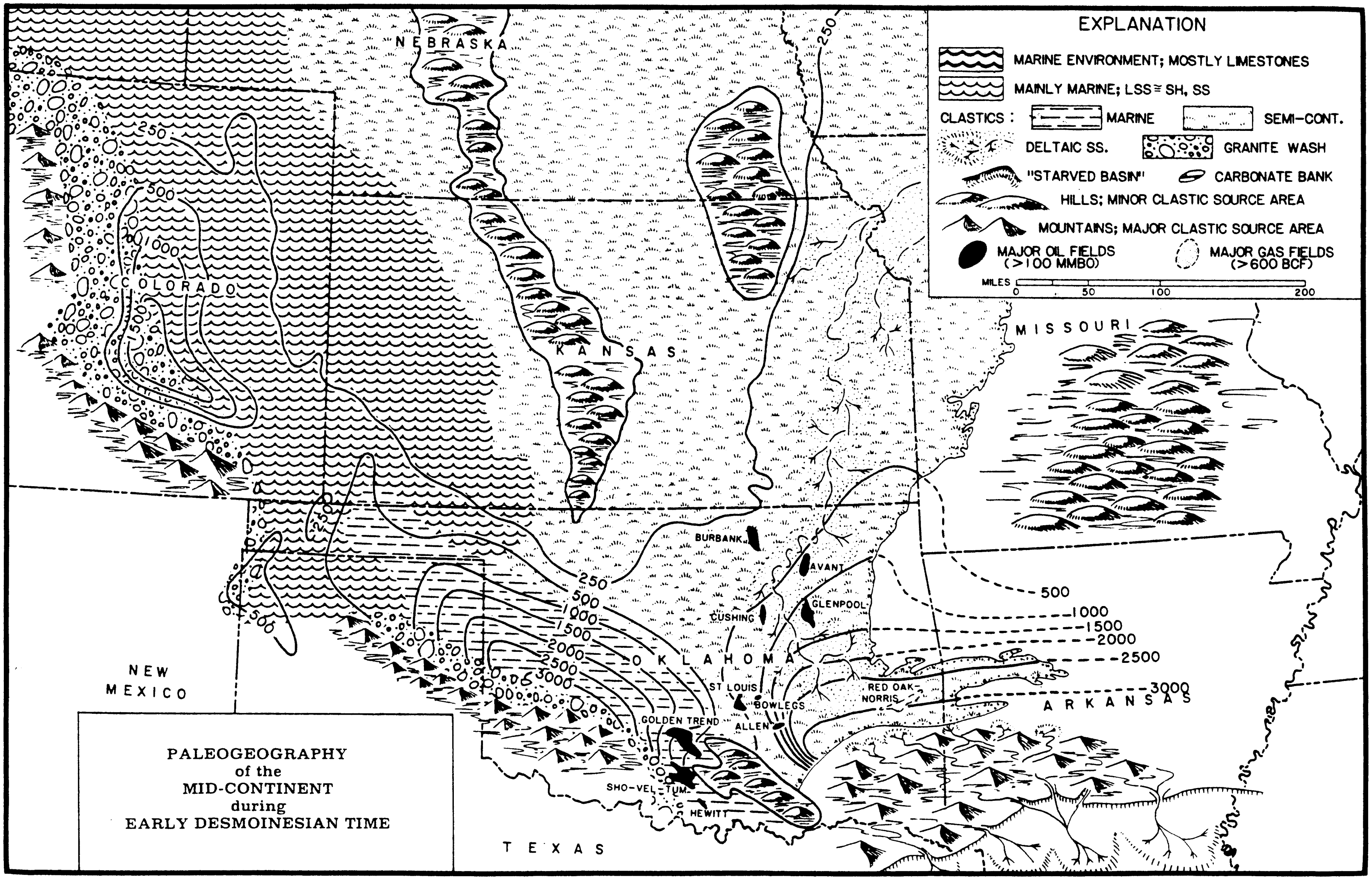


Figure 4. Early Desmoinesian Paleogeography
(From Rascoe and Adler, 1983)

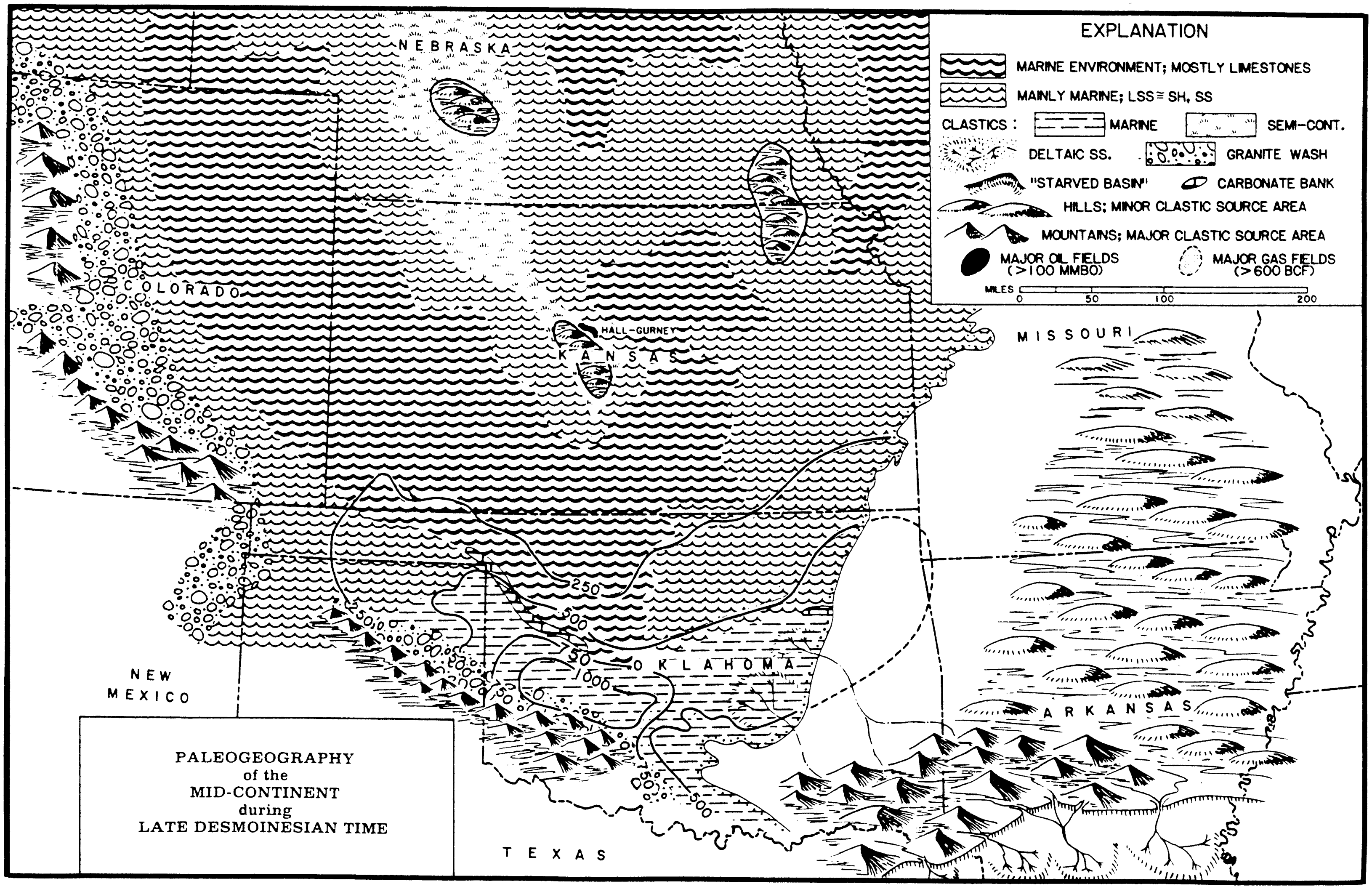


Figure 5. Late Desmoinesian Paleogeography
(From Rascoe and Adler, 1983)

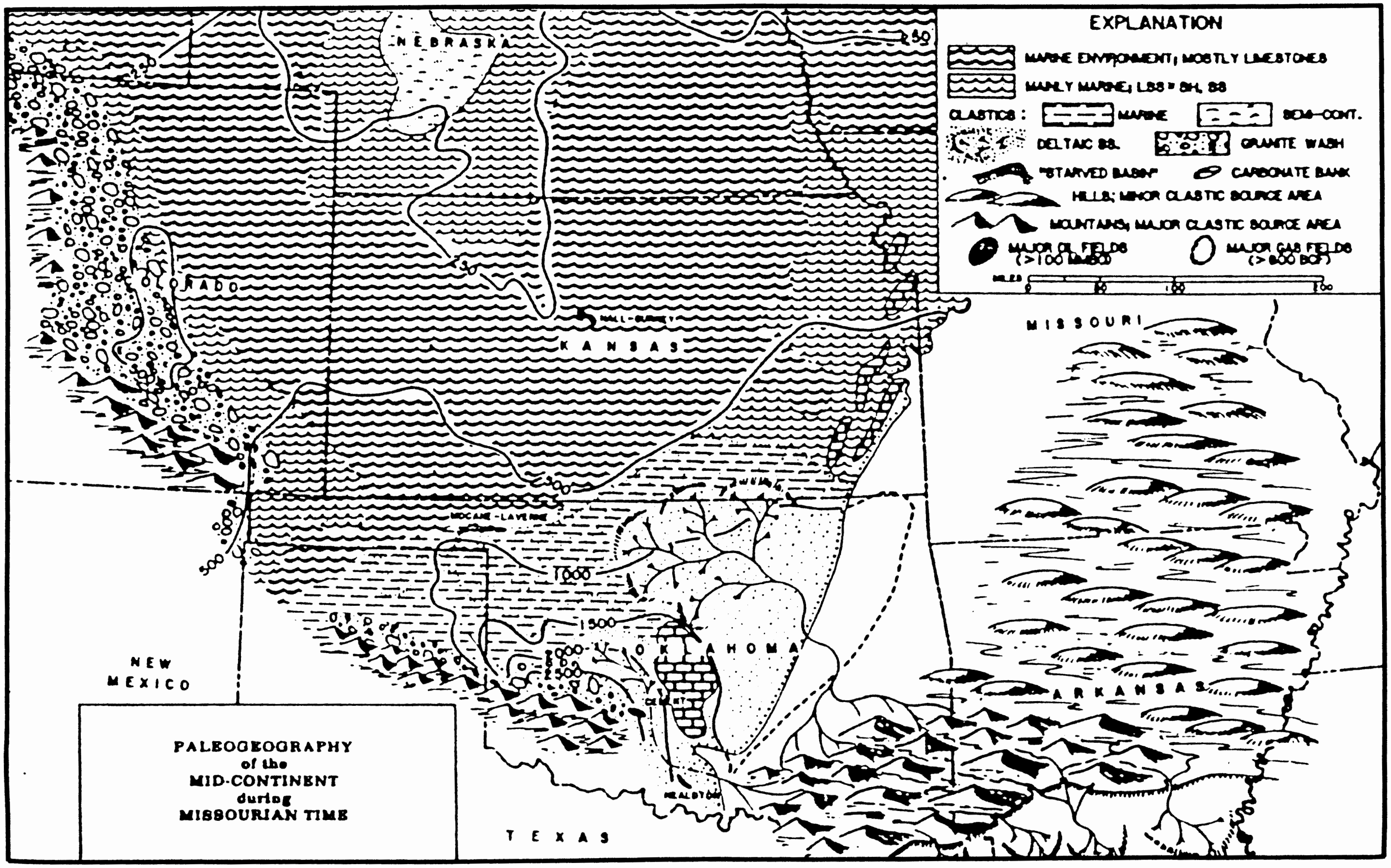


Figure 6. Missourian Paleogeography
(From Rascoe and Adler, 1983)

shale cyclothems. Heckel (1977) described the deposition of a typical Missourian cyclothem as occurring in this sequence. First, transgression begins with the deposition of a "nearshore" shale and continued with the deposition of a "transgressive limestone". Maximum transgression is indicated by the deposition of an "offshore" shale. Finally, regression is indicated by the deposition of high energy, calcarenites in the upper portion of the regressive limestone (Figure 7).

The Nellie Bly Formation fits Heckel's cyclothem model in that the Nellie Bly overlies the Hogshooter Limestone conformably. The Hogshooter Limestone is composed of four members, all of which represent various portions of Heckel's cyclothem. The Canville Limestone Member represents the "transgressive limestone", the Stark Shale Member represents the "offshore" shale of maximum transgression and the Winterset Limestone Member represents the "regressive limestone" (A.P. Bennison, 1979). It follows from this that the Missourian Nellie Bly Formation was deposited during a period of maximum marine regression when fluvial-deltaic processes were dominant across the study area.

Brown (1990) also studied cyclic sedimentation and found that cyclic deposits were deposited in depositional sequences. He also noted that each depositional sequence could be divided into three subsequences, which he termed systems tracts. The three systems tracts are the lowstand

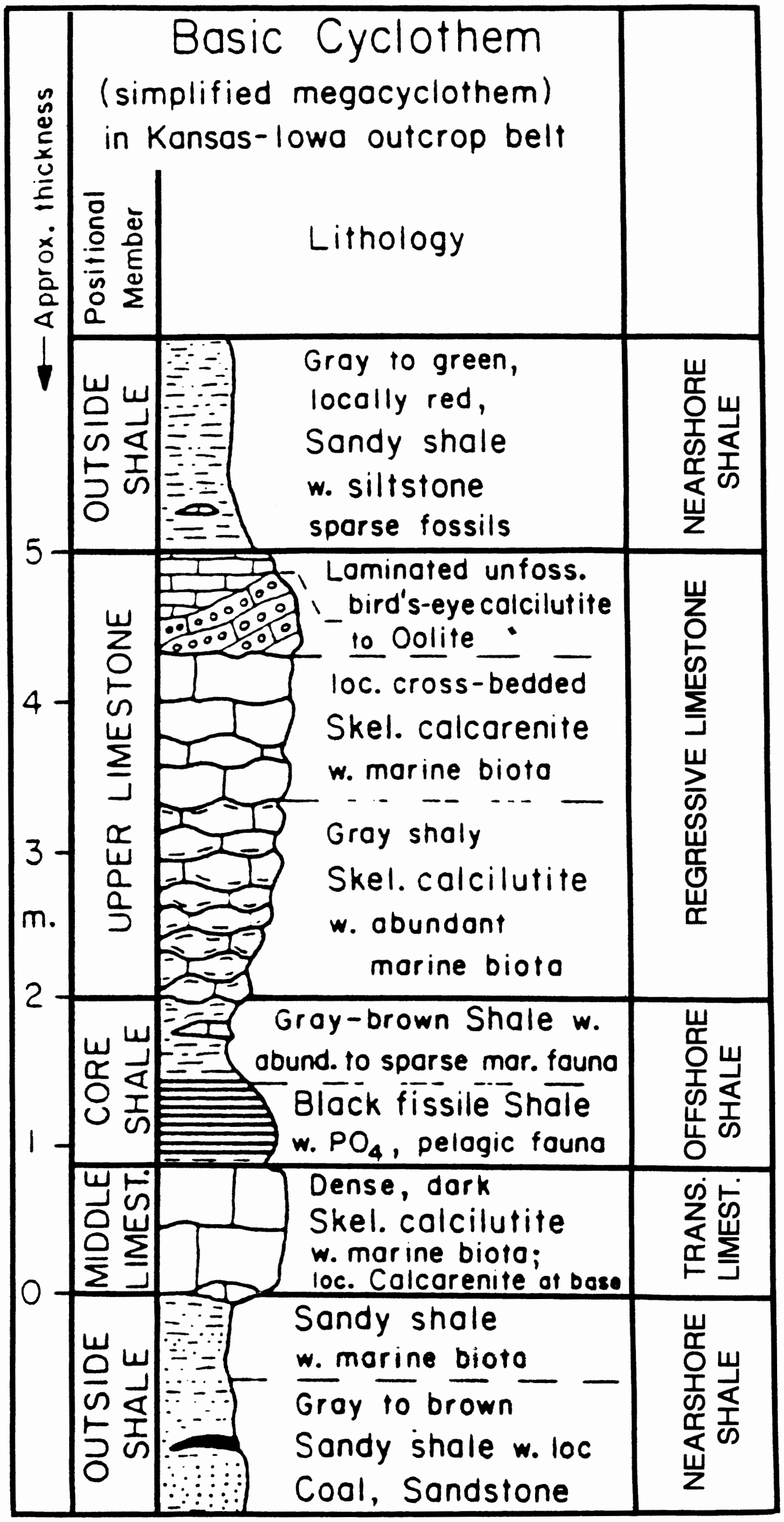


Figure 7. Heckel Cyclothem Diagram
(Heckel, 1975)

systems tract, the retrogradational (transgressive) systems tract and the highstand systems tract.

The lowstand systems tract is characterized by a rapid fall in relative sea level to a point where sea level would be below the preexisting shelf edge. At this time sediment derived from incised valleys would be deposited as basin floor fans. When sea level stopped falling and started to slowly rise, slope fans and lowstand deltaic/slope deposits would prograde basinward until rising sea levels would eventually flood the lowstand coastal plain (Brown, 1990).

As sea level continued to rise retrogradational systems tracts would be deposited. Retrogradational (transgressive) systems tracts are composed of transgressive, aggradational and progradational limestones (Brown, 1990).

Highstand systems tracts are composed primarily of terrigenous clastic deposits. Highstand systems tracts occur when the rise of relative sea level ceases and alluvial drainage systems become reestablished. With adequate sediment supply estuaries are filled and deltas begin to prograde basinward (Brown, 1990).

Brown noted that the presence of lowstand systems tracts could be inferred by the presence of two significant items in the systems tracts. First, incised valley-fill deposits are cut into highstand fluvial-deltaic facies if the delta system was active during both the highstand and lowstand. Second, the lowstand tract will contain a shelf-edge deltaic system that also supplies sediment to a deep water submarine fan system. Brown also noted that highstand systems tracts can be inferred by the presence of aggradational deltaic and alluvial-plain facies high on the shelf and away from the shelf margin.

Based upon Brown's information and that the Nellie Bly Formation does not exhibit any incised valley-fill deposits, it is believed that the Nellie Bly Formation was deposited in a high constructive lobate deltaic environment during a period which would correspond to Brown's highstand systems tract (Figure 8). The delta lobes deposited during the highstand were subsequently abandoned, before a major eustatic drop in sea level took place. An incised valley fill developed on the delta plain of the lobe that was actively prograding when a major sea level drop began. However, no such lobe developed in the study area.

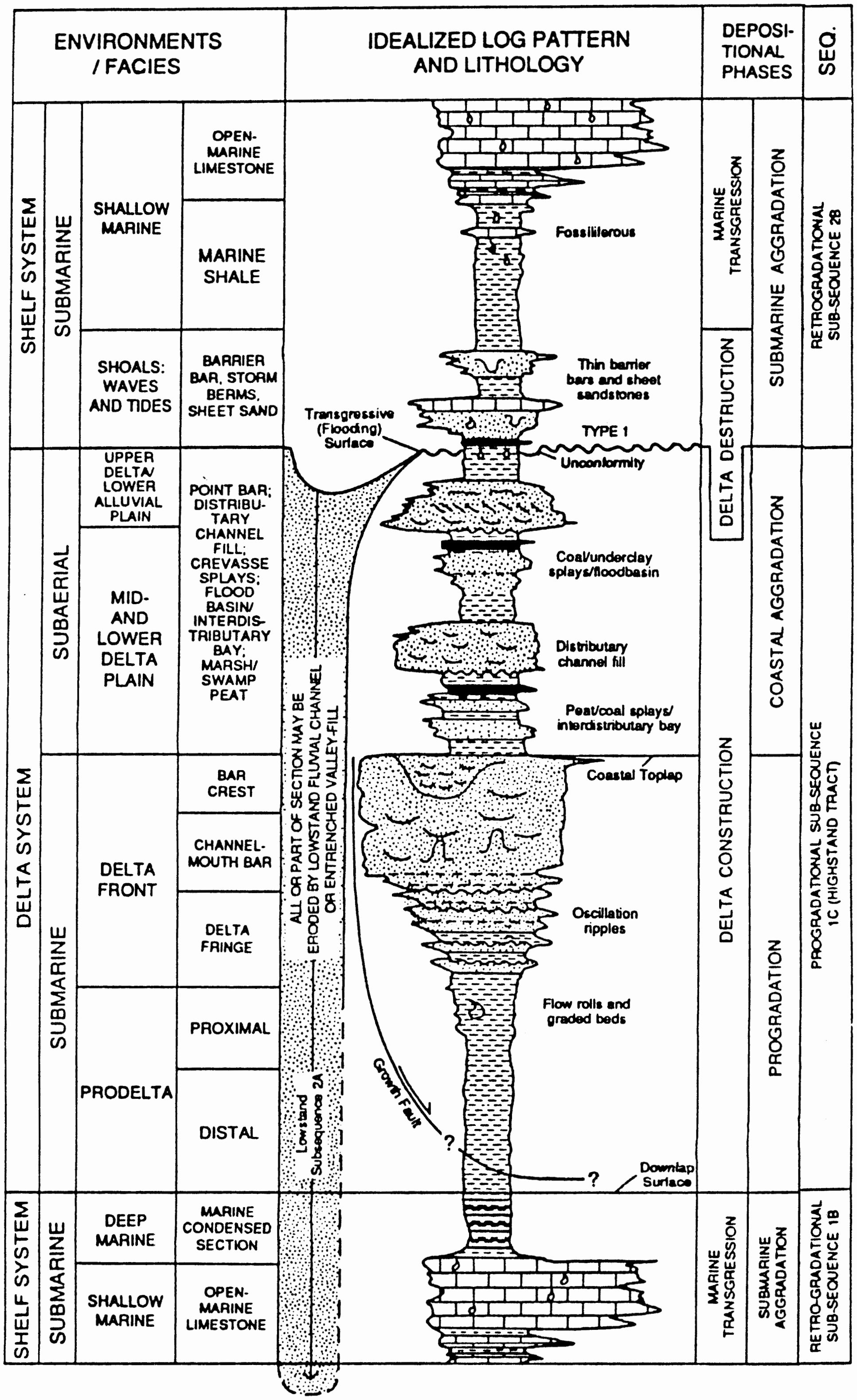


Figure 8. Brown Highstand Fluvial-Deltaic Facies Diagram (Brown, 1990)

Depositional Models

The sandstones of the Nellie Bly Formation appear to represent small separate phases of a single deltaic event. However, a more precise determination of the depositional environment of the Nellie Bly Formation is desired. For this reason, certain specific deltaic depositional models are presented, as follows.

In the particular time the Nellie Bly Formation was deposited, much of the midcontinent was covered by low energy, epicontinental sea where depths most likely did not exceed 100 feet. With this in mind, two deltaic depositional models are appropriate. These depositional models are the high constructive elongate delta and the high constructive lobate delta. Both of these models depict an environment in which fluvial processes are dominant over marine processes. They also involve the deposition of large amounts of sediment.

These two models have several characteristics which set them apart. High constructive lobate deltas are characterized by marine reworked delta front sandstones, lobate geometry, thin preserved channel mouth bar sandstones and contemporaneous growth faults (Brown, 1979) (Figure 9). High constructive elongate deltas differ in that they are characterized by narrow, elongate delta front sandstones. These sandstones are normally channel mouth bar and/or distributary channel fill deposits, which collectively are termed "bar fingers". High constructive

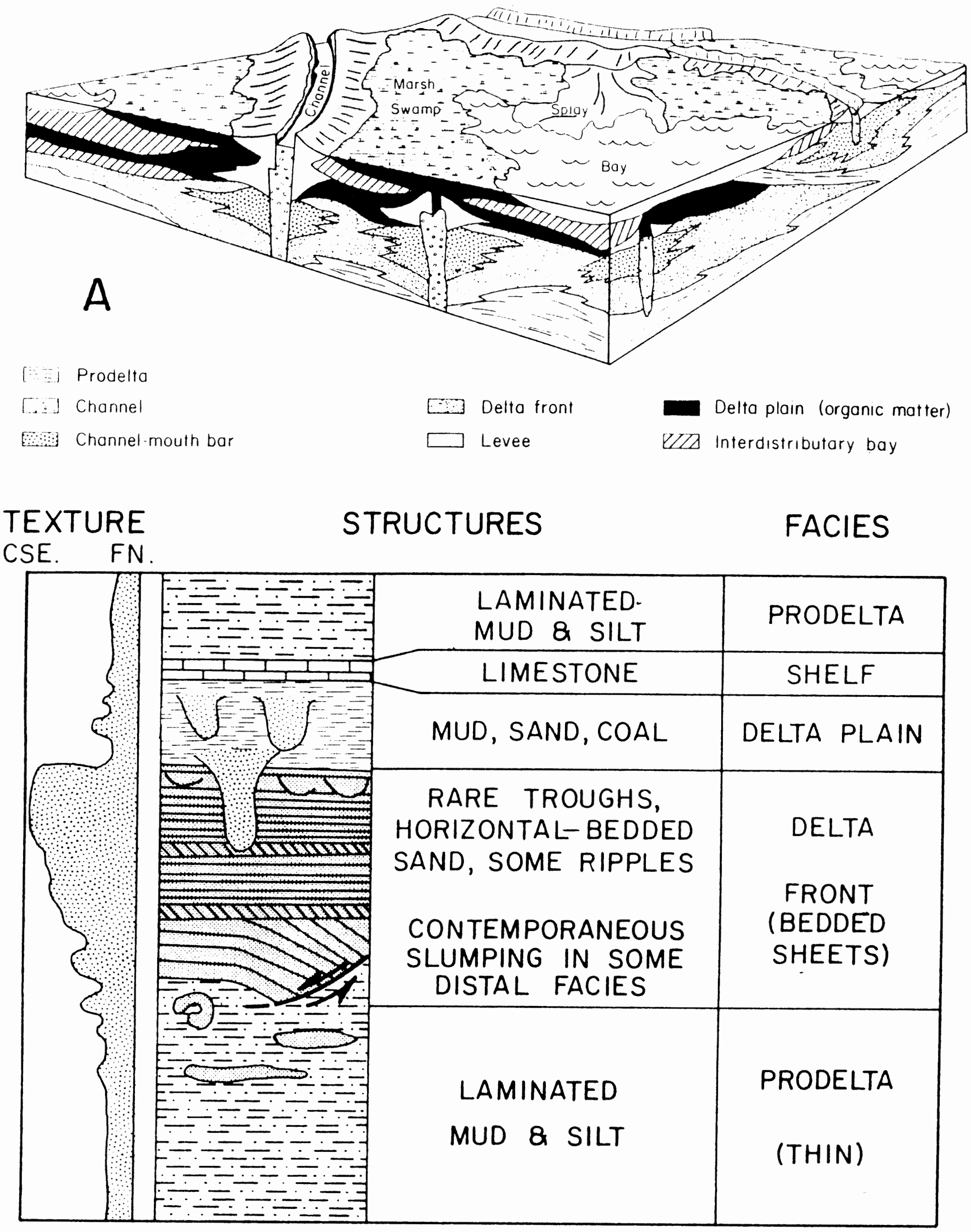


Figure 9. High Constructive Lobate Delta
(Brown, 1979)

elongate delta deposits are usually deposited rapidly over very thick prodelta muds. Because of this rapid deposition and thick underlying mud column, these sandstones are frequently deformed due to rapid subsidence and injection of mud diapirs (Brown, 1979) (Figure 10).

The character of the delta-front sands varies according to the geometry of the delta (Figure 11). Lobate delta-front sandstones exhibit serrate electric log patterns, whereas the elongate delta-front sandstones exhibit massive, blocky electric log patterns.

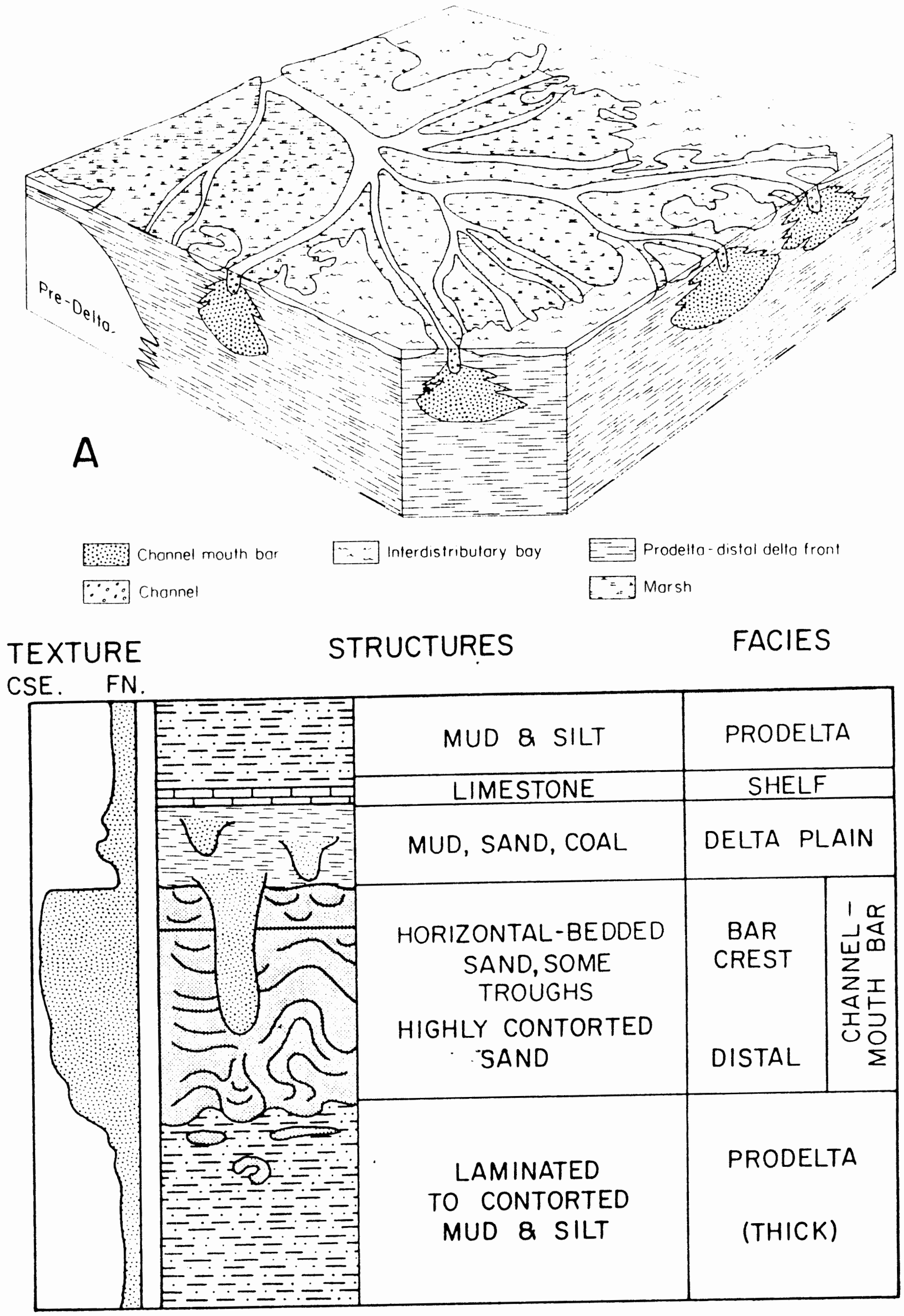
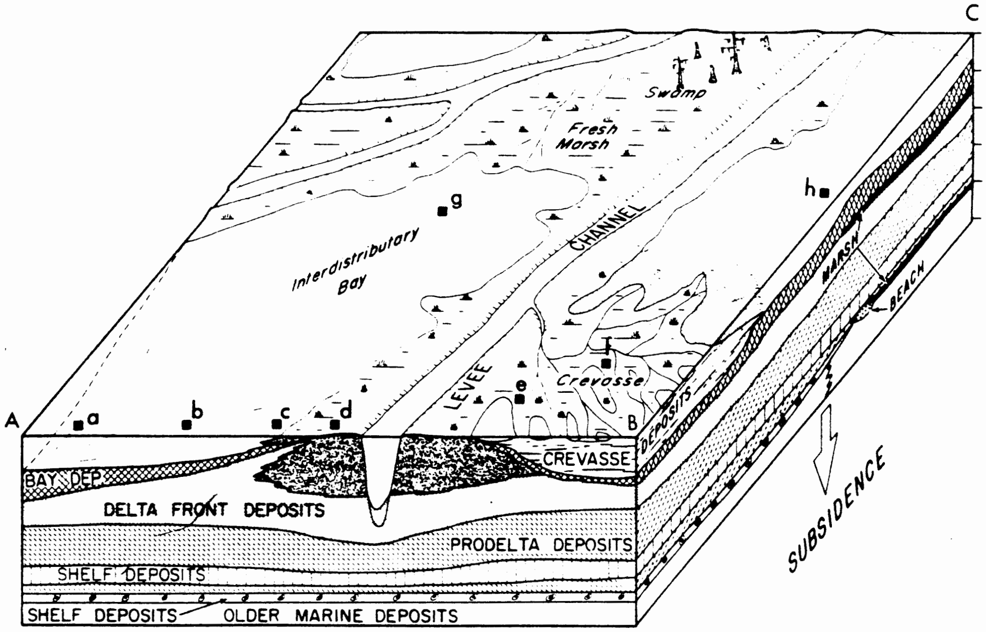


Figure 10. High Constructive Elongate Delta
(Brown, 1979)



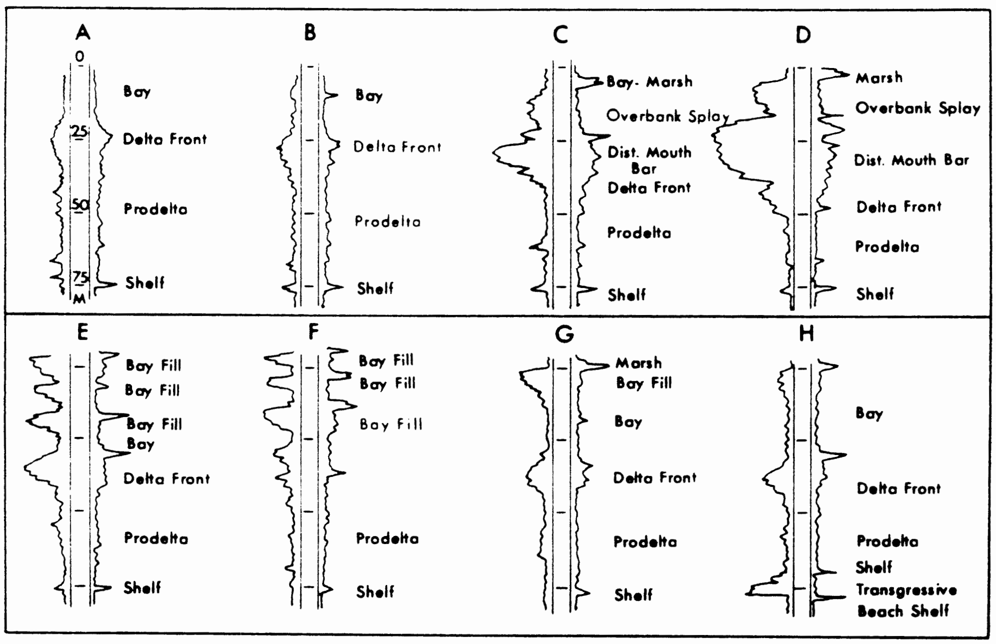


Figure 11. Log Patterns Diagram of Lobate Delta
(J. M. Coleman, D. B. Pryor, 1980)

CHAPTER IV

SUBSURFACE GEOLOGY

Methods and Problems

This investigation has been devoted to the study of the Nellie Bly Formation in the shallow subsurface. The Nellie Bly Formation has no name applied to its subsurface equivalent because it pinches out very rapidly to the west. The main source of subsurface data has been electric well logs displaying spontaneous potential and resistivity readings. Data derived from these well logs was incorporated for use in the construction of subsurface maps and cross sections.

Several problems were encountered when gaining and utilizing data from well logs. The first problem involved finding useable data because most of this area was developed prior to 1930 and many of the wells were not logged using modern wireline log surveys. Next, those wells which were logged very close to the outcrop of the section were often useless because of the fresh water encountered in the section of study. Fresh water in the section poses two problems. First it causes resistivity measurements to be shifted way off scale and secondly it will produce a positive deflection of the spontaneous potential curve. Another problem encountered was the age of the wire line surveys, since most of the wells used were logged in the 1940's, 1950's, and 1960's and equipment had not been refined to today's standards.

Maps

Data from electric logs was used in constructing several subsurface maps. These maps include:

Structure Maps	: Top of Hogshooter Limestone
	: Top of Dewey Limestone
Isopach Maps	: Total Thickness, Nellie Bly Interval
	: Total thickness, Hogshooter Limestone
Isolith Map	: Net Sandstone, Nellie Bly Interval
Ratio Map	: Sandstone / Shale Ratio

Structure Map: Top of Hogshooter Limestone

A structural contour map was constructed using a data base the top of the Hogshooter Limestone (Plate 2). This structure map illustrates the configuration of the top of the Hogshooter Limestone, which directly underlies the stratigraphic interval of interest, in the study area. The major features observed on this map are faults, anticlinal domes and synclinal depressions.

Three major faults were mapped in the study area. The fault observed in the central portions of T19N R7E and T18N R7E trends in a northerly direction and has a maximum of 300 feet of throw. The upthrown side of this fault is to the northwest and the downthrown side to the southeast. Another fault is observed trending northeasterly through

T15N R7E, T16N R7E and T17N R7E. This fault has approximately 10 to 50 feet of throw with the upthrown side to the northwest and the downthrown side to the southeast. The third major fault noted in the study area trends northeast through T14N R7E, T14N R7E and T15N R8E. This fault has approximately 10 to 40 feet of throw with the upthrown side to the northwest and the downthrown side to the southeast.

Several major anticlinal structures area noted across the study area. One major anticlinal structure extends across T17N R7E and fingers up into the southeastern corner of T18N R7E and the southwestern corner of T18N R8E. Another anticlinal structure is observed in the northcentral portion of T16N R7E and extends into the southeastern corner of T17N R7E. This particular structure has been intersected by a fault. Other structural highs can be observed across the study area. Several structurally high noses can be observed in T12N R8E, in the central to northeastern portions of T16N R8E and in the southeast corner of T19N R9E.

Structurally low areas are also present across the study area. Structural depressions are seen in the eastern portions of T18N R7E and stretch into the western parts of T18N R8E. Another structural low was mapped in the southern portion of T19N R7E and stretches southward into the northern part of T18N R7E. This structurally low area has been intersected by a fault. Another small depression is noted in the southwestern corner of T19N and extends slightly into the northwestern corner of T18N R7E. Structurally low noses can be observed in the northwestern portions of T13N R9E, in the southwestern corner of T17N R8E and in the southern portions of T19N R8E. The Hogshooter Limestone throughout the rest of the study area is gently dipping to the northwest with an approximate dip of one degree.

The structural features noted throughout the study area are the result of uplift of the Ouachita Foldbelt to the southeast. The Ouachita Foldbelt continued to rise well into Permian time. This area may also have been influenced by the late Pennsylvanian Arbuckle Orogeny to the south. The structural features noted and mapped across the study area seem to correspond to the major structural trends noted by Miser on the state geologic map.

Structure Map: Top of Dewey Limestone

Another structural contour map was constructed, this time using as a datum the top of the Dewey Limestone (Plate 3). This structure map illustrates the configuration of the top of the Dewey Limestone, which directly overlies the stratigraphic interval of interest, in the study area. This structure map illustrates many of the same subsurface structural features observed on the structure map of the top of the Hogshooter Limestone and discussed above.

The same three faults observed on the Hogshooter structure map are observed on this structure map. These three faults are located in the central parts of T19N R7E extending southward into the northcentral portions of T18N R7E, and in the southeastern corner of T17N R7E extending southwesterly across T16N R7E into the northwestern corner of T15N R7E, and, finally, in the northwestern corner of T14N R8E extending northeasterly into the central portions of T15N R8E.

Major anticlinal structures are very similar as those observed on the structure map of the Hogshooter Limestone. A large domal structure is noted in the central portions of T17N R7E. Another domal structure is noted in the northeastern corner of T19N R7E. This anticlinal structure is intersected by a fault. A final large domal structure is noted in the northcentral portions of T16N R7E. This domal structure is also intersected by a fault. Several anticlinal noses are noted throughout the study area. Anticlinal noses are observed in T12N R8E extending west into T12N R7E, and in T15N R9E, and in T18N R7E extending southward into T17N R7E, and in the north central portions of T17N R8E, and, finally, in the south-central portions of T19N R9E.

Major synclinal structures are noted across the study area and are very similar to those noted on the structure map of the Hogshooter Limestone. A large synclinal depression is noted in T19N R7E. This depression is intersected by a fault. Another large depression is noted in the northeast corner of T17N R7E and spans across portions of the northwest corner of T17N R8E and the southwest corner of T18N R8E. Another depression is located in the north-central portion of T16N R8E. Several synclinal noses are noted across the study area. These synclinal noses can be observed in T13N R8E, and in T14N R8E, and in the northcentral portions of T18N R9E and in the central portions of T19N R9E. Throughout the rest of the study area the Dewey Limestone exhibits a relatively continuous dip to the northwest of approximately one degree.

Isopach Map: Total Thickness, Nellie Bly Interval

An isopach map was constructed of the Nellie Bly interval to illustrate the areal changes in thickness of the Nellie Bly Formation (Plate 4). This map conceptualizes a three dimensional form on a two dimensional surface. Three major areas were noted on this isopach map. A northern area where the Nellie Bly interval thickened dramatically, a central area where the thickness of the interval remained relatively constant and a southern interval where the interval thickness changed dramatically, both thicker and thinner, locally.

In the northern portions of the study area the Nellie Bly interval thickens dramatically with local thicknesses of over 400 feet. This northern area is characterized by locally thick areas that trend southwesterly across portions of T19N R9E, T19N R8E, T18N R7E, T18N R8E and T17N R7E of Creek County, Oklahoma. These locally thick trends appear to outline a single lobe of a high constructive lobate delta which prograded in a southwesterly direction across the study area. A boundary trending across T17N R7E, T17N R8E and across T17N R9E to the outcrop divides the northern area of thickening from the central area that exhibits relatively consistent thickness. This central area is characterized by relatively small changes in interval thickness, with an average thickness of approximately 340 feet. This central area which is characterized by relatively small changes in interval thicknesses. In this area, the Nellie Bly interval is dominate by shale with very little, if any, sandstone present. This area appears to correspond to an interdeltaic embayment between two deltaic lobes located in the northern and southern portions of the study area. Another boundary is noted trending northeasterly across T13N R7E and T14N R8E to the outcrop. This boundary divides the central area from the southern area. The southern area is characterized by drastic changes of interval thickness of the Nellie Bly Formation. The Nellie Bly locally attains thicknesses of up to approximately 440 feet. These locally thick areas tend to trend northeasterly across portions of T12N R7E, T13N R7E, Okfuskee county, Oklahoma and across portions of T14N R7E, T14N R8E, T15N R8E and T16N R8E Creek County, Oklahoma. This trend of locally thick areas appears to outline a second lobe of a high constructive lobate delta which prograded in a northerly direction across the study area.

Isopach Map: Total Thickness, Hogshooter Limestone

An isopach map was constructed of the total thickness of the Hogshooter Limestone to exhibit the areal changes in the thickness of the limestone across the study area (Plate 5). The thickness of the Hogshooter Limestone is relatively constant across the study area, however local thick areas are also noted. The Hogshooter Limestone ranges from 10 to 25 feet in thickness across the study area, but locally thick areas, up to 60 feet are also observed. These locally thick areas are located in the northeastern and central portions of T18N R7E. Another locally thick region is located in the southcentral to eastern parts of T18N R10E, while still another is located in T12N R8E. These locally concentrated areas of increased thickness in the Hogshooter Limestone probably represent moundal carbonate accumulations where the limestone is reefed up. Because of the random arrangement of these localized thick areas it appears that these "thick" areas correspond to some form of interior shelf reefs. These interior shelf reefs appear to have possibly been deposited on locally higher areas. These areas appear to have been slightly higher than their surroundings because the major areas of deltaic progradation of the Nellie Bly Formation appear to have been diverted around these areas not over them.

Isolith Map: Net Sandstone, Nellie Bly Interval

A net sandstone isolith map was constructed to illustrate the relative amount of sand deposited across the study area (Plate 6). The map indicates three areas of interest in the study area. These three areas include a northern area which has a moderate thickness of net sandstone, a central area in which little or no sand was deposited, and a southern area in which large quantities of sand were deposited.

The northern area is characterized by total sand thicknesses which vary from 20 to 60 feet but may be locally as thick as 100 feet. These locally thick portions of the northern area are located in portions of T19N R8E, T19N R9E, T18N R7E, T18N R8E, Creek County, Oklahoma. These localized areas of significant sand thicknesses outline what appears to be a single lobe of a high constructive lobate delta. The vertical electric log signatures exhibited in these locally thick areas are composed of serrate coarsening upward sequences which are characteristic of lobate deltas. Based upon the geometry of these locally thick areas it appears that the high constructive lobate delta prograded in a southwesterly direction across the study area.

Just south of this northern area is a central area in which little or no sand was deposited. This area includes portions of T17N R7E, T17N R8E, T17N R9E, T18N R10E, and portions of T16N R7E and T16N R8E. This area represents a probable interlobe embayment between a northern and a southern lobe, of a high constructive lobate delta, where mostly shale and very little sand were deposited.

The southern area is characterized by its large areal distribution and large quantities of deposited sand. Thicknesses of total sand deposited range from 40 to 80 feet with locally thick areas of up to as much as 140 feet. These locally thick portions of the southern area are located in portions of T12N R7E, T13N R7E, Okfuskee County, Oklahoma and in portions of T14N R7E, T14N R8E, T15N R8E, T16N R8E, Creek County, Oklahoma. The vertical electric log signatures exhibited in these locally thick areas are also composed of serrate coarsening upward sequences. Based on the electric log signatures and the geometry of theses locally thick areas it appears that these locally thick areas outline a second lobe of a high constructive lobate delta. This second lobe appears to have prograded in a northerly direction across the study area.

Ratio Map: Sandstone/Shale Ratio, Nellie Bly Interval

A sandstone to shale ratio map was constructed to illustrate the relative proportions of sand and shale in the stratigraphic interval (Plate 7). The map was also utilized to show the lateral changes in proportions of the two components across the study area. The sandstone to shale ratio map can be divided into three distinct areas, a northern area, a central area and a southern area.

The northern area is characterized by having sandstone to shale ratio values of .20 to .30 sand. The northern area extends across portions of T19N R7E, T19N R8E and T19N R9E, Creek County Oklahoma.

The central area is characterized by having sandstone to shale ratio values of 0.0 to .15 sand. The central area encompasses portions of T18N R7E, T18N R8E, T18N R9E, T18N R10E, T17N R7E, T17N R8E, T17N R9E, T16N R7E and T16N R8E, Creek County, Oklahoma.

The southern area is characterized by sandstone to shale ratio values ranging from .20 to .30 sandstone. The southern area encompasses portions of T16N R9E, T15N R7E, T15N R8E, T15N R9E, T14N R7E, T14N R8E, Creek County, Oklahoma and portions of T13N R7E, T13N R8E, T12N R7E and T12N R8E, Okfuskee County, Oklahoma.

The sandstone bodies of the Nellie Bly Formation tend to occur in the upper half of the formation and exhibit serrate coarsening upward sequences. We can therefore use the sandstone to shale ratio map as an indicator as to the amount of sandstone deposition that took place across the study area. By using the relative amounts of sand deposited, we can determine the areas across which the deltas prograded and direction of the source area. The southern area experienced a lot of deltaic progradation as seen by the large ratio values and patterns in this area. The northern area had some deltaic progradation as seen by the relatively large ratio values and patterns in this area. The central area, however, did not experience much in the way of deltaic progradation. This can be seen in the low ratio values and patterns exhibited by this area.

Cross Sections

Electric logs were also used in the construction of five stratigraphic subsurface cross sections across the study area. These include two north-south cross sections and three east-west cross sections (Plate 8). The north-south cross sections include:

Cross Section A-A′
Cross Section B-B′

The east-west cross sections include:

Cross Section C-C′
Cross Section D-D′
Cross Section E-E′

Cross Section A-A'

Cross Section A-A' is one of two north to south stratigraphic cross sections, hung on the top of the Dewey Limestone, constructed across the study area (Plate 9). This cross section was constructed by using nine separate SP/Resistivity electric well logs spaced four to six miles apart. This cross section is used to illustrate the lateral stratigraphic changes of the Nellie Bly interval across the western one half of the study area.

This cross section illustrates several different stratigraphic changes. The Dewey Limestone is approximately ten feet thick in the northern portion of the study area, but thins to a few feet in the southern portions of the study area. The Hogshooter Limestone also thins in a southerly direction. The Hogshooter Limestone is 40 to 60 feet thick in the northern portions of the study area but thins to 10 to 20 feet in the southern portions of the study area.

The lithologic characteristics of the Nellie Bly interval also changes dramatically from north to south. In the northern portion of the study area the Nellie Bly interval is composed mostly of shales with very few sandstones. The interval changes dramatically to the south with deltaic coarsening upward sequences becoming more prevalent in the section. The Nellie Bly interval ranges in thickness from 240 feet in the north to 360 feet in the south. The interval does tend to thicken slightly to the south, with the larger interval thicknesses being associated with those sections having an abundance of sandstones in the interval.

The sandstones of the Nellie Bly Formation tend to be located in the upper half of the formation. They normally exhibit a serrate coarsening upward sequence which would indicate that they were deposited in a high constructive lobate deltaic environment. These serrate coarsening upwards sequences can be easily identified on the electric log of Melco Drilling Company's well #1 George and on Sunray Oil Company's well #1 Jordan which have been incorporated into cross section A-A'.

Cross Section B-B'

Cross Section B-B" is the second of two north to south stratigraphic cross sections, hung on the top of the Dewey Limestone, constructed across the study area (Plate 10). This cross section parallels Cross Section A-A' and was constructed by using ten separate SP/Resistivity electric well logs spaced four to five miles apart. This cross section illustrates the lateral stratigraphic changes of the Nellie Bly interval across the eastern one half of the study area.

Several stratigraphic changes are noted in this cross section. The Dewey Limestone ranges in thickness, locally, from a few feet up to approximately ten feet. Because of the thickness variation of the Dewey Limestone it is often hard to pick out on the SP/Resistivity well logs. The Hogshooter Limestone is 20 to 40 feet thick in the northern portions of the study area, but thins to approximately 10 to 15 feet in the southern portions of the study area.

The Nellie Bly interval also exhibits significant stratigraphic change across the study area. The Nellie Bly Formation ranges in thickness from approximately 270 feet in portions of T17N R8E, Creek County, Oklahoma to 370 feet in portions of T18N R8E, Creek County, Oklahoma. In the extreme northern portions of the study area deltaic coarsening upward sequences and channel sands occur frequently in the Nellie Bly interval. Towards the center of the study area the Nellie Bly interval is dominated by shale. In the southern portions of the study area deltaic coarsening upward sequences and channels sands become more frequent in occurrence in the stratigraphic interval. The Nellie Bly interval tends to thicken to the south. Larger interval thicknesses are associated with those areas which have an abundance of sandstones in the stratigraphic interval and the smaller interval thicknesses being associated with those areas with few or no sandstones in the stratigraphic interval.

In the southern portions of the cross section on can clearly see three different sandstone packages in the Nellie Bly Formation. These three separate packages can be easily identified on the electric logs of Whitten & Zaran's well #2 Ross and on Skelly Oil Company's #9 Egnew, both of which have been incorporated into cross section B-B′.

Cross Section C-C′

Cross section C-C′ is one of three east to west stratigraphic cross sections, hung on the top of the Dewey Limestone, constructed across the study area (Plate 11). This cross section was constructed by using six separate SP/Resistivity electric well logs spaced approximately three to five miles apart. This cross section illustrates the stratigraphic changes of the Nellie Bly interval in the northern one third of the study area. Several stratigraphic changes are noted on this cross section. The Dewey Limestone ranges, locally, from a few feet to approximately ten feet in thickness across the cross section.

The Hogshooter Limestone ranges in thickness from 20 to 35 feet thick and tends to thicken slightly to the east across this cross section. The Nellie Bly interval, as illustrated by this cross section, is composed almost entirely of shales with a very few channel sands being noted.

Cross Section D-D′

Cross Section D-D′ is the second of three east to west stratigraphic cross sections, hung on the top of the Dewey Limestone, constructed across the study area (Plate 12). This cross section parallels Cross Section C-C′ and is used to illustrate the stratigraphic changes of the Nellie Bly interval across the central one third of the study area. This cross section was constructed by using five separate SP/Resistivity electric well logs spaced approximately two to four miles apart.

Several stratigraphic changes are noted on this cross section. The Dewey Limestone ranges from a few feet to approximately ten feet in thickness and tends to thin to the east on this cross section. The Hogshooter Limestone ranges from 10 to 35 feet in thickness and also tends to thin to the east. The Nellie Bly interval changes very little across this cross section. The Nellie Bly interval, as illustrated by this cross section, is dominated by shales with a few small sandstones being noted. The Nellie Bly interval tends to thicken slightly to the east across this cross section.

Cross Section E-E′

Cross Section E-E′ is the third of three east to west stratigraphic cross sections, hung on the top of the Dewey Limestone, constructed across the study area (Plate 13). This cross section parallels Cross Section D-D′ and is used to illustrate the stratigraphic changes of the Nellie Bly interval across the southern third of the study area. This cross section was constructed by using five separate SP/Resistivity electric well logs spaced approximately two to four miles apart. Several stratigraphic changes are noted on this cross section. The Dewey Limestone ranges from a few feet to approximately ten feet in thickness and tends to thicken to the east across this cross section. The Hogshooter Limestone ranges from a few feet to approximately 15 feet in thickness and tends to thicken to the east in this cross section. The Nellie Bly interval does not change significantly across this cross section. The Nellie Bly interval is comprised mostly of shales with a few sandstones being noted. The interval tends to thin slightly to the east.

CHAPTER VI

CONCLUSIONS

The Pennsylvanian Missourian Series Nellie Bly Formation in northcentral Oklahoma is composed predominantly of shales, siltstones and sandstones. The structural dip of the Nellie Bly Formation, in the study area, is approximately one degree to the northwest. The study area is located on the northern shelf of the Arkoma Basin. Electric well log signatures indicate thin sandstones interbedded in massive shales. Spontaneous potential signatures are serrate and typically exhibit coarsening upward sequences common with deltaic deposits. These spontaneous potential signatures indicate that high constructive lobate deltaic processes affected this area of the shelf. These deltaic processes were more prevalent in the northern and southern portions of the study area than in the central area.

Subsurface maps outline the boundaries of two separate lobes of a high constructive lobate delta. There is a northern lobe which spreads across the northern one third of the study area and a southern lobe which stretches across the southern one third of the study area. Both of the lobes were prograded and abandoned during the highstand phase of the eustatic cycle. Incised valley fills are absent from the delta plains of these lobes. Between these two lobes is what appears to be an interlobe embayment which is characterized by little or no sand deposition (Figure 12). This interlobe embayment spans across the central one third of the study area.

The Nellie Bly Formation in Creek and Okfuskee Counties, Oklahoma is a regressive clastic unit. It was deposited on a shallow marine shelf at a time of maximum marine regression when fluvial and deltaic processes dominated the study area. The Nellie Bly Formation was deposited in a high constructive deltaic environment.

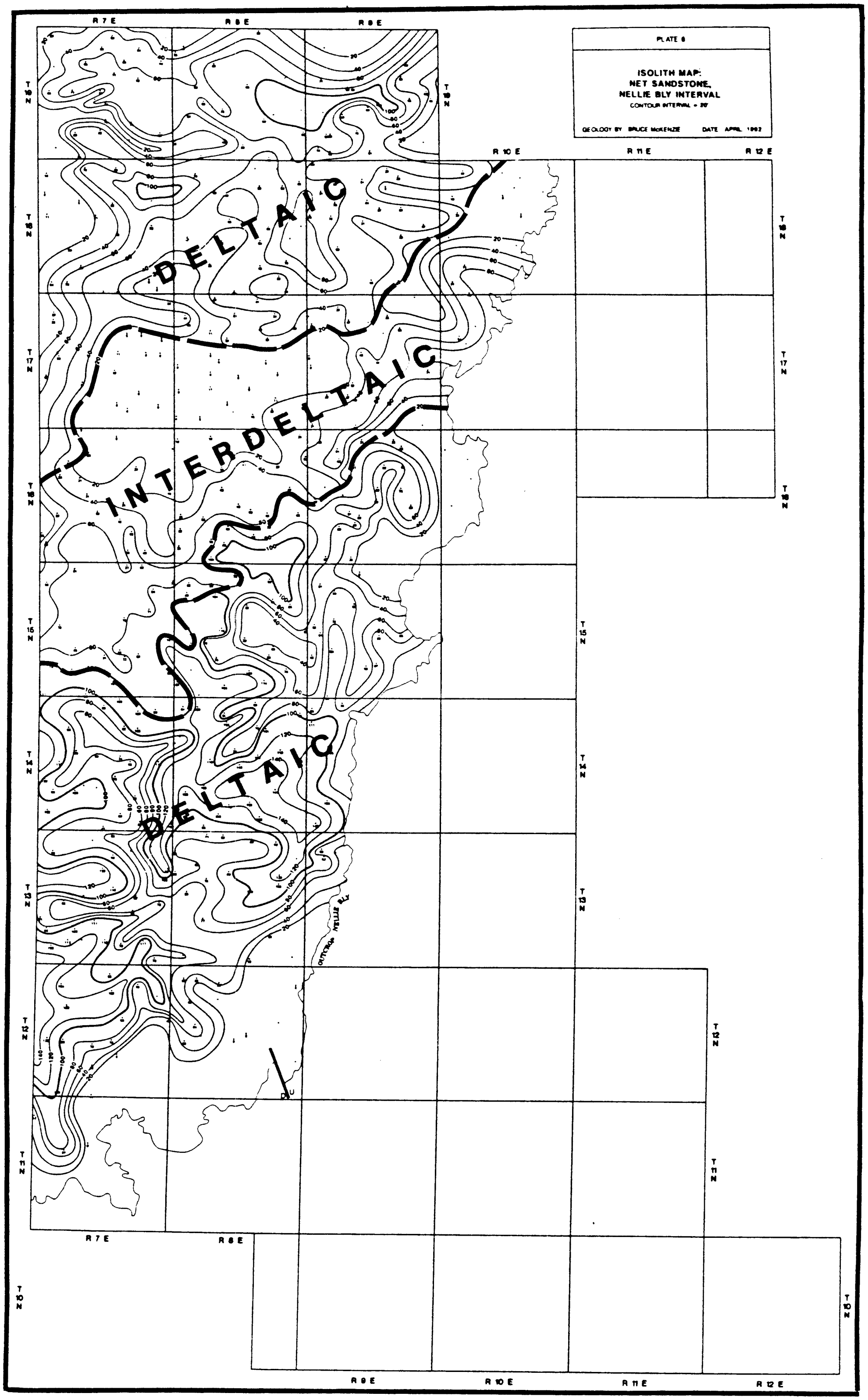


Figure 12. Deltaic and Interdeltaic Areas of Study Area.

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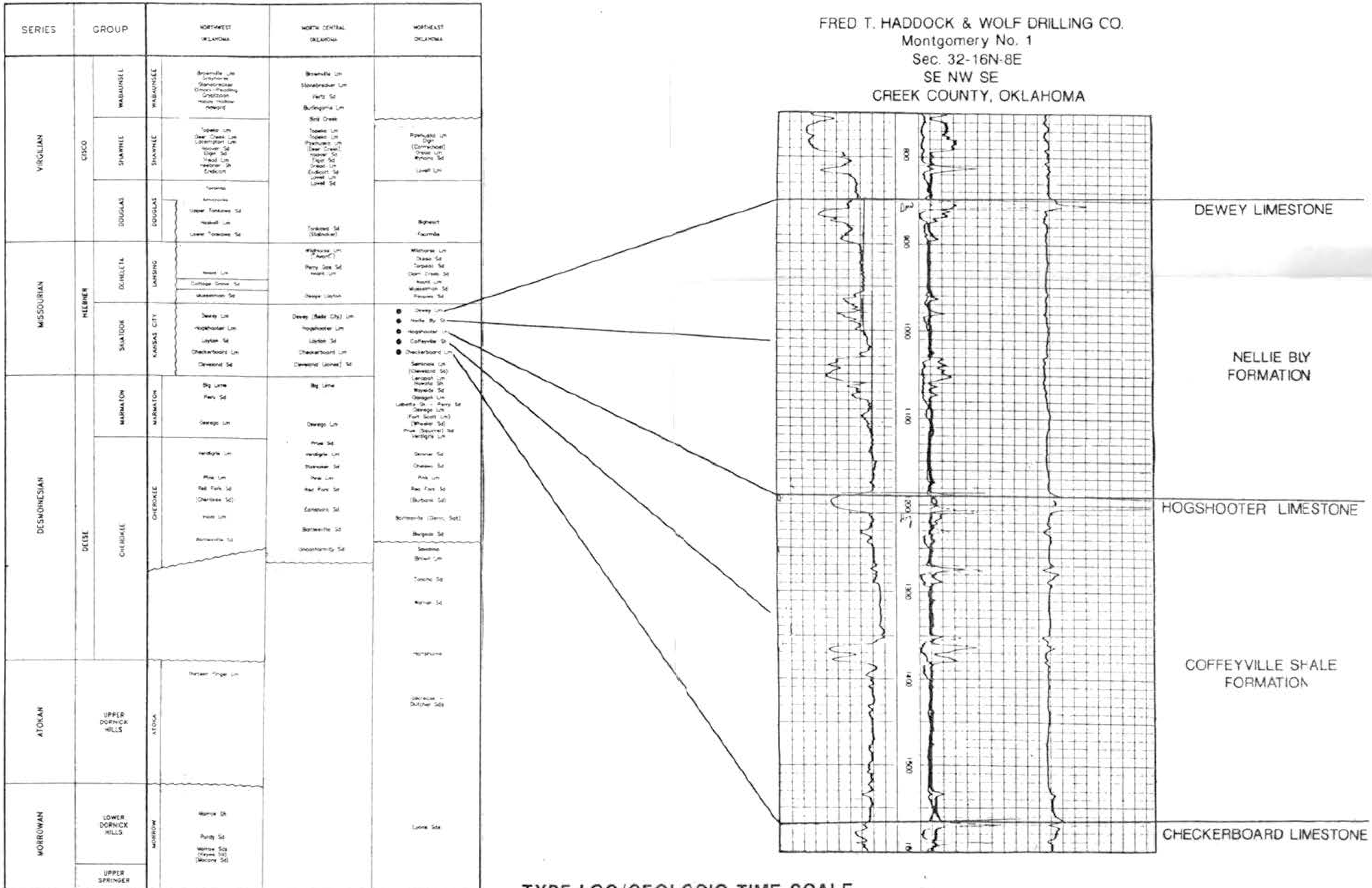

TYPE LOG/GEOLOGIC TIME SCALE

PLATE 1

PLATE 2
STRUCTURE MAP:
TOP OF HOGSHOOTER LIMESTONE
CONTOUR INTERVAL = 50'
GEOLOGY BY: BRUCE McKENZIE
DATE: APRIL, 1992
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
OUTCROP TOP OF DEWEY


PLATE 3
STRUCTURE MAP:
TOP OF DEWEY LIMESTONE
CONTOUR INTERVAL = 50'
GEOLOGY BY: BRUCE McKENZIE
DATE: APRIL, 1992
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
OUTCROP TOP OF DEWEY


PLATE 4
ISOPACH MAP:
TOTAL THICKNESS,
NELLIE BLY INTERVAL
CONTOUR INTERVAL = 20'
GEOLOGY BY: BRUCE McKENZIE
DATE: APRIL, 1992
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
OUTCROP TOP OF DEWEY
D
U

PLATE 5

ISOPACH MAP: TOTAL THICKNESS, HOGSHOOTER LIMESTONE

CONTOUR INTERVAL = 5'

GEOLOGY BY: BRUCE McKENZIE DATE: APRIL, 1992

PLATE 6
ISOLITH MAP:
NET SANDSTONE,
NELLIE BLY INTERVAL
CONTOUR INTERVAL = 20'
GEOLOGY BY: BRUCE McKENZIE
DATE: APRIL, 1992
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
OUTCROP TOP OF DEWEY
D
U


PLATE 7
RATIO MAP:
SANDSTONE/SHALE RATIO
CONTOUR INTERVAL = .10
GEOLOGY BY: BRUCE McKENZIE
DATE: APRIL, 1992
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
OUTCROP TOP OF DEWEY
D
U

PLATE 8
LOCATOR MAP
GEOLOGY BY: BRUCE McKENZIE
DATE: APRIL, 1992
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
A
A'
B
B'
C
C'
D
D'
E
E'
D
U
OUTCROP TOP OF DEWEY

PLATE 9

CROSS SECTION A-A'

GEOLOGY BY: BRUCE McKENZIE DATE: APRIL, 1992

PLATE 10

CROSS SECTION B-B'

GEOLOGY BY: BRUCE McKENZIE   DATE: APRIL, 1992

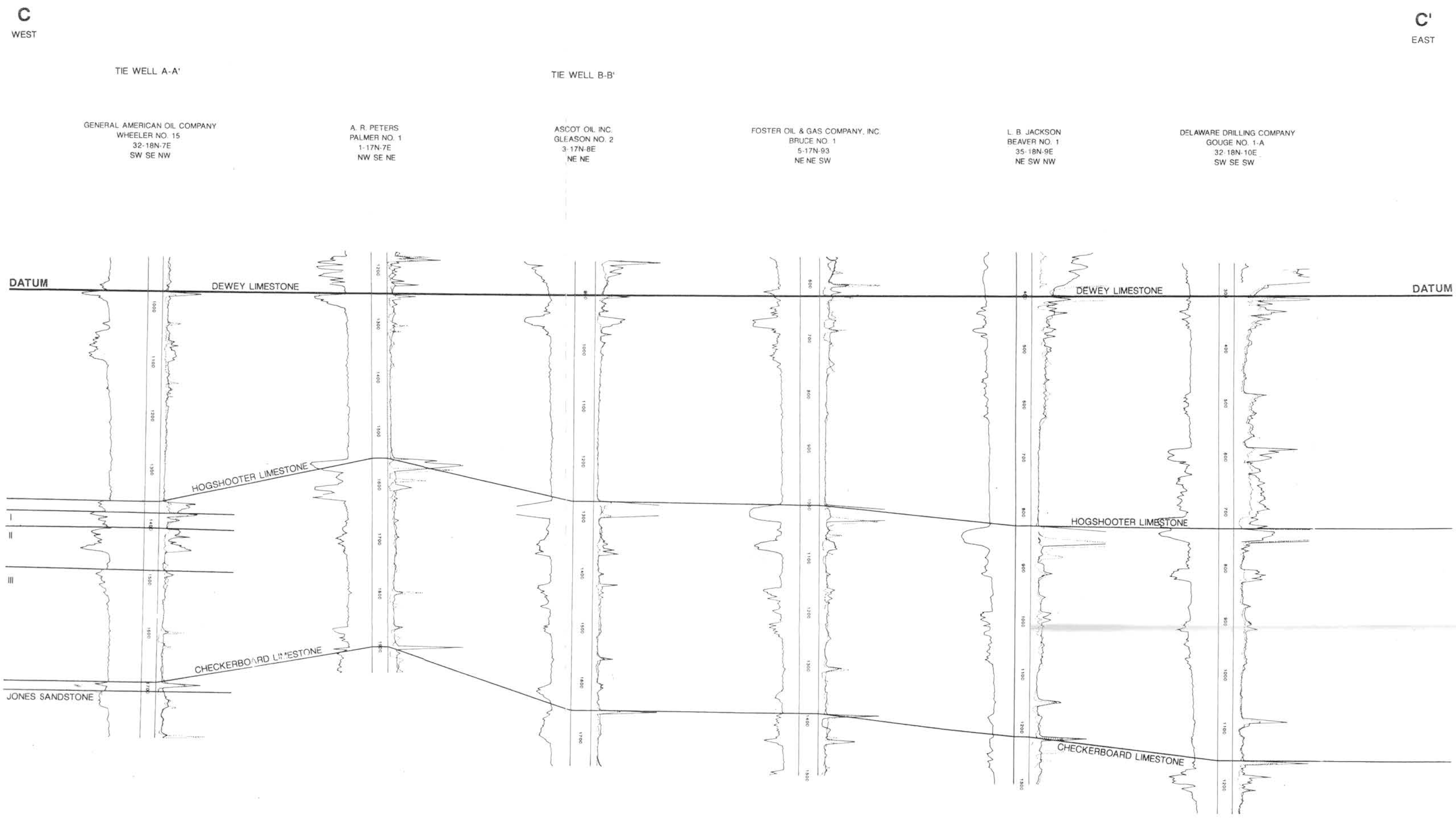

PLATE 11

CROSS SECTION C-C'

GEOLOGY BY: BRUCE McKENZIE

DATE: APRIL, 1992

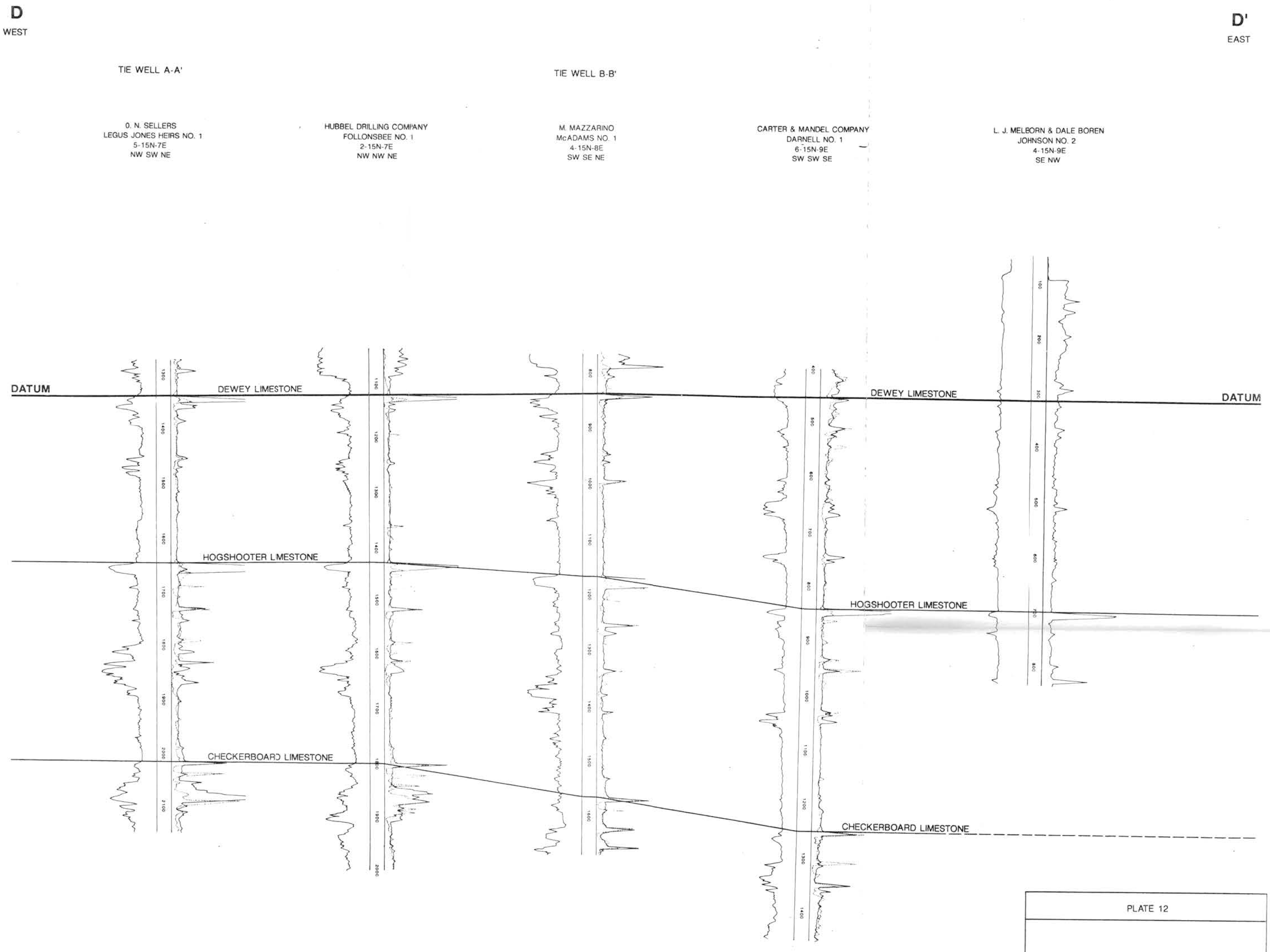

PLATE 12

CROSS SECTION D-D'

GEOLOGY BY: BRUCE McKENZIE

DATE: APRIL, 1992

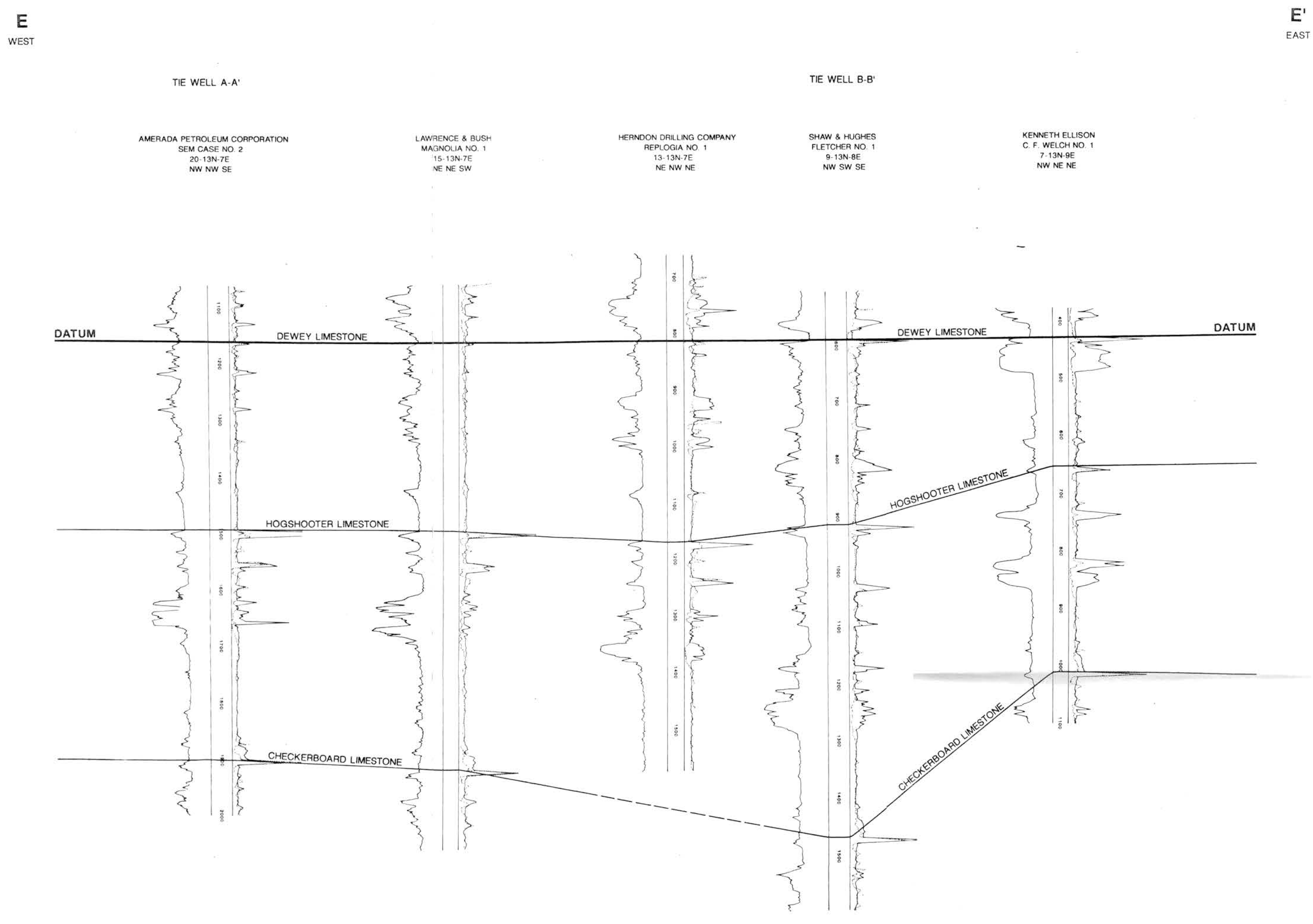

PLATE 13

CROSS SECTION E-E'

GEOLOGY BY: BRUCE McKENZIE

DATE: APRIL, 1992