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Lithostratigraphy of Silurian rocks in southern Ohio and adjacent Kentucky and West Virginia

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University of Cincinnati, 1988

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UMI

LITHOSTRATIGRAPHY OF SILURIAN ROCKS IN SOUTHERN OHIO AND ADJACENT KENTUCKY AND WEST VIRGINIA

A dissertation submitted to the

Division of Graduate Studies and Research
of the University of Cincinnati

in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY

in the Department of Geological Sciences
of the College of Arts and Sciences

1988

by

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UNIVERSITY OF CINCINNATI

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I hereby recommend that the thesis prepared under my supervision by David M. Lukasik

entitled Lithostratigraphy of Silurian Rocks in Southern Ohio and Adjacent Kentucky and West Virginia

be accepted as fulfilling this part of the requirements for the degree of Doctor of Philosophy

Approved by:

Paul Edwin Potter

David L. Meyer

D B Nash

ABSTRACT

A unified study of outcrop and subsurface Silurian rocks from the Brassfield Formation through the C unit in adjacent portions of Ohio, Kentucky, and West Virginia enhances our understanding of regional stratigraphy, paleogeography, and sea level variations.

Five hundred ninety four nuclear logs, one hundred thirty seven well sample suites, ten cores, and thirty four outcrops are used to define lateral and vertical stratigraphic limits, and develop interregional correlations and depositional models. Results are portrayed by thirteen thickness maps, two structure maps, fourteen cross sections, and numerous representative well logs. Three stratigraphic columns are developed to describe Silurian rocks in both outcrop and subsurface in southern Ohio, northeastern Kentucky, and western West Virginia.

New stratigraphic contributions include, 1) correlation of the Brassfield at the base of the Silurian-beneath the Clinton sandstone, 2) linking the Oldham and Dayton Limestones with the drillers' "Packer shell" and "Casing shell" units respectively, 3) identification of Cacapon and Keefer Sandstones in Ohio counties, 4) correlation of Lockport and lower Salina strata in Ohio with the Lockport Dolomite in West Virginia, and 5) redefinition of the Greenfield-Tymochtee boundary in subsurface.

Five transgressive and six regressive sea level hemi-cycles are identified. Significant lowering of sea level produced unconformities at the Ordovician-Silurian systemic boundary, and locally below the Dayton Limestone and at the Niagaran-Cayugan contact. Sea level highstands are typically recorded by shale units. Paleogeographic analysis indicates progressive post-Medina northeastward rotation of depositional strike coinciding with the development of the Wabash Platform, differential subsidence along the platform margin, and occurrence of a localized northeast-southwest oriented reef trend in Lockport strata.

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I wish to especially thank my principal research advisor, Dr. Paul E. Potter, for his many thoughtful suggestions and encouragement during the course of this study, and also research committee members Dr. David L. Meyer (University of Cincinnati), for his manuscript review, and Dr. David B. Nash (University of Cincinnati). Thanks are extended to Dr. D. G. Patchen (West Virginia Geological Survey) for his thoughtful and thorough review of the manuscript, and to Dr. Richard S. Bowman (Davon Inc.), who provided detailed knowledge of Silurian rocks in outcrop and a critical review of the paper. Acknowledged also are the contributions by the following: Mr. John D. Gray (Ohio Geological Survey) helped with subsurface stratigraphic relationships in Ohio counties, Dr. G. Sarwar (Conoco Inc.) gave several key geophysical logs, Dr. Owen Bement (Shell Development Corp.) provided the SEM-EDX analysis, Messrs. T. Hudson and D. Leigh (University of Cincinnati) assisted in the field and discussed many Silurian problems, and Dr. Reginald Shagam (Rider College), who was always encouraging. The project was partially funded by a grant from the Sedimentology Fund (University of Cincinnati).

Finally, I am indebted to my wife Susan, who sacrificed her time, money, and energy during the course of this study, and was an unwavering source of encouragement.

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INTRODUCTION

This investigation provides a regional analysis of the thickness, lithology, and distribution of the Silurian Brassfield Formation through C unit in the subsurface of southern Ohio and adjacent Kentucky and West Virginia. It further explores the stratigraphic correlation of these rocks with equivalent strata in northern Ohio, western Pennsylvania, West Virginia, and Indiana where many studies exist. A relative sea level curve and a review of paleogeography are also presented.

The Silurian of the southern Ohio area is of interest for several reasons. From a regional point of view, knowledge of southern Ohio strata is essential to understanding the stratigraphy of equivalent rocks in adjacent states. This is especially true, because southern Ohio stands as a critical paleogeographic link between the clastic-dominated Appalachian Basin to the east and the carbonate-dominated Wabash Platform to the west. The area also provides key information about the nature of the Ordovician-Silurian systemic boundary and the timing of the Cincinnati Arch. Petroleum production from several Silurian reservoirs within and adjacent to the study area is of further interest. Thus, this investigation has both theoretical and practical significance.

Several factors have slowed progress toward a better understanding of the regional Silurian stratigraphy and paleogeography of the eastern midcontinent. One problem concerns the recognition, interpretation and naming of time-equivalent facies that represent stable shelf, shelf flank, and basin-center depositional settings. Effects of both localized and differential subsidence during Silurian time and a general lack of time-stratigraphic indicators further complicate this problem. In addition, outcrops are distributed around basin margins near midcontinent arch systems where sections are typically condensed. Consequently, it has been difficult to correlate expanded sections in basin centers to the outcrop. Another problem stems from the attempts of early workers to extend New York State stratigraphic terminology throughout the eastern midcontinent.

In the last decade, however, several studies of regional application which incorporate lithostratigraphic, paleogeographic, and tectonic interpretations have greatly enhanced our knowledge of Silurian historical geology in the eastern midcontinent: e.g. Smosna and Patchen (1978), Droste and Shaver (1983, 1985) and Shaver (1974). My study follows their approach.

METHODOLOGY AND DATA BASE

The primary purpose of this study is to describe Silurian rocks in the subsurface of southern Ohio and adjacent portions of Kentucky and West Virginia. The study area includes the Silurian outcrop on the west, extends east to 82° 00′ west longitude, and is respectively bounded at the north and south by 39° 27′ and 38° 05′ north latitude (Fig. 1). The southern and eastern margins were chosen to include sections that illustrate facies transitions in the Niagaran Series from carbonate to mixed clastic-carbonate, the rapid eastward expansion of the Lower Silurian Medina Group, and to extend subsurface correlations across state boundaries.

The stratigraphic interval considered ranges from the top of the Ordovician Queenston Shale through the Silurian C unit, inclusively. Thickness maps are presented for many of the formal Silurian stratigraphic units, along with two structure maps. These maps are of lithostratigraphic units rather than time-stratigraphic units and, therefore, illustrate conditions of a formation and not necessarily at any single point in time.

The examination of well cuttings and cores, and information derived from geophysical logs is the primary basis for this report. Described exposures selected from the literature were also examined in order to link subsurface and outcrop.

The geophysical logs available for study consist of gamma ray and neutron, porosity, density, or sonic logs. Such logs are especially useful in recognizing marker beds that are too thin to be distinguished in cuttings, and in providing more accurate determination of formation thickness than is possible from cuttings alone. The gamma ray curve is the most useful for determining formation contacts and identifying lithologic breaks seen in well cuttings. Log control within the study area is concentrated in areas of Clinton sandstone production, but is sparse elsewhere. Logs were studied at the geological surveys of Ohio, Kentucky, and West Virginia.

Sample cuttings from 137 wells and 10 cores were examined and described from Ohio and West Virginia. Priority was given to wells with both sample and geophysical log control. This allowed for the comparison and integration of lithologic data with geophysical log characteristics. Once established, these control wells were used to construct a cross section network and to correlate logs without samples. Stratigraphic correlations for Kentucky are based chiefly on log characteristics, and should be considered tentative until lithologic information can be integrated. Published descriptions of well cuttings and cores were also consulted, including those of Horvath (1964) for Ohio; Freeman (1951) and Currie (1981) for Kentucky; and Tucker (1936), Martens (1939, 1945), Overby (1961), and Smosna (1974, 1983) for West Virginia.

Drillers' logs do not commonly subdivide the Silurian Lockport and Salina Groups in the southern Ohio area, but instead include this interval within the thick Silurian-

Devonian carbonate sequence referred to as the "Big Lime", "Corniferous", or "Newburg". Drillers' tops are more useful for sub-Lockport correlations where several widespread stratigraphic marker beds are consistently recognized and conventionally termed. However, elevations of drillers' logs are considered to be the least accurate of available information, and are used only in areas of sparse well control.

Well data are summarized in Appendix A, and selected sample descriptions are presented in Appendix B. Figure 2 shows the general distribution of subsurface data. A numerical tabulation of well cuttings, cores, and logs used in this study, by county, is presented in Table 1. Figure 3 shows in detail the location of key outcrops and all wells with Silurian samples in the study area. A locality register and pertinent information for each outcrop is given in Appendix C.

Figure 1. Boundaries and counties of the study area. Stipple pattern shows distribution of Silurian outcrop.

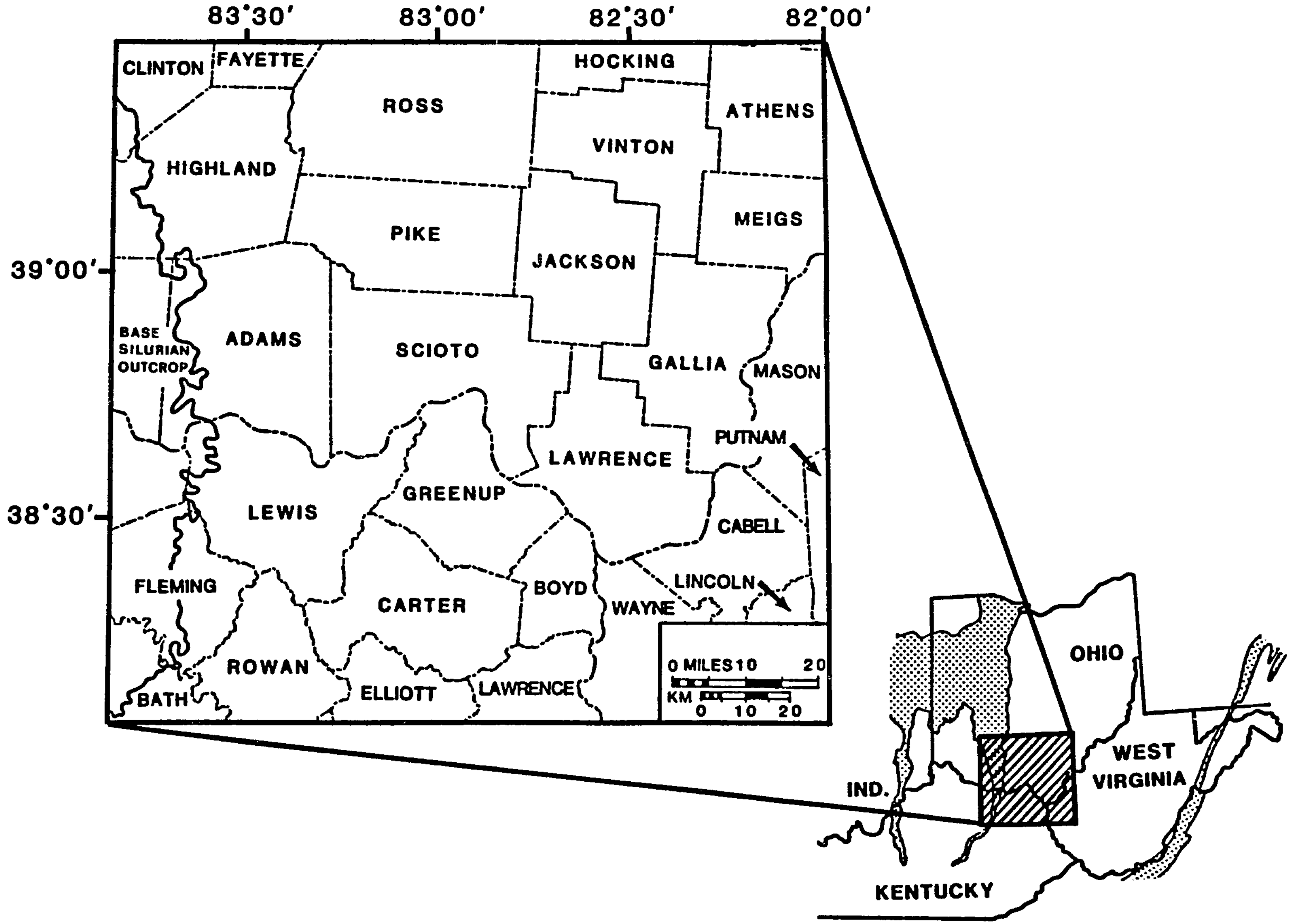


Figure 2. Distribution of subsurface data. Available cores shown by solid circles; numbers indicate nuclear logs and well cuttings studied by county. Also see Table 1 for numerical summary of subsurface data used in this investigation.

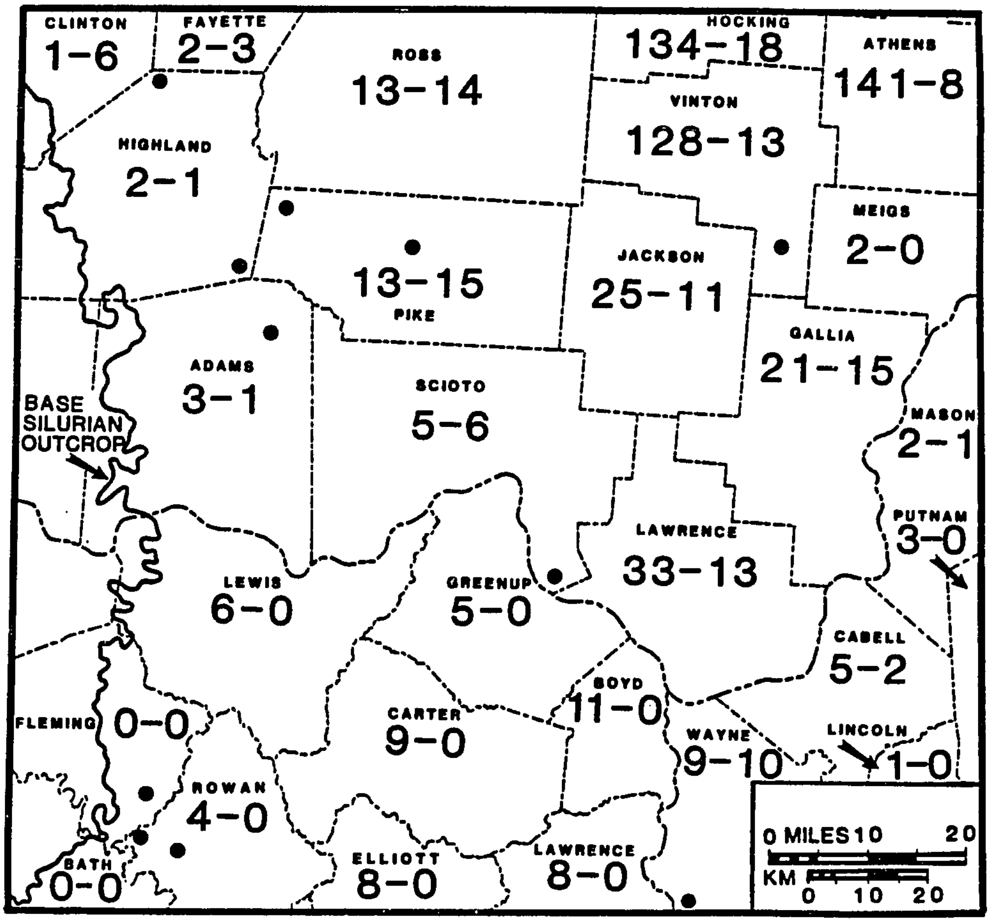


Table 1. Tabulation by county of well samples, nuclear logs, and cores used in this investigation.

State	COUNTY	SAMPLES	GRN LOGS	BOTH	CORES
OHIO	Adams	1	3	1	3
	Athens	8	141	8	0
	Clinton	6	1	1	0
	Fayette	3	2	2	0
	Gallia	15	21	10	0
	Highland	1	2	1	2
	Hocking	18	134	11	0
	Jackson	11	25	4	0
	Lawrence	13	33	7	0
	Meigs	0	2	0	0
	Pike	15	13	11	2
	Ross	14	13	12	0
	Scioto	6	5	3	1
	Vinton	13	128	5	1
W. VA.	Cabell	2	5	1	0
	Lincoln	0	1	0	0
	Mason	1	2	1	0
	Putnam	0	3	0	0
	Wayne	10	9	1	1
KENTUCKY	Bath	0	0	0	0
	Boyd	0	11	0	0
	Carter	0	9	0	0
	Elliott	0	8	0	0
	Fleming	0	0	0	0
	Greenup	0	5	0	0
	Lawrence	0	8	0	0
	Lewis	0	6	0	0
	Rowan	0	4	0	0
	TOTAL	137	594	79	10

Figure 3 (map pocket). Detailed location of key outcrops and all wells with sample control in the study area. Permit numbers identify the wells and correspond to index numbers used in Appendix A and Appendix B. Outcrops sequentially numbered north to south and listed in Appendix C.

REGIONAL SETTING

Major Lower Paleozoic tectono-sedimentational features of the eastern midcontinent include the Appalachian Basin, proto-Michigan Basin, proto-Illinois Basin (Vincennes Basin of Droste and Shaver, 1980, p. 568, Fig. 1), Cincinnati Arch, Wabash Platform, Rome Trough, and Waverly Arch. The study area is situated on the southwest flank of the Appalachian Basin, directly east of the Cincinnati Arch and southeast of the Wabash Platform (Fig. 4).

The Cincinnati Arch has been interpreted as a positive element during much of the Middle Paleozoic and forms the boundary between the southwest flank of the Appalachian Basin and the east flank of the Illinois Basin. The arch acted as a possible barrier to westward sedimentation from post-Brassfield time to the Middle Devonian (Freeman, 1951, p. 15).

The Waverly Arch is a broad, concealed arch of low structural relief situated east of the Cincinnati Arch; extending from central Ohio to east-central Kentucky. Woodward (1961, p. 1645) defined the Waverly Arch on the basis of thickness trends in Cambrian-Ordovician strata, and Tankard (1986) has shown the arch to be again active in the Carboniferous. No structural or thickness evidence indicates that the Waverly Arch was active during Silurian time, although the western pinch-out of the Clinton sandstone in Ohio does coincide with the crest, or proximal eastern flank of the arch.

The Rome Trough, named by McGuire and Howell (1963) is a graben which forms an extension of the Eastern Interior Aulacogen of Harris (1978). The structure is partially included within the southern portion of the study area where it is bounded at the north by the Kentucky River Fault System; a series of down-to-the-south basement growth faults that strike east-northeast (Ammerman and Keller, 1979). Movement along the faults was greatest during the Cambrian-Ordovician and continued with progressively decreasing magnitude into the Pennsylvanian (Webb, 1969, p. 7). Minor thickening of Silurian rocks occurs within the Rome Trough.

Silurian rocks crop out along a narrow, arcuate belt on the east margin of the Cincinnati Arch; Devonian and younger strata form the bedrock farther down dip toward the Appalachian Basin. From the outcrop, Silurian rocks thicken to the east and north in the subsurface. To the west and southwest Silurian strata are progressively truncated by pre-Upper Devonian erosion, and have been removed entirely from the crest of the arch except for a few outliers of the Brassfield Formation. Units subcropping beneath the Devonian Ohio Shale, which blankets this unconformity, are shown in Figure 5. The boundaries which mark initial erosional truncation for each stratigraphic unit were used as the westward limits for mapping purposes. Overall thickness of the interval from the base of the Brassfield Formation through the C unit ranges from less than 100 feet in erosionally overstepped outcrops, to greater than 600 feet in Athens County, Ohio.

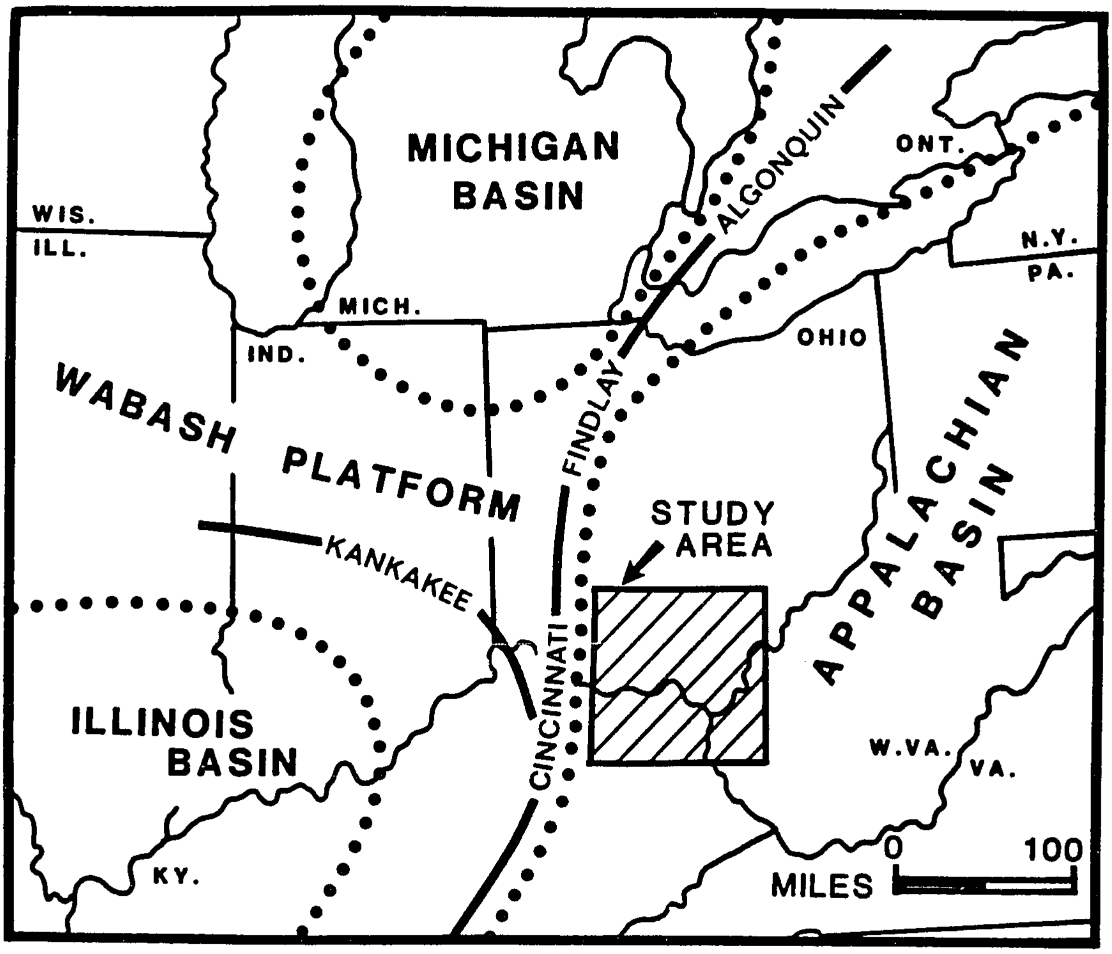
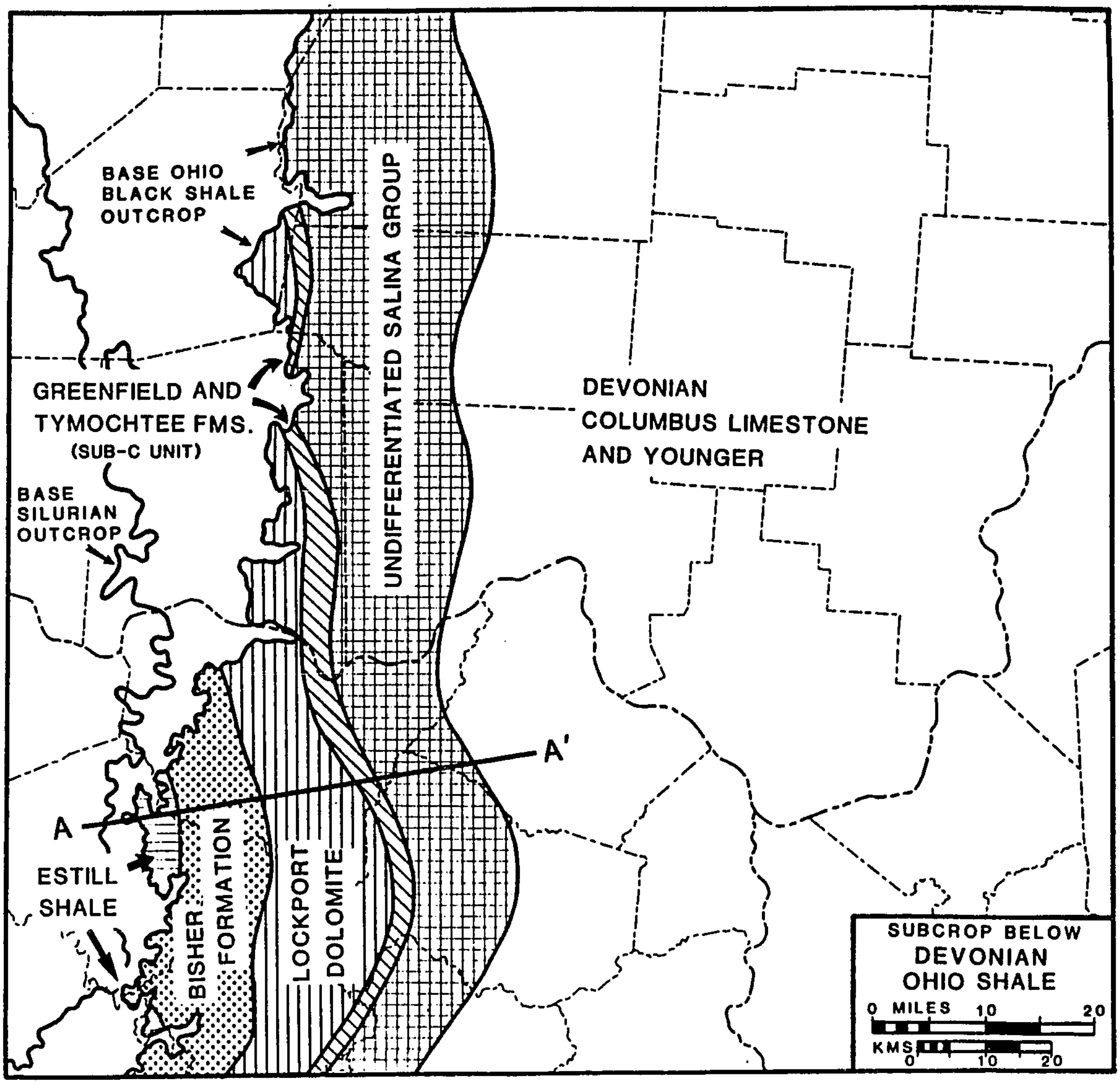
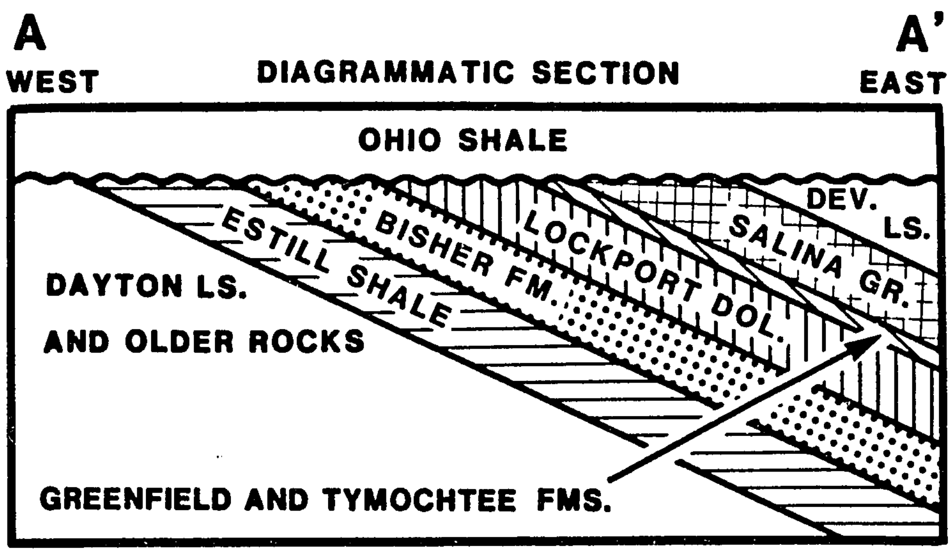


Figure 4. Map of the eastern midcontinent showing the position of lower Paleozoic major basins and arches and location of the study area. Modified from Droste and Shaver (1983, Fig. 1, p. 2).

Figure 5. Sequence and boundaries of stratigraphic units subcropping beneath the Devonian Ohio Shale. Undifferentiated Salina Group represents all Silurian strata above the C unit, Lockport dolomite includes equivalents of the Lilley and Peebles Formations in outcrop, all other units as marked. Dip of strata in cross section greatly exaggerated.


BASE OHIO
BLACK SHALE
OUTCROP
GREENFIELD AND
TYMOCHTEE FMS.
(SUB-C UNIT)
BASE
SILURIAN
OUTCROP
A
A'
ESTILL
SHALE
BISHER FORMATION
LOCKPORT DOLOMITE
UNDIFFERENTIATED SALINA GROUP
DEVONIAN
COLUMBUS LIMESTONE
AND YOUNGER
SUBCROP BELOW
DEVONIAN
OHIO SHALE
0 MILES 10 20
KMS 0 10 20


A
WEST
DIAGRAMMATIC SECTION
A'
EAST
OHIO SHALE
DEV.
LS.
ESTILL SHALE
BISHER FM.
LOCKPORT DOL.
SALINA GR.
DAYTON LS.
AND OLDER ROCKS
GREENFIELD AND TYMOCHTEE FMS.

PREVIOUS STUDIES

Literature pertaining to the Silurian System of the eastern midcontinent is extensive and largely concerns three main topics: 1) the distribution, geometry and paleontology of reef strata; 2) the lithostratigraphy of Salina evaporites and their facies relationship with Niagaran reefs; and 3), the geology of Lower Silurian sandstone petroleum reservoirs. The discussion below focuses on those studies that are relevant to the southern Ohio area, and is not intended as a comprehensive review. Reserved for later is discussion of papers directed primarily at outcrop and subsurface stratigraphic nomenclature and its historical development.

Important regional studies addressing the lithostratigraphy and paleogeography of Silurian rocks include the work of Ulteig (1964) and Janssens (1977) in northern Ohio; Smosna and Patchen (1978) and Chen (1977) in West Virginia and areas of directly adjacent states; Dennison (1970) in southern West Virginia and Virginia; Freeman (1951) in Kentucky; and Pinsak and Shaver (1964), Shaver (1974) and Becker (1974) in Indiana.

Other broad based studies that consider the Silurian over larger areas of the eastern midcontinent include: the Lower Silurian lithofacies maps of Amsden (1955); the sedimentary facies reconstructions of Berry and Boucot (1970) and Colton (1970); the stratigraphic cross sections and treatment of Silurian reefs by Mesolella (1978); the study of Clinton iron sedimentation by Hunter (1960, 1970);

and the paleogeographic reconstructions of Droste and Shaver (1983).

A few papers directly consider subsurface correlations of Silurian strata within the boundaries of this project's area. The most comprehensive treatment is that of Horvath (1964, and also 1967, 1969), who provided regional cross sections for the complete Silurian section between the adjoining states of Ohio, West Virginia, Kentucky and Indiana. Recently, Currie (1981) and Currie and MacQuown (1984) have presented information on the subsurface stratigraphy and depositional environments of the Silurian-Devonian "Corniferous" sequence in Kentucky. Other subsurface studies of interest include the work of Perry (1960) on Brassfield-Clinton relationships; Patchen and Smosna (1975) on the McKenzie Formation; Osten (1982) on the Albion Group; and Nelson (1983) on the Brassfield-Rochester Shale sequence.

Several unpublished Master's and Doctoral theses that consider Silurian rocks exposed along the east side of the Cincinnati Arch were helpful in linking subsurface stratigraphy to that of the outcrop. These include the works of Holbrook (1964), Kallio (1976), and Busch (1939) on the Silurian section in general; O'Donnell (1967) and Childs (1969) on the Brassfield Formation; Scott (1971) on the Crab Orchard Group; Bowman (1956) and Herring (1987) on the Niagaran formations; and Miller (1955) on the Greenfield and Tymochtee Formations.

STRATIGRAPHIC NOMENCLATURE

Historically, a diverse nomenclature has been applied to both outcrop and subsurface Silurian rocks in Ohio, Kentucky, and West Virginia (Tables 2-6). From this nomenclature three stratigraphic columns are developed to describe rocks in the study area (Table 7); no single set of stratigraphic terms is adequate. Reviewed below are the origin, definition, and application of the terms used here. The discussion is broken into separate outcrop and subsurface sections, because several units recognized in outcrop can not be accurately distinguished in the subsurface, and because origin of the subsurface nomenclature is in part independent of the outcrop.

OUTCROP NOMENCLATURE

The stratigraphic classification of Silurian rocks in North American began with reports of Conrad, Hall and Vanuxem to the New York State Geological Survey during the mid 1800's. The classic exposures of New York (Fisher, 1960) remain as the standard reference sections for correlation in the Appalachian region, because they were well studied and their faunas recognized relatively early. The world Silurian type sections are in Europe, and correlation to North America is paleontologic.

Division of the New York Silurian into three "series of formations" was originally proposed by Clarke and Schuchert (1899, p. 876).

Silurian
- Cayugan Series
- Niagaran Series
- Oswegan Series

The lack of diagnostic fossils within the Oswegan Series, however, made recognition of equivalent strata away from New York difficult. Alternate standard sections and series names were proposed to replace the Oswegan, including the Medinian, Albion, and Alexandrian. All four terms persist in the literature; however their meaning and application have not been constant. This has made interregional correlations difficult and confusing.

Berry and Boucot (1970, p. 14-15) recommend that use of North American Series be discontinued, and that British Series be adopted. However, because of the scarcity of available paleontologic criteria necessary to use British standards, and because of the importance of North American terminology in historical literature, it is inappropriate to disregard completely these series names.

Recently COSUNA (1985a, 1985b) established the Alexandrian, Niagaran, and Cayugan as standard series nomenclature in the northern Appalachian Basin, and their terminology is used in this study (Table 7).

Development of stratigraphic nomenclature for the Silurian outcrop in southern Ohio began during the 1800's with the works of Locke (1838), Orton (1871a, 1871b) and Newberry (1873). The terminology of these reports followed that of the New York State Geological Survey, and recognized in ascending order, the Medina, Clinton, Niagara, Salina, and Waterlime Groups (Newberry, 1873, p. 126-139). Although

Table 2. Development of nomenclature applied to Silurian outcrops in Adams and Highland Counties, Ohio, and Fleming and Bath Counties, Kentucky.

LOCKE (1838)	ORTON (1871)	FOERSTE (1917)	FOERSTE (1923)	FOERSTE (1929)	FOERSTE (1931)	FOERSTE (1935)	ROGERS (1936)	MILLER (1955)	BOWMAN (1956)	REXROAD ET. AL. (1965)	MC DOWELL (1983)
	HELDERBERG LIMESTONE or GREENFIELD STONE							TYMOCHTEE DOLOMITE			
					GREENFIELD DOLOMITE	GREENFIELD DOLOMITE	GREENFIELD DOLOMITE	GREENFIELD DOLOMITE	GREENFIELD DOLOMITE	GREENFIELD DOLOMITE	
	HILLSBORO SS.										
—?——?—	GUELPH LS. or CEDARVILLE LS. or PENTAMERUS LS.	CEDARVILLE DOLOMITE	GUELPH DOLOMITE	PEEBLES DOLOMITE	PEEBLES FORMATION	PEEBLES FORMATION	PEEBLES DOLOMITE	PEEBLES FORMATION	PEEBLES FORMATION	PEEBLES DOLOMITE	
UPPER CLIFF LIMESTONE	WEST UNION FM.: UPPER CLIFF or BLUE CLIFF or SPRINGFIELD	WEST UNION FM.: LILLEY MEMBER	LILLEY FORMATION	LILLEY FORMATION	LILLEY FORMATION	LILLEY FORMATION	LILLEY DOLOMITE	NOT CONSIDERED	LILLEY FORMATION	LILLEY FORMATION	
LOWER CLIFF LIMESTONE	WEST UNION FM.: LOWER CLIFF or WEST UNION CLIFF	WEST UNION FM.: BISHER MEMBER	BISHER FORMATION	BISHER FORMATION	BISHER FORMATION	BISHER FORMATION	BISHER DOLOMITE		BISHER FORMATION	BISHER FORMATION	BISHER DOLOMITE
GREAT MARLE STRATUM	NIAGARA SHALE	CRAB ORCHARD CLAY SHALE	ALGER CLAY SHALE	ALGER CLAY	RIBOLT SHALE / ESTILL CLAY	CRAB ORCHARD GROUP: RIBOLT SHALE / ALGER CLAY SHALE	CRAB ORCHARD SHALE		ALGER FORMATION	CRAB ORCHARD GROUP: ESTILL SHALE	CRAB ORCHARD GROUP: ESTILL SHALE
	DAYTON STONE	DAYTON LIMESTONE	DAYTON LIMESTONE	DAYTON LIMESTONE	DAYTON LIMESTONE	CRAB ORCHARD GROUP: DAYTON LS.	DAYTON LIMESTONE		DAYTON FORMATION	CRAB ORCHARD GROUP: NOLAND FM.: DAYTON LIMESTONE MEMBER	CRAB ORCHARD GROUP: DROWNING CREEK FORMATION: DAYTON DOLOMITE MEMBER
										CRAB ORCHARD GROUP: NOLAND FM.: UNDIFFERENTIATED	CRAB ORCHARD GROUP: DROWNING CREEK FORMATION: UNDIFFERENTIATED
FLINTY LIMESTONE	CLINTON LIMESTONE	BRASSFIELD LIMESTONE	BRASSFIELD LIMESTONE	BRASSFIELD LIMESTONE	BRASSFIELD LIMESTONE	BRASSFIELD LIMESTONE	BRASSFIELD LIMESTONE		BRASSFIELD FORMATION	BRASSFIELD FORMATION	CRAB ORCHARD GROUP: DROWNING CREEK FORMATION: BRASSFIELD MEMBER
	—?——?——?— MEDINA RED SHALE		BELFAST FORMATION	BELFAST BED	BELFAST BED					BELFAST MEMBER	CRAB ORCHARD GROUP: DROWNING CREEK FORMATION: BELFAST BED

Table 3. Development of nomenclature applied to Silurian outcrops in Bath County, Kentucky and farther south.

<table>
<tr><th colspan="3">FOERSTE (1905, 1906,1923)</th><th colspan="2">FOERSTE (1931, 1935)</th><th colspan="3">REXROAD, ET. AL. (1965)</th><th colspan="3">MC DOWELL (1983)</th></tr>
<tr><td colspan="3">BISHER FORMATION</td><td colspan="2">BISHER FORMATION</td><td colspan="3">BISHER FORMATION</td><td colspan="3">BISHER DOLOMITE</td></tr>
<tr><td rowspan="6">CRAB ORCHARD DIVISION</td><td rowspan="4">ALGER FORMATION</td><td rowspan="2">ESTILL CLAY</td><td rowspan="6">CRAB ORCHARD GROUP</td><td>RIBOLT CLAY SHALE</td><td rowspan="6">CRAB ORCHARD GROUP</td><td colspan="2" rowspan="2">ESTILL SHALE FORMATION</td><td rowspan="8">CRAB ORCHARD GROUP</td><td rowspan="4">ALGER SHALE</td><td rowspan="2">ESTILL SHALE MEMBER</td></tr>
<tr><td>ESTILL CLAY</td></tr>
<tr><td>WACO LIMESTONE</td><td>WACO LIMESTONE</td><td rowspan="4">NOLAND FORMATION</td><td>WACO MEMBER</td><td>WACO MEMBER</td></tr>
<tr><td>LULBEGRUD CLAY</td><td>LULBEGRUD CLAY</td><td>LULBEGRUD SHALE MB.</td><td>LULBEGRUD SHALE MB.</td></tr>
<tr><td rowspan="2">INDIAN FIELDS FM.</td><td>OLDHAM LIMESTONE</td><td>OLDHAM LIMESTONE</td><td>OLDHAM LIMESTONE MEMBER</td><td rowspan="4">DROWNING CREEK FORMATION</td><td>OLDHAM MEMBER</td></tr>
<tr><td>PLUM CREEK CLAY</td><td>PLUM CREEK CLAY</td><td>PLUM CREEK CLAY MB.</td><td>PLUM CREEK SHALE MB.</td></tr>
<tr><td colspan="3" rowspan="2">BRASSFIELD LIMESTONE</td><td colspan="2">BRASSFIELD LIMESTONE</td><td colspan="3">BRASSFIELD FORMATION</td><td rowspan="2">BRASSFIELD MEMBER</td></tr>
<tr><td colspan="2">BELFAST BED</td><td colspan="2"></td><td>BELFAST MB.</td></tr>
</table>

subsequently modified, the most widely recognized group names in Ohio stem from this New York nomenclature. These are, in ascending order, the Medina, Clinton, Lockport, and Salina (including Bass Islands) Groups, as used herein (Table 7).

The various group subdivisions serve principally as a convenience in discussion and mapping, and no time connotation should be applied to these names away from the type areas (Fisher, 1960). Unfortunately, the meaning and application of Silurian group nomenclature has not been constant, and confusion exists concerning the stratigraphic position of the group boundaries. In this study the assignment of group boundaries follows conventional practice where possible; however, in areas of disagreement the regional applicability of the boundary and convenience for mapping purposes were also given consideration.

Formation and member terminology in the southern Ohio area was most strongly influenced by the studies of A.F. Foerste, from 1896-1935. Foerste's summary paper (1935), concerning Silurian nomenclature in states bordering the Cincinnati Arch, provides the foundation on which our present classification of these rocks is based. Changes in outcrop nomenclature since 1838 are presented in Tables 2 and 3.

In this study a single stratigraphic column is used to describe outcrop units in southern Ohio and northeastern Kentucky (Table 7); the nomenclature following close to that of Rexroad et al. (1965) and McDowell (1983). The following formations, in ascending order, are recognized:

Brassfield Formation and Plum Creek Shale, comprising the Medina Group; Oldham Limestone, Lulbegrud Shale, Dayton Limestone, Estill Shale, and Bisher Formation, comprising the Clinton Group; Lilley Formation and Peebles Formation, comprising the Lockport Group; and the Greenfield Formation and Tymochtee Formation, which comprise the Salina Group. The designations Crab Orchard Group and Drowning Creek Formation of McDowell (1983) and Rexroad et al. (1965) are not used in this study; instead the Estill Shale and older stratigraphic units are considered of formation rank and placed within the regionally accepted Medina and Clinton Groups. A brief review of original literature citations for the outcrop stratigraphy is given below.

Foerste (1906, p. 10, 27) named the Brassfield Limestone from exposures in Madison County, Kentucky, and later (1909) extended the name to equivalent strata in Ohio. Rexroad et al. (1965, p. 12) elevated the Brassfield to formation status, and included the Belfast "bed" described originally by Foerste (1896, p. 163-164) as a basal member of the Brassfield.

Orton (1871b, p. 271) named strata near Dayton, Ohio, the Dayton "stone"; later to be termed the Dayton Limestone by Foerste (1917, p. 187). In Ohio, the Dayton locally rests unconformably on Brassfield strata, as first suggested by Foerste (1906, p. 52). In Kentucky counties (Table 3), the Brassfield is overlain by the Plum Creek Shale, Oldham Limestone, Lulbegrud Shale, and Waco Limestone (Dayton equivalent), in ascending order; as first described and identified by Foerste (1906, p. 44-52).

The term Estill was first applied as a clay member of the Alger Formation (Foerste, 1906, p. 59) and described from exposures of shale in Estill County, Kentucky. Renamed the Estill Shale, Rexroad et al. (1965, p. 12) raised the unit to formation status, because of its thickness, distinct lithology, and clearly defined boundaries.

Foerste (1917, p. 189-190) named and described the Bisher and Lilley dolomites from exposures near Hillsboro, Highland County, Ohio, and later (1923, p. 24) raised them to formation status. The Peebles dolomite was first termed by Foerste (1929, p. 168-169) as a replacement for the Ontario term, Guelph, and later received formation status (Foerste, 1931, p. 191).

The Greenfield "stone" was first described by Orton (1871b, p. 287-294) from exposures near Greenfield, Highland County, Ohio. In 1873, Winchell (p. 633) applied the term Tymochtee "slate" to a section of rock exposed in Wyandot County, Ohio. Both units have been considered of formational status in southern Ohio outcrop (Miller, 1955; Horvath, 1964). Of note was the inclusion of the Greenfield and Tymochtee in the Monroe "division"; a term proposed by Lane (1893, in Wadsworth, 1893. p. 66) to include rocks ranging in age from Cayugan to Middle Devonian. The Monroe was later rejected because of its lack of standard stratigraphic significance, however, it persists on the Geologic Map of Ohio (Bownocker, 1981). The Greenfield and

Tymochtee were later included in the Bass Islands Group (Lower Monroe) of Lane et al. (1908, p. 554), and are now considered separate from the Bass Islands and within the Salina Group (Ehlers et al., 1951, p. 10; Ulteig, 1964, p. 31-34).

SUBSURFACE NOMENCLATURE

A wide range of names is used to describe equivalent Silurian formations in the subsurface of Ohio, Kentucky, and West Virginia (Tables 4 and 5). This nomenclature is a combination of drillers' terminology (Table 6) and formal lithostratigraphic names derived from nearest-neighbor outcrops; variations resulting from proximity to New York, Valley and Ridge, and midcontinent outcrop, and also to the well studied Michigan Basin subsurface. Ohio has an especially diverse set of terms for subsurface Silurian nomenclature.

In this study two stratigraphic columns are used to describe the subsurface (Table 7); the first covering southern Ohio and northeastern Kentucky counties, and the second, western West Virginia counties. The stratigraphy used in the former closely follows that proposed by Horvath (1964), whereas that of the latter is partly similar to that of Patchen and Smosna (1975, p. 2268, Fig. 2) and Smosna and Patchen (1978, p. 2309; 1980, Fig. 2). The following is a brief review of the subsurface stratigraphy.

The Brassfield Formation can be traced from outcrop into the subsurface, where it is recognized and correlated

Table 4. Correlation and review of stratigraphic terms applied to the Medina and Clinton Groups in subsurface portions of Ohio, West Virginia, and Kentucky.

	OHIO					W. VA.	KENTUCKY	
	NORTHWEST		EASTERN	EASTERN	SOUTHERN	WESTERN	SOUTHEAST	NORTHWEST
CLINTON GROUP	NOT REPRESENTED				BISHER FM. / KEEFER SS.	KEEFER SANDSTONE	BIG SIX SANDSTONE	BISHER LIMESTONE
CLINTON GROUP	ROCHESTER FORMATION		ALGER FORMATION	ROCHESTER SHALE	ROSE HILL SHALE	ROSE HILL FORMATION	ROSE HILL SHALE	ESTILL SHALE
CLINTON GROUP	DAYTON FM.	UPPER MEMBER	DAYTON LS. / REYNALES LS.	DAYTON FORMATION	DAYTON LIMESTONE			
CLINTON GROUP	DAYTON FM.	UNNAMED SHALE	NEAHGA SHALE	UNNAMED SHALE	LULBEGRUD SHALE			
CLINTON GROUP	DAYTON FM.	LOWER MEMBER	BRASSFIELD LIMESTONE	UNNAMED DOLOMITE	OLDHAM LIMESTONE			OLDHAM LIMESTONE
MEDINA GROUP	CABOT HEAD FORMATION		THOROLD SANDSTONE	THOROLD SANDSTONE	UPPER CABOT HEAD SHALE	TUSCARORA SANDSTONE	"CLINTON" SANDSTONE	PLUM CREEK SHALE
MEDINA GROUP			GRIMSBY SANDSTONE	GRIMSBY SANDSTONE	"CLINTON" SANDSTONE			
MEDINA GROUP			CABOT HEAD SANDSTONE	CABOT HEAD SANDSTONE	LOWER CABOT HEAD SHALE			
MEDINA GROUP	BRASSFIELD FORMATION		WHIRLPOOL SANDSTONE	MANITOULIN DOL / WHIRLPOOL SS.	BRASSFIELD FORMATION		BRASSFIELD DOLOMITE	BRASSFIELD DOLOMITE
	ORDOVICIAN		QUEENSTON	QUEENSTON	JUNIATA	JUNIATA	JUNIATA	DRAKES
	JANSSENS (1977)		SANTINI AND COOGAN(1983)	OHIO GEOLOGICAL SURVEY	HORVATH (1964)	SMOSNA AND PATCHEN (1978)	WILSON AND SUTTON (1976)	

Table 5. Correlation and review of stratigraphic terms applied to the Lockport and Salina Groups in subsurface portions of Ohio, West Virginia, and Kentucky.

OHIO										W. VA.		KENTUCKY
NORTHWEST		NORTHEAST		EASTERN		EASTERN		SOUTHERN		WESTERN		SOUTHEAST
	BASS ISLANDS DOLOMITE	BASS I. GR.	UNDIFFER-ENTIATED IN SUBSURFACE	BASS I. GR.	RAISIN RIVER DOLOMITE	SALINA GROUP	BASS ISLANDS DOLOMITE	BASS I. GR.	BASS ISLANDS DOLOMITE		NOT CONSIDERED	BASS ISLANDS FORMATION
					PUT-IN-BAY DOLOMITE							
SALINA GROUP	G UNIT	SALINA GROUP	G UNIT	SALINA GROUP	TYMOCHTEE FORMATION		G UNIT	SALINA GROUP	TYMOCHTEE FORMATION		SALINA FORMATION	SALINA FORMATION
	F UNIT		F UNIT				F UNIT					
	E UNIT		E UNIT				E UNIT					
	D UNIT		D UNIT				D UNIT					
	C UNIT		C UNIT				C UNIT				WILLIAMSPORT SANDSTONE	
	B UNIT		B UNIT				B UNIT			MCKENZIE FORMATION	UPPER MCKENZIE MEMBER	
	A UNIT: A_2 CARB.		GREENFIELD (EQUIVALENT TO A_1 AND A_2 CARBONATES)		GREENFIELD FORMATION		TYMOCHTEE		GREENFIELD FORMATION			LOCKPORT DOLOMITE
	A UNIT: A_2 ANHY.											
	A UNIT: A_1 CARB.						GREENFIELD					
	A UNIT: A_1 ANHY.											
LOCKPORT GR.	GUELPH DOLOMITE	LOCKPORT GR.	LOCKPORT UNDIFFER-ENTIATED IN SUBSURFACE	LOCKPORT GR.	GUELPH	LOCKPORT GR.	LOCKPORT UNDIFFER-ENTIATED IN SUBSURFACE	LOCKPORT GR.	LOCKPORT UNDIFFER-ENTIATED IN SUBSURFACE		LOCKPORT MEMBER	
	GOAT ISLAND DOLOMITE				CEDARVILLE							
	GASPORT DOLOMITE				SPRINGFIELD							
					EUPHEMIA							
JANSSENS (1977)		ULTEIG (1964)		SANTINI AND COOGAN (1983)		OHIO GEOLOGICAL SURVEY		HORVATH (1964)		PATCHEN AND SMOSNA(1975)		WILSON AND SUTTON (1976)

Table 6. Comparison of drillers' terminology and formal rock-stratigraphic nomenclature.

<table>
<tr><th colspan="3">STRATIGRAPHIC TERMS</th><th colspan="3">DRILLERS' TERMS</th></tr>
<tr><td colspan="3">OHIO (BLACK) SHALE</td><td colspan="3"></td></tr>
<tr><td colspan="3">DEVONIAN CARBONATES</td><td></td><td rowspan="11">BIG LIME (OHIO)</td><td rowspan="11">CORNIFEROUS (KENTUCKY)</td></tr>
<tr><td rowspan="8">SALINA GROUP</td><td colspan="2">BASS ISLANDS</td><td></td></tr>
<tr><td colspan="2">G UNIT</td><td></td></tr>
<tr><td colspan="2">F UNIT</td><td></td></tr>
<tr><td colspan="2">E UNIT</td><td></td></tr>
<tr><td colspan="2">D UNIT</td><td></td></tr>
<tr><td>C UNIT</td><td>WILLIAMSPORT SS.</td><td>NEWBURG SAND</td></tr>
<tr><td colspan="2">B UNIT</td><td></td></tr>
<tr><td colspan="2">A UNIT</td><td></td></tr>
<tr><td colspan="3">LOCKPORT GROUP (UNDIFFERENTIATED)</td><td>NEWBURG OR SECOND WATER</td></tr>
<tr><td colspan="3">KEEFER SANDSTONE</td><td>BIG SIX SAND</td></tr>
<tr><td colspan="3">ESTILL SHALE</td><td colspan="3">NIAGARAN SHALE</td></tr>
<tr><td colspan="3">DAYTON LIMESTONE</td><td colspan="3">CASING SHELL</td></tr>
<tr><td colspan="3">LULBEGRUD SHALE</td><td colspan="3">—</td></tr>
<tr><td colspan="3">OLDHAM LIMESTONE</td><td colspan="3">PACKER SHELL</td></tr>
<tr><td colspan="3">UPPER CABOT HEAD SHALE</td><td colspan="3">—</td></tr>
<tr><td colspan="3">THOROLD SANDSTONE</td><td colspan="3">STRAY CLINTON</td></tr>
<tr><td colspan="3">GRIMSBY SANDSTONE</td><td colspan="3">RED CLINTON</td></tr>
<tr><td colspan="3">CABOT HEAD SANDSTONE</td><td colspan="3">WHITE CLINTON</td></tr>
<tr><td colspan="3">LOWER CABOT HEAD SHALE</td><td colspan="3">CABOT HEAD</td></tr>
<tr><td colspan="3">WHIRLPOOL SANDSTONE</td><td colspan="3">MEDINA OR ALBION SAND</td></tr>
<tr><td colspan="3">QUEENSTON SHALE</td><td colspan="3">RED MEDINA</td></tr>
</table>

Table 7. Stratigraphic correlation and nomenclature used in this paper.

System	Series	Group	OUTCROP: SOUTHERN OHIO NORTHEASTERN KENTUCKY	SUBSURFACE: SOUTHERN OHIO NORTHEASTERN KENTUCKY	SUBSURFACE: WESTERN WEST VIRGINIA
SILURIAN	CAYUGAN	SALINA	DEVONIAN OHIO SH.	UNDIFFERENTIATED SALINA	SALINA D UNIT AND YOUNGER
SILURIAN	CAYUGAN	SALINA	DEVONIAN OHIO SH.	C UNIT	C UNIT / NEWBURG SS.
SILURIAN	CAYUGAN	SALINA	TYMOCHTEE FM.	TYMOCHTEE FM.	TYMOCHTEE EQUIVALENT
SILURIAN	CAYUGAN	SALINA	GREENFIELD FM.	GREENFIELD FM. ?	LOCKPORT DOLOMITE
SILURIAN	NIAGARAN	LOCK.	PEEBLES FM.	LOCKPORT GRP. (LILLEY & PEEBLES RECOGN. LOCALLY)	LOCKPORT DOLOMITE
SILURIAN	NIAGARAN	LOCK.	LILLEY FM.	LOCKPORT GRP. (LILLEY & PEEBLES RECOGN. LOCALLY)	LOCKPORT DOLOMITE
SILURIAN	NIAGARAN	CLINTON	BISHER FM.	BISHER FM.	KEEFER SS.
SILURIAN	NIAGARAN	CLINTON	ESTILL SH.	ESTILL SH. ?	ROSE HILL SH.
SILURIAN	NIAGARAN	CLINTON	DAYTON LS.	DAYTON LS. ?	
SILURIAN	NIAGARAN	CLINTON	LULBEGRUD SH.	LULBEGRUD SH.	CACAPON SS. / ROSE HILL SH.
SILURIAN	NIAGARAN	CLINTON	OLDHAM LS.	OLDHAM LS.	OLDHAM LS.
SILURIAN	ALEXANDRIAN	MEDINA	PLUM CREEK SHALE	CABOT HEAD SHALE: UPPER	U. CABOT HD. SH.
SILURIAN	ALEXANDRIAN	MEDINA	PLUM CREEK SHALE	CABOT HEAD SHALE: CLINTON SS.	TUSCARORA SS.
SILURIAN	ALEXANDRIAN	MEDINA	PLUM CREEK SHALE	CABOT HEAD SHALE: LOWER	L. CABOT HD. SH.
SILURIAN	ALEXANDRIAN	MEDINA	BRASSFIELD FM.	BRASSFIELD FM	BRASSFIELD FM.
SILURIAN	ALEXANDRIAN	MEDINA	BELFAST MB.	WHIRLPOOL SS.	
			DRAKES FM.	QUEENSTON SH.	QUEENSTON SH.

at the base of the Silurian System throughout the study area. This correlation is substantially different from a widely accepted correlation of the Brassfield with the drillers' "Packer shell", which is identified above the Clinton sandstone (Knight, 1969, p. 1462; Santini and Coogan, 1983, p. 182; Nelson and Coogan, 1984, p. 4; COSUNA, 1985a, Column 8). Positioning the Brassfield at the base of the Silurian is a key contribution of this paper.

Locally in Athens County, Ohio, a thin sandstone persists at the base of the Brassfield and is known to drillers as the "Medina" or "Albion". This sandstone is stratigraphically continuous with the Whirlpool Sandstone (Paska, 1981, p. 19-20), which is the basal Silurian formation recognized in northern and eastern Ohio (Ohio Geological Survey, unpubl.; Santini and Coogan, 1983, p. 182; Knight, 1969, p. 1426; Keltch et al., 1987, p. 68).

Cabot Head Shale is the accepted subsurface term for shales directly overlying the Whirlpool Sandstone, and also extending below and above the Clinton sandstone. Horvath (1964, p. 22) traced the Cabot Head from southern Ohio nearly to the type area in Ontario, Canada, thus assuring its stratigraphic position. The Plum Creek Shale of Kentucky outcrop is in the equivalent stratigraphic position, however, Cabot Head Shale is the preferred subsurface term because of its regional applicability. Where the Clinton sandstone is present, the Cabot Head is informally divided into an upper and lower tongue (Table 7).

Drillers designate Lower Silurian oil and gas producing sandstones in eastern Ohio as the Clinton. This has caused some confusion, because these sandstones are not time-equivalent to the Clinton Group of New York. The Clinton sandstone of Ohio is instead laterally coextensive with the Tuscarora Sandstone of West Virginia and Pennsylvania, and is positioned within the Medina Group. The term as applied in Ohio lacks priority and is strictly a drillers' subsurface unit of informal designation. However, because the name Clinton sandstone is now so deeply entrenched in the literature it should continue to be used as a subsurface term, albeit informal, to designate sandstones in Ohio which are equivalent to the Tuscarora.

Drillers further subdivide the Clinton sandstone into three units; the "Stray" Clinton, "1st" or "Red" Clinton, and "2nd" or "White" Clinton (Table 6). These divisions are not clearly identified in most of southern Ohio because the Clinton is relatively thin in this area, however, they are recognized locally in Vinton, Athens, and Hocking Counties.

A pair of thin, persistent carbonate units overlie the Clinton sandstone in Ohio subsurface, separated from each other by a thin shale, and from the Clinton sandstone by the upper Cabot Head Shale. Both carbonates are traceable into outcrop where the upper correlates with the Dayton Limestone, and the lower with the Oldham Limestone; as first suggested by Horvath (1964, p. 33) and later by Janssens (1968, p. 2; 1977, p. 4). Drillers typically call the upper carbonate the "Casing shell", and the lower the "Packer shell" (Table 6). They are also reported on scout tickets as the "1st" or "Little shell" and the "2nd" or "Big shell", respectively, or collectively as the "Packer shell". As noted previously, the "Packer shell" is considered by some workers as the subsurface equivalent of the Brassfield Formation.

The Oldham Limestone is traced eastward into western West Virginia counties where it is clearly identified; the Dayton Limestone pinching-out near the Ohio-West Virginia border. Occupying a stratigraphic position slightly below the level of the Dayton in western West Virginia is a thin siltstone which is tentatively correlated with the formal Cacapon Sandstone identified elsewhere in West Virginia (COSUNA, 1985a, cols. 1-3, 9).

Shales separating the Dayton and Oldham Limestones in the Ohio subsurface have been called the Neahga (Santini and Coogan, 1983, p. 182; Keltch et al., 1987, p. 68); named after shale beds between the Thorold Sandstone and Reynales Limestone at the Niagara Gorge in New York. Direct correlation of the Neahga from New York to Ohio remains to be established, however, and it is possible that application of the term in Ohio is inappropriate. The Lulbegrud Shale, which separates Dayton and Oldham carbonates in northeastern Kentucky outcrops and can be traced with certainty into the subsurface, is considered a more appropriate term and is used in this study. The Lulbegrud is not recognized as a formal unit in the subsurface beyond the depositional limit of the Dayton Limestone.

The name Rochester Shale is widely used in the Ohio subsurface to formalize the drillers' "Niagaran shale" (COSUNA, 1985b, cols. 16, 17; Janssens, 1977, p. 2; Nelson and Coogan, 1984, p. 4), which separates the thick Lockport and Cayugan carbonate sequence above from the Dayton Limestone below (Tables 4, 6). The Rochester is therefore defined in the subsurface like the Estill Shale in southern Ohio outcrop. Correlation of the two units is not completely assured, however. This is because the Rochester Shale in New York outcrop lies above the Irondequoit Limestone (Fisher, 1960), and in West Virginia outcrop and subsurface above the Keefer Sandstone (Woodward, 1941, p. 107); both units considered younger than the Estill Shale. Until these stratigraphic relationships are made clear it is preferable to extend the term Estill Shale from southern Ohio outcrop into the nearby subsurface.

Beyond the depositional limit of the Dayton Limestone in western West Virginia, shales correlative with the Estill are positioned within the Rose Hill Formation, which includes all strata between the top of the Oldham Limestone and the base of the Keefer Sandstone (COSUNA, 1985a, col. 1, 8). Formally recognized within the Rose Hill Formation is the Cacapon Sandstone.

Overlying the Rose Hill Formation in West Virginia is the Keefer Sandstone, which has been clearly identified and traced eastward to surface exposures (Smosna and Patchen, 1978, p. 2316; Smosna, 1983; Folk, 1960; COSUNA, 1985a). To the west and southwest the Keefer grades into the Bisher Formation, which is also traceable into outcrop, thus assuring its subsurface stratigraphic application. Drillers in eastern Kentucky and Wayne County, West Virginia, identify a gas producing interval of sandstone and sandy dolomite as the "Big Six sand", which loosely correlates with the Keefer-Bisher (Table 6). Patchen and Smosna (1975, p. 2278) convincingly illustrate, however, that "Big Six" gas production is from both the Keefer Sandstone and overlying beds of the Lockport Dolomite (McKenzie Formation); therefore, the "Big Six" does not have a strict stratigraphic meaning.

Rocks of the overlying Lockport Group can only be differentiated locally into the Lilley and Peebles Formations in Ohio subsurface, and throughout a large portion of the southern Ohio area, they remain without formal division. Correlation with the Gasport, Goat Island, and Guelph Formations identified in northern Ohio, and the Euphemia, Springfield, Cedarville, and Guelph Formations in west central Ohio is unclear (Table 5). In western West Virginia counties, rocks of the Lockport Group are included within the Lockport Dolomite, following the terminology of Smosna and Patchen (1980, Fig. 2), but farther to the east in West Virginia, they are recognized in the Mckenzie Formation (Patchen and Smosna, 1975). The relationship between the Lockport of Ohio and West Virginia is a primary consideration of this paper.

Drillers in Ohio include Lockport rocks within the "Big

Lime" (Table 6), which incorporates all Silurian and Devonian carbonates and evaporites that overlie the Estill Shale and underlie the Devonian Ohio Shale (Owens, 1970). In Kentucky, the term "Corniferous" carries a similar definition (Miles, 1972). The interval most widely reported by Ohio drillers in the Silurian Lockport portion of the "Big Lime" is the "Newburg sand". The "Newburg", also reported as the "Big Water" or "Second Water", was originally used in Ohio to designate a porous zone below the Lockport-Salina contact, and now designates any interval in the Lockport Group composed of porous, brown, crystalline dolomite with the drilling characteristics of sandstone (Ulteig, 1964, p. 16). In this use, the "Newburg" has no stratigraphic significance. The "Big Lime" of Ohio should not be confused with the Mississippian "Big Lime" of West Virginia (Greenbrier) or Kentucky (Newman).

In southern Ohio, the lack of diagnostic evaporite beds in the Salina Group limits application of the conventional lettered unit stratigraphy used by drillers in the Michigan Basin and elsewhere (Table 5), and here the group is simply divided into the Greenfield and Tymochtee Formations. Shales characteristic of the C unit are, however, clearly identified within the Tymochtee, and provide a regionally useful lithologic and nuclear log marker.

Eastward into West Virginia, Greenfield strata gradually become indistinguishable from underlying rocks of the Lockport Group, and the two units merge to form the

Lockport Dolomite. Sub-C unit Tymochtee rocks remain distinct in West Virginia; however, formal use of the term Tymochtee is restricted to areas where the Greenfield can be recognized. Shales of the C unit are traced into West Virginia, where they locally contain sandstone beds correlative with the Newburg sandstone (Patchen and Smosna, 1975, p. 2268; Smosna and Patchen, 1980, p. 2; COSUNA, 1985a, cols. 1, 2, 8). Here the term Newburg is an informal drillers' name for a sandstone tongue of the Wills Creek Formation, also known as the "Williamsport" sandstone (COSUNA, 1985a; Patchen, 1988, pers. comm.).

Super-C unit Salina strata are not considered in detail in this study.

LITHOSTRATIGRAPHY

This study is principally concerned with rock-stratigraphic units recognizable in the subsurface. Age designations applied to the units are based solely on correlation to strata which occupy equivalent stratigraphic positions in outcrop. Therefore, units illustrated on maps and cross sections are rock-stratigraphic rather than time-stratigraphic.

Each of the stratigraphic units recognized in the subsurface between the top of the Ordovician Queenston Shale and the Silurian C unit is discussed individually in the text. The units are presented in ascending stratigraphic order, and further assembled under the larger headings of the Medina, Clinton, Lockport, and Salina Groups. Discussion of each unit begins with statements regarding formational contacts and areal limits, and is followed by treatment of the unit's thickness, lithology, and regional stratigraphic relations.

A summary of the lithology, thickness, and clarity of contacts in well samples and on nuclear logs for each stratigraphic unit is presented in Table 8, and four reference nuclear logs show positions of stratigraphic boundaries and characteristic log signatures in Figure 6.

Table 8. Summary of Silurian stratigraphy of the southern Ohio area.

SYS	GRP	FORMATION NAME	AVG THK FT	GENERAL LITHOLOGIC DESCRIPTION	CONTACTS WITH BOUNDING UNITS: LOGS	CONTACTS WITH BOUNDING UNITS: CUTTINGS
SILURIAN	SALINA	C unit	10	Shale, dolomitic, green and gray, silty, anhydritic.	distinct	indistinct
SILURIAN	SALINA	Tymochtee Formation	60	Dolomite, gray, lithographic to microcrystalline, argillaceous to shaly, laminated, trace silty, anhydritic.	indistinct	indistinct
SILURIAN	SALINA	Greenfield Formation	45	Dolomite, brown gray, brown, finely to microcrystalline, trace silty, more crystalline than above.	distinct	distinct
SILURIAN	LOCKPORT	Peebles Formation	95	Dolomite, yellow gray, light gray, pure, finely to medium crystalline, sucrosic in part, homogeneous, porous to dense.	gradational	distinct
SILURIAN	LOCKPORT	Lilley Formation	40	Dolomite, gray, mottled tan and white, argillaceous to shaly, some crystalline, fossiliferous, trace silty.	indistinct	indistinct
SILURIAN	CLINTON	Bisher Formation	50	Silty dolomite and dolomitic siltstone, gray and tan, calcareous, shaly in part, slightly fossiliferous.	distinct	distinct
SILURIAN	CLINTON	Estill Shale	150	Shale, medium gray to greenish-gray, reddish-gray toward base, dolomitic, moderately soft, trace micaceous.	distinct	indistinct
SILURIAN	CLINTON	Dayton Limestone	7	Limestone and dolomite, white, mottled gray and tan, medium crystalline, sparry, glauconitic, trace silty.	distinct	indistinct
SILURIAN	CLINTON	Lulbegrud Shale	40	Shale, medium gray and greenish-gray, soft to moderately soft, dolomitic.	distinct	distinct
SILURIAN	CLINTON	Oldham Limestone	25	Limestone and dolomite, medium gray, mottled tan, finely crystalline, argillaceous in part, ferruginous and silty.	distinct	indistinct
SILURIAN	MEDINA	Upper Cabot Head Shale	10	Shale, greenish-gray, moderately soft, dolomitic.	distinct	distinct
SILURIAN	MEDINA	Clinton sandstone	15	Siltstone and sandstone, fine grained, white, tan, light gray, well sorted, calcareous and ferruginous in part.	distinct	indistinct
SILURIAN	MEDINA	Lower Cabot Head Shale	45	Shale, greenish gray, reddish gray, moderately hard, carbonate and siltstone stringers, few ferruginous beds.	gradational	distinct
SILURIAN	MEDINA	Brassfield Formation	45	Limestone and dolomite, white and tan, medium to coarsely crystalline, fossiliferous, cherty, silty, glauconitic.	gradational	distinct
ORD	RCH	Queenston Formation	-	Shale, reddish gray, calcareous, in part silty, and siltstone, gray, brown, calcareous, pyritic, micaceous.		

Figure 6 (map pocket). Reference nuclear logs showing geophysical identification of Brassfield Formation through C unit strata.

ORDOVICIAN-SILURIAN BOUNDARY

The Ordovician-Silurian Systemic boundary is the contact of the basal Silurian Brassfield Formation with the underlying Queenston Shale in the subsurface, and the Drakes or Whitewater Formation in outcrop. This contact is generally considered unconformable.

The Ordovician-Silurian contact is distinct to indistinct on nuclear logs (Fig. 9a; compare wells 5 and 471), and is identified most readily where lower beds of the Brassfield are dominantly carbonate or where the Whirlpool Sandstone is present and a sharp increase in gamma-radiation marks the Queenston shales (ex. Fig. 9c, well 30078; Fig. 9a, well 3008). In areas where the lower Brassfield is more argillaceous, gamma radiation intensity increases gradually through a 5-10 foot interval and placement of the boundary is less precise.

In well samples the contact is drawn at the transition from red and grayish red, silty, calcareous and micaceous shales of the Queenston, to the gray and green-gray dolomitic shales and fossil fragmental carbonates of the overlying Brassfield Formation. Along the outcrop and in nearby counties the red shales of the Queenston are replaced by greenish gray calcareous shales and argillaceous limestones of the Drakes Formation (Plate 1a, b) in association with a gradual westward loss of red coloration and introduction of marine fauna in the Queenston and equivalents (Dennison and Head, 1975, p. 1095). Where gray colored shales and carbonates extend across the boundary, a sharp change from dolomitic (Silurian) to calcareous (Ordovician) shale typically coincides with the systemic contact. Locally in eastern areas, where the "red boundary" is laterally extensive, a few atypical wells also show gray calcareous shales at the top of the Ordovician, with red coloration appearing 20-100 feet below; possibly this is the result of different diagenetic effects linked to lithofacies changes in the uppermost Queenston (Thompson, 1970, p. 1258).

Structural configuration on top of the Ordovician shows a very uniform regional strike of N 15 E and a regional dip gradually increasing eastward from approximately 50 feet per mile near the outcrop to 70 feet per mile along the eastern margin of the study area (Fig. 7). The structural dip is in large part a result of late Paleozoic tectonism and does not accurately reflect depositional dip of the Silurian basin. At the mapped horizon, vertical displacement of faults along the Kentucky River Fault System in Elliott, Carter, and Boyd Counties, Kentucky range from approximately 100 to 300 feet. In Vinton and Athens Counties, Ohio a few normal faults of minor vertical displacement (20 to 30 feet) can be defined in areas of dense well control, and may extend laterally a greater distance. Elevation of the Ordovician-Silurian boundary ranges from 1,000 or more feet above mean sea level in outcrop of Fayette County, Ohio to depths in excess of -4,800 feet in Lincoln County, West Virginia.

Structure on top of the Ordovician was mapped in West

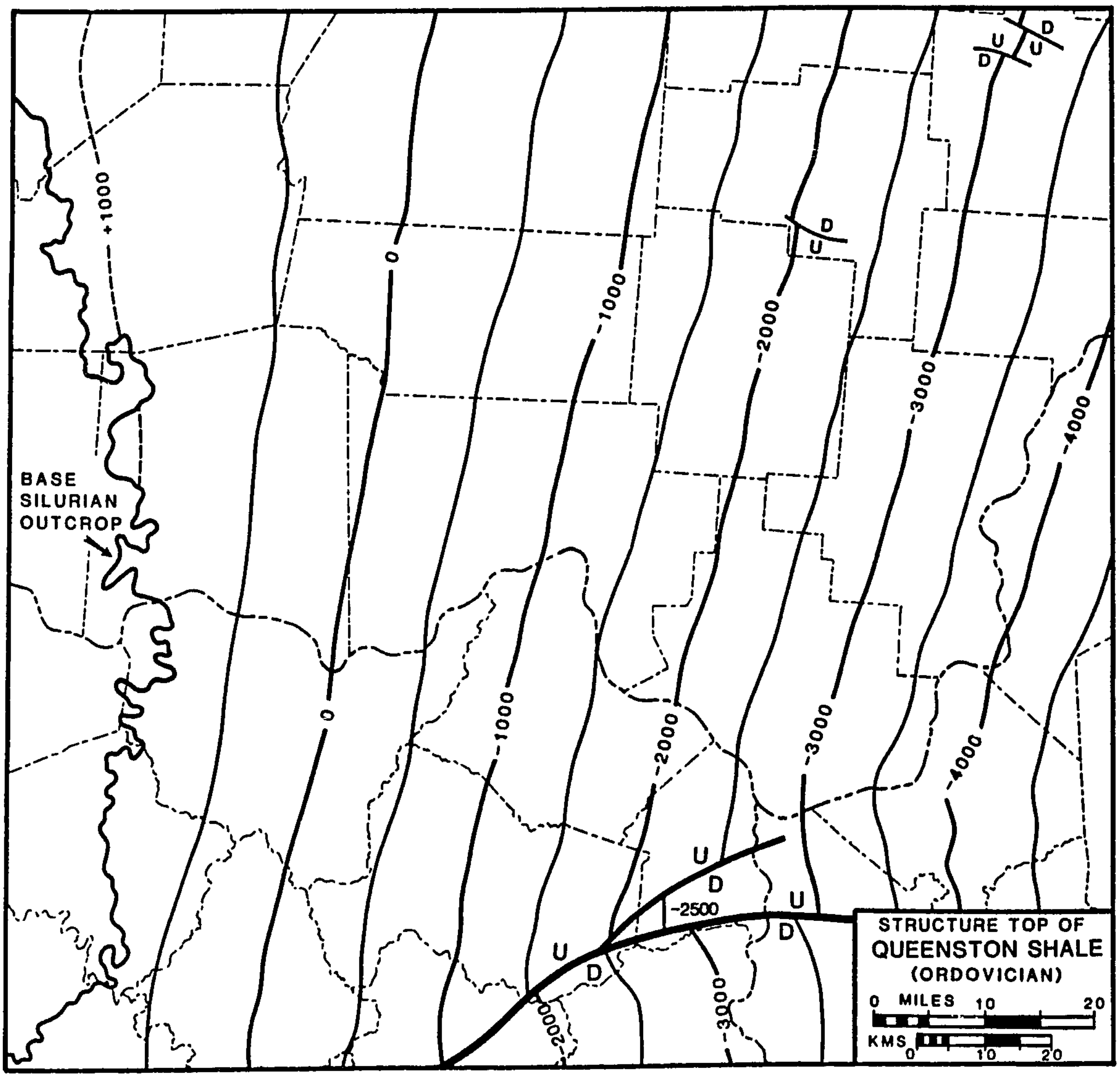


Figure 7. Structure contour map on top of the Queenston Shale (Ordovician) with a fairly uniform regional dip of approximately 60 feet per mile at E 15° S shows the Kentucky River Fault in Lawrence, Boyd, and Elliott Counties, Kentucky, and small normal faults in Vinton and Athens County, Ohio. Contour interval 500 feet.

Virginia by Cardwell (1977), who placed the Ordovician-Silurian boundary at the base of the Tuscarora Sandstone. In western West Virginia counties, however, rocks of the Brassfield Formation and lower Cabot Head Shale can be traced between the Tuscarora and the Queenston (Figs. 9c, 10c, e), which places the systemic boundary 80-100 feet below the Tuscarora in this area rather than at the base of the massive sandstone. In this regard, the structure elevations of the Ordovician top in Figure 7 do not match those of Cardwell (1977, Plate 1). Farther to the east, where the Brassfield and lower Cabot Head pinch-out and the Tuscarora rests directly on the Queenston (Juniata), the systemic boundary employed by Cardwell (1977) is accurate.

Evidence indicating a pre-Silurian unconformity in the eastern midcontinent is clear (Ham and Wilson, 1967; Dennison and Head, 1975; Laferriere et al., 1986; Kaufmann, 1964; Rexroad et al., 1965; Rexroad, 1967; O'Donnell, 1967). Palynologic (Gray and Boucot, 1972) and lithologic evidence (Wier and Peck, 1968) from the east flank of the Cincinnati Arch suggest an upward shallowing of water depth in latest Ordovician, followed by a deepening of water in earliest Silurian above the unconformity, with possible emergence of the present Cincinnati Arch area. Conodont evidence (Liebe and Rexroad, 1977, p. 849) further substantiates the presence of a pre-Silurian depositional hiatus resulting in the stratigraphically modest unconformity (paraconformity) at the Ordovician-Silurian systemic boundary.

Dennison and Head (1975, p. 1096) and Dennison (1976,

p. 115) suggest that the pre-Silurian unconformity is confined primarily to the margins of the Appalachian Basin, and that deposition was continuous across the systemic boundary in axial portions of the basin. It is unclear how this applies to the Queenston-Brassfield contact in easternmost Ohio and western West Virginia. The sharp lithologic break witnessed in many well samples along with the presumably unconformable onlap of Whirlpool sandstones over Queenston shales in Athens and Hocking Counties, Ohio suggests the boundary is unconformable throughout the study area, although confirmatory paleontologic evidence is as yet unavailable.

MEDINA GROUP

In the study area the Medina Group consists of all Silurian strata beneath the Oldham Limestone (Table 7). In the eastern subsurface this interval includes the Brassfield Formation, lower and upper tongues of the Cabot Head Shale, and the Clinton-Tuscarora sandstones. In areas west of the depositional edge of the Clinton sandstone (Fig. 10a-c), the Brassfield and Cabot Head (undivided) persist into the outcrop, where the latter is called the Plum Creek Shale.

The Medina Group thickens uniformly eastward from outcrop into the subsurface (Fig. 8). Minimum thicknesses of less than 30 feet are recorded from complete Medina sections exposed in Bath County, Kentucky (Locs. 32, 33, 34), with maximum thicknesses in excess of 140 feet

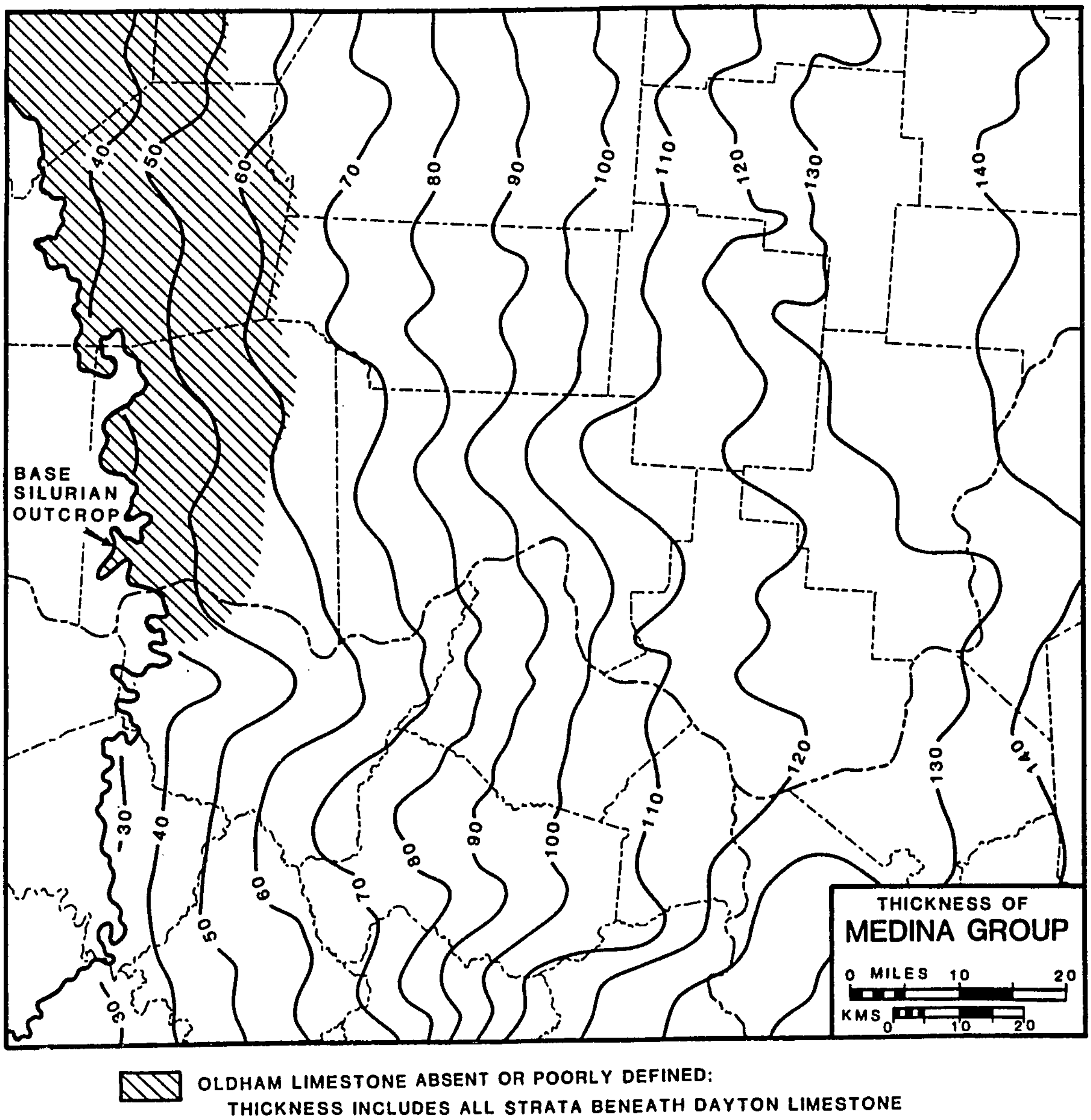


Figure 8. Thickness map of the Medina Group (Brassfield Formation, Cabot Head Shale, and Clinton sandstone combined) shows eastward thickening and well defined north-south depositional strike. Contour interval 10 feet.

Figure 9 (map pocket). Nuclear log cross sections showing geophysical identification and correlation of the Medina and lower Clinton Groups. See Appendix A for well identifications.

Figure 10 (map pocket). Cross sections showing stratigraphic relations, general lithology, and thickness of the Medina and lower Clinton Groups. See Appendix A for well identifications.

occurring in counties along the eastern border of the study area. Slight thickening (10-15 feet) of Medina strata takes place to the south across the Kentucky River Fault System into the Rome Trough in Elliott and Lawrence Counties, Kentucky. North and west of outcrops in Highland County, Ohio the Medina Group is partially truncated by a sub-Dayton erosional unconformity and the Dayton Limestone rests directly on Cabot Head shales (Figs. 9a, 10a, 12).

BRASSFIELD FORMATION

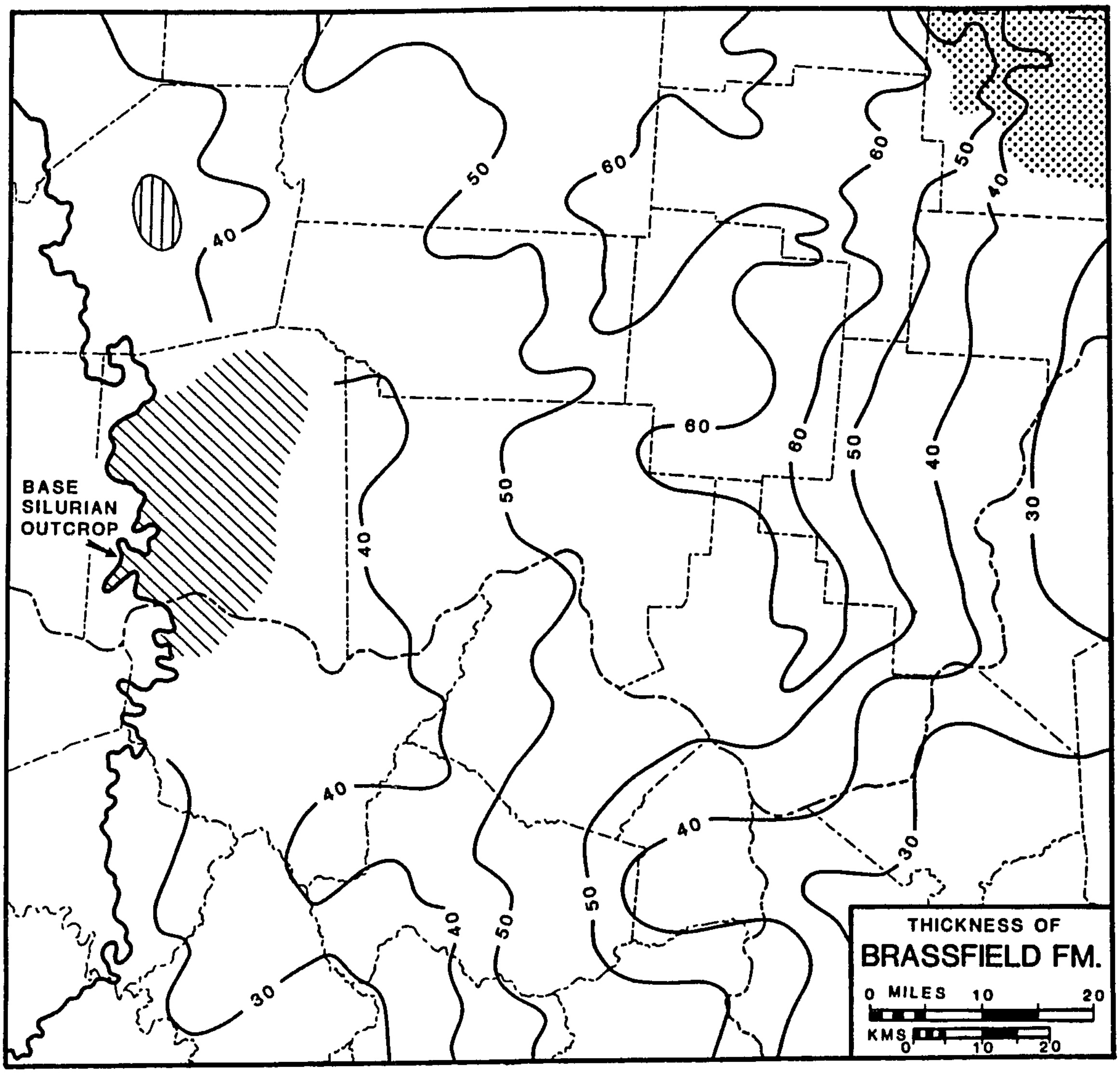
The Brassfield Formation is recognized throughout the study area as the basal Silurian stratigraphic unit and everywhere unconformably overlies rocks of Ordovician age. Overlying the Brassfield with apparent conformity are shales of the Cabot Head in the subsurface, and the Plum Creek in outcrop, except locally in Highland County (Loc. 8), where Dayton carbonates rest unconformably on uppermost Brassfield strata.

In counties near the outcrop the contact between the Brassfield Formation and the Cabot Head Shale is typically sharp on geophysical logs and in well samples (Fig. 9d). In eastern counties, however, the contact becomes increasingly gradational and is difficult to find owing to interfingering and the displacement of discontinuous carbonates in the upper Brassfield by shales of the Cabot Head (Fig. 9a-c). Here the top of the Brassfield is arbitrarily set at the upper limit of the gradational interval where carbonate strata comprise greater than fifty percent of the section.

Gamma ray logs provide the most accurate means to determine this contact. Definition of the boundary between the Brassfield and underlying Ordovician strata is relatively clear and has been previously discussed.

In outcrop, a regionally accepted upper stratigraphic boundary for the Brassfield remains to be established (see discussion of McDowell, 1983, p. 7-8). Determination of the unit's upper limit is especially difficult in Adams County, Ohio, and northern Lewis County, Kentucky, where Plum Creek shales are strongly interbedded with both Brassfield and Oldham carbonates, and in addition, strata which are assignable to the Brassfield are uncharacteristically shaly (Fig. 8; Plate 1b). In these counties previous workers have either assigned all sub-Dayton strata to the "Brassfield" (O'Donnell, 1967), or have expressed difficulty in separating Brassfield strata from overlying "undifferentiated" rocks (Rexroad et al., 1965; McDowell, 1983).

Thickness - The Brassfield Formation is most condensed in outcrops of Bath County, Kentucky where only 21 feet occurs (Loc. 34; Fig. 11). From here the Brassfield thickens to the east and north both along outcrop and into the subsurface, principally by addition of thin carbonates and shales in its upper portions. The irregularity of isopach contours suggests that the addition of strata is not everywhere uniform, and may also reflect slight topographic irregularities on the Queenston surface at the base of the



WHIRLPOOL SANDSTONE PRESENT AT BASE OF BRASSFIELD FORMATION

UPPER BRASSFIELD UNDIFFERENTIATED FROM OLDHAM LIMESTONE AND PLUM CREEK SHALE: EXACT THICKNESS UNKNOWN

DAYTON LIMESTONE IN EROSIONAL CONTACT WITH THE BRASSFIELD FORMATION

Figure 11. Thickness map of the Brassfield Formation shows north-south depositional axis and maximum isopach trend in Hocking, Vinton, Gallia, and Lawrence Counties, Ohio. Contour interval 10 feet.

Brassfield.

Maximum thickness of the formation (68 feet) occurs in Vinton County, Ohio within a north-south trending, irregularly lobate area defined by the 60 foot contour. East of the area of maximum thickness, the Brassfield thins uniformly into West Virginia owing to progressive replacement of Brassfield carbonate beds by shales of the overlying Cabot Head (Figs. 9, 10, 11). The formation eventually pinches-out beyond the confines of the study area.

Locally 0 to 12 feet of Whirlpool Sandstone represent the basal facies of the Brassfield in Athens County, Ohio, effecting no change in the thickness of the formation as a whole. Southward into the Rome Trough in Lawrence County, Kentucky and Wayne County, West Virginia, minor formational thickening occurs as a result of expansion of the shaly upper Brassfield.

Depositional strike of the Brassfield is oriented approximately north-south over most of the study area, although a northwestward deflection of strike takes place west of Pike and Ross Counties, Ohio (Fig. 11).

Lithology - In the study area lithologic characteristics of the Brassfield Formation vary both laterally and vertically, with maximum lateral change coinciding with the east-west direction of depositional dip.

In counties adjacent to the outcrop, the Brassfield consists of three vertically gradational lithologies. The basal 2-10 feet consist of medium to dark gray, argillaceous, slightly silty, dolomitic limestone with thin interbeds of greenish gray shale. Medial portions of the formation are relatively shale-free, and consist of white, cream, and tan, commonly mottled, medium to coarsely crystalline, fossil fragmental limestones and dolostones with a trace to several percent light gray chert. Dolostones dominate medial portions of the Brassfield in Kentucky, whereas variably dolomitic limestones are common in Ohio. Upper portions of the Brassfield consist of light to medium gray, argillaceous, fine to medium grained, bioclastic limestones with common interbeds of greenish gray shale. One or more beds of reddish brown, friable, fossiliferous, oolitic or pelletal, ferruginous limestone are common in the upper Brassfield. Glauconite is common throughout the entire formation, both as discrete beds and disseminated grains. Gamma ray and neutron log signatures are typically bell-shaped, reflecting the increased shale content in the upper and lower portions of the Brassfield (Fig. 9). Locally, the position of ferruginous beds is indicated by sharp peaks on density and porosity curves.

The previously described lithologies correspond well with both formal and informal subunits of the Brassfield defined in outcrop studies (Hoover, 1963; Horvath and Sparling, 1967; O'Donnell, 1967; Rexroad et al., 1965; Frost, 1977; Stith and Stieglitz, 1979; Gordon and Ettensohn, 1984). In outcrop the Belfast Member can be generally recognized at the base, and is overlain by a lower massive carbonate unit with chert and an upper thin bedded carbonate unit with intercalated shales (Plate 1).

East of a meridian which approximates the western edge of Vinton, Jackson and Lawrence Counties, the Brassfield becomes more homogeneous and the previously designated lithologies are no longer discrete. Here the Brassfield is less dolomitic, increasingly argillaceous and shaly, and also contains a few thin interbeds of tan and gray, fine to very fine grained argillaceous siltstone. Glauconite remains common although chert is absent.

Eastward from the outcrop, the discontinuous carbonate beds of the upper Brassfield are progressively split due to expansion of intervening shales. East of a meridian which approximates the western edge of Athens, Meigs, and Gallia Counties these carbonate beds are nearly completely replaced by dolomitic shales of the Cabot Head. By definition in this area, the Brassfield is restricted to the lower, carbonate dominated portion of the section. Ferruginous beds appear to persist the greatest distance to the east, and often are recognizable within the Cabot Head Shale after separating from the Brassfield. The overall shale content of the entire formation also increases eastward, as reflected by progressively higher gamma radiation in that direction.

The Whirlpool Sandstone, which occurs locally in Athens County as a basal facies of the Brassfield, consists of argillaceous to shaly, slightly calcareous, coarse siltstone and fine to medium grained sandstone with a trace of glauconite.

In West Virginia counties where the Brassfield extends beneath the massive Tuscarora Sandstone (Figs. 9, 10), it consists of an admixture of lithologies. These include, in order of decreasing abundance, gray, medium to finely crystalline, fossil fragmental, silty, argillaceous limestone and dolostone; gray and reddish gray, moderately soft, slightly silty shale; and light gray, tan, occasionally white, argillaceous to pure, very fine to fine grained, calcareous siltstone. In this area a subtle increase in gamma radiation intensity marks the Brassfield-Queenston contact (Fig. 9c, well 776), matching closely the appearance of red silty Queenston shales in well samples.

Regional Stratigraphic Relationships - The Brassfield represents a portion of a regionally extensive basal Silurian carbonate sheet, which blankets much of the midcontinent. The Brassfield is recognized from its nearly continuous outcrop around the periphery of the Cincinnati Arch and has been traced as far south as Tennessee and Alabama (Rexroad, 1967, p. 4). The formation is stratigraphically coextensive to the north and west with the Manitoulin Dolomite of Michigan and Ontario, and the Sexton Creek Limestone, Elwood Formation, Kankakee Dolomite, and Blanding Formation in Indiana and Illinois (Rexroad, Gray and Noland, 1983, p. 4). These rocks range in age from Lower to early Upper Llandovery and are time-transgressive to the north and west (Rexroad et al., 1965, p. 12-13).

Study of the Brassfield Formation from Ohio outcrops eastward into the Appalachian Basin subsurface has resulted in several miscorrelations. The foremost of these is the misidentification of carbonate units which overlie the Clinton sandstone interval as Brassfield (i.e. drillers' "Packer" and "Casing" shells). Figures 9 and 10 clearly illustrate that, within the area of investigation, Brassfield strata extend only beneath the Clinton sandstone interval, and that supra-Clinton carbonates correspond instead with the Oldham and Dayton Limestones of outcrop. It is important, therefore, that correlation of the Brassfield with the drillers' subsurface "Packer" and "Casing" shells be discontinued. Further clarification of the relations between these units is presented with discussion of the Oldham Limestone.

Additionally, the Brassfield is not considered to be in facies relationship with the Clinton sandstone in southern Ohio as often suggested. Again, Figures 9 and 10 show that Brassfield strata everywhere interfinger with Cabot Head shales, and not the sandstones of the Clinton. The carbonates of the Brassfield are completely replaced by shales of the Cabot Head east of the study area. Farther to the east, in areas more proximal to the source, the entire Medina Group is represented by course clastics (ex. Tuscarora, Grimsby, Clinch, Shawangunk), which are in part chronostratigraphically equivalent to the Brassfield (Berry and Boucot, 1970).

CABOT HEAD SHALE

The Cabot Head Shale persists throughout the study area and is bounded by carbonates of the Brassfield Formation below and the Oldham Limestone above save for the area north and west of Highland County, Ohio, where it is unconformably overlain by the Dayton Limestone (Figs. 12, 9a, 10a). Entirely confined within the Cabot Head is the westward thinning wedge of Clinton (Tuscarora) sandstone (Fig. 10). Where the Clinton is present in the eastern one-third of the study area (Fig. 12), the Cabot Head is informally divided into upper and lower tongues which extend, respectively, above and below the sandstone interval.

The upper limit of the Cabot Head is usually distinctive on gamma ray logs and in well samples in Ohio counties, where the overlying Oldham is a compact carbonate (Fig. 9a, b). This contact is gradational in many Kentucky and West Virginia counties, because of progressive splitting of the basal Oldham carbonates into thin discontinuous beds, which interfinger with Cabot Head shales (Fig. 9c, wells 221 and 776). Here the top of the Cabot Head is placed at the upper limit of continuous shale section overlying the Clinton sandstone.

A sharp contact separates the upper Cabot Head Shale tongue and Clinton sandstone, and is marked by a distinctive lithologic break in cuttings and readily identifiable change in gamma ray character (Fig. 9). Contact between the Clinton and lower Cabot Head is locally sharp, but in the majority of wells studied gamma ray response indicates a gradational boundary. This contact tends to be obscure in well cuttings because of caving.

The Plum Creek Shale is the outcrop equivalent of the Cabot Head, and is best displayed in Kentucky exposures where it separates Brassfield and Oldham carbonates (Plate 2a). In northern Lewis County, Kentucky and Adams County, Ohio contacts of the Plum Creek can not be clearly differentiated because of extreme interbedding with the adjacent carbonate units (Fig. 12; Plate 1b). North of these counties along outcrop and in the adjacent subsurface, however, the Plum Creek can be traced as a thin, distinctive shale lying conformably atop the Brassfield and unconformably beneath the Dayton Limestone (Plate 2b). In a single exposure in central Highland County (Loc. 8) the Plum Creek has been removed entirely by sub-Dayton erosion.

Thickness - Figure 12 shows the thickness of the Cabot Head Shale, which is combined with the thickness of the Clinton (Tuscarora) sandstone in the eastern one-third of the study area.

In outcrop the Cabot Head (Plum Creek) is typically less than 10 feet thick. The unit thickens rather uniformly eastward into the subsurface, where 50 to 60 feet occur along the western feather-edge of the Clinton sandstone. East of the Clinton depositional edge, the now combined isopach increases at a greater rate as a result of progressive eastward thickening of the sandstone, slight expansion of the upper Cabot Head Shale tongue, and

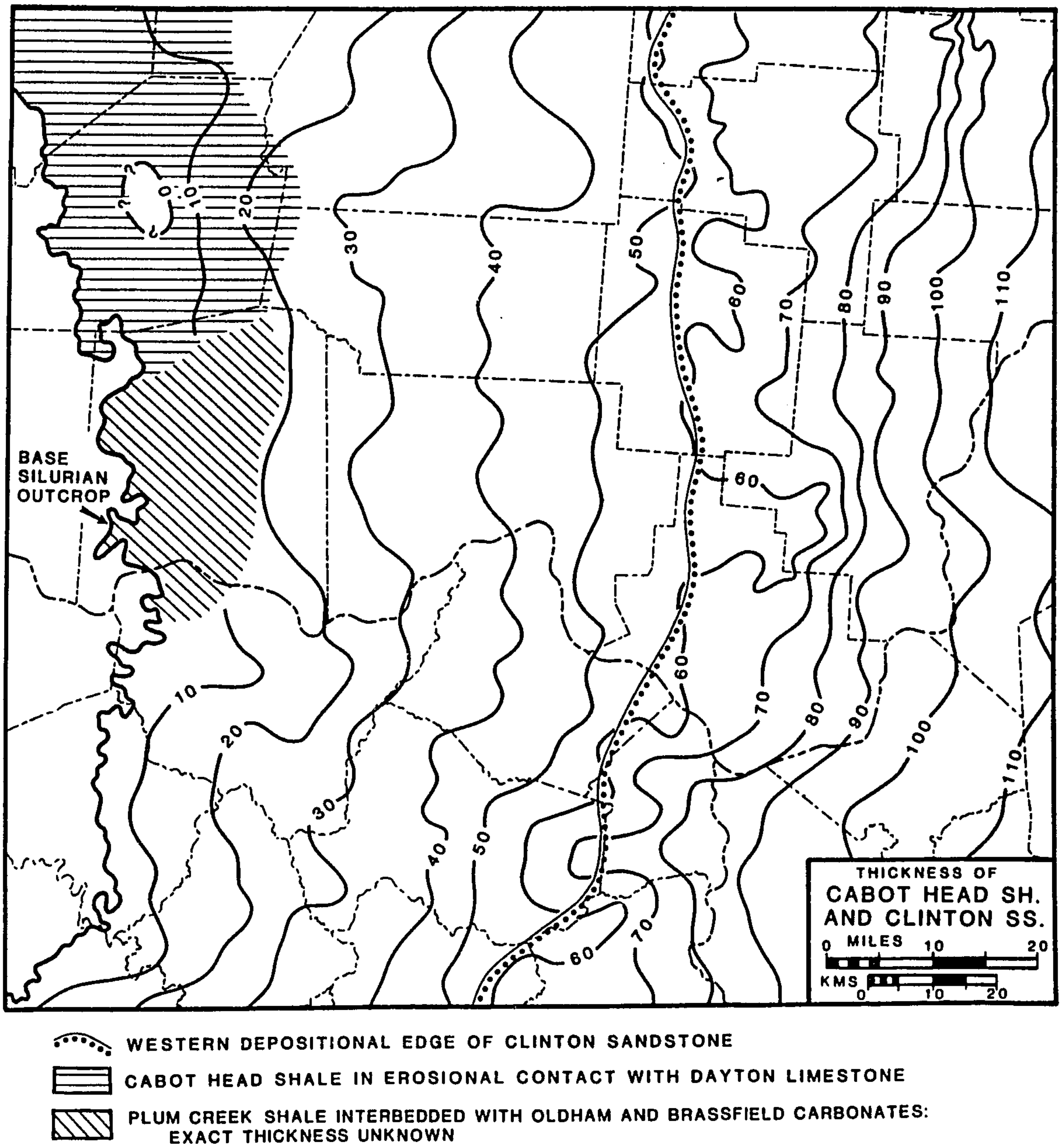


Figure 12. Combined thickness map of the Clinton (Tuscarora) sandstone and lower and upper Cabot Head Shale shows eastward thickening and well defined north-south depositional strike. Contour interval 10 feet.

progressive replacement of Brassfield carbonates by lower Cabot Head shales (Fig. 10a-c). In counties bordering the eastern edge of the study area, 65 to 80 feet of the combined isopach comprise the thickness of the upper and lower Cabot Head tongues.

A north-south depositional strike is clearly defined on the map. Also noticeable is an eastward deflection of contours south of the Kentucky River Fault in Lawrence County, Kentucky, which suggests a slight thinning of the combined Clinton-Cabot Head interval into the Rome Trough.

Lithology - The dominant lithology of the Cabot Head is greenish gray to reddish gray, soft, moderately fissile, unfossiliferous, dolomitic shale which is slightly silty, pyritic, and glauconitic. Other lithologic components of the Cabot Head include thin lenses of limestone, dolomite, and siltstone which locally comprise up to 20 percent of the unit.

The carbonate interbeds are typically medium to light gray, finely to medium crystalline, poorly fossiliferous, argillaceous, and occasionally ferruginous. These beds are most common near the Cabot Head-Brassfield contact, and increase in abundance eastward as shales of the Cabot Head progressively interfinger with, and replace carbonates of the Brassfield. Thin stringers of light gray and tan, very fine to medium grained, argillaceous, slightly calcareous siltstone are interbedded within the Cabot Head shales adjacent to contacts with the Clinton sandstone, especially in the lower Cabot Head tongue. The abundance of interbedded siltstones also increases to the east.

In outcrop, the equivalent Plum Creek Shale consists of blue gray to greenish gray, slightly calcareous to dolomitic, fissile shale with a few thin interbeds of gray, finely crystalline dolomite.

Regional Stratigraphic Relationships - The subsurface Cabot Head Shale can be traced with certainty westward into the Plum Creek Shale of outcrop. It is also clear from the correlations shown in Figures 9c, 10c, and 10e that the lower Cabot Head Shale tongue extends to the east beneath the Tuscarora Sandstone into westernmost West Virginia counties where previously the base of the Tuscarora was accepted as the Ordovician-Silurian systemic boundary (e.g. COSUNA, 1985a, cols. 1, 8; Cardwell, 1977; Smosna and Patchen, 1978). The upper Cabot Head tongue is correctly positioned by COSUNA (1985a, cols. 1, 8) in western West Virginia, directly atop the Tuscarora Sandstone.

Horvath (1964, p. 22) traced the Cabot Head of southern Ohio nearly to the type section in Ontario, where it lies between the Manitoulin and Dyer Bay Dolomites, thus assuring lateral correlation to the north and appropriate application of the name. The Cabot Head is progressively replaced by clastics of the Tuscarora to the east of the study area (Dennison, 1970, p. 8), until finally in west-central West Virginia the entire Medina Group is represented by sandstones. Northwest of the study area, toward the Wabash Platform in Indiana, a lithostratigraphic equivalent to the

Cabot Head is absent as a result of westward depositional thinning coupled with erosion by the sub-Dayton unconformity (Rexroad, Gray, and Noland, 1983, p. 3).

CLINTON AND TUSCARORA SANDSTONES

The stratigraphically equivalent Clinton and Tuscarora sandstones occur in the eastern one-third of the study area and form a westward thinning wedge bounded above and below by shales of the Cabot Head (Figs. 9, 10, 13). The Clinton shales-out completely along a line which approximates the western margin of Hocking, Vinton and Lawrence Counties, Ohio and Boyd and Lawrence Counties, Kentucky, and is therefore wholly confined to the subsurface in the study area (Fig. 13).

Although the overall lithologic and log character of the Clinton interval is distinctive, intertonguing of the sandstones with Cabot Head shales and strong lateral variation in continuity and thickness of the sandstone bodies commonly make difficult the definition of stratigraphic contacts. This is especially true near the pinch-out in western areas where Clinton sandstones are more lenticular and broken.

The top of a thin, fairly persistent calcareous siltstone (drillers' "Stray"?), which is separated from the main body of sandstone by 1 to 3 feet of shale, proved to be a useful standard for the Clinton-upper Cabot Head Shale contact (Fig. 14). This siltstone is sharply overlain by 5 to 15 feet of continuous shale assigned to the upper Cabot

Head. Where absent, the top of the Clinton is placed at the first identifiable sandstone bed beneath the continuous shale section. The boundary between the Clinton and lower Cabot Head Shale is variably sharp, intercalated, or gradational and is placed at the base of the lowermost sandstone bed which overlies continuous shales of the lower Cabot Head (Figs. 9, 14). This contact is difficult to determine in well cuttings, because of downhole sample contamination, and is best placed on nuclear logs; particularly those with bulk density curves which afford a means to differentiate thin sandstones of the lower Clinton from thin carbonates interbedded in the directly subjacent lower Cabot Head.

The Clinton thicknesses reported in Appendix A incorporate all lithologies from the top of the aforementioned calcareous siltstone to the base of the lowermost sandstone bed, including intervening shales, and should not be equated with net feet of sandstone.

Locally in Athens, Hocking, and Vinton Counties, Ohio drillers' further subdivide the Clinton interval into three informal stratigraphic units, including: 1) the "Stray" Clinton which is in contact with and intertongues with the upper Cabot Head Shale; 2) the "1st", or "Red" Clinton which comprises the central body of sandstone, is often red in coloration, and is separated from the "Stray" and "White" by shale breaks; and 3) the "2nd", or "White" Clinton which is in contact with and intertongues with the lower Cabot Head and is generally white or light colored. Practical use of these subdivisions is limited within the study area because of the lateral discontinuity of shale breaks between sandstone lenses, the poor correlation between sandstone coloration and position, the lack of diagnostic log signatures for separating the "1st" and "2nd" Clinton, and the overall thin nature of the Clinton sequence in southern Ohio. Drillers' subdivisions therefore are not employed in this study; however they have been recognized and traced throughout counties bordering the northern margin of the study area (Overby and Henniger, 1971; Msek, 1973).

Thickness - The Clinton sandstone interval thickens steadily eastward from zero to approximately 30 to 35 feet in West Virginia counties. In Ohio and Kentucky rapid changes in thickness are not uncommon (Fig. 14a). Several wells in this area show nearly a complete absence of sandstone because of grading to shale, whereas a few others show in excess of 50 net feet of sandstone. Sandstone of the Clinton is more uniform in thickness in West Virginia. On average, 10 to 15 net feet of sandstone is present, with shale comprising one-fourth to one-third of the total Clinton interval.

The distribution of Clinton sandstone is presented as a slightly generalized clastic ratio map, calculated from net sandstone and net shale in the combined Clinton-Cabot Head section (Fig. 13). Conspicuous on the sand-shale ratio map are two depositional lobes extending westward into Ohio and outlined by the 1:3 contour. These are informally named the

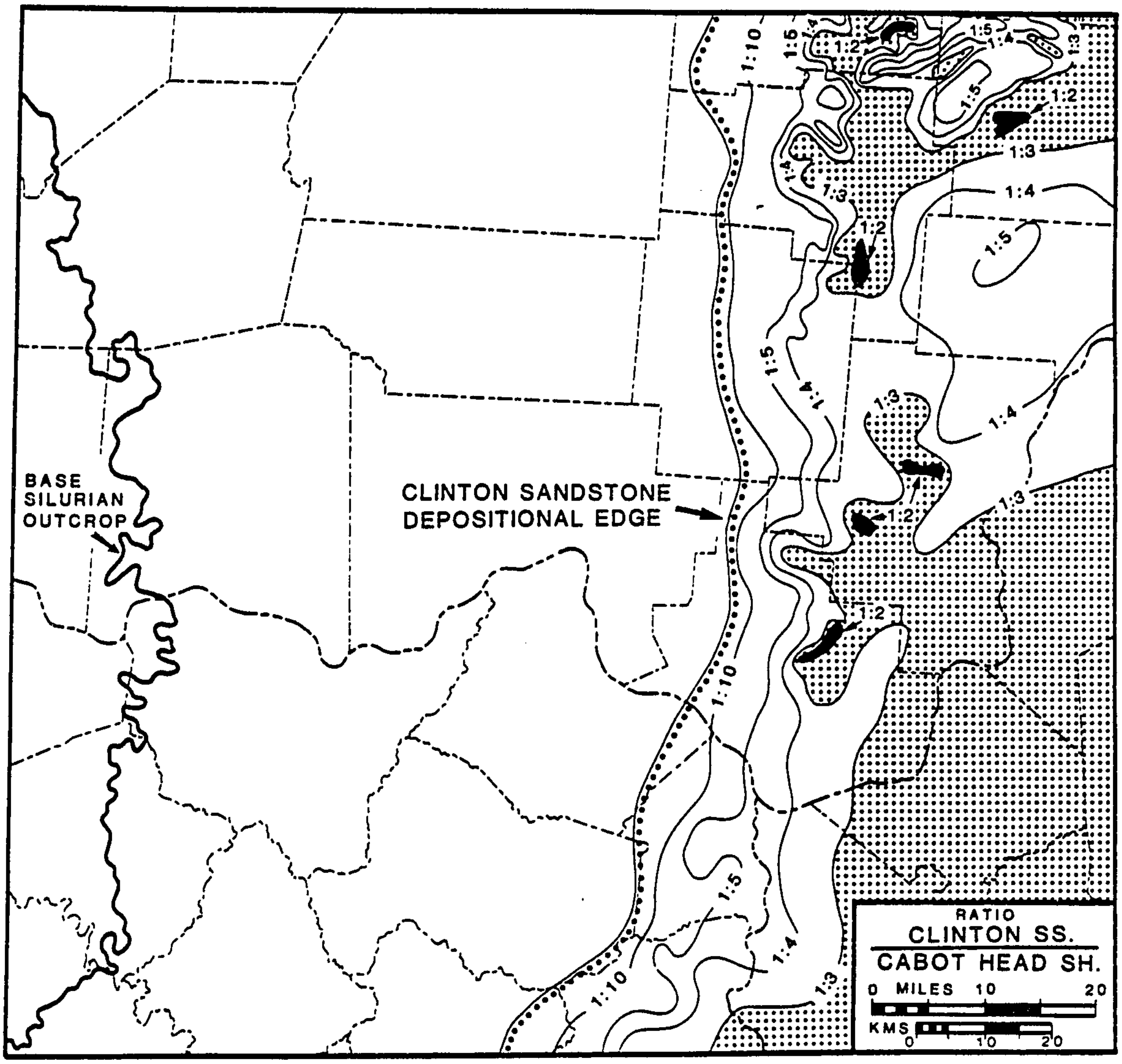
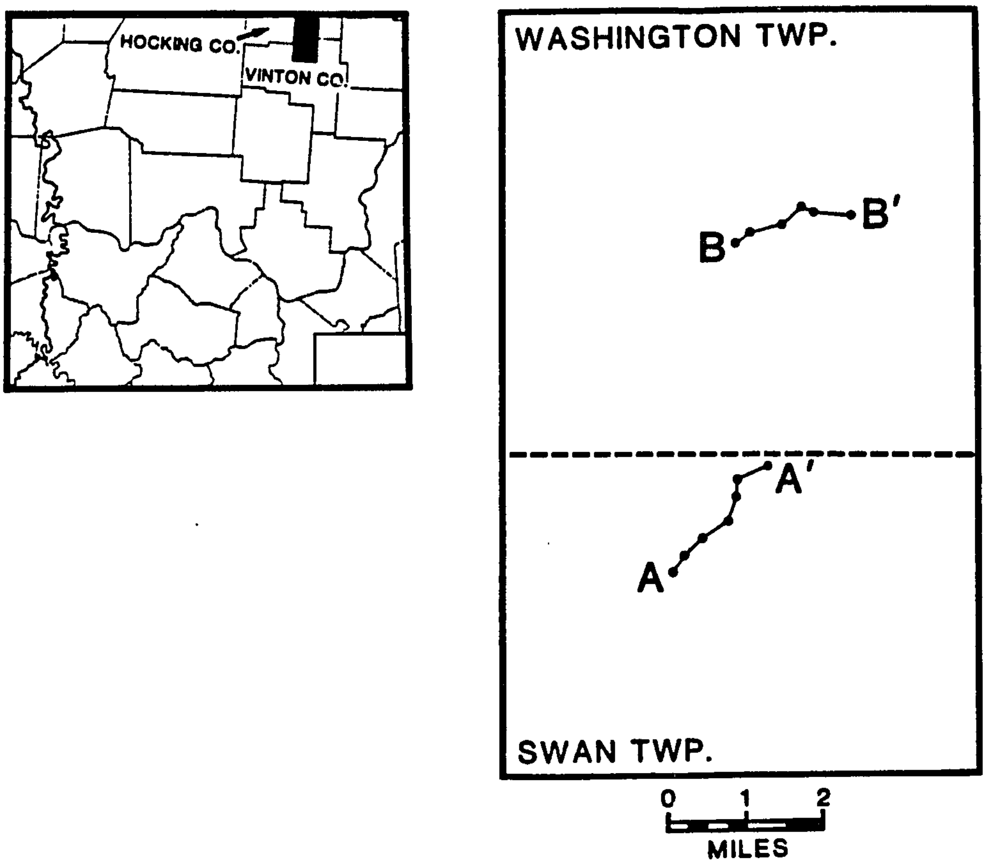
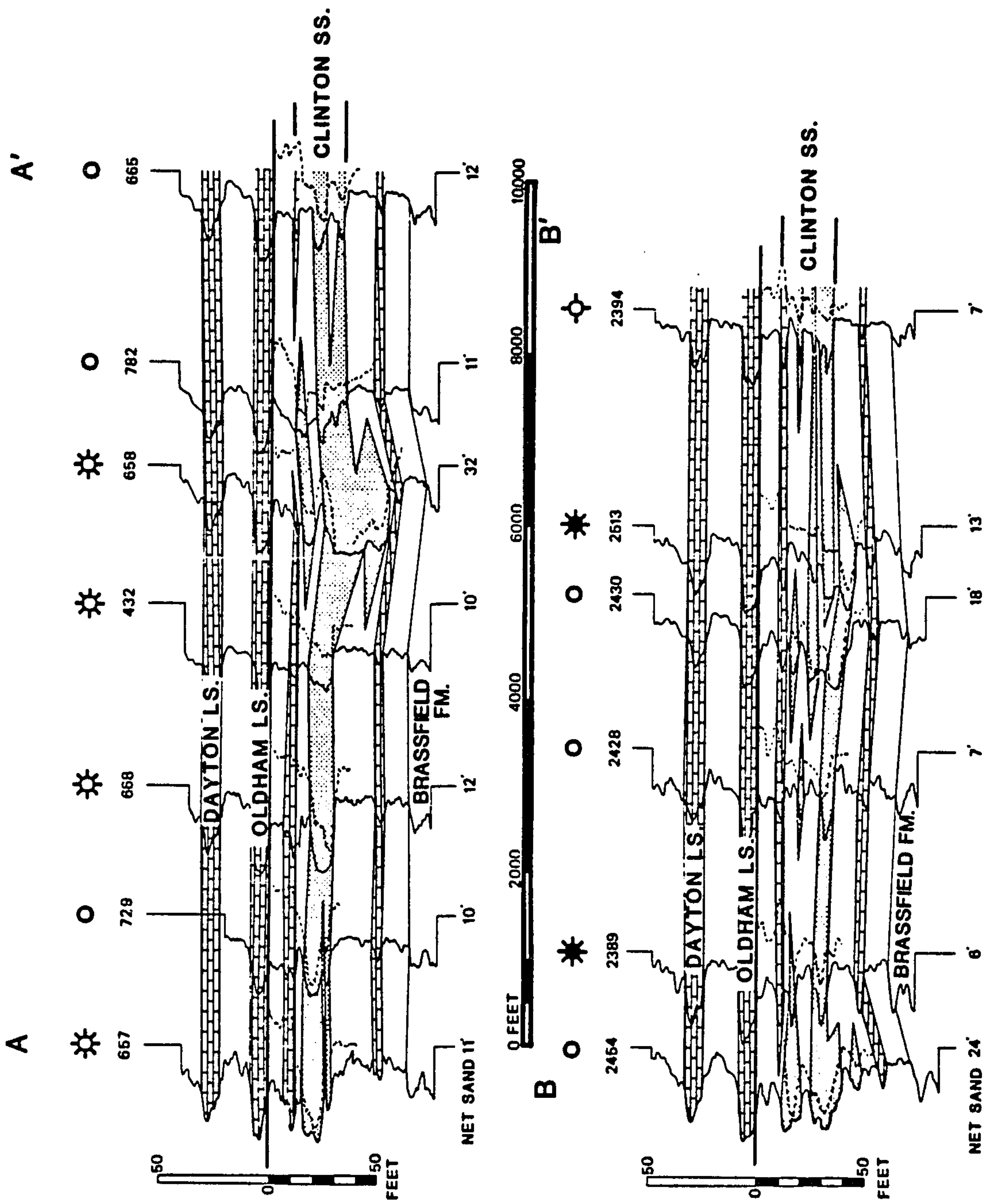


Figure 13. Sandstone/shale ratio map determined as net thickness of sandstone relative to net thickness of shale in Clinton-Cabot Head section; carbonate thickness excluded. Note delta lobes centered on Vinton and Gallia Counties, and general increase in sandstone to the east and southeast within the interval. Results slightly generalized in Hocking, Vinton, and Athens Counties owing to density of well control.

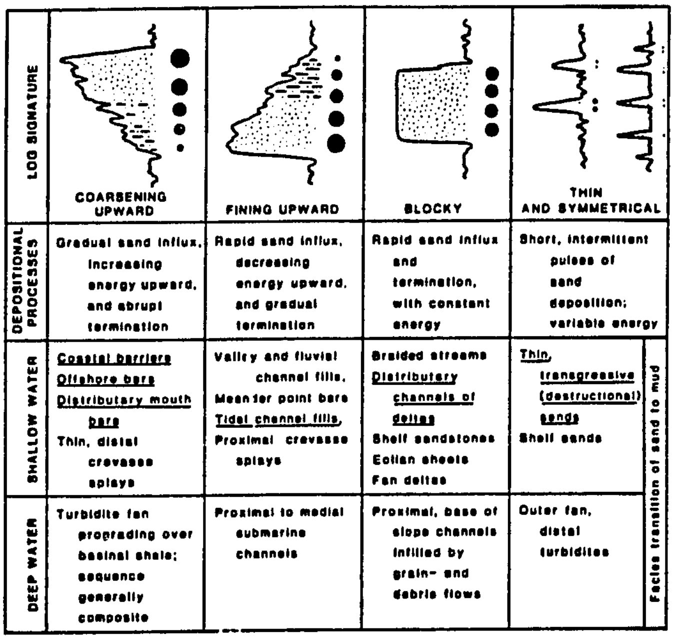
Figure 14. Detailed nuclear log cross sections of the Clinton sandstone and adjacent stratigraphic units in Vinton and Hocking Counties. Note horizontal scale, rapid variation in net Clinton sandstone thickness, and lenticular and often discontinuous nature of sandstone bodies. See Appendix A for well identifications.





A
A'
657
729
668
432
658
782
665
DAYTON LS.
OLDHAM LS.
CLINTON SS.
BRASSFIELD FM.
NET SAND 11'
10'
12'
10'
32'
11'
12'
50
0
50
FEET
0 FEET
2000
4000
6000
8000
10000
B
B'
2454
2389
2428
2430
2513
2394
DAYTON LS.
OLDHAM LS.
CLINTON SS.
BRASSFIELD FM.
NET SAND 24'
6'
7'
18'
13'
7'
50
0
50
FEET

Figure 15. Representative Clinton sandstone gamma-ray log signatures and generalized environmental interpretations for common sandstone log responses.

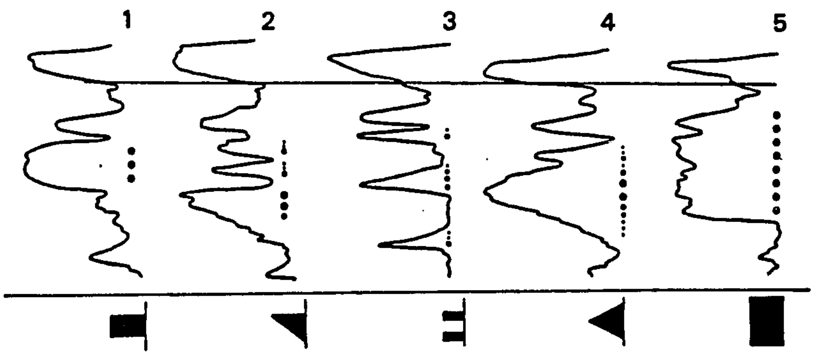


	COARSENING UPWARD	FINING UPWARD	BLOCKY	THIN AND SYMMETRICAL
LOG SIGNATURE				
DEPOSITIONAL PROCESSES	Gradual sand influx, increasing energy upward, and abrupt termination	Rapid sand influx, decreasing energy upward, and gradual termination	Rapid sand influx and termination, with constant energy	Short, intermittent pulses of sand deposition; variable energy
SHALLOW WATER	Coastal barriers Offshore bars Distributary mouth bars Thin, distal crevasse splays	Valley and fluvial channel fills, Meander point bars Tidal channel fills, Proximal crevasse splays	Braided streams Distributary channels of deltas Shelf sandstones Eolian sheets Fan deltas	Thin, transgressive (destructional) sands Shelf sands
DEEP WATER	Turbidite fan prograding over basinal shale; sequence generally composite	Proximal to medial submarine channels	Proximal, base of slope channels infilled by grain- and debris flows	Outer fan, distal turbidites

Facies transition of sand to mud

(from Potter, et. al., 1983, Figure 9, page 20)

TYPICAL CLINTON LOG SIGNATURES



Vinton County lobe and Gallia County lobe. Both are irregularly digitate and show moderate north-south elongation along the finger-like extensions. Definition of the Vinton lobe is based on over 400 control wells, the Gallia lobe on less than 50, and the intervening area on very sparse control.

Additionally, the map clearly indicates thickening and a more uniform distribution of Clinton sandstones to the southeast in West Virginia.

Lithology - The Clinton consists primarily of gray, white, and tan, subangular to subround, moderately to well sorted, argillaceous to pure, variably hard to friable, slightly pyritic and glauconitic, fine grained sandstone and medium to coarse grained siltstone. Silica, calcite, and dolomite serve as cementing agents, with the carbonate cements most commonly appearing in upper and lower sandstones near contacts with Cabot Head shales. Red colored, calcareous, slightly oolitic, ferruginous siltstones occur sporadically within the Clinton, typically near the upper limit of the interval. Available bulk density logs indicate that the ferruginous beds are most abundant in Kentucky counties.

In Core 962, Vinton County, Ohio, Clinton sandstones are thin to medium bedded, contain numerous shale partings, and are extensively bioturbated. The individual sandstone beds are typically homogeneous, although faint cross and parallel lamination, normal grading, irregularly contorted lamination, and ripple lamination are observed uncommonly.

The sandstone-shale contacts vary from sharp and planar to irregularly diffuse and interpenetrating where burrowed. Rounded shale pebbles are scattered throughout the core, and concentrated in a few thin conglomeratic beds near the upper limit of the interval.

Shales interbedded with the sandstones are medium to dark gray, greenish gray, and reddish gray, soft, slightly pyritic, micaceous, and silty, and commonly contain thin stringers and flasers of siltstone.

Following an eastward trend across the area of investigation, the Clinton becomes slightly coarser grained, less shaly and argillaceous, and lighter in color. The individual sandstone bodies are typically discontinuous, and persist laterally only a few miles before grading to shale. Gamma ray log signatures of the sandstones are variable, and include massive and blocky, fining upward, coarsening upward, thin and symmetrical, and bell-shaped forms (Fig. 15).

<u>Regional Stratigraphic Relations</u> - On the basis of lithology and stratigraphic position (Figs. 9, 10), it is clear that the informal Clinton sandstone recognized by Ohio drillers is coextensive with the formal Tuscarora Sandstone of West Virginia.

Lithostratigraphic equivalents of the Clinton-Tuscarora occur throughout the Appalachian Basin, extending westward to a subsurface depositional pinch-out which follows a north-south trend passing through west-central Ohio. These include the Grimsby Sandstone of New York, Tuscarora Sandstone of West Virginia and Pennsylvania (Castanea), Clinch Sandstone of Virginia, and Shawangunk of eastern New York and Pennsylvania (Berry and Boucot, 1970; Yaekel, 1962; Smosna and Patchen, 1978).

CLINTON GROUP

The stratigraphic succession of the Clinton Group is fully represented throughout most of the subsurface in the southern Ohio area, and includes, in ascending order, the Oldham Limestone, Lulbegrud Shale, Dayton Limestone, Estill Shale, and Bisher Formation (Table 7). All of these units can be traced southwestward into Kentucky outcrop, where the Bisher Formation is locally truncated by the pre-Middle Devonian unconformity. Northwestward toward Ohio outcrops, lower Clinton Group strata are progressively truncated by a sub-Dayton erosional unconformity, and only the Dayton Limestone, Estill Shale, and Bisher Formation persist north and west of Adams County.

In West Virginia the Clinton Group is limited below by the upper Cabot Head Shale and above by the Lockport Dolomite, and includes beds of the Oldham Limestone, Rose Hill Formation, Cacapon Sandstone, and Keefer Sandstone.

OLDHAM LIMESTONE

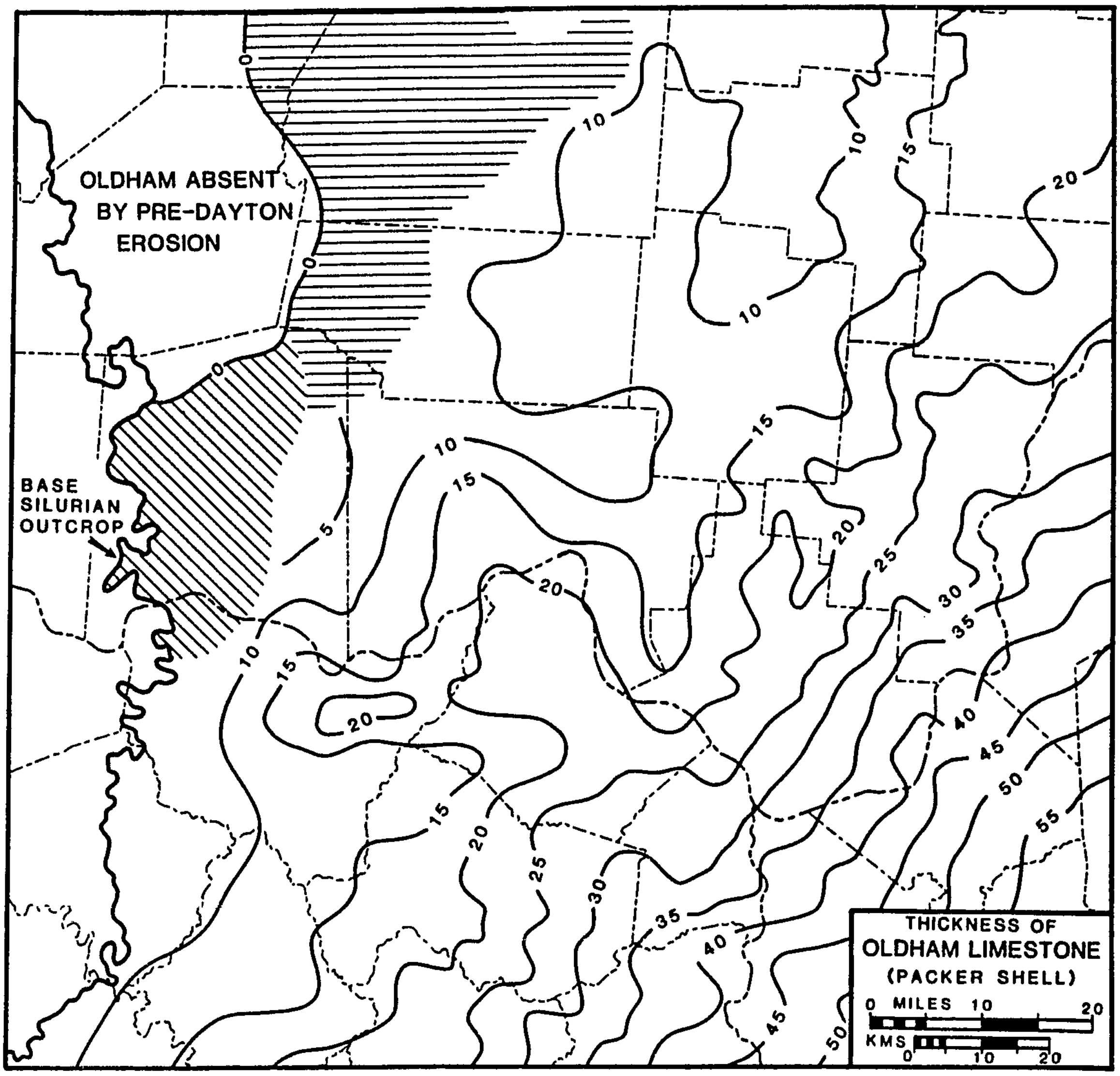
The Oldham Limestone is a thin, persistent carbonate which conformably overlies the Cabot Head Shale (Plum Creek of outcrop) throughout the study area. In outcrops south of Bath County, Kentucky (Loc. 27) and throughout most of the subsurface, the Oldham is conformably overlain by the Lulbegrud Shale; which in turn is overlain by a second thin persistent carbonate, the Dayton Limestone (Plate 4a). In subsurface portions of Pike and Ross Counties, Ohio (Fig.

16), the Oldham is unconformably overlain directly by the Dayton, as a result of erosional removal of Lulbegrud shales prior to Dayton deposition (Figs. 9a, 10a-b). Farther to the west in Highland, Fayette, and Clinton Counties, Oldham beds are absent owing to continued erosional overstep by the sub-Dayton unconformity.

In the subsurface, contacts of the Oldham with bounding shales can be accurately established on nuclear logs, and less so on the basis of well samples. The upper contact is everywhere sharp within the area of investigation, whereas the lower contact becomes increasingly intercalated to the south and east as Oldham carbonates progressively interfinger with shales of the underlying Cabot Head (Fig. 9c-d). Differentiation of the Oldham and Dayton Limestones where shales of the Lulbegrud are absent is possible only in cores.

<u>Thickness</u> - The Oldham is typically 8 to 10 feet thick in Kentucky outcrops, and thickens southeastward across the study area to a maximum of over 55 feet in Lincoln and Putnam Counties, West Virginia (Fig. 16). Where the isopach is less than 15 to 20 feet, the Oldham shows a gradual, rather irregular thickening trend and appears on logs as a relatively compact (shale free) carbonate, whereas in areas where isopach values exceed 20 feet, the Oldham thickens in a more rapid and uniform manner and displays a hackly log signature, owing to the southeastward expansion of shale interbeds (Fig. 9c, compare wells 261 and 221).

A thick, relatively shaly lobe of Oldham extends



OLDHAM LIMESTONE INTERBEDDED WITH BRASSFIELD LIMESTONE AND PLUM CREEK SHALE: EXACT THICKNESS UNKNOWN

OLDHAM LIMESTONE IN EROSIONAL CONTACT WITH DAYTON LIMESTONE: COMBINED THICKNESS 10-24 FEET, NOT SEPARABLE ON LOGS

Figure 16. Thickness map of the Oldham Limestone shows thickening to southeast and well defined northeast-southwest depositional strike. Contour interval 5 feet.

northwestward into Greenup and Lewis Counties, Kentucky and Scioto County, Ohio, which seems to cause problems in differentiating the intercalated shales and carbonates of the Lulbegrud, Oldham, Plum Creek, and upper Brassfield in outcrops of northern Lewis and southern Adams Counties (Plate 1b).

A northeast-southwest oriented depositional strike is clearly defined for Oldham strata in West Virginia and adjacent counties, but is more obscure closer to the outcrop because of the irregular trend of contours there. This orientation marks a clockwise rotation of approximately 30 degrees from that of the underlying Medina Group (compare Figs. 16 and 8).

Lithology - In both outcrop and subsurface, the Oldham consists principally of light gray, tan, cream, and white, often mottled, finely to medium crystalline, thin to medium bedded, fossiliferous, slightly silty, argillaceous, and glauconitic, limestone and dolomitized equivalents (Plates 2a, 4a). Commonly interbedded are gray and greenish gray shales as thin partings and beds 1 to 2 inches thick and more. Locally in the subsurface, one or more beds of reddish brown, fine to medium grained, fossil fragmental, oolitic, silty, ferruginous limestone are present, typically at the base and occasionally in medial and upper portions of the unit.

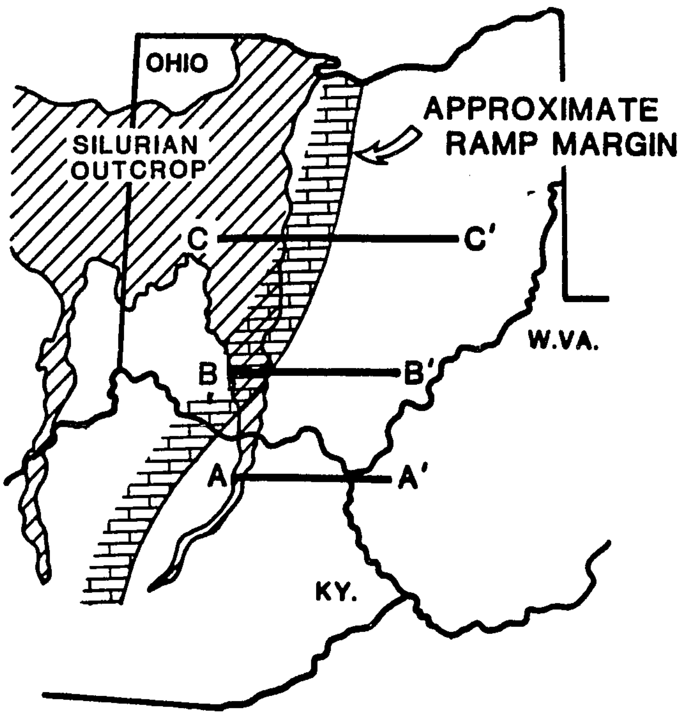
East of the western depositional margin of the Clinton sandstone (Fig. 13), the Oldham becomes markedly siltier, and contains a few thin stringers of light colored, argillaceous, dolomitic or calcareous, fine to medium grained siltstone. Clastic content in the Oldham continues to increase east of the study area in West Virginia, where in Kanawha County sandstones occupy the interval (Patchen, 1988, pers. comm.). Southeast of a meridian approximating the 20 foot isopach contour (Fig. 16), interbeds of gray, greenish gray, and some reddish gray, slightly micaceous, moderately soft to soft shale progressively expand to a thickness of several feet and split lower carbonate beds of the Oldham, resulting in the overall thickening of the unit in this direction (Fig. 9c, 10c, e).

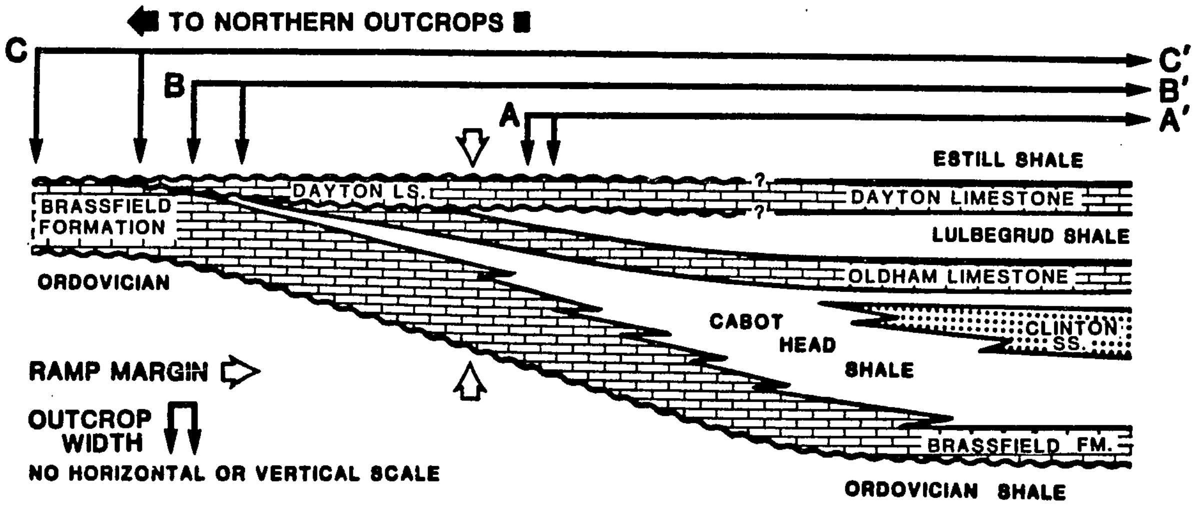
Regional Stratigraphic Relations - On the basis of lithology, thickness, and stratigraphic position, the Oldham Limestone can be traced eastward from outcrop into the subsurface, where it lies directly atop the Cabot Head Shale-Clinton sandstone sequence (Fig. 9). Ohio drillers' identify the Oldham as the "Packer", "2nd", or "Big" shell, and employ the carbonate as a marker bed signaling approach to the underlying sandstones.

Previously, the subsurface "Packer shell" (Oldham) has often been correlated with the Brassfield Formation in outcrop (ex. Knight, 1969, p. 1433; Nelson and Coogan, 1986, p. 4; COSUNA, 1985a, col. 1, 2, 8). However, Figures 9 and 10 clearly show that Brassfield strata extend from outcrop into the subsurface at the base of the Silurian; remaining beneath the Clinton sandstone. Also clear, are correlation of the drillers' "Packer" and "Casing" carbonate markers overlying the Clinton interval, with the Oldham and Dayton Limestones respectively.

Partially explaining the "Packer"-Brassfield miscorrelation is the common belief that ferruginous limestones are entirely confined to the Brassfield, when in fact, these beds show a fairly wide stratigraphic range within the lower Silurian and are common to Brassfield, Clinton, and Oldham strata. Further complicating subsurface to nearest-neighbor outcrop correlation is a westward trend of stratigraphic condensation and corresponding truncation of some Medina and lower Clinton Group units, as shown schematically in Figure 17. For example, in areas of Clinton drilling in eastern Ohio, the carbonates beds which overlie the Clinton sandstone are prominent, whereas Brassfield strata beneath are obscured by interfingering with shales of the Cabot Head (Fig. 17 A'-C'; see also Fig. 9a-c, eastern wells). Westward correlation from east-central Ohio (Fig. 17C-C') leads to outcrops lying atop the Wabash Platform where Dayton and Oldham strata have been erosionally removed and only the Brassfield persists, leading to the obvious, albeit incorrect, "Packer shell"-Brassfield correlation. Southward along the outcrop belt stratigraphic condensation is progressively less severe, owing to increasing distance away from the Wabash Platform (i.e. toward the basin), and eventually all of the carbonate units are fully represented in Kentucky outcrops, where the clearest avenue to link outcrop to subsurface exists (Fig. 17A-A').

Figure 17. Diagrammatic cross sections and map showing westward condensation of carbonate and shale units in the Medina and lower Clinton Groups. Cross sections perpendicular to the approximate ramp margin have nearly identical stratigraphic relations, and a full sequence of carbonate and shale units to the east in the subsurface. Westward toward the carbonate ramp (Wabash Platform), the stratigraphic sequence is progressively condensed as a result of depositional pinch-out and erosional truncation of shale and carbonate units. At outcrops A, B, and C different degrees of stratigraphic condensation occur, because the outcrop belt extends diagonally across the ramp margin. Thus travel to northern outcrops leads the observer from a position basinward of the ramp (A), across the ramp margin (B), and eventually to outcrops atop the carbonate ramp (C); the corresponding exposures along the path showing progressively greater stratigraphic condensation.


OHIO
SILURIAN OUTCROP
APPROXIMATE RAMP MARGIN
C
C'
B
B'
A
A'
W.VA.
KY.


TO NORTHERN OUTCROPS
C
C'
B
B'
A
A'
ESTILL SHALE
DAYTON LS.
DAYTON LIMESTONE
BRASSFIELD FORMATION
LULBEGRUD SHALE
OLDHAM LIMESTONE
ORDOVICIAN
CABOT HEAD SHALE
CLINTON SS.
RAMP MARGIN
OUTCROP WIDTH
NO HORIZONTAL OR VERTICAL SCALE
BRASSFIELD FM.
ORDOVICIAN SHALE

Oldham stratal equivalents are therefore absent in most areas north and west of the study area along the Cincinnati-Findlay Arch axis as a result of erosional overstep. Locally in northwestern Ohio, Janssens (1977, p.9) was able to differentiate Oldham rocks within his expanded Dayton Formation. It is recommended that the name Oldham Limestone replace the lower member of the Dayton Formation recognized by Janssens (1977, p. 12), and also the "unnamed dolomite" recognized on the Ohio Geological Survey (unpubl.) generalized column of rocks in Ohio.

In northeastern Ohio successive splitting of Oldham carbonates by tongues of shale make accurate correlations difficult (Nelson, 1983), although the Reynales Limestone of New York and Pennsylvania and the Dyer Bay Formation of Ontario are likely lithostratigraphic equivalents.

In West Virginia counties within the area of investigation the Oldham can be traced with certainty between the upper Cabot Head Shale below and the Rose Hill Shale above. In this area, and farther east, COSUNA (1985a, cols. 1, 2, 8, 9) identifies the carbonate unit in this position as the Brassfield Dolomite, and it is recommended that this term be replaced by the Oldham Limestone. Drillers include sandy Oldham rocks in West Virginia in their informal Cacapon "division", which loosely designates any interval of ferruginous sandstone near the base of the Rose Hill Formation.

LULBEGRUD SHALE

The Lulbegrud Shale is bounded above and below by carbonate rocks of the Dayton and Oldham Limestones, respectively, and is traceable throughout most of the study area (Fig. 18). Along the outcrop belt Lulbegrud shales are well exposed in southern Lewis and Fleming Counties, Kentucky (Locs. 26, 27; Plate 4a), but are difficult to distinguish with certainty or erosionally absent in counties further to the north (Plate 1b). In portions of Bath, Rowan, and Elliott Counties, Kentucky, the Dayton Limestone is absent by nondeposition and the Lulbegrud is continuous with the Estill Shale which elsewhere overlies the Dayton.

The Lulbegrud can be readily traced into the subsurface between the Oldham and Dayton Limestones (Figs. 9, 10). East of a meridian which approximates the western edge of Gallia County, Ohio and Boyd and Lawrence Counties, Kentucky the Lulbegrud is pierced by the thin Cacapon Sandstone (Figs. 9c, 10c, 10e, 21). Along the border of West Virginia, the eastern depositional edge of the Dayton is encountered (Fig. 18), beyond which the Lulbegrud is not recognized formally.

Contacts of the Lulbegrud with adjacent units are everywhere sharp, and most clearly distinguished on nuclear logs. The lower contact with the Oldham is considered conformable, whereas the upper contact with the Dayton is unconformable, at least locally in counties adjacent to the Ohio outcrop.

<u>Thickness</u> - The Lulbegrud is 6 to 10 feet thick in

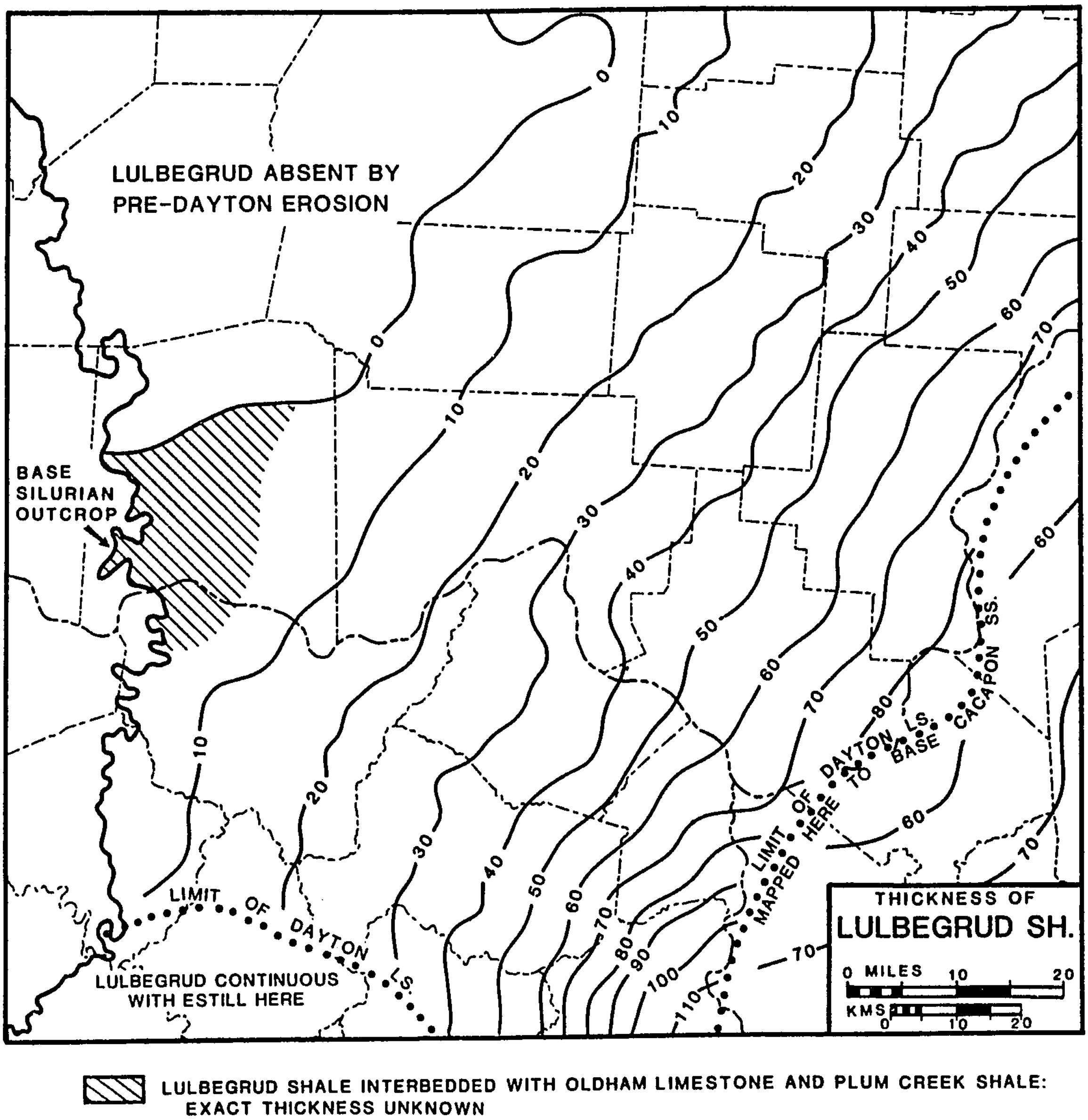


Figure 18. Thickness map of the Lulbegrud Shale shows thickening to the southeast and well defined northeast-southwest depositional strike. Contour interval 10 feet.

Kentucky outcrops, and thickens in a uniform manner to the southeast across the study area (Fig. 18). A maximum thickness in excess of 100 feet occurs in Lawrence County, Kentucky, where in addition the associated Dayton and Cacapon are uncharacteristically shaly. A decrease in isopach values in West Virginia counties results from a change in the mapped interval beyond the limit of the Lulbegrud/Dayton.

The eastward limit at which Lulbegrud shales are initially truncated by sub-Dayton erosion is not known, however, the greater spacing of contours at isopach values less than 30 feet may reflect a change in depositional slope and possibly mark the erosional margin. Depositional strike of the Lulbegrud is clearly defined as northeast-southwest, corresponding with that of the underlying Oldham Limestone (compare Figs. 18 and 16).

<u>Lithology</u> - The Lulbegrud consists of variably gray, greenish gray, and reddish gray, slightly silty, moderately soft shale, containing a few thin stringers of gray argillaceous dolomite. Lulbegrud shales directly adjacent to the Cacapon Sandstone are slightly micaceous and contain a few thin beds of argillaceous siltstone in addition to the dolomite stringers.

<u>Regional Stratigraphic Relations</u> - The Lulbegrud Shale can be traced from outcrop into the subsurface of southern Ohio and northeastern Kentucky, where it maintains a constant stratigraphic position between the Oldham and Dayton Limestones. The eastern limit of the Lulbegrud is defined

by pinch-out of the overlying Dayton Limestone along the West Virginia border, beyond which Lulbegrud shales are continuous with shales of the lower Rose Hill Formation.

In most areas north and west of Pike County, Ohio the Lulbegrud and lithostratigraphic equivalents are absent as a result of northwestward depositional thinning and erosional overstep by the sub-Dayton unconformity. Locally in northwestern Ohio, Janssens (1977, p. 9) was able to differentiate Lulbegrud shales in his expanded Dayton Formation. It is recommended that the term Lulbegrud Shale replace the "unnamed shale" recognized by Janssens (1977, p. 12) and the Ohio Geological Survey (unpubl.) generalized column of rocks in Ohio.

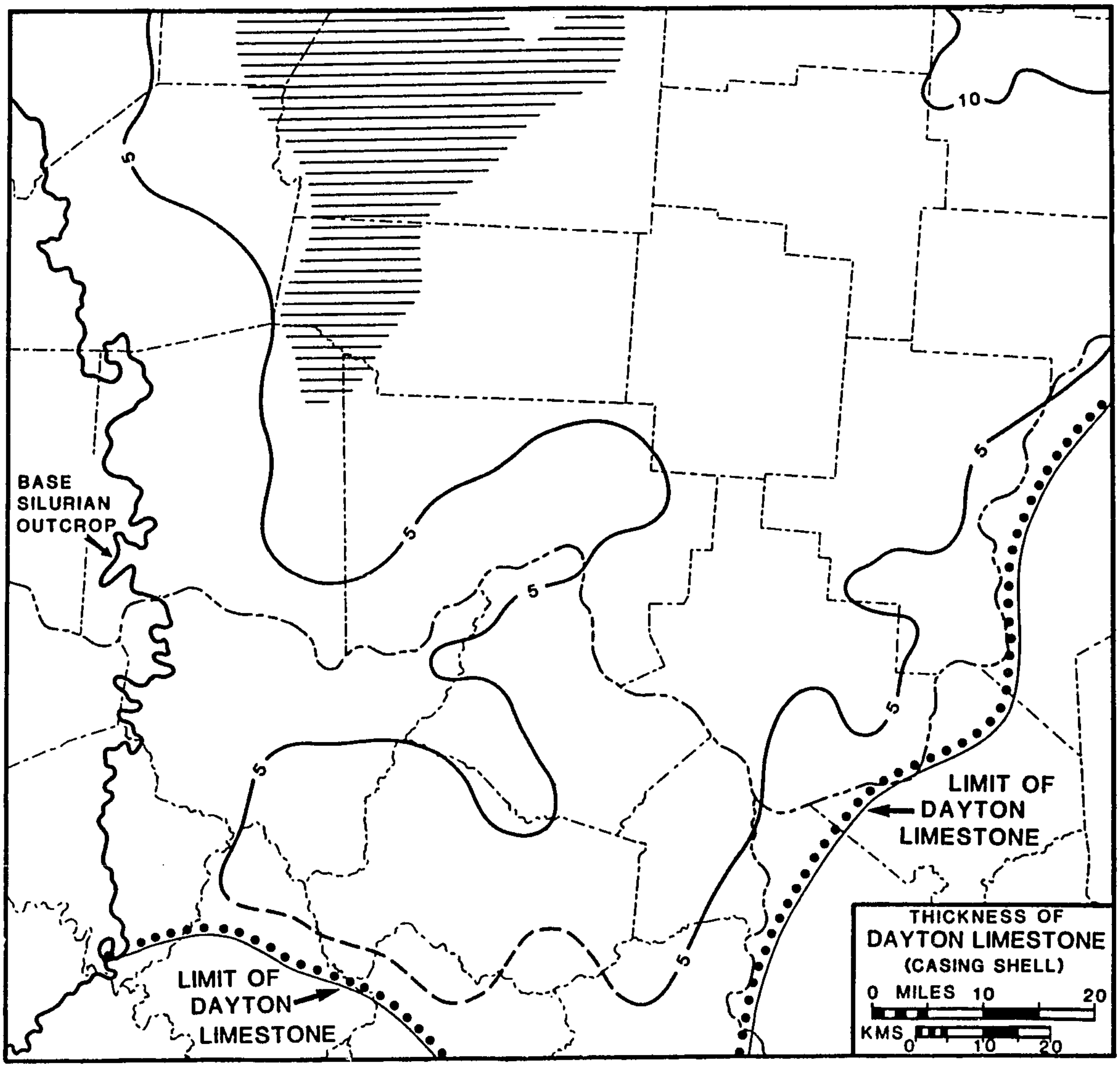
Correlation of the Lulbegrud with the Neagha Shale of Ontario and western New York (Santini and Coogan, 1983) is at best tentative, and at present it appears appropriate to employ the Kentucky nomenclature until substantive correlations to the northeast can be made. If in fact the Oldham and Reynales Limestones are equivalent as previously suggested, then the Sodus Shale of New York would be the likely Lulbegrud equivalent (Hunter, 1970, p. 103, 105), rather than the Neagha.

DAYTON LIMESTONE

The Dayton Limestone is a very thin, regionally persistent carbonate which extends throughout most of the study area (Fig. 19). The unit can be traced with certainty from the type area near Dayton, Ohio southward along outcrop into Fleming County, Kentucky, where it pinches out in outcrop and subsurface portions of southern Fleming, northern Bath, Rowan, and Elliott Counties. The Dayton persists eastward into the subsurface to a depositional edge which approximates the border of West Virginia with Ohio and Kentucky.

The Dayton is overlain throughout its extent by the Estill Shale. The contact is nearly everywhere sharp on nuclear logs, with shale cavings tending to obscure the contact in well samples. In outcrop a distinct biostratigraphic break occurs between the two units, indicating a paraconformable boundary at least locally (Berry and Boucot, 1970; Rexroad et al., 1965; Rexroad and Nicoll, 1972; Liebe and Rexroad, 1977). McDowell (1983, p. 19-20) expresses a conflicting opinion and considers the Dayton-Estill contact to be one of conformity in Kentucky outcrop.

North and west of Pike and Ross Counties, Ohio lithologic and stratigraphic evidence clearly indicate the presence of an unconformity at the base of the Dayton. Progressive erosional overstep sequentially removes the Lulbegrud Shale, Oldham Limestone, Cabot Head Shale, and upper Brassfield strata toward the northwest, with the



DAYTON LIMESTONE IN EROSIONAL CONTACT WITH OLDHAM LIMESTONE: COMBINED THICKNESS 10-24 FEET, NOT SEPARABLE ON LOGS

Figure 19. Thickness map of the Dayton Limestone shows depositional limits and regionally uniform thickness of generally less than 10 feet. Contour interval 5 feet.

Dayton resting on each unit in succession (Figs. 9, 10, 17; Plate 2b). South and east of the initial truncation margin of the Oldham Limestone (Fig. 16), the Dayton sharply overlies shales of the Lulbegrud and the areal limits of the unconformity can not be established with certainty.

Thickness - The Dayton is remarkably uniform in thickness. In outcrop the unit is typically 3 to 5 feet thick, and in most subsurface areas 5 to 10 feet thick (Fig. 19). Near the eastern limit of the Dayton along the West Virginia border, the unit thins to less than 5 feet prior to shaling out completely. North and east of the study area the Dayton expands slightly to over 10 feet in thickness (Summerson, 1963, p. 51).

Lithology - In well cuttings the Dayton is fairly homogeneous, and consists of light gray, greenish gray, and buff, locally mottled, fine to medium grained, dense, sparsely fossiliferous, slightly silty and argillaceous limestone and dolomitized equivalents which are characteristically glauconitic.

In cores and outcrop the Dayton is typically composed of 3 or 4 medium beds separated by thin shale partings, and exhibits a characteristic lumpy or mottled appearance as a result of extensive burrowing. To the east and south the Dayton becomes increasingly silty and argillaceous, is less frequently color mottled, and is more commonly a dolomite. Rarely is the Dayton ferruginous.

Regional Stratigraphic Relations - Within the area of investigation, the Dayton can be traced with certainty from outcrop into the upper of two thin carbonate units which overlie the Clinton Sandstone-Cabot Head Shale interval in the subsurface (Figs. 9, 10). The Dayton is identified by Ohio drillers as the "Casing", "1st", or "Little" shell, and eventually shales out along the West Virginia border.

South of its pinch-out in Bath, Rowan, and adjacent counties in Kentucky, the Waco Limestone occurs in a position stratigraphically equivalent to the Dayton, and also shows a close similarity in thickness and lithology (McDowell, 1983, p. 15; Rexroad, 1970, p. 92). Preliminary investigation of well data from south of the study area indicates the two units are continuous in the subsurface.

Regional limits of the Dayton in areas northwest of this study are poorly defined and should be traced. Dayton strata have been reported as far west as Franklin County, Indiana (Summerson, 1963); however they have not been recognized with certainty elsewhere on the western flank of the Cincinnati Arch. Both Horvath and Sparling (1967, p. 16) and Rexroad, Gray, and Noland (1983, p. 30) suggest that Dayton beds shale out into the lower Osgood Shale (Estill equivalent) to the west. It is interesting to note that the Lee Creek Member of the Brassfield Formation, defined by Rexroad (1980, p. 71) and locally present in Clark, Jefferson, and Ripley Counties, Indiana, contains a conodont assemblage comparable to the Dayton-Waco. Perhaps the Lee Creek represents a highly condensed lithostratigraphic equivalent of these units, which would correspond well with the established trend of westward sedimentary condensation in the Brassfield through Dayton interval (Fig. 17). Janssens (1977, p. 9) has recognized Dayton strata with certainty in northwestern Ohio.

In western New York and Pennsylvania the Wolcott Limestone occurs in a stratigraphic position similar to the Dayton (Hunter, 1970, p. 105), although direct correlation remains to be established.

CACAPON SANDSTONE

A thin persistent dolomitic siltstone which occurs in the southeastern part of the study area is tentatively correlated with the Cacapon Sandstone recognized by COSUNA (1985a, cols. 1, 2, 9) in eastern and central West Virginia The Cacapon extends throughout western West Virginia counties, and pinches out to the north and west in adjacent counties of Ohio and Kentucky (Fig. 20). Although the Cacapon lies closely beneath the Dayton Limestone, they are everywhere separated by intervening shales (Figs. 9c, 10e); the two units have an areal overlap about 15 miles in width and approximately subparallel depositional limits (Fig. 21).

The Cacapon is bounded above and below by shales of the Lulbegrud in the area of Dayton overlap, and shales of the Rose Hill Formation elsewhere (Table 7; Fig. 21 inset). Contacts of the Cacapon with bounding shales are typically sharp on nuclear logs, except locally in Lawrence and

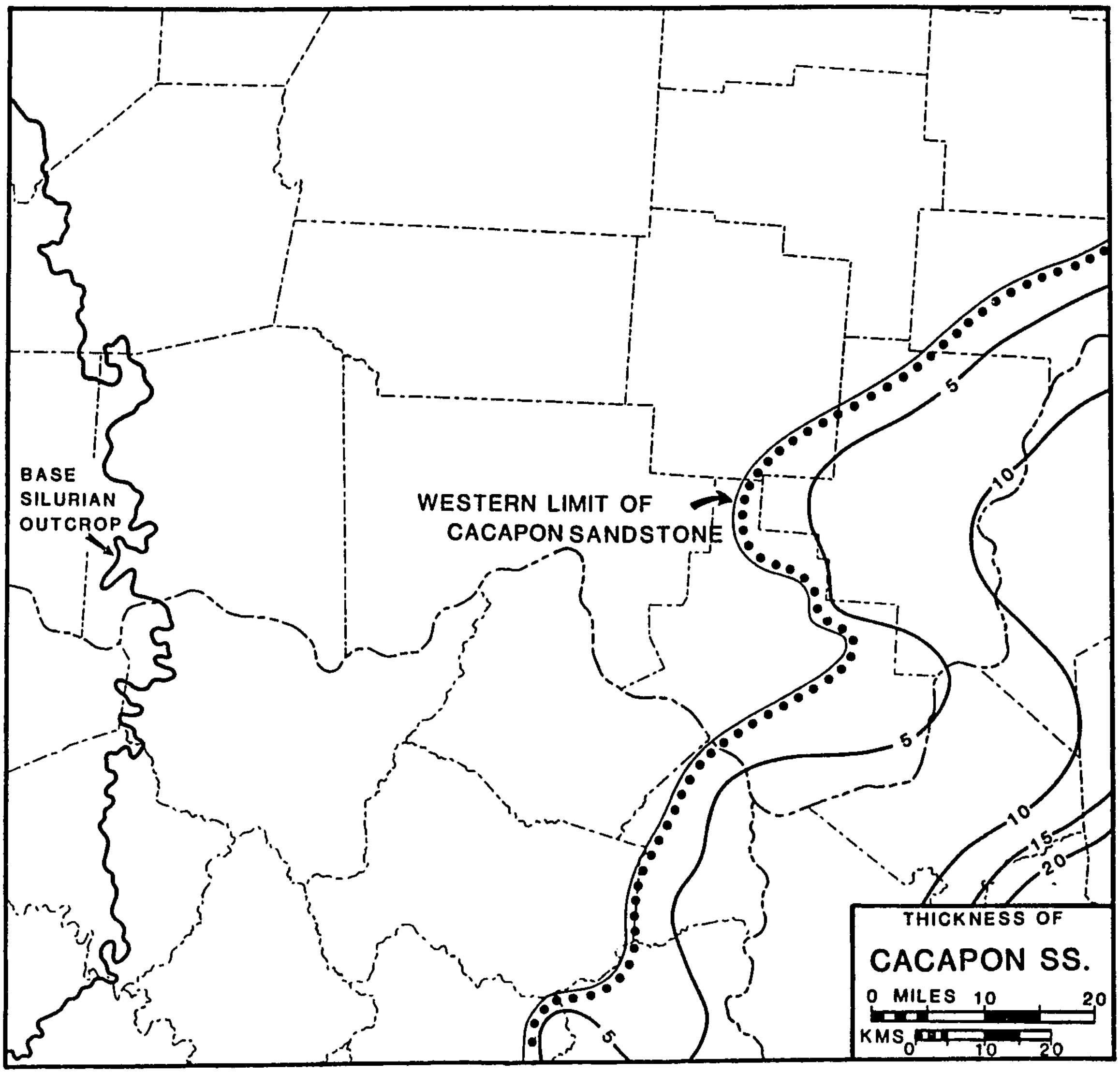


Figure 20. Thickness map of the Cacapon Sandstone shows thickening to the southeast and depositional limits. Contour interval 5 feet.

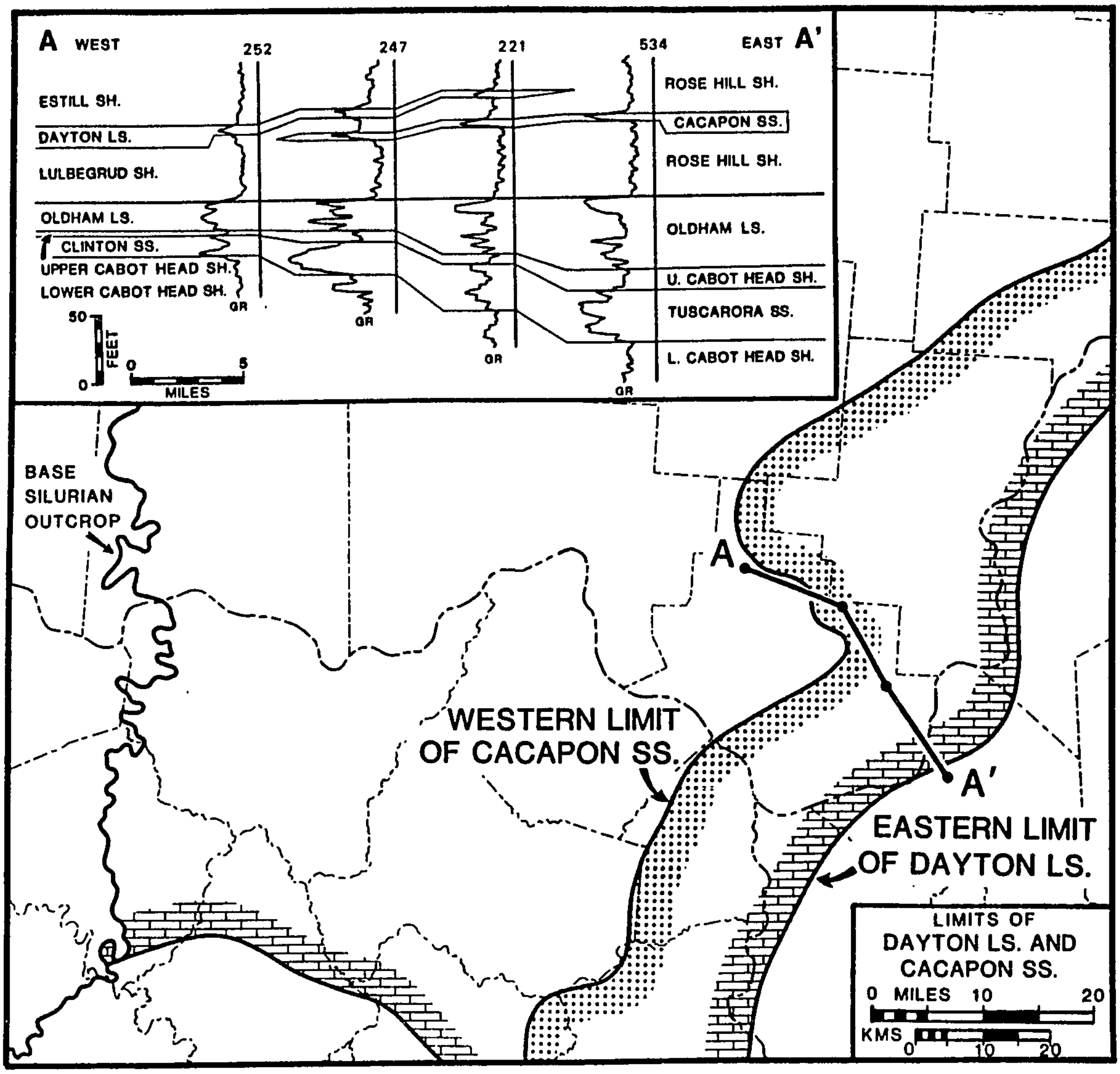


Figure 21. Dayton Limestone and Cacapon Sandstone depositional limit overlap and gamma-ray log cross section showing stratigraphic relation of the two units.

Elliott Counties, Kentucky where the unit is shaly and somewhat sporadic in occurrence.

Thickness - The Cacapon ranges in thickness from zero at its western depositional terminus to generally less than 10 feet (Fig. 20). Well 1625 in Lincoln County, West Virginia, however, shows a thickness of 21 feet which establishes the southeastward thickening trend.

Lithology - In well cuttings the Cacapon consists of light to medium gray and tan, fine grained, well sorted, slightly argillaceous and glauconitic, friable to compact dolomitic siltstone which is locally ferruginous. The unit becomes more argillaceous toward the western depositional limit, and is particularly shaly in the Rome Trough in Lawrence and Elliott Counties, Kentucky.

The geophysical log character of the Cacapon is variable, gamma ray, neutron, and bulk density curves indicating local changes from sandstone to carbonate. In some cases the Cacapon coincides with a low gamma ray-high bulk density character, very high in density (3.0 gms./cc.) and of low resistivity. Patchen (1988, pers. comm.) suggests that the mineral pyrite fits these criteria, and that the high bulk density interval is a very consistent marker in the Rose Hill Formation in southern West Virginia.

Regional Stratigraphic Relations - The Cacapon Sandstone in the study area is tentatively correlated as a western tongue of the more massive, commonly ferruginous Cacapon Sandstone Member of the Rose Hill Formation recognized in the subsurface of southern and eastern West

Virginia (COSUNA, 1985a, cols. 1, 2, 3, 9). Additional study is needed to define more clearly the relation between these units, and also potential correlation of the Oldham Limestone with Cacapon sandstone to the east.

In Virginia correlative sandstones are designated as either the Lower Hematitic Sandstone Member or Cacapon Sandstone Member of the Rose Hill Formation, and in Pennsylvania as the Castanea Sandstone Member (Hunter, 1970, p. 103; Smosna and Patchen, 1978, p. 2312-2313).

Although the Cacapon Sandstone and Dayton Limestone are not directly continuous, their very close stratigraphic proximity suggests that their origin is perhaps linked to a single basin-wide event, as considered more fully with in the discussion of paleogeography.

ESTILL SHALE

The Estill Shale is stratigraphically limited below by the Dayton Limestone and above by the Bisher Formation throughout most of its extent. Contact with the Bisher is considered conformable and varies from sharp to gradational on nuclear logs and in well samples (Fig. 24), whereas contact with the Dayton is typically abrupt (Fig. 9) and is paraconformable, at least locally.

Limited exposures of the Estill occur along the entire length of outcrop in Ohio and Kentucky (Plate 3a). In portions of Fleming, Bath, Rowan, and Elliott Counties, Kentucky where the Dayton Limestone is absent, the Estill can not be accurately distinguished from the Lulbegrud Shale which elsewhere underlies the Dayton (Fig. 22). South of Fleming County, Kentucky (Loc. 28) the Estill is unconformably overlain by the Devonian Ohio Shale in most outcrops and nearby subsurface, (Figs. 5, 22), except locally where isolated erosional remnants of the Bisher intervene (Plate 3b).

The Estill is readily identified from samples or gamma ray logs in the subsurface and can be traced with certainty into shales of the upper Rose Hill Formation. A functional boundary between the Estill and Rose Hill is set at the eastern limit of the Dayton Limestone which closely follows the western border of West Virginia (Fig. 22).

Thickness - The Estill Shale ranges in thickness from a minimum of less than 40 feet in Clinton County, Ohio to a maximum in excess of 170 feet in Gallia and Meigs Counties, Ohio; over a distance of approximately 75 miles (Fig. 22). Initial thickening of the Estill southeast of Clinton County is rapid and rather uniform, but where greater than 130 feet, the thickening is both more irregular and gradual. This change perhaps reflects different depositional patterns associated with the basin flank to the northwest, as compared to more central basin areas to the south and east. To the southeast the Estill-Bisher contact becomes increasing gradational and more difficult to determine (Fig. 24b, e), thus accounting in part for the more irregular contours.

Depositional strike of the Estill is most clearly

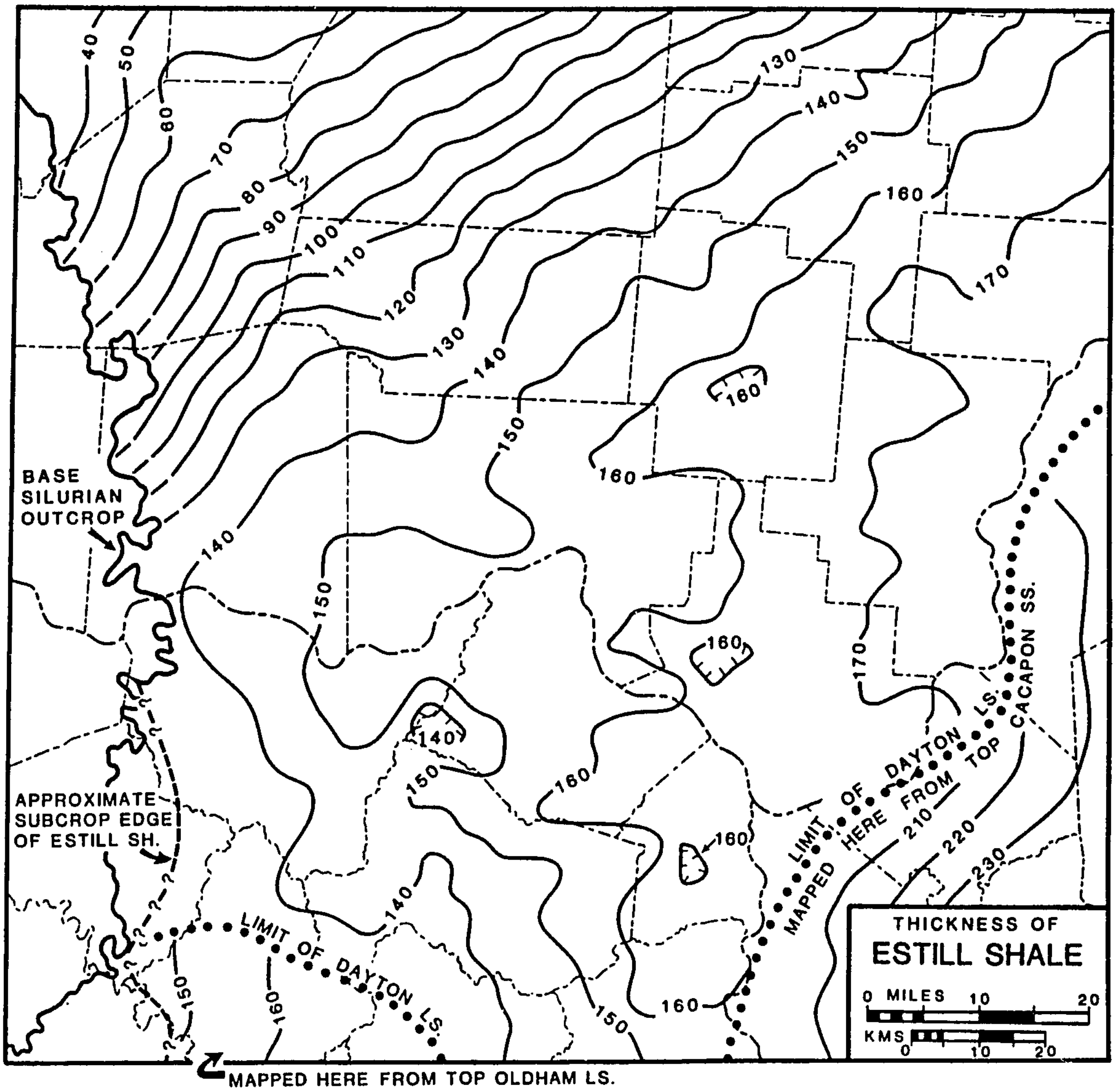


Figure 22. Thickness map of the Estill Shale shows southeastward thickening and well defined northeast-southwest depositional strike in the northern part of the study area. Note change in contours across limit of Dayton Limestone. Contour interval 10 feet.

defined in the northern one-third of the map, and trends east-northeast to west-southwest. This shows a continued clockwise rotation from the depositional strike of the underlying Lulbegrud and Oldham (compare Fig. 22 with Figs. 18 and 16).

A lobe of slightly thicker Estill, marked by the 150 foot contour, extends westward into Scioto and Adams Counties, Ohio and Lewis and Greenup Counties, Kentucky and corresponds to a similar trend in the Oldham Limestone (Fig. 16). The Rome Trough in Lawrence, Boyd, and Elliott Counties, Kentucky effects no apparent change in Estill thickness.

Lithology - The Estill consists principally of variably gray, greenish gray, and reddish gray, slightly silty and micaceous, moderately soft to soft, dull, dolomitic and locally calcareous shale. Glauconite is common in its shales and is commonly concentrated near the basal contact with the Dayton. Color of the shale is typically gradational from gray and greenish gray in upper portions to reddish gray and maroon near its base (Plate 3a).

Sparsely intercalated within the shale, especially near the upper contact with the Bisher, are yellowish gray and tan, very finely crystalline, argillaceous and silty, faintly cross bedded thin stringers of dolomite and more rarely limestone. To the southeast where the shale becomes siltier and more micaceous, thin interbeds of very fine to fine grained argillaceous dolomitic siltstone commonly occur near both lower and upper limits of the section.

Regional Stratigraphic Relations - The Estill Shale can be traced within the study area from outcrop eastward to the limit of the Dayton Limestone, beyond which it is stratigraphically coextensive with shales of the upper Rose Hill Formation. Northwest of the study area the lithostratigraphic equivalent is the Osgood Shale, which is recognized in west-central Ohio and portions of Indiana on the west flank of the Cincinnati Arch (Horvath, 1969, p. 332). Additionally, the Laurel Limestone and Massie Shale, which overlie the Osgood in west-central Ohio, have been considered equivalent to the Estill (Horvath and Sparling, 1967, p. 22); however, the true nature of their relationship to Estill or perhaps Bisher strata in southern Ohio remains to be firmly established and needs study.

The Estill has been traced to a depositional pinch-out in northwestern Ohio (Horvath, 1969, p. 329, Fig. 3; Janssens, 1977, p. 12), but has not been linked directly with strata equivalents to the northeast. There Berry and Boucot (1970) consider the Estill to be time-equivalent to all or portions of the Sodus Shale, Wolcott Limestone, Williamson Shale, and Irondequoit Limestone along the Niagara Escarpment in New York and Ontario. On the basis of lithology and stratigraphic position, the Williamson Shale appears most representative of the Estill, because the bounding Wolcott and Irondequoit carbonates correspond closely with the Dayton and Bisher, respectively.

Confusion surrounds the relationship between the Estill and Rochester Shales in the subsurface of northeastern Ohio, where both terms have been applied to the shale section bounded below by the Dayton Limestone and above by Lockport carbonates (Table. 4). Elsewhere, the Rochester and Estill (or equivalents) are everywhere separated, by the Keefer Sandstone in West Virginia and the Irondequoit Limestone in New York, and thus their equivalency in northeastern Ohio appears inappropriate. In northeastern Ohio the absence or poor recognition of Keefer-Irondequoit strata makes it difficult to demonstrate whether only one of the shales is present, and if so which one, or whether the two units have merged. Further study should be directed at this problem.

ROSE HILL FORMATION

The Rose Hill Formation is a recognized stratigraphic unit in this study only in West Virginia counties beyond the depositional pinch-out of the Dayton Limestone, where it designates all strata from the top of the Oldham Limestone to the base of the Keefer Sandstone (Table 7). Stratigraphic units occurring in the outcrop and subsurface of Ohio and Kentucky which are laterally coextensive with the Rose Hill Formation include, in ascending order, the Lulbegrud Shale, Cacapon Sandstone, and Estill Shale; only the Cacapon Sandstone being recognized as a formal member of the Rose Hill Formation.

Thickness of the Rose Hill Formation is not mapped separately. Rather, thickness of the Cacapon, and sub- and supra-Cacapon Rose Hill shales are presented in Figures 18, 20, and 22 in combination with their closest western equivalents. Also presented previously with these units is discussion of the lithology and regional stratigraphic relations of the Rose Hill.

BISHER FORMATION

In southern Ohio the youngest stratigraphic unit of the Clinton Group is the Bisher Formation, which is conformably bounded by the Estill Shale below, and the Lilley and Peebles Formations of the Lockport Group above. To the southeast, the clastic content of the Bisher steadily increases, and eventually the formation grades laterally into the Keefer Sandstone. The functional boundary between the Bisher and Keefer is set where the section is comprised of greater than 50 percent clastic material. This procedure defines an northeast-southwest arcuate trend extending along the western edges of Mason County, West Virginia and Lawrence County, Ohio and through the east central portions of Greenup and Carter Counties, Kentucky (Fig. 23). This limits the areal distribution of the Bisher to the northwestern two-thirds of the study area.

The lower limit of the Bisher is usually distinctive on nuclear logs, less so in well samples, and is placed at the base of an variably abrupt to gradual increase in gamma radiation intensity effected by Estill shales (Fig. 24). This contact is widely recognized by drillers, and is reported on scout tickets in Ohio as the base of the "Big

Lime", and in Kentucky as the base of the "Corniferous" or "Big Six sand".

In the northwestern one-half of the study area (Fig. 25) the Bisher is overlain by rocks of the Lilley Formation. In well samples the contact is usually transitional and is drawn at the top of the representative light gray and tan silty and sandy dolomite of the Bisher that is overlain by generally darker colored, fossiliferous and argillaceous dolomite of the Lilley. In wells where the basal Lilley is non-argillaceous, the boundary between the two formations is more obscure, and is drawn at the upper limit of carbonate beds containing appreciable quartz silt. In portions of Vinton, Hocking, and Athens Counties, Ohio, characteristic lithologies of the Bisher and Lilley, although recognizable, are not stratigraphically confined, and separation of the two units is impractical (Fig. 24a, e). The writer found no satisfactory method for distinguishing the Bisher and Lilley on nuclear logs. Beyond the traceable limit of the Lilley Formation, the Bisher is directly overlain by undifferentiated rocks of the Lockport Group (Lilley and Peebles combined; Table 7) which typically consist of relatively pure to slightly argillaceous, generally light colored crystalline dolomites.

Bisher strata are well exposed in outcrops of Adams and Highland Counties, Ohio, where the stratigraphy and lithology of the unit have been described in detail by other workers (ex. Bowman, 1956; Kallio, 1976; Lovrak, 1978;

Herring, 1987). South of the Ohio River (Loc. 23) the formation is everywhere truncated by the pre-Middle Devonian unconformity, with most outcrops restricted to thin erosional remnants occurring sporadically beneath the Ohio Shale as far south as Estill County, Kentucky (McDowell, 1983; Plate 3b). The initial erosional overstep of Bisher strata occurs a short distance east of the outcrop belt in the Kentucky subsurface, and is shown by the approximate subcrop edge in Figure 23.

Thickness - In subsurface the Bisher has a fairly uniform isopach, averaging between 40 and 50 feet in thickness (Fig. 23). Some local variation is present, with thicknesses ranging from less than 30 feet to in excess of 60 feet, although these are minor in comparison to overall uniformity. The formation has a weak thickening trend to the north and west.

The map of the Bisher includes 36 outcrop localities previously measured by Bowman (1956) and Herring (1987) in Adams and Highland Counties, Ohio. Here the Bisher exhibits stronger local variations in thickness, ranging from less than 30 feet to in excess of 70 feet over a distance of a few miles. In addition, local isopach mapping of outcrop areas shows a linear orientation of Bisher "thicks" along a northeast-southwest directional trend (Herring, 1987, p. 46; Swinford, 1983, p. 37-38). A similar trend, albeit obscure owing to limited availability of well data, is also suggested for subsurface areas.

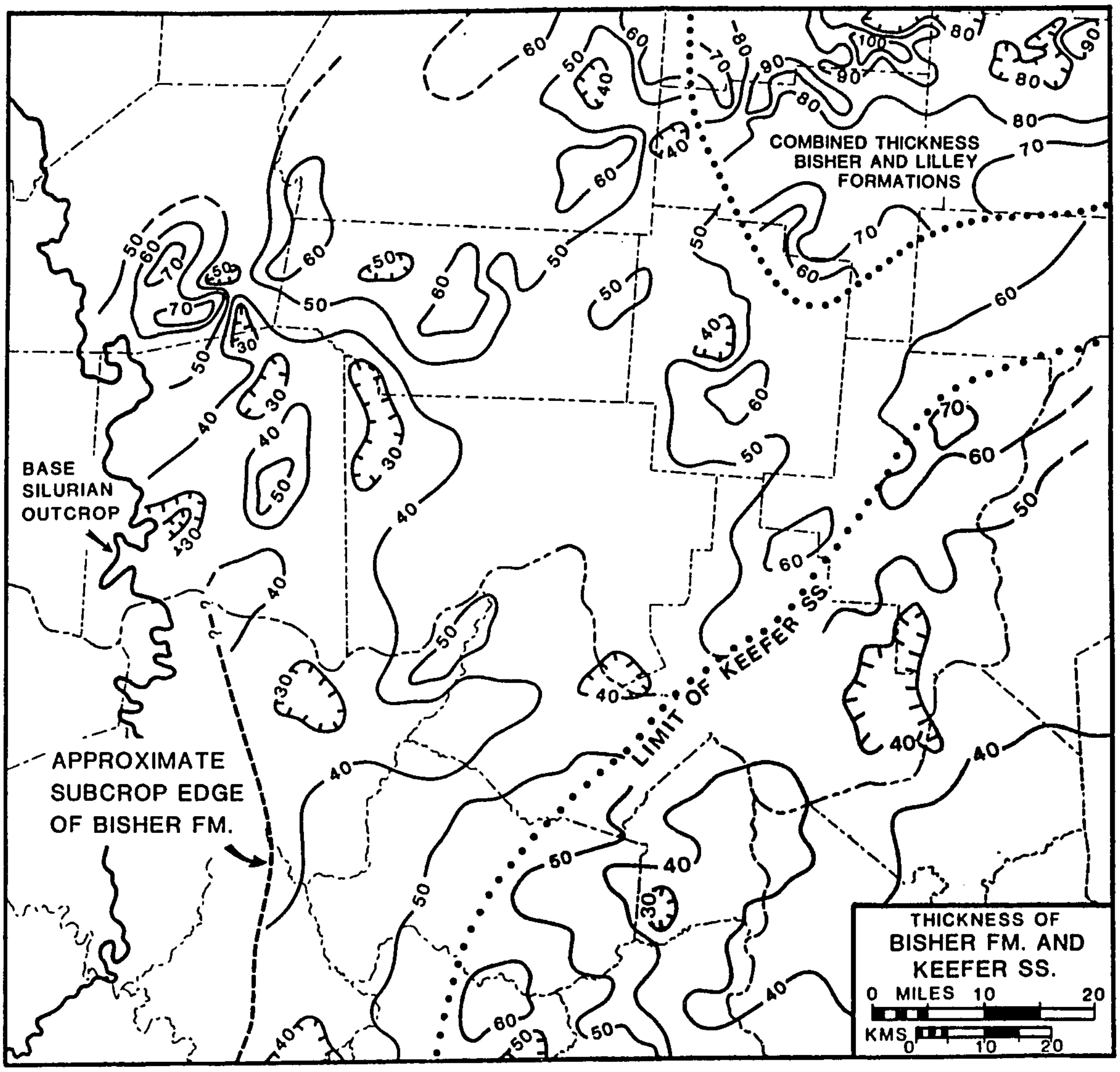


Figure 23. Thickness map of the Bisher Formation and equivalent Keefer Sandstone shows regionally uniform thickness distribution and faint north-northeast orientation of depositional "thicks". Contour interval 10 feet.

Figure 24 (map pocket). Nuclear log cross sections showing geophysical identification, correlation, and lithology of the upper Clinton, Lockport, and lower Salina Groups. See Appendix A for well identifications.

Lithology - The Bisher consists in well samples and cores chiefly of light to medium gray, brownish gray, and tan, rarely mottled, finely to medium crystalline, silty and sandy dolomite which is slightly argillaceous and pyritic, variably calcareous, and has scattered fossil debris. Thin partings and whispy laminae of medium gray shale are common. This lithology is most representative of the Bisher in southern Ohio, and corresponds directly to the silty carbonate lithofacies first defined in outcrop by Bowman (1956, p. 35). Northwestward in Clinton, Fayette, Highland, and western Ross Counties, the Bisher dolomite becomes increasingly calcareous and less silty, rarely occurring as a relatively pure, yellowish limestone. Toward the eastern limit of the formation the dolomite contains progressively more quartz silt and sand, and commonly includes beds of oolitic dolomite (Fig. 25a).

In counties which abut the northern boundary of the study area, and locally elsewhere, up to 30 percent of medial and upper portions of the Bisher section are comprised of medium to dark gray, very argillaceous to shaly, slightly silty dolomite. This lithology corresponds to the dolomitic shale and argillaceous dolomite lithofacies described in outcrops of Highland and Adams Counties by Bowman (1956, p. 40) and Herring (1987, p. 20), respectively. A proportionate increase in the argillaceous dolomite northward along outcrop is noted by Bowman (1956, p. 41), and Horvath (1964, p. 44) considers this the dominant Bisher lithology in portions of central Ohio.

Several bedding features are common to the silty Bisher dolomite in cores, and especially in outcrop where weathering accentuates their definition (Plate 4b, c). Common are hummocky bedding, low angle unidirectional and bimodal cross stratification, rippled and megarippled beds, parallel lamination, and graded bedding. Less commonly cut-and-fill structures, load casts, contorted bedding, and small shale diapirs are present. The thin, coarse grained bioclastic zone dominated by _Cryptothyrella_ _cylindrica_ brachiopods is widely persistent in outcrop, but cannot be traced in the subsurface, although it has been tentatively recognized in Pike County cores.

A cursory examination of the Bisher dolomite in thin-section shows 1) a generally equigranular hypidiotopic fabric consisting of coarse decimicron to fine centimicron grade crystals; 2) abundant skeletal fragments chiefly of echinoderm components; 3) dominance of nonferroan dolomite cement, with but minor ferroan zoned dolomite, calcite, and anhydrite cements; 4) scattered fine silt to sand grade quartz; and 5) 10 to 15 percent intercrystalline porosity. Routine SEM analysis reveals widely scattered amounts of pyrite, sparsely scattered clay in the form of illite as pore-fillings and grain coatings, and also some euhedral, authigenic quartz crystals (Plate 7a, b). A thorough petrographic description of the Bisher is presented by Lovrak (1978).

Regional _Stratigraphic_ _Relations_ - In the study area it is clear on the basis of thickness, lithology and stratigraphic position that the Bisher is laterally coextensive to the southeast with the Keefer Sandstone (Fig. 24).

Stratigraphic relations in west-central Ohio are less clear. Horvath (1964, p. 48) and Berry and Boucot (1970) consider the Bisher to be equivalent to the Euphemia and Springfield Dolomites in west-central Ohio, the latter of which contains fine silt grade quartz residues (Butterman, 1961, p. 58). Direct correlation, however, remains to be established owing to the sparse well control and large gap in exposures north of Highland County. The increasing prevalence of calcareous beds in the Bisher Formation in Clinton, Fayette and adjacent counties led Horvath (1964, p. 44) to speculate that the Bisher might also be equivalent in part to the Laurel Limestone of west-central Ohio and adjacent Indiana. The Laurel lies at the approximate stratigraphic position of the Bisher and also contains fair quantities of silt and clay residues (Summerson, 1963, p. 52). If a Bisher-Laurel correlation can be confirmed, the thin Massie Shale, which persists between the Laurel and Euphemia locally in Clark and Greene Counties, is the likely counterpart of the argillaceous dolomite lithology of the Bisher in southern Ohio. Additional study should be directed at stratigraphic correlation of Silurian strata between these areas.

Berry and Boucot (1970) assign an Early Wenlock age to the Bisher, and consider the Irondequoit Limestone to be the chronostratigraphic equivalent in New York and Ontario. This is further substantiated by the stratigraphic cross sections of Hunter (1970, p. 105, Fig. 4).

KEEFER SANDSTONE

The Keefer Sandstone is the eastern clastic equivalent of the Bisher Formation; the boundary between the two formations is gradational and is arbitrarily set where the interval consists of greater than 50 percent clastics. This restricts the Keefer within the area of investigation to western West Virginia, adjacent Gallia and Lawrence Counties, Ohio, and Boyd, Lawrence, and eastern portions of Greenup and Carter Counties, Kentucky (Fig. 23).

The lower boundary of the Keefer is conformable with underlying shales of the Estill and Rose Hill, and is typically gradational in both well samples and on nuclear logs where it is drawn at the first appearance of siltstone and sandstone beds overlying the continuous shale section (Fig. 24). Conformably overlying the Keefer are carbonate rocks assigned to the undifferentiated Lockport Group (Lilley and Peebles combined) in Ohio counties, and elsewhere to the Lockport Dolomite. The Keefer-Lockport Dolomite contact is gradational, with 10 to 15 feet of transitional silty carbonate occurring above the prominent sandstone interval (Patchen and Smosna, 1975, p. 2274; Smosna and Patchen, 1980, p. 631-631). On gamma ray logs the Lockport Dolomite carbonates effect a decrease in radiation intensity from the Keefer interval, which marks the general position of the contact (Fig. 24b, c, e). Contact of the Keefer with the undifferentiated Lockport Group in Lawrence and Gallia Counties, Ohio is also fairly distinct on nuclear logs, and is drawn in well samples at the top of a thin, oolitic dolomitic siltstone which persists between the two formations there (Fig. 24b, c). The direct juxtaposition of the Keefer (Clinton Group) with strata of the Lockport Group results from the absence of the Rochester Shale (Clinton Group) within the area of investigation; the Rochester intervening elsewhere in portions of West Virginia.

Thickness - Thickness of the Keefer is mapped continuously with the equivalent Bisher in Figure 23. Over most of its distribution the Keefer maintains a fairly uniform thickness, averaging between 40 and 50 feet. Slightly greater thicknesses, up to 70 feet locally, are present in Gallia County, Ohio.

Within the limited area of coverage, expression of linear thickness trends in the Keefer Sandstone is poor. Preliminary mapping of several counties south of the study area, however, indicate northeast-southwest oriented Keefer "thicks" which conform with previously recognized linear trends in other West Virginia counties (Smosna, 1983, p. 107, Fig. 8; Smosna and Patchen, 1978, p. 2315, Fig. 8).

Lithology - The Keefer consists principally of slightly mottled, light gray, tan, and rarely white, very fine to medium grained, subangular to subround, moderately to fairly well sorted, dolomitic and less commonly calcareous silty sandstone which is slightly pyritic, argillaceous, and friable. Thin interbeds and whispy laminae of medium to dark gray shale are common in the lower part of the unit, and gradually decline upsection where the sandstone is coarser grained, purer, and slightly lighter in coloration. In core 1549, Wayne County, West Virginia, Keefer sandstones are typically thin to medium bedded, homogeneous, and extensively burrowed; some also have faint, parallel lamination and cross stratification, and less commonly ripple lamination, shale rip-up clasts, flaser and graded bedding (Plate 5a, b).

Westward the Keefer becomes increasingly dolomitic and finer grained before eventually passing laterally into the silty dolomites of the Bisher Formation. In Ohio counties the Keefer is commonly a light gray to buff, fine to medium grained, slightly argillaceous dolomitic siltstone which is shaly at the base and commonly oolitic and slightly calcareous in the upper 10 feet.

Further lithologic and petrographic characterization of the Keefer is available in papers by Smosna (1983), Woodfork and Patchen (1970), Patchen (1968b), and Folk (1960).

<u>Regional Stratigraphic Relations</u> - The Keefer Sandstone is laterally coextensive with the Bisher Formation to the northwest and is recognized as a formation throughout West Virginia and adjacent portions of Ohio, Kentucky, Pennsylvania, Maryland, and Virginia. To the northeast the

Keefer can be traced into the Shawangunk Formation (Smosna and Patchen, 1978, p. 2316), and to the southeast into the thick, informal "Keefer" sandstone recognized by Dennison (1970) in Virginia. Along the Niagara Escarpment in New York and Ontario the equivalent stratigraphic position is occupied by the Irondequoit Limestone (Berry and Boucot, 1970; Hunter, 1970, p. 105, Fig. 4; Dennison and Head, 1975, p. 1097).

The Keefer is recognized by Kentucky drillers as the "Big Six sand", which includes additionally lower beds of the Lockport Dolomite (McKenzie Formation) as clearly shown by Patchen and Smosna (1975, p. 2278). Ohio drillers only rarely recognize the Keefer or the Bisher at the base of the "Big Lime", although this practice should be encouraged for both the acquisition of stratigraphic data and to determine the petroleum potential of the interval, which is currently productive in nearby Kentucky and West Virginia counties.

LOCKPORT GROUP

Rocks of the Lockport Group extend throughout the study area, except locally along the outcrop and in the nearby subsurface of Kentucky where pre-Middle Devonian erosion has completely removed this portion of the Silurian section (Fig. 5). In most southern Ohio counties the Lockport Group is represented by the Lilley and Peebles Formations, which are bounded below by the Bisher Formation of the Clinton Group, and above by the Greenfield Formation of the Salina Group. In counties bordering West Virginia and Kentucky, Lilley strata are not readily differentiated from overlying Peebles rocks, and here the two units are combined, and simply considered the undifferentiated Lockport Group (Table 7). Farther to the south and east, the Greenfield Formation of the Salina Group cannot be distinguished with certainty from undifferentiated Lockport Group rocks below; and the Lockport-Greenfield interval is combined into the Lockport Dolomite following the stratigraphic nomenclature of Smosna and Patchen (1980, p. 631).

Stratigraphic correlations of Lockport and overlying Salina units in the investigation area were determined by means of 11 nuclear log cross sections. These incorporated a total of 87 separate wells, 53 of which had sample suites or cores which were examined and used to substantiate log correlations. From this network five were selected and included in Figure 24; these show key correlations between Ohio, Kentucky, and West Virginia strata on the basis of nuclear log signatures and lithologies.

LILLEY FORMATION

The Lilley Formation maintains a constant stratigraphic position between the Bisher and Peebles Formations in the northwestern one-half of the study area and can be traced with certainty in Adams and Highland County outcrops, and through all or portions of Ross, Pike, Scioto, Greenup, and Jackson Counties in the subsurface (Fig. 25). To the northeast in Vinton, Hocking, and Athens Counties, lithologies characteristic of the Lilley are locally interbedded with lithologies typical of the Bisher and the two formations are not readily separable. Elsewhere in the investigation area the Lilley can not be traced with certainty.

Contacts of the Lilley with bounding formations are conformable and nearly everywhere gradational. In the majority of wells examined, basal Lilley beds consist of fossiliferous, variably argillaceous dolomite which is similar in appearance and transitional with underlying Bisher rocks; the formational contact being drawn in samples at the appearance of appreciable quartz silt which marks the upper limit of the Bisher. Neither unit exhibits a diagnostic log signature (Fig. 24). Southeastward the fossiliferous Lilley dolomite progressively incorporates quartz silt and eventually the contact with the Bisher becomes indistinguishable. Locally in a few wells where either basal Lilley beds or uppermost Bisher beds are markedly argillaceous or shaly, the contact is more clearly defined.

Upper portions of the Lilley typically consist of gray argillaceous dolomite which can be easily distinguished from the lighter colored, pure crystalline dolomite of the overlying Peebles Formation. Commonly the upper Lilley and Peebles dolomites are distinctly interbedded through a transition zone 10 to 20 feet in thickness; less commonly the contact is abrupt. Where an intercalated contact is present, the upper limit of the Lilley is placed at the highest occurrence of argillaceous dolomite, which commonly corresponds with a change in gamma ray log character from the rather erratic response of the Lilley to the uniform, low radiation intensity effected by the pure Peebles dolomite (Fig. 24). In a few wells where the upper Lilley consists of non-argillaceous rocks, contact with the Peebles is obscure. To the southeast the distinct lithologic differences between the two formations become less apparent owing to gradual changes in both (Fig. 24b, d; Bowman, 1988, pers. comm.). Eventually the two units cannot be separated, and are combined and mapped as the undifferentiated Lockport Group.

<u>Thickness</u> - A thickness map of the Lilley Formation is presented in Figure 25, and has been augmented in Adams and Highland Counties, Ohio by the addition of 28 outcrop sections measured by Bowman (1956) and Herring (1987). In northeastern counties of the study area where the Lilley and Bisher are not separable, the interval is mapped in combination and shown in Figure 23.

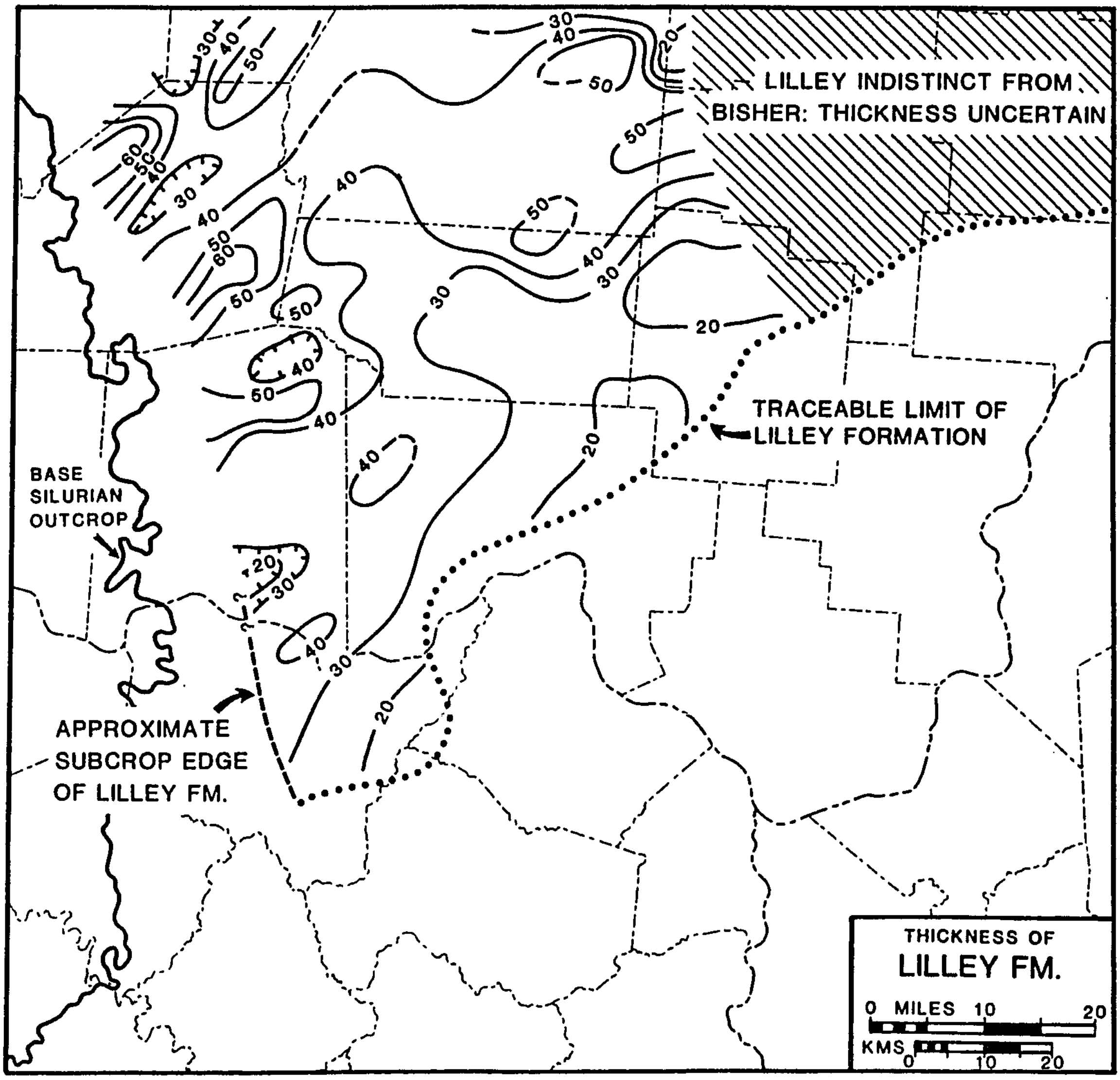


Figure 25. Thickness map of the Lilley Formation shows north-northeast orientation of sediment "thicks". Contour interval 10 feet.

Regionally, the Lilley averages approximately 45 feet in thickness with variations ranging locally from less than 20 feet to in excess of 60 feet. The overall thinning of Lilley strata to the southeast is in part real, and in part a result of vertical gradation with adjacent units near the traceable limit of the formation. Outlines of thick intervals of Lilley strata in outcrop, and less so in subsurface areas, clearly follow a northeast-southwest directional orientation which conforms to the trend established for the underlying Bisher Formation.

Comparison of the Lilley and Bisher isopach maps (Figs. 25 and 23) shows a general inverse relationship between the thickness of the two formations; areas of thickest Lilley corresponding to areas of thin Bisher and vice versa. This is most evident along and adjacent to the outcrop in Adams and Highland Counties where the availability of data is best, and less apparent in subsurface areas where well control is limited. Both Bowman (1956, p. 46) and Herring (1987, p. 55) have demonstrated that the thickness and distribution of various Lilley lithologies are strongly influenced by topography of the underlying Bisher, as further discussed below.

Lithology - The Lilley Formation consists of several different lithologies in the subsurface which vary locally both in thickness and occurrence, making the unit difficult to trace and to characterize in general terms. Bowman (1956, p. 17) noted similar circumstances in outcrop where he divided the Lilley into three principal lithologies, which have been further described by Kallio (1976) and Herring (1987). These include a crinoidal carbonate, argillaceous carbonate, and dolomitic shale; all three of can be recognized in the subsurface.

In well samples and cores, the counterpart of the crinoidal carbonate consists of light to medium gray and brownish gray, in part mottled white and tan, medium to finely crystalline, slightly silty and pyritic, variably argillaceous to pure dolomite containing scattered to abundant crinoidal fragments and other medium to coarse grained skeletal debris. The dolomite is locally calcareous, rarely oolitic, and ranges from moderately porous to dense. Gray shale as thin partings and whispy laminae, faint cross bedding, and burrow mottling are common, along with a few graded beds enriched in coarse grained fossil fragments and quartz silt. This lithology occurs nearly everywhere at the base of the Lilley, and locally ranges from less than 10 feet to nearly the entire Lilley section; rarely it also recurs near the top of the formation above the argillaceous carbonate lithology.

In outcrop, Herring (1987, p. 55, Fig. 23) and Bowman (1956, p. 46) demonstrate that local thickening of the Lilley crinoidal carbonate occurs in areas where the underlying Bisher is thin. A similar relationship was established in the subsurface nearby the outcrop; a more regional determination in the subsurface is restricted by the limited availability of well data and difficulties in selecting lithologic contacts without the aid of bedding and weathering characteristics used in outcrop.

The most distinctive Lilley lithology in the subsurface is the argillaceous carbonate, which consists of medium to medium dark gray, blue gray, and tan gray, finely crystalline, moderately to very argillaceous, rather dull, slightly silty, burrowed to faintly laminated dolomite. Dark gray dolomitic shale commonly accompanies this lithology, occurring as shale beds up to 1 foot thick in cores and comprising up to 25 percent of associated well cuttings. Although typically thin bedded and containing only scattered fine to medium grained fossil debris, the argillaceous dolomite in outcrop (Locs. 9, 11) and core can occur as biohermal, massively to non-bedded, grain-supported argillaceous dolomite containing abundant coarse grained fragmented and complete fossils, especially favositid corals and stromatoporoids. Also, in a few wells, the interval commonly occupied by argillaceous carbonate partially consists of medium tan to light tan gray, finely crystalline, only slightly argillaceous dolomite. This dolomite contains irregular shale partings and has a clotted or "brecciated" texture of possible algal origin.

Both argillaceous dolomite and dolomitic shale nearly everywhere occur in upper portions of the Lilley section; gradationally overlying Lilley crinoidal dolomite. Only rarely do they occur at the base of the Lilley in direct juxtaposition with the Bisher.

Of note is the distribution of the massively bedded biohermal phase of the argillaceous dolomite, which in outcrop is restricted locally to areas which are underlain by thick bodies of Bisher (Herring, 1987, p. 55). A similar relationship is suggested from cored wells in Highland and Pike Counties, where biohermal Lilley can be recognized with certainty; neither cuttings nor nuclear logs permit such a determination.

Regional Stratigraphic Relations - Areal restriction of the Lilley Formation to the northwestern one-half of the study area and to subsurface portions of counties directly adjacent to the north (Horvath, 1964, p. 69), limits the known stratigraphic relationships between the Lilley and strata from nearby areas.

Berry and Boucot (1970) assign a Lower Wenlock age to the Lilley and consider chronostratigraphic equivalents in New York and Ontario to include the upper Irondequoit Limestone, Rochester Shale, Decew Dolomite, and Gasport Dolomite, although direct correlation remains to be established. Additional study would perhaps allow the Lilley to be traced directly into Gasport rocks recognized in northwestern Ohio (Janssens, 1977, p. 18, Fig. 12), which occupy an appropriate stratigraphic position and display a grossly similar lithology. In west-central Ohio Berry and Boucot (1970) and Bowman (1956, p. 65) consider the Cedarville Dolomite to be equivalent to the Lilley on the basis of stratigraphic position, lithology, and contained fauna. Correlation farther west with units recognized in southeastern Indiana is unclear, although Berry and Boucot (1970) show the Laurel Limestone and Waldron Shale to be chronostratigraphically equivalent to the Lilley.

Beyond the traceable limit of the Lilley to the southeast, the formation grades laterally into undifferentiated rocks of the Lockport Group and can not be recognized with certainty in several southeastern Ohio counties (Figs. 24b, d, 25). Near the West Virginia border, however, rocks in the lower portion of the Lockport Dolomite show lithologic and distribution characteristics nearly identical to those of the Lilley (Smosna and Warshauer, 1983; Smosna and Patchen, 1980). And although the study of well samples and nuclear logs in this investigation did not allow these units to be traced directly one-to-one, their remarkable lithologic similarity and corresponding stratigraphic position strongly suggests lithostratigraphic equivalence.

PEEBLES FORMATION AND UNDIFFERENTIATED LOCKPORT GROUP

The Peebles Formation conformably overlies the Lilley in outcrops and the nearby subsurface in northwestern portions of the study area. The formational contact is typically intercalated, and is drawn at the change from gray argillaceous dolomite below to light yellowish gray, pure crystalline dolomite above. The contact becomes increasingly gradational to the southeast, until eventually the Peebles and Lilley cannot be consistently separated on the basis of log or sample characteristics; marking the traceable limit of the Lilley Formation (Fig. 25). Beyond this limit the two units are combined to form the undifferentiated Lockport Group, which conformably overlies Bisher-Keefer strata (Fig. 24b, d).

Overlying the Peebles is the Greenfield Formation of the Salina Group, except locally in a few outcrops and adjacent subsurface areas where the Ohio Shale is in direct juxtaposition as a result of pre-Middle Devonian erosion (Fig. 5). In outcrop, an abrupt contact separates the massively bedded light colored Peebles dolomite from the darker gray, thin bedded dolomite of the Greenfield (Plate 6a); the boundary is considered disconformable (Bowman, 1956, p. 143; Miller, 1955, p. 36). Up to 3 feet of local relief is present on the upper Peebles surface, and a thin seam of greenish gray shale commonly separates the two formations and at a few places fills solution cavities a few feet below the Peebles surface.

In the subsurface of Pike, Ross, northern Vinton, and Hocking Counties, Ohio, where the Peebles is thickest (Fig. 26), contact with the Greenfield remains sharp and disconformable, and is distinctive on logs and in well samples (Fig. 24a, b). The thin shale seam which persists at the contact in outcrop generally has a sharp radiation spike on gamma ray logs; this shale seam is also present in cores from Pike County where it overlies a few feet of severely brecciated and fractured Peebles rock. In well cuttings a sharp lithologic break occurs at the formational boundary, corresponding closely to the base of a slight upward increase in radiation intensity effected by the more argillaceous Greenfield (Fig. 24). In addition, caliper logs can show an abrupt widening of the bore hole in uppermost Peebles rocks owing to washouts of the shale and fractured dolomite. Only a few exceptional wells in Ross County show apparent interbedding of representative Peebles and Greenfield lithologies; where this occurs, it is in association with an atypical brown, dense, crystalline Peebles dolomite.

Elsewhere in the subsurface the boundary between the Greenfield and Peebles, or undifferentiated Lockport Group, is moderately gradational and considered conformable. In well samples the contact is drawn at the change from the relatively pure, yellowish gray, medium crystalline dolomite of the Peebles, to the medium tan and gray, finely crystalline, slightly silty, argillaceous, and anhydritic dolomite of the Greenfield; the lithologic change commonly takes place through a transitional interval 20 or more feet in thickness. On nuclear logs the argillaceous nature of Greenfield causes a characteristic increase in gamma radiation that makes the boundary a reliable marker (Fig. 24). Porosity logs typically indicate a zone of high-porosity at or near the top of the Peebles which corresponds loosely to the drillers' Newburg porosity zone (Fig. 6, well 221).

Strata of the undifferentiated Lockport Group and overlying Greenfield can be traced to the southeast where they loose their distinct identities, grading laterally into the Lockport Dolomite in counties which lie along the border of Ohio with West Virginia and Kentucky (Figs. 24c, 24e, 26, 27).

<u>Thickness</u> - Thickness of the Peebles is shown in Figure 26, and is mapped continuously with rocks of the undifferentiated Lockport Group beyond the traceable limit of the Lilley (Fig. 25). In southeastern areas beyond the traceable limit of the Greenfield Formation, the isopach interval is changed to conform with the limits of the Lockport Dolomite (undifferentiated Lockport Group and Greenfield equivalent combined).

The Peebles and undifferentiated Lockport Group are regionally thickest under cover of the Greenfield Formation in Ross, western Vinton, and Hocking Counties, Ohio, where the interval exceeds 170 feet along a well defined east-northeast oriented trend. The unit is comparatively thin in surrounding areas, varying locally from less than 110 feet to greater than 130 feet in Athens and eastern Hocking and Vinton Counties. Otherwise the Peebles-undifferentiated Lockport shows a general southward thinning pattern with a minimum thickness of less than 60 feet occurring near the traceable limit along the Ohio River.

The Peebles "thick" in Ross, Hocking, and Vinton Counties is best interpreted as an organic buildup associated with localized conditions conducive to biogenic productivity. This follows the conclusion of previous

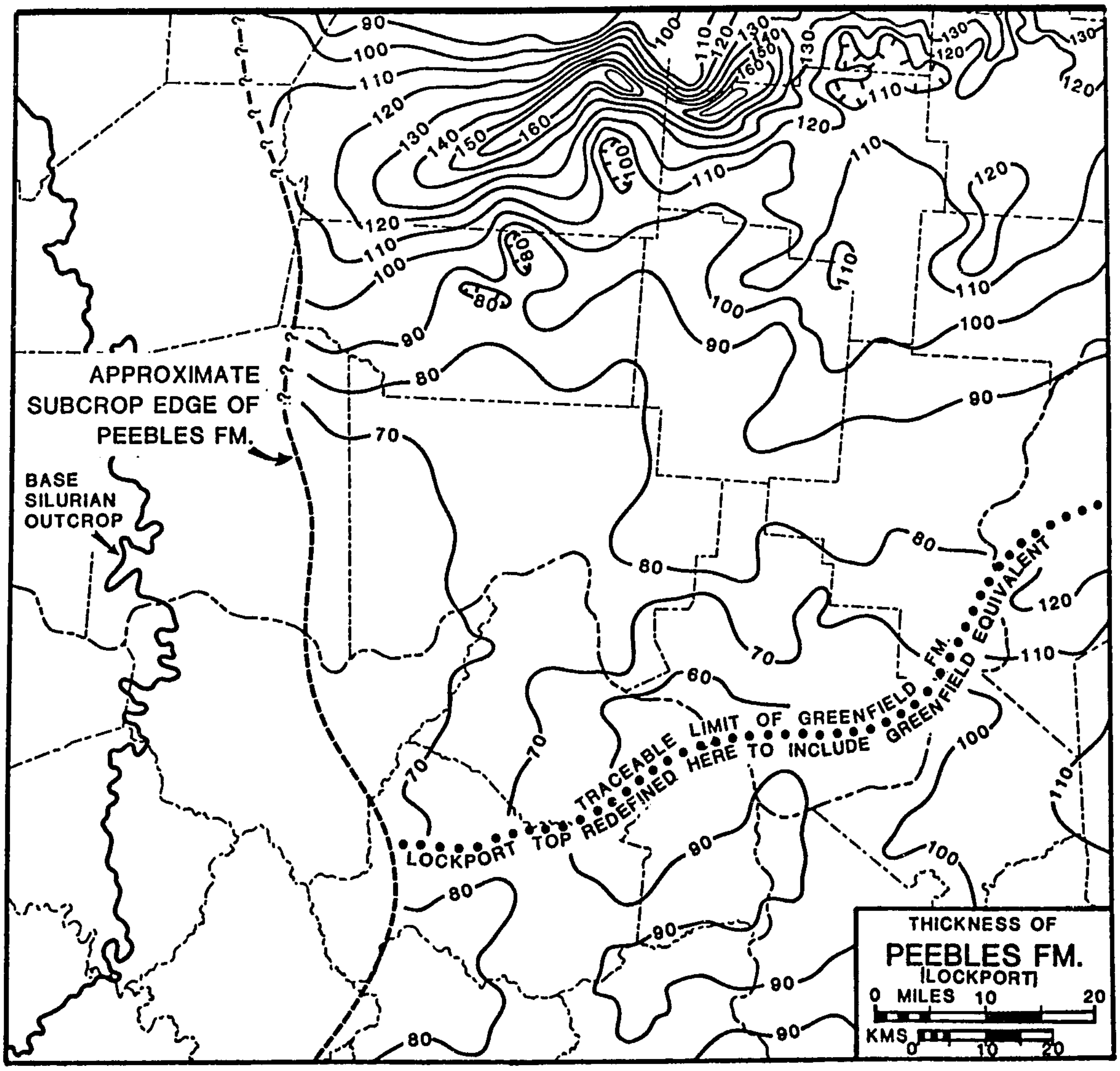


Figure 26. Thickness map of the Peebles Formation shows well defined east-northeast oriented reef trend extending through Ross, Vinton, and Hocking Counties, and general southward thinning elsewhere. Note south of the Greenfield traceable limit the mapped interval conforms with the Lockport Dolomite recognized in West Virginia. Contour interval 10 feet.

workers that Peebles and other upper Wenlock-lower Ludlow equivalents throughout the eastern midcontinent are comprised chiefly of reef, bank, and interreef strata (for example see Droste and Shaver, 1983, p. 20-21, Fig. 33, 1985; Shaver et al., 1978; Mesclella, 1978; Smosna and Patchen, 1978, 2318; Ulteig, 1964, p. 16-18; Floto, 1955; Mallin, 1951). The relation of this buildup to others recognized in the eastern midcontinent is discussed in regional paleogeography.

Lithology - The Peebles consists principally of light yellowish gray, light gray, and light tan, finely to coarsely crystalline, commonly sucrosic and sparry, pure, uncommonly homogeneous, massively bedded dolomite which in large part is fossil fragmental (Plate 5c). Fair to excellent vuggy and intercrystalline porosity is typical, especially near the upper contact. The relative purity, light coloration, and homogeneity of the Peebles dolomite make it distinctive in outcrop, core, and well samples, and also on gamma ray logs which exhibit a characteristically low radiation intensity for the formation (Fig. 24).

A cursory examination of thin sections indicates that a xenotopic mosaic consisting chiefly of medium decimicron to medium centimicron grade, low- and non-ferroan dolomite crystalline cement is most representative of the pure Peebles dolomite. Secondary porosity averages approximately 15 percent, and dissolution or replacement of allochems by dolomite is nearly complete. Fragments of corals, brachiopods, and bryozoans are recognizable, but are largely obscured by the extensive dolomitization. SEM reveals intracrystalline microporosity, caused by leaching of the cements, in addition to the more common intercrystalline macropores which are typically lined with euhedral coarse-centimicron grade dolomite rhombs (Plate 7c, d). Pyrite was not observed and only very sparse amounts of isolated illite are present as grain coatings.

Locally in southeastern Ross, southern Vinton, eastern Pike, Scioto, and Jackson Counties, 10 to 30 feet of medium- and brownish gray, finely to medium crystalline, sightly argillaceous and silty dolomite persists within the medial portions of the Peebles section (Fig. 24b well 86, 24c wells 212 and 219, 24d well 194). In well samples the darker coloration and impurity of this dolomite make it quite distinct from the representative light yellowish gray, pure Peebles dolomite above and below it; the argillaceous character of the medial zone effects a weak increase in gamma-radiation intensity on nuclear logs. Farther to the southeast, where the Peebles and Lilley merge into the undifferentiated Lockport, the medial argillaceous dolomite is less distinct owing to the darker coloration and more argillaceous character gradually taken on by the lower Lockport dolomite.

In Lawrence and Gallia Counties, Ohio the undifferentiated Lockport section is roughly divided into lower, medial, and upper portions which respectively correspond to the bioherm, sandy, and oolite lithofacies recognized by Smosna and Patchen (1980) in the nearby Lockport Dolomite (Lockport Member of the McKenzie Formation of Patchen and Smosna, 1975, p. 2275-2283). The lower undifferentiated Lockport consists of medium gray and brownish gray, mottled white and tan, finely to medium crystalline, variably calcareous and argillaceous, fossil fragmental dolomite which is commonly silty, especially near the base where it overlies the Keefer Sandstone. To the northwest this interval thickens and is laterally gradational with both the pure dolomite of the lower Peebles and at least upper portions of the Lilley Formation.

Medial portions of the undifferentiated Lockport near the West Virginia border consist of variably medium to light gray, tan gray, and tan, finely to medium crystalline, silty to very silty, slightly argillaceous dolomite. This interval carries a color which is often similar to, or lighter than the subjacent fossiliferous Lockport section, and typically the boundary between the two lithologies is gradational to obscure. To the northwest, the medial Lockport interval is continuous with the argillaceous and silty, darker colored dolomite piercing the Peebles section approximately in the center, and either thins or is partially replaced by more representative light colored Peebles rocks in that direction.

Upper portions of the undifferentiated Lockport section near the West Virginia border remain most similar to the lithology farther to the northwest, as yellowish gray and tan gray, finely to medium crystalline, slightly silty, very rarely oolitic, fairly homogeneous and pure dolomite.

Regional Stratigraphic Relations - The Peebles Formation of southern Ohio represents a portion of the upper Wenlock-lower Ludlow (Lockport) reefal carbonate blanket which covers much of the eastern midcontinent. Berry and Boucot (1970) recognize various Lockport Group members as chronostratigraphic equivalents along the Niagara Escarpment, including the Goat Island and Oak Orchard Members in New York, and the Lockport and Guelph Dolomites in Ontario. These correlations remain, as yet, paleontologic, even though Horvath (1964, p. 73) was able to extend the Peebles as far north as Morrow County, Ohio, while Janssens (1977, p. 17-22) has recognized the Goat Island and Guelph in directly adjacent Crawford County; additional work would presumably allow for physical correlation. Droste and Shaver (1982, p. 8-9, Fig. 4) have traced the Lockport of northwestern Ohio directly into the Salamonie Dolomite of adjacent Indiana.

Directly north and west of Highland County, the Peebles has not been identified in outcrop, although Calvert (1968, p. 70) has suggested the Peebles is coextensive in the subsurface with the Cedarville Dolomite of west-central Ohio. Similarly, Horvath and Sparling (1967, p. 22-23) link the Peebles with the "Guelph" in west-central Ohio; a term which they restrict in application to reefal portions of the Cedarville.

Traced to the southeast, the Peebles is stratigraphically continuous with most of the undifferentiated Lockport Group as defined in this study, and farther eastward, with the majority of the Lockport Dolomite (Lockport Member of the McKenzie Formation) as defined by Smosna and Patchen (1980, p. 631). Figure 24 shows regional correlations between these units, and demonstrates that the Lockport Dolomite includes both Lockport (Peebles and Lilley) and Salina Group (Greenfield) strata.

LOCKPORT DOLOMITE

The Lockport Dolomite is recognized in the area of investigation in counties of West Virginia and northeastern Kentucky that lie southeast of the traceable limit of the Greenfield Formation (Fig. 26). The formation is limited below by the Keefer Sandstone and above by Tymochtee equivalent strata (Table 7), and includes strata equivalent to the undifferentiated Lockport Group and Greenfield Formation recognized to the west (Fig. 24c-e). Use of the term Lockport Dolomite in this area follows the revised nomenclature of COSUNA (1985a, cols. 1, 8, 9) and Smosna and Patchen (1980, p. 631); the unit was originally named and described, and is identical with the Lockport Member of the McKenzie Formation (Patchen and Smosna, 1975, p. 2268).

The basal contact of the Lockport Dolomite with the Keefer Sandstone is conformable, and everywhere gradational through 10 to 15 feet of transitional silty carbonate lying above the prominent sandstone interval. On gamma ray and neutron logs the contact is marked by a gradual to abrupt upward decrease in radiation intensity, with the upper sandstone beds of the Keefer commonly showing an abrupt response on density curves. Contact between the Lockport Dolomite and Tymochtee equivalent is typically sharp and is drawn at the base of the medium to dark gray and brownish gray, finely to microcrystalline argillaceous dolomite that is underlain by generally lighter colored, coarser crystalline, relatively pure oolitic dolomite of the Lockport Dolomite. Lithologic characteristics of Tymochtee equivalent strata effect a markedly more erratic and higher gamma-radiation response in comparison to the lower, more uniform response typical of the Lockport Dolomite. Thus, the contact is a readily identifiable log marker (Fig. 24c, e).

Thickness - Thickness of the Lockport Member is shown in Figure 26 where the unit is recognized in southeastern portions of the study area beyond the traceable limit of the Greenfield Formation. The 20 to 40 foot increase in isopach thickness southeastward across the undifferentiated Lockport Group-Lockport Dolomite transition results from the inclusion of Greenfield-equivalent rocks in the latter (compare Greenfield edge in Fig. 27).

Thickness of the Lockport Dolomite increases to the east-northeast, ranging from less than 80 feet in Elliott and Carter Counties, Kentucky near the initial truncation edge of the pre-Middle Devonian unconformity, to in excess of 120 feet in Mason County, West Virginia. The irregularity of thickening, which is especially noticeable along the 90-foot contour, is principally a result of differential thickening of the biohermal facies in its lower parts as demonstrated by Smosna and Patchen (1980, p. 634, Fig. 5) and Smosna and Warshauer (1983, p. 32, Fig. 3). Additionally, the Rome Trough which extends through Elliott, Boyd, and Lawrence Counties, Kentucky, may have effected minor thickness variations in the Lockport Dolomite.

Lithology - Smosna (1974) divided the Lockport Dolomite in western West Virginia counties into three vertically stacked lithofacies; including a lower biohermal carbonate, a medial sandy dolomite, and an upper oolitic dolomite. Additional lithologic descriptions, petrographic characterizations, and subsurface correlations have been presented by Patchen and Smosna (1975), Smosna and Warshauer (1978, 1983), and Smosna and Patchen (1980); the lithofacies having been further traced throughout Kentucky counties by Currie (1981, p. 27-30) and Currie and MacQuown (1984, p. 6-12). This study adds little to these investigations, and in the following discussion of the lithologies, emphasis is placed on well cutting descriptions completed in the course of this project, accompanied by brief reviews of core descriptions provided by the aforementioned authors.

In well cuttings, lower portions of the Lockport Dolomite consist of fossil fragmental dolomite, which is medium gray and brownish gray, commonly mottled white and tan, medium to finely crystalline, slightly to moderately argillaceous, silty, and variably calcareous. Gray shale forms up to 20 percent of individual samples. In core, the corresponding biohermal lithofacies is calcareous dolomite consisting in large part of whole and broken fossils entombed in a gray to brownish gray, typically burrow mottled, slightly argillaceous and silty matrix which decreases in abundance upsection (Smosna, 1974, p. 11-12). Smosna and Warshauer (1983, p. 33-36) document the occurrence of faunal zonation; a crinoid-bryozoan bafflestone persisting at the base, overlain by coral, and finally stromatoporoid-coral framestone at the top of the bioherm interval. They further demonstrate (1983, p. 47) that the bioherm lithofacies is thickest where underlain by thick Keefer Sandstone, and that where Keefer sandstones are comparatively thin the overlying biohermal Lockport is represented chiefly by argillaceous to shaly, moderately to poorly fossiliferous dolomite.

In samples, medial portions of the Lockport Dolomite consist of light and medium gray, light brown gray, and tan, silty to very silty, finely crystalline, slightly argillaceous dolomite which is typically gradational with the underlying fossiliferous dolomite. In core, the corresponding interval is a sandy microcrystalline dolomite or very fine grained dolomitic sandstone, which is variably laminated to burrow mottled, rarely cross-bedded, and contains a few flat shale-pebble intraclasts, mud cracks, and sparsely scattered fossil fragments (Smosna, 1974, p. 9-11; Smosna and Warshauer, 1978, p. 136).

Yellowish gray, light to medium tan, and light gray, finely crystalline, slightly silty oolitic dolomite is representative of upper portions of the Lockport Dolomite in well cuttings. In core, the interval is a light colored oolitic dolomite or calcareous dolomite, with ooids increasing in abundance and size upsection, irregular to thin bedding, faint burrow mottling and cross-bedding, and scattered fossil fragments, intraclasts and sand grade quartz grains (Smosna, 1974, p. 9; Smosna and Warshauer, 1978, p. 132).

Gamma ray log characteristics allow separation of the biohermal, sandy, and oolitic facies (Fig. 24e; Smosna and Patchen, 1980, p. 636, Fig. 7; Patchen and Smosna, 1975, p. 2279-2282, Figs. 15-19). Typically the biohermal facies at the base of the Lockport exhibits a very low gamma-radiation response, and is overlain by a zone showing the highest gamma-radiation response in the Lockport and corresponding to the sandy facies, and finally an intermediate and locally hackley response in upper portions which correlates with the oolitic facies.

Regional Stratigraphic Relations - It is clear the Lockport Dolomite is coextensive with undifferentiated Lockport Group and Greenfield strata recognized to the northwest on the basis of stratigraphic position, lithology, and nuclear log characteristics (Fig. 24). Of additional interest is the relationship between the three established lithofacies of the Lockport Dolomite and stratigraphic divisions recognized in Ohio.

The bioherm lithofacies of the Lockport Dolomite can be traced directly into the lower section of undifferentiated Lockport in Lawrence and Gallia Counties, Ohio, which as suggested, includes strata equivalent to the lower Peebles and Lilley farther to the northwest (compare Fig. 24b and 24e). The compelling similarity in lithology and distribution of the Lilley Formation in northwestern areas with the biohermal lithofacies of the Lockport Dolomite in West Virginia counties strongly suggests lithostratigraphic equivalence; the representative lithology of the lower Peebles section being largely distinct from both. However, lithofacies determined from sample suites examined in this study and from cores nearby the outcrop (Bowman, 1988, pers. comm.) suggest that the lower Peebles and Lilley gradually merge to the southeast with concomitant changes in each, eventually grading into the biohermal lithofacies as a combined unit.

The thin tongue of slightly argillaceous and silty, darker colored dolomite medially piercing the Peebles dolomite and extending locally as far west as Pike and Ross Counties, likely represents a vestige of the middle sandy dolomite lithofacies of the Lockport Dolomite. To the east, Patchen and Smosna (1975, p. 2276) have linked the middle sandy McKenzie interval with a westward-projecting tongue of the Bloomsburg Formation; namely the Rabble Run Redbed Member.

The oolitic dolomite lithofacies of the Lockport

Dolomite displays characteristics of both the Greenfield Formation, which contains oolitic beds at the base in Ohio, and upper Peebles-undifferentiated Lockport rocks, which are typically light colored and pure (Fig. 24). The amalgamation of Greenfield-upper Peebles strata into West Virginia is important for two reasons. First, it reveals rapid southeastward thinning of the interval, from in excess of 230 feet in Ross County, Ohio to generally less than 60 feet in Mason County, West Virginia, over a distance of approximately 70 miles. Second, it suggests continuous deposition across the Lockport-Salina boundary, at least locally. This reinforces the opinion of Droste and Shaver (1982, p. 2; 1985, p. 80-84) and others that a regionally pervasive unconformity does not occur at the Lockport-Salina boundary, a controversial subject for decades.

The McKenzie Formation *in toto*, in which the Lockport Dolomite was originally correlated, has been traced from outcrop in the Valley and Ridge throughout the subsurface of West Virginia and portions of adjacent states (Travis, 1962a, 1962b; Smosna and Patchen, 1978). The McKenzie is eventually replaced northeastward into Pennsylvania and Maryland by lower and middle redbeds of the Bloomsburg Formation and upper Shawangunk sandstones (Patchen and Smosna, 1975, p. 2267), and to the southeast into Virginia the formation grades into the thick "Keefer" sandstone recognized there by Dennison (1970, p. 9).

SALINA GROUP

In southern Ohio, the lack of diagnostic evaporite beds limits application of the lettered A-G unit stratigraphy of Landes (1945) which is used elsewhere to subdivide the Upper Silurian section; in southern Ohio the Salina Group is simply split into the Greenfield and Tymochtee Formations. These correlate roughly with the A unit, and B through G units respectively, as recognized in northern Ohio by Ulteig (1964, p. 22-26) and Janssens (1977, p. 25-26).

In the study area, shales characteristic of the C unit are clearly recognizable within the otherwise undifferentiated Tymochtee Formation; these shales provide a regionally useful stratigraphic marker. Recognized beneath the C unit in southern Ohio and adjacent counties in Kentucky are the Tymochtee Formation (sub-C unit restricted) and the Greenfield Formation (Table 7, Fig. 24). Eastward into West Virginia, the Greenfield Formation grades into the Lockport Dolomite, which is there overlain by Tymochtee equivalent strata and the C unit. Locally present within the C unit are sandstone beds correlative with the drillers' Newburg ("Williamsport") sandstone.

In this investigation, only the lower portion of the Salina Group is examined in detail, the upper limit of study being drawn at the top of the C unit. For descriptions of supra-C unit Tymochtee strata (undifferentiated Salina) in Ohio see Horvath (1964, p. 97-122), and for Salina D unit and younger strata in West Virginia see Smosna et al. (1977) and Smosna and Patchen (1978).

GREENFIELD FORMATION

The Greenfield Formation is stratigraphically positioned between the Peebles and Tymochtee Formations, and can be traced with certainty from outcrop to counties near the border of Ohio with West Virginia and Kentucky (Fig. 27). There the Greenfield loses identity, merges with undifferentiated Lockport strata, and grades laterally into the Lockport Dolomite (Figs. 24, 26). Contacts of the Greenfield are locally unconformable in the northwestern one-third of the study area where it disconformably overlies Peebles strata, and also adjacent to the outcrop where it is unconformably overlain by Devonian Ohio Shale. Elsewhere the Peebles and Tymochtee bound the Greenfield in conformable fashion.

In outcrop the Greenfield-Tymochtee formational boundary is gradational and not readily determined (Plate 6b), and is set rather arbitrarily (Miller, 1955, p. 37; Schmidt et al., 1961, p. 287). In well samples, the contact is also gradational, and is placed at the transition from the gray and brown gray, microcrystalline to lithographic, dull, argillaceous dolomite above, which is generally underlain by tan and gray, finely crystalline, saccharoidal dolomite. No distinct lithologic break occurs, however, and the respective Tymochtee and Greenfield lithologies are typically gradational through an interval 10 to 40 feet in thickness, with the representative lithology of each becoming progressively more distinct with added distance from the contact. On nuclear logs, a regionally persistent gamma ray shoulder lying within the zone of lithologic transition was employed to separate the two formations, Tymochtee rocks having a higher radiation intensity (Fig. 24a, b, e).

Thickness - The Greenfield thickens to the north across the study area, from generally less than 35 feet along its southern traceable margin, to in excess of 60 feet in Ross, Hocking, and Athens Counties, Ohio (Fig. 27). The formation continues to expand northward into central Ohio, where it averages approximately 150 feet in thickness (Ulteig, 1964, p. 21, Fig. 8; Horvath, 1964, Plate III).

The inverse thickness relationship between Greenfield and Lockport strata demonstrated by Ulteig (1964, p. 20) in northern Ohio is not apparent in this study. Instead, the Greenfield isopach remains fairly uniform in areas of maximum Lockport thickness (compare Figs. 27 and 26; Fig. 24a).

Miller (1955) and Schmidt et al. (1961) report Greenfield thicknesses of approximately 25 feet from outcrops in Adams and Pike Counties (Locs. 12, 15). These are significantly less than the 40 to 45 feet of Greenfield recognized in nearby subsurface areas of Pike and Scioto Counties, suggesting that the Greenfield-Tymochtee contact employed in the subsurface lies 15 to 20 feet above the arbitrarily established contact in outcrop. The additional subsurface section corresponds closely in thickness to the informal lower Tymochtee recognized by Schmidt et al. (1961,

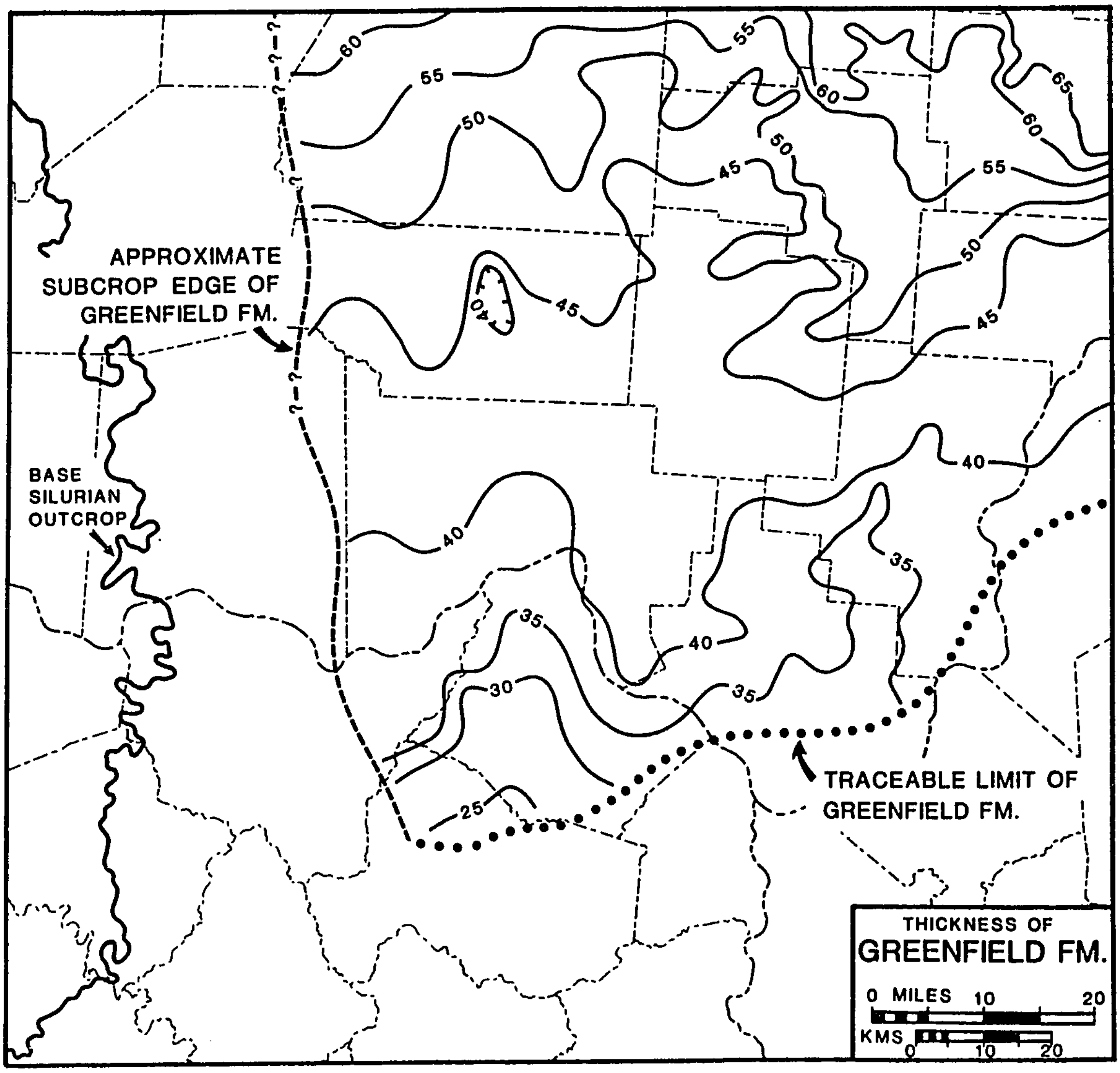


Figure 27. Thickness map of the Greenfield Formation shows irregular thickening to the north across the study area. Contour interval 5 feet.

p. 286) in Adams County outcrop; thus, the Greenfield mapped in the subsurface of this study represents both Greenfield and Lower Tymochtee rocks in outcrop section. Only locally on gamma ray logs, and rarely in well cuttings, is the informal lower Tymochtee-Greenfield boundary of outcrop distinguishable within the established boundaries of the subsurface Greenfield; the contact occurring respectively at 600 and 2,690 feet in wells 22 and 1222 in Figure 6.

Bowman (1988, pers. comm.) recommends that the Greenfield-Tymochtee boundary in outcrop be raised approximately 18-20 feet to be the same contact as has been used for the informal upper and lower Tymochtee; based on distinct lithologic and paleontologic differences and a local unconformity present at the latter boundary. This revison would bring the outcrop and subsurface stratigraphy into agreement. However, before the change is formalized, additional study is necessary to more accurately describe and trace the revised boundary in outcrop.

Lithology - In subsurface the Greenfield consists of typically uniform tan to medium gray, finely crystalline, slightly silty dolomite that generally displays a saccharoidal crystalline texture. Commonly it becomes more coarsely crystalline and lighter colored down section, with several feet of oolitic dolomite occurring near the basal contact. Fair to good intercrystalline and vuggy porosity is present in isolated zones, but the majority of the formation is dense and tight. Traces of white, finely crystalline anhydrite commonly occur in well samples from the Greenfield in areas east of Ross County and north of Lawrence County, Ohio.

In cores the Greenfield is a tan and grayish tan, thin to medium bedded dolomite which displays, as a rule, horizontal and contorted algal(?) lamination, faint cross-bedding, black carbonaceous partings and stylolites, and color banding (Plate 5d). Less common are thin intraclast breccias, scattered fossil fragments, burrow mottling, and bird's-eye structure. This corresponds closely to the representative Greenfield lithology described from outcrop by Miller (1955, p. 55-70), where in addition, the formation locally contains massively bedded algal(?) bioherms less than 10 feet in thickness.

A cursory study of Greenfield dolomites in thin section indicates an interlocking mosaic of anhedral to subhedral, fairly equigranular medium to coarse decimicron grade, non- and low-ferroan crystalline dolomite, with very slight intercrystalline porosity and scattered coarse silt grade quartz is most representative. Routine SEM analysis revels the presence of pyrite in scattered areas, widely dispersed illite particles as grain coatings, and more extensive dolomitic cementation than witnessed in Peebles samples (Plate 7e).

<u>Regional Stratigraphic Relations</u> - The Greenfield Formation defined in the subsurface of this study is equivalent to the combined Greenfield and informal lower Tymochtee recognized by Schmidt et al. (1961, p. 28) in

outcrop. It is recommended, that with further study, the Greenfield-Tymochtee contact in outcrop be rasied to be the same contact as has been used for the lower and upper Tymochtee.

In the subsurface to the southeast, the Greenfield grades laterally along with undifferentiated Lockport Group strata into the Lockport Dolomite (Lockport Member of the McKenzie Formation of Patchen and Smosna, 1975, p. 2275-2283) in counties along the southern border of Ohio (Fig. 24d-e).

The relationship between Greenfield strata in the study area and stratigraphic units recognized in northern Ohio remains unclear. There Ulteig (1964, p. 22) considers the Greenfield to be equivalent to the A1 and A2 carbonate units in the subsurface, whereas Janssens (1977, p. 25) shows the Greenfield-Tymochtee contact positioned between the A2 anhydrite and A2 carbonate, thereby excluding A2 carbonates from Greenfield strata. Further study of the relation between these units is necessary, and should emphasize definition of the areal limits where differrent formational boundaries are acceptable as standards.

TYMOCHTEE FORMATION AND TYMOCHTEE EQUIVALENT STRATA

The Tymochtee Formation *in toto* is a thick sequence of dolomite with a few thin shales and interbeds of anhydrite. The term is employed in areas where diagnostic evaporite beds are lacking and the approximately equivalent Salina B-G units can not be accurately distinguished. In southern Ohio, the formation is conformably bounded below by Greenfield rocks, and according to Horvath (1964, p. 104-105), is conformably overlain in some areas by the Silurian Bass Islands Group, and elsewhere unconformably by Devonian rocks of the Helderberg Limestone or Ohio Shale (Fig. 24d).

Extending throughout the study area within the otherwise undifferentiated Tymochtee Formation, is the C shale-unit, which is a widely recognizable log and lithologic marker (Fig. 24). In this investigation the C unit forms the upper limit to lithostratigraphic analysis, and in the following discussion the term Tymochtee is restricted in definition to sub-C unit Tymochtee strata only, unless specified otherwise.

The lower contact of the Tymochtee is defined in the subsurface principally on the basis of a distinct shoulder on gamma ray logs that is traceable throughout the study area (Figs. 6, 24). As previously discussed, this contact does not conform to the Tymochtee-Greenfield contact established in outcrop (Miller, 1955, p. 37), but rather corresponds more closely to the boundary between the informal lower and upper Tymochtee divisions recognized in outcrop by Schmidt et al. (1961, p. 287).

The upper contact of the Tymochtee in the report area is distinct on nuclear logs, and is marked by a sharp increase in radiation intensity effected by the C shale-unit (Fig. 24). The contact is less sharp in cuttings, where it is drawn at the top of the gray and grayish brown, microcrystalline, argillaceous dolomite, that is generally overlain by greenish gray shale and argillaceous dolomite of the C unit (Fig. 24).

The Tymochtee Formation is formally defined only where underlying rocks of the Greenfield can be recognized with certainty. Beyond the traceable limit of the Greenfield (Fig. 27), Tymochtee equivalent strata are recognized between the Lockport Dolomite below and the C unit above. In western West Virginia, this interval was previously correlated in combination with the C unit as the Upper Member of the McKenzie Formation (Patchen and Smosna, 1975, p. 2268) The lower boundary of the Tymochtee equivalent is sharp in samples and well logs, whereas contact with the C unit becomes progressively less clear to the south (Fig. 24d, e).

Thickness - Thickness of the combined Tymochtee and overlying C unit are mapped continuously with equivalent strata to the east in Figure 28. The interval ranges in thickness from less than 30 feet in Elliott County, Kentucky, to in excess of 90 feet in Mason and Putnam Counties, West Virginia, maintaining a fairly uniform east-northeast thickening trend across most of the study area. A

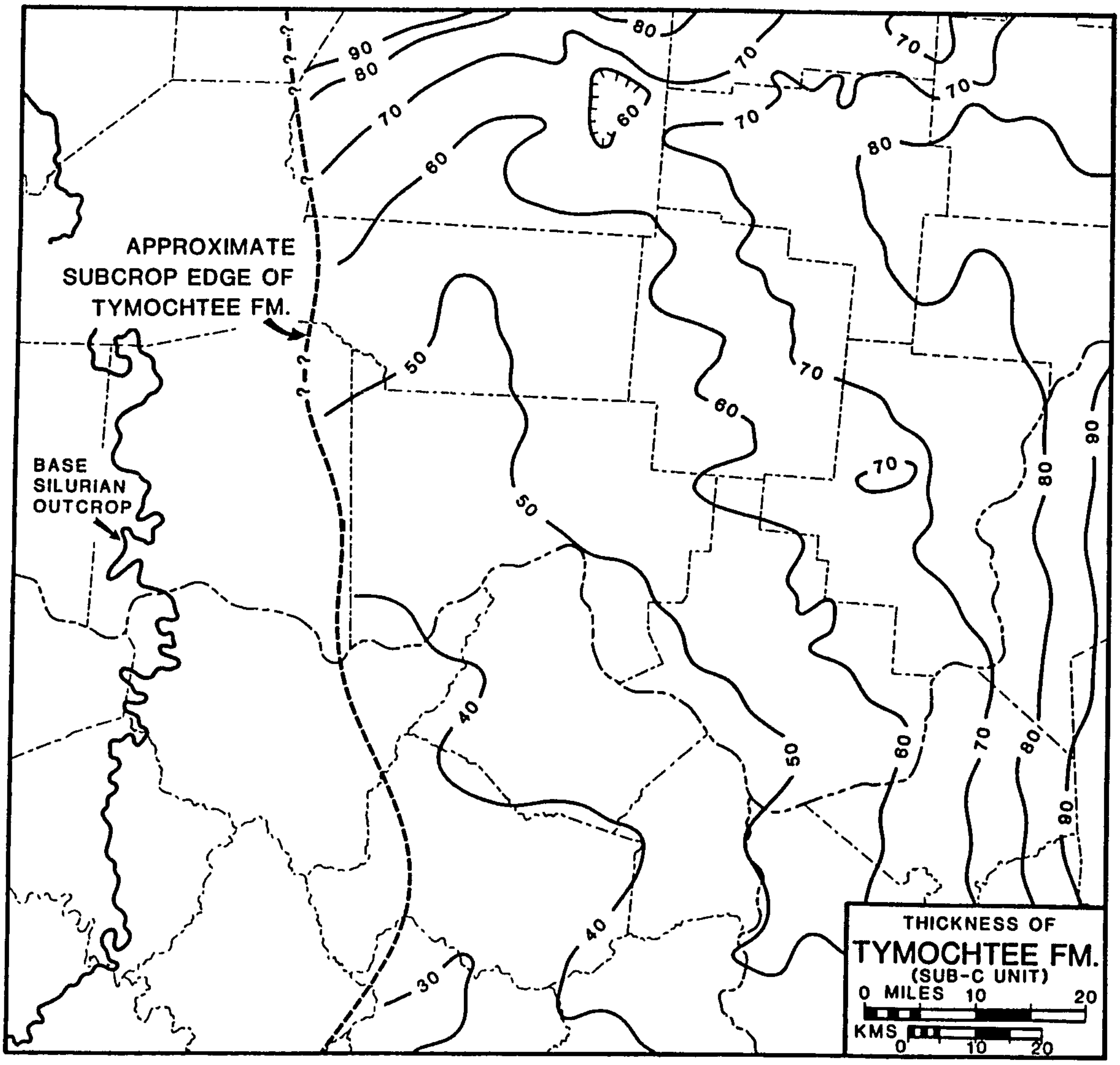


Figure 28. Thickness map of the C unit and Tymochtee Formation and equivalent strata combined shows northeastward thickening across much of the area, and irregular contours and thickness reversals along the northern margin of the area which reflect influence of the underlying Peebles reef trend. Contour interval 10 feet.

major component of this trend is the C unit, which thickens from less than 3 feet in Pike County, Ohio to over 25 feet in Mason County, West Virginia, whereas underlying Tymochtee strata expand less dramatically in an eastward direction.

In Ross, Hocking, Vinton, and Athens Counties a marked deflection of contours takes place along with minor interval thinning. This area corresponds in position to maximum Lockport thickness (compare Fig. 26), suggesting that variation in the underlying Peebles effected thickness of the Tymochtee; i.e. areas of thin Tymochtee correspond to areas of thick Lockport. Preliminary study of Pickaway County, which directly abuts Ross County, indicates rapid northward thickening of Tymochtee strata coincident with thinning of the Peebles section; generally less than 60 feet of Peebles strata are recognized in counties north of the study area (Horvath, 1964, p. 74). This strongly suggests an inverse thickness relationship, and areal restriction of the Lockport buildups to the east-northeast linear trend defined in Figure 26.

Lithology - In well cuttings the Tymochtee is generally colored gray, tan gray, and grayish brown, rarely mottled, dull, very finely to microcrystalline, commonly lithographic, argillaceous, slightly silty, dense dolomite which typically shows faint lamination, black carbonaceous partings, and black shale streaks. White, light gray, and rarely brown, finely crystalline anhydrite is common, appearing first in the subsurface very near the outcrop and increasing in abundance to the east. In addition, medium to dark gray and locally black shale, and gray to grayish brown dolomitic siltstone constitute up to 20 percent of individual samples and increase in abundance to the east. The Tymochtee may rarely be oolitic.

In Ohio, cores of the Tymochtee show thin to medium bedding and consist of subequal portions of algal laminated dolomite and variably bioturbated to laminated and cross-bedded dolosiltite. Very thin beds of gray shale and black carbonaceous partings separate the individual dolomite beds. Common features include intraformational breccias, scattered rip-up clasts, mud cracks, stylolites, color banding, and mottling; less commonly ripple marks and bird's-eye structure are present. Miller (1955, p. 105-128) reports similar bedding and textural characteristics from a study of the entire Tymochtee Formation in outcrop, where in addition, a calcareous facies persists which was not observed in the subsurface.

Tymochtee equivalent strata (Upper Member of the McKenzie Formation) in West Virginia carries a slightly darker coloration and contains a greater quantity of quartz silt than its western counterpart, but otherwise is very similar. Core No. 1549 in Wayne County, West Virginia, examined by the author and described in detail by Smosna (1974), shows the Tymochtee equivalent to consist almost entirely of stromatolitic (algal laminated) dolomite. Smosna (1974, p. 4-7) notes the same features for Tymochtee equivalent rocks in West Virginia as those listed above for the Tymochtee to the west, with the addition of soft-sediment deformation, cut-and-fill structures, and interbeds of pelletal dolomite.

Preliminary examination of Tymochtee dolomites in thin section shows that a xenotopic to hypidiotopic fabric of fairly equigranular, fine to medium and less commonly coarse decimicron grade, non- and low-ferroan dolomite is representative. The Tymochtee, with a denser crystalline fabric, scattered silt-size quartz, and more abundant illite clays, is otherwise very similar to the Greenfield in thin section and SEM (Plate 7f).

Regional Stratigraphic Relations - Within the study area, the restricted Tymochtee (sub-C unit) mapped and described in the subsurface does not correspond directly to the Tymochtee of outcrop. Rather, it excludes lower Tymochtee strata recognized by Schmidt et al. (1961, p. 287) in Adams County. As discussed previously, it is recommended the outcrop Greenfield-Tymochtee boundary be raised to conform to the subsurface, which in this study is more practical from a regional view because of its distinct character and direct correlation with the Lockport Dolomite-Tymochtee equivalent boundary in West Virginia (Fig. 24).

Regional correlation of the Tymochtee Formation (unrestricted) from southern Ohio to the north is difficult because the stratigraphic definition, contacts, and areal boundaries of the unit as a whole are inadequately defined and in need of revision in Ohio. Miller (1955, p. 74-75) and Horvath (1964, p. 88, Fig. 2) in southern Ohio, and

Ulteig (1964, p. 26) in northeastern Ohio similarly define the formation in outcrop as all strata overlying the Greenfield Formation and underlying the Bass Islands Group, or the Devonian unconformity where the Bass Islands is absent. Ulteig (1964, p. 26) considers the Tymochtee to be equivalent to the B-G units in the subsurface. In northwestern Ohio, however, Janssens (1977, p. 25) defines the Tymochtee in a more restricted sense, considering the formation to be principally equivalent to only A2 carbonates in areas where the B unit and those above can be recognized. Where the B and overlying units cannot be defined with certainty, Janssens incorporates these strata into "Undifferentiated Salina" rather than extending limits of the Tymochtee Formation. He includes within the Undifferentiated Salina the widely recognizable C unit, which elsewhere can be traced within undifferentiated Tymochtee strata.

It is apparent, therefore, that the term Tymochtee incorporates any or all strata which overlie the Greenfield (top variably defined) in areas where absence of salt beds and shales limit identification of the A-G Salina units. An attempt should be made to standardize the Tymochtee in adherence to conventional stratigraphic guidelines.

C UNIT AND NEWBURG SANDSTONE

The C unit is a unique shaly interval lying conformably within the otherwise undifferentiated Tymochtee Formation in the southern Ohio area (Table 7). Lithology of the C unit produces a characteristic signature on nuclear logs (Fig. 24), the base of which lies 60 to 155 feet above the top of the Lockport in the area of investigation. In well samples the lower limit coincides with the base of a section consisting predominantly of greenish gray shale and argillaceous dolomite, below which lies gray and tan, microcrystalline, anhydritic dolomite typical of sub-C unit Tymochtee and equivalent rocks. The upper limit is placed at the change to brown, finely to microcrystalline, slightly argillaceous and anhydritic dolomite typical of supra-C unit Salina strata. The C unit becomes less distinct in both samples and on well logs to the south, and is difficult to recognize with certainty in Wayne County, West Virginia, and Lawrence, Elliott, and Rowan Counties, Kentucky (Fig. 24d-e).

One or more thin beds of silty and sandy dolomite are locally present within, or directly atop the prominent shale section of the C unit in southern Ohio. Eastward into West Virginia, these beds grade laterally into the drillers' Newburg ("Williamsport") sandstone, a westward projecting sandy tongue of the Wills Creek Fomation (COSUNA, 1985a, cols. 1-3, 8-9).

Thickness - The C unit increases in thickness to the east and north across the study area, ranging from less than

3 feet in Pike County, Ohio to in excess of 25 feet in Mason County, West Virginia, over a distance of 60 miles. Along the West Virginia-Ohio border, the C unit consists of approximately 10 feet of shale and argillaceous dolomite locally overlain by 2 to 10 feet of sandy dolomite (Newburg) and an additional 3 to 8 feet of shaly dolomite.

The C unit isopach is combined with underlying Tymochtee and equivalent strata in Figure 28, and in large part accounts for the east-northeast thickening trend shown. The unit thickens uniformly across areas of Lockport maxima apparently unaffected by thickness variations in underlying strata (Fig. 24).

A structure map contoured on the top of the C unit (Fig. 29) has a pattern very similar to structure on top of the Queenston Shale (compare Fig. 7); a fairly uniform structural dip at approximately E 15 S gradually increases to the southeast from approximately 50 feet per mile in Pike County to over 70 feet per mile in Lawrence County. The restricted area of maximum Lockport thickness in Ross, Vinton, and Hocking Counties is not reflected in C unit structure as a result of the contour interval employed (200 feet), and the minor compensatory thinning of underlying Salina strata in areas where the Lockport is thickest and vice versa.

<u>Lithology</u> - The C unit consists of greenish gray, medium gray, and locally black, fissile, silty dolomitic shale with a few thin, discontinuous interbeds of gray and

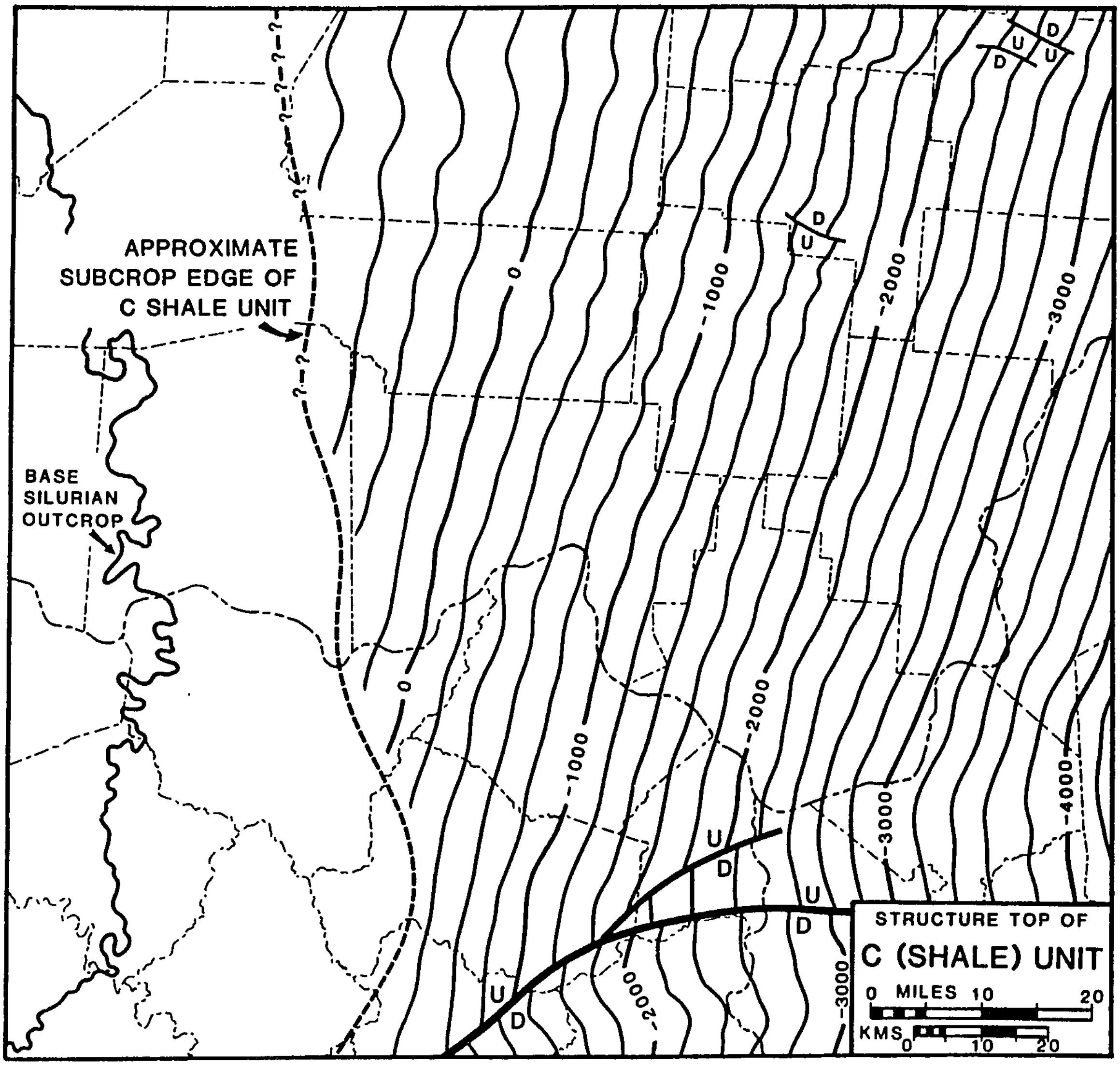


Figure 29. Structure contour map on top of the C unit shows a fairly uniform regional dip of approximately 60 feet per mile at E 15° S, the Kentucky River Fault System in eastern Kentucky counties, and small normal faults in Vinton and Athens Counties, Ohio. Contour interval 200 feet.

brown, argillaceous, silty and sandy dolomite. White, very finely crystalline anhydrite comprises a trace to 10 percent of well cuttings from the interval. Quartz silt and sand grains, commonly frosted, are scattered in shales of the C unit; the presence of frosted sand is a characteristic of the C unit noted by Janssens (1977, p. 25) in northern Ohio and Sanford (1969, p. 18) in Ontario.

To the east, beds of argillaceous silty dolomite and sparsely oolitic, medium to coarse grained dolomitic siltstone become more prominent in the C unit. These grade laterally into the Newburg sandstone which is recognized by drillers'throughout west central West Virginia counties and also in Meigs County, Ohio. Patchen (1968a) describes the Newburg as a light gray to white, fine to very fine grained, subangular to rounded, fairly well sorted, friable to compact dolomitic sandstone containing abundant frosted quartz grains.

<u>Regional</u> <u>Stratigraphic</u> <u>Relations</u> - The C unit and equivalents are recognized throughout the Appalachian and Michigan Basins, where they serve as a lithologic and log marker to drillers and stratigraphers alike. The C unit was originally defined by Landes (1945) in the Michigan Basin, and has subsequently been traced into northern Ohio (Ulteig, 1964, p. 25-26; Janssens, 1977, p. 25), Pennsylvania and New York (Mesolella, 1978, p. 1611), Ontario (Sanford, 1969, p. 17-18), and southern Ohio and northern Kentucky (Horvath, 1964, p. 104). Droste and Shaver (1982, p. 21) consider the Mississinewa interval of the Wabash Formation to be the C

unit equivalent in Indiana. In West Virginia the stratigraphic position of the C unit is occupied by shales and locally thin sandstones of the drillers' Newburg, which are traced into the Wills Creek Formation (COSUNA, 1985a, cols. 1-3, 8-9). The Newburg sandstone is also known to West Virginia drillers as the "Williamsport", and is younger than the type Williamsport Sandstone to the east (COSUNA, 1985a, cols. 8-10).

STRATIGRAPHIC SUMMARY

The following list reviews the key lithostratigraphic correlations identified within the boundaries of the study area. Table 8 summarizes lithology, thickness, and the clarity of contacts for the general stratigraphic column; geophysical and lithologic correlations are provided in Figures 9, 10, and 24.

1) The Brassfield Formation as identified in the outcrop area is continuous throughout the subsurface where it is traced at the base of the Silurian System. The lower contact of the Brassfield with Ordovician rocks is unconformable. The unit interfingers with shales of the Cabot Head above. The Brassfield is not in direct facies relation with the Clinton sandstone, and it is recommended that correlation of Brassfield with the drillers' "Packer" and "Casing" shells be discontinued.

2) Locally in Athens County, the Whirlpool Sandstone (drillers' "Medina" or "Albion" sand) occurs at the base of the Silurian within the Brassfield Formation.

3) The Cabot Head Shale is identified throughout the subsurface and is traced directly into the Plum Creek Shale in outcrop areas. Entirely contained within the Cabot Head are the Clinton and Tuscarora sandstones, which split the shale into informal upper and lower tongues.

4) The informal Clinton sandstone recognized by Ohio drillers is correlative with the formal Tuscarora Sandstone identified in West Virginia. The Clinton is confined wholly to the subsurface, and pinches-out westward into shales of the Cabot Head. The drillers' subdivision of "Stray", "Red", and "White" Clinton are impractical for use in the study area.

5) The Oldham Limestone identified in outcrop areas is continuous throughout the subsurface, and correlates with the drillers' "Packer shell", which directly overlies the Clinton-Cabot Head section. It is recommended that this correlation be adopted, and that correlation of the "Packer shell" with Brassfield strata be abandoned.

6) Shales identified as the Lulbegrud in outcrop areas are traced into the subsurface, where they separate the Oldham and Dayton Limestones. The Lulbegrud is extended formally only to the limit of the Dayton Limestone, beyond which the unit is continuous with shales of the lower Rose Hill Formation.

7) The Dayton Limestone, as identified in outcrop, extends throughout the subsurface to a depositional edge which approximates the border of West Virginia with Ohio and Kentucky. The Dayton correlates with the drillers' "Casing shell". An unconformity present at the base of the Dayton increases in magnitude to the west, and results in progressive erosional overstep of underlying units.

8) The Estill Shale as defined in outcrop areas is formally extended in the subsurface to the limit of the Dayton Limestone, beyond which the shales are continuous with the upper Rose Hill Formation. The Estill-Dayton contact exhibits none of the physical characteristics associated with an unconformity, although, biostratigraphic evidence indicates an unconformity locally in outcrop.

9) The Rose Hill Formation is formally recognized in western West Virginia beyond the depositional limit of the Dayton Limestone. The Cacapon Sandstone is contained as a member of the Rose Hill, lying near the base of the formation. The Cacapon extends westward a limited distance into Lulbegrud shales, where it closely underlies the Dayton Limestone.

10) The Bisher Formation as identified in outcrop areas is traced eastward into the subsurface, where it grades laterally into the Keefer Sandstone. A functional boundary between the units is established, where the section is comprised of greater than 50 percent clastics.

11) As a group, the Lockport can be identified in the subsurface, but the Lilley and Peebles Formations identified in outcrop are only recognized locally. Difficulty is encountered in differentiating the units to the southeast in the subsurface, and there the Lockport remains undivided. Farther to the south and

east, the Greenfield Formation of the Salina Group cannot be distinguished with certainty from undifferentiated Lockport rocks below, and the Lockport-Greenfield interval is combined into the Lockport Dolomite.

12) Locally in northern counties, the Niagaran-Cayugan contact in the subsurface exhibits characteristics associated with an unconformity, which are recorded also in outcrop. To the southeast, evidence of an unconformity is lacking and the bondary is considered conformable; eventually the Lockport and lowest Salina rocks can not be differentiated.

13) The lower Salina Group in most parts of the study area is divided into the Greenfield Formation, Tymochtee Formation (restricted), and C unit. The lack of diagnostic evaporite beds makes further subdivision of the Salina into lettered A-G units impractical.

14) The Greenfield-Tymochtee boundary identified in the subsurface corresponds closely to the contact between informal lower and upper Tymochtee in outcrop. The identified contact is more distinct and of greater regional practicality; corresponding to the contact between the Lockport Dolomite and Tymochtee equivalent strata in areas where the Greenfield cannot be identified.

15) The Tymochtee Formation is here limited to strata overlying the Greenfield and underlying the regionally recognized C unit. Strata equivalent to the Tymochtee are recognized throughout the subsurface, however formal application of the term is restricted to areas where the Greenfield can be recognized with certainty.

16) The C unit is clearly identified above the Tymochtee Formation and equivalent strata throughout the subsurface save for southern portions of Wayne County, West Virginia, and Lawrence, Elliott, and Rowan Counties, Kentucky. The C unit is not identified in outcrop, however, special effort should be made to locate the shale in appropriate quarries. Locally in eastern counties, sandstones correlative to the drillers' Newburg ("Williamsport") sandstone occur within the C unit.

17) In outcrop and nearby subsurface, Estill Shale and younger Silurian units are truncated by a regional unconformity, which in the study area represents the Silurian-Devonian systemic boundary.

PALEOGEOGRAPHY AND SEA LEVEL CHANGES

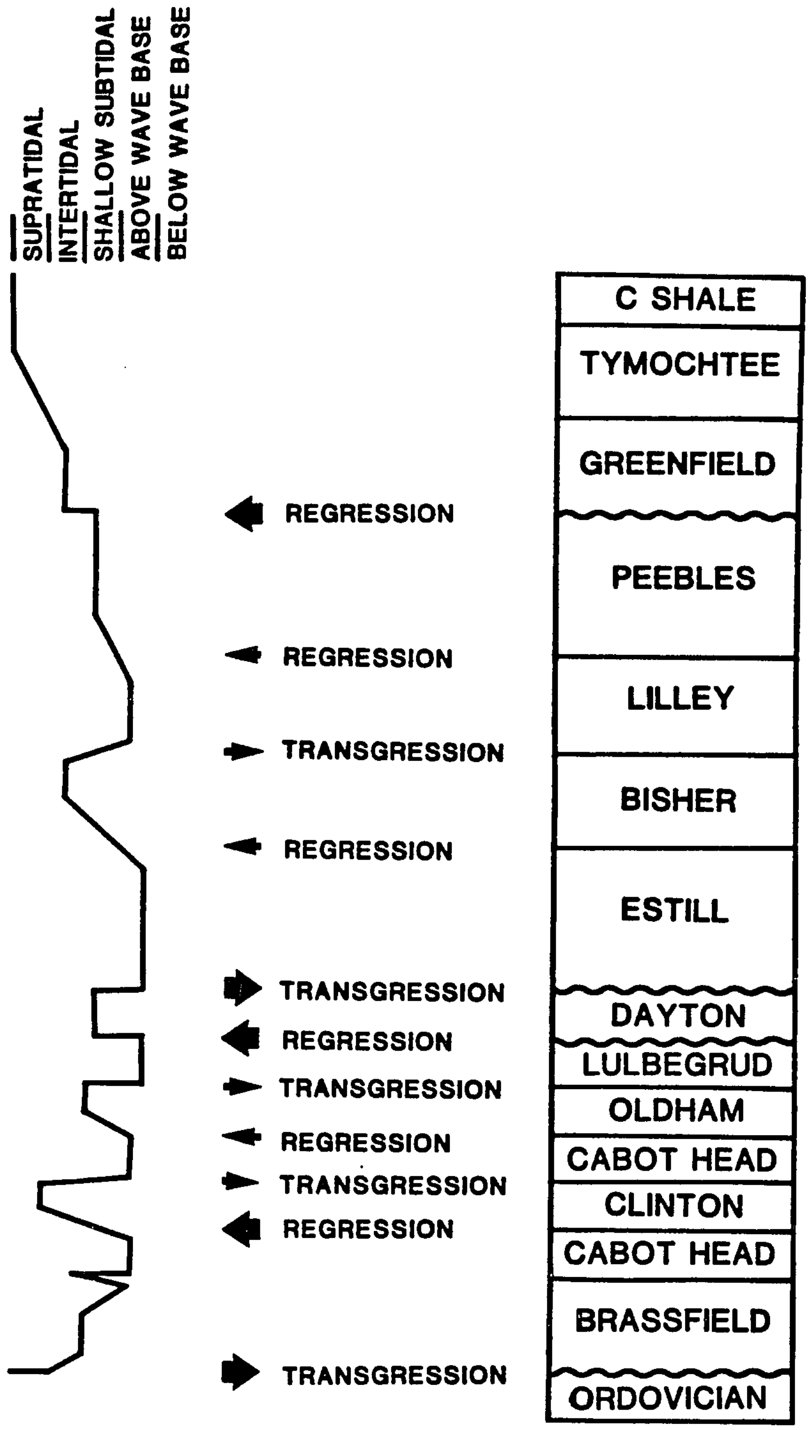
Five transgressive and six regressive hemicycles of various magnitudes are recognized in the southern Ohio area (Fig. 30). These add a significant refinement to the global second order sea level cycles identified by Vail et al. (1977, p. 84, Fig. 1), which include a drawdown associated with the Ordovician-Silurian systemic boundary, followed by a steady rise in sea level until Late Silurian (Cayugan?), when another drawdown of greater magnitude is recognized.

Silurian paleomagnetic poles from cratonic North America indicate generally equatorial conditions, ranging between 20° - 30° north latitude and 100° - 130° east longitude (McCabe et al., 1985, p. 2964, Fig. 8).

The following discussion reviews the paleogeography, environments of deposition, and sea level changes determined for Silurian formations studied, and is based on lithostratigraphic relationships identified here and the reports of other Silurian workers from surrounding areas.

Upper Ordovician. A significant sea level drop (Taconic Discontinuity), resulting from a combination of basin infilling and glacio-eustatic drawdown occurred contemporaneously with the Late Ordovician Taconic orogeny along eastern margins of the Appalachian Basin in Pennsylvania, New York, and New England (Dennison and Head, 1975, p. 1094; Dennison, 1976, p. 110-112). Extensive redbeds of the Queenston deltaic complex spread to the west from this source area, and also from source areas effected by Middle Ordovician tectonic disturbance farther to the

Figure 30. Relative water depths of Silurian formations in southern Ohio showing general environments of deposition and sea level changes.



south (Rodgers, 1967, p. 412). Red sandstones and siltstones of the Juniata Formation accumulated as channel, overbank, and alluvial plain deposits in proximal areas (Dennison, 1976, p. 111). These grade westward into the red shales and siltstones of the Queenston Formation in Ohio, which accumulated as lower delta plain silty muds under subaerial conditions (Folk, 1960), and farther westward as marine prodeltaic muds later exposed to subaerial conditions (Knight, 1969, p. 1446). Farther west near the present Cincinnati Arch, the Queenston grades laterally into gray shales and carbonates of the Drakes and Whitewater Formations of the Richmond Group, which contain a marine fauna and were deposited under peritidal to supratidal conditions (Droste and Shaver, 1983, p. 18-19). It was over this broad, gently sloping, largely subaerial and red colored surface that Silurian sedimentation began.

Medina Group. Initial Silurian deposition occurred during a phase of transgressive onlap, with carbonates of the Brassfield Formation and shales of the lower Cabot Head. The transgressive episode was promoted by a combination of slow regional subsidence of the Appalachian Basin and northwesterly directed flooding of the eastern midcontinent. Axial subsidence in the basin resulted in a shallow carbonate platform dipping gently eastward from the Cincinnati Arch and a clastic-dominated shelf dipping gently westward from the eastern margin of the basin. Lithofacies belts in the Medina Group are elongate north-south parallel to depositional strike, and sediment dispersal patterns have an east-west orientation (Amsden, 1955, p. 62-63, Fig. 1; Yaekel, 1962; Dennison, 1970).

Near the present Cincinnati Arch, lowermost Brassfield beds (Belfast) paraconformably overlie the slightly irregular Ordovician paleosurface and represent very shallow water deposition in lagoonal (Gordon and Ettensohn, 1984, p. 107-108) or tidal flat (Wier and Peck, 1968, p. 168) environments. Progressive upward deepening in the formation is indicated by faunal (Gray and Boucot, 1972) and lithologic evidence (Gordon and Ettensohn, 1984); the majority of the Brassfield consisting of bioclastic carbonates and subordinate shales with normal shallow-marine faunas which represent stable shelf bioclastic facies deposited under peritidal conditions (Droste and Shaver, 1983, p. 20, Fig. 31). The increasingly argillaceous and shaly upper Brassfield along with overlying Cabot Head shales record continuation of the transgressive sequence attendant with increased clastic input. Gordon and Ettensohn (1984, p. 107, Fig. 5) suggest the sequence was interrupted by at least one minor regressive interlude, in order to account for the lithologic and faunal characteristics of the one or more, commonly ferruginous, coarse bioclastic beds (Bead bed of Rexroad et al., 1965) present in the upper Brassfield. Locally, differential subsidence and/or uplift along the platform margin effected facies of the Brassfield. Slightly deeper water conditions, indicated by the shalier nature of the Brassfield in Adams

County, Ohio and Lewis County, Kentucky, suggest the presence of a reentrant or shaly embayment into the shelf margin. In addition, stratigraphic condensation and a greater prevalence of near-shore shoaling conditions in the Brassfield south of Bath County, Kentucky suggest differential uplift in that area (Gordon and Ettensohn, 1984).

Lithologic changes and facies relations with the lower Cabot Head shales suggest that carbonate-dominated Brassfield facies were progressively replaced by terrigenous clastics eastward into the basin. Locally, the base of the initial Silurian transgressive episode is marked by the Whirlpool Sandstone (Belfast facies equivalent ?), which represents an eastward transgressive strandline sheet-sand (Laughrey, 1984, p. 49, Fig. 2) presumably sourced by cannibalization of the underlying Queenston (Knight, 1969, p. 1446). Remaining Brassfield-equivalent strata consist of thin argillaceous carbonates, dolomitic shales, and subordinate siltstones deposited in lower peritidal to subtidal conditions in a mixed carbonate-clastic regime. These in turn are overlain gradationally by the prodeltaic shales, thin siltstones, and lesser carbonates of the lower Cabot Head, which derive from an eastern source and eventually replace Brassfield strata entirely in west-central West Virginia. Farther to the east sandstones of the Tuscarora replace the lower Cabot Head shales, and there record earliest Silurian deposition. Nowhere, however, are these sandstones in direct facies contact with the Brassfield, but rather the two are always separated by shales of the Cabot Head.

Westward progradation of the Clinton-Tuscarora sandstones into the Appalachian Basin marks a regressive sequence, which occurred in response to increased clastic influx from renewed uplift of the Taconic highlands; the source area lying principally to the east (Yaekel, 1962) and southeast (Perry, 1962; Dennison, 1970). Facies belts of the Tuscarora and equivalents are oriented approximately north-south, and change sequentially in a westward direction from sandstone to shaly sandstone to sandy shale, becoming less massive, more broken, and eventually grading completely into shales of the Cabot Head in Ohio (Amsden, 1955, p. 62-63, Fig. 1). A fluvial and/or littoral depositional origin is generally accepted for the Tuscarora in areas proximal to the source (Yaekel, 1962; Folk, 1960, Cotter, 1983), grading westward to marginal marine deltaic and eventually shallow marine depositional environments. In eastern Ohio the Clinton represents the transition from marginal marine to marine facies, and was deposited as a complex of small prograding deltas which are seen as northwest trending lobes (Knight, 1969, p. 1442, Fig. 14; Keltch et al., 1987, p. 69, Fig. 4), as in Vinton and Gallia Counties. A complex of depositional environments have been identified in the Clinton, including fluvial distributary channels and mouth bars, flood plain and lagoonal muds, tidal deposits, coastal barrier islands, offshore bars, and some marine shales and rare limestones (Overby and Henniger, 1971, p. 198; Knight, 1969, p. 1436-1446; Msek, 1973; Osten, 1982, p. 81-111). Fluctuations in the sediment supply and lateral shifting of the delta subenvironments produced the multi-stacked, coalescing and lenticular sandbodies which typically show strong lateral variations in lithology and thickness. Delta abandonment coincided with an episode of marine onlap, which initially resulted in transgressive reworking of delta plain deposits to produce the thin sandstones and carbonates overlying the main Clinton sandstone bodies ("Stray" Clinton, for example), followed by deposition of the overlying upper Cabot Head shales.

Clinton Group. Continued transgression pushed the shoreline eastward, restricting both the size of the eastern source area and the availability of coarse clastics to the basin, resulting in deposition of the Lulbegrud, Estill, and Rose Hill shales, which contain a normal-marine fauna and presumably accumulated under lower peritidal and subtidal conditions. Several regressive episodes interrupted this overall transgressive trend, accounting for the spread of thin, regionally persistent carbonates within the clastic dominated sequence. These include the Oldham and Dayton Limestones and their equivalents, which show similar stratigraphic relationships throughout much of the Appalachian Basin and are generally time-transgressive to the east. In southern Ohio, eastward progradation of the Oldham and Dayton carbonates into the basin coincided, or nearly so, with westward progradation of regressive sandstones of the Cacapon, which consist principally of ferruginous oolitic carbonates and sandstones derived from a southeastern clastic source area (Smosna and Patchen, 1978, p. 2313; Hunter, 1970, p. 107-108). Lithologic and faunal character of the Oldham and Dayton carbonates indicate deposition in relatively shallow, moderately agitated peritidal conditions; Hunter (1970, p. 112) postulated progressive shallowing westward into Ohio. Intermittent depositional hiatuses promoted by minor oscillations in sea level would be consistent with the occurrence of ferruginous beds and the prevalence of glauconite in these units.

Progressive northeastward rotation of depositional strike took place contemporaneously with deposition of the Oldham through Estill sequence. This was caused in large part by differential axial subsidence in the basin, which initiated development of the broad, shallow, Wabash Platform which dips gently to the east and south from west-central and northwestern Ohio. On the platform and along its margins, shale units pinch-out or are erosionally truncated, and intervening carbonate units becoming condensed. Here, maximum regressive episodes are clearly marked by erosional bevelling of strata, and include unconformities at both the base and top of the Dayton Limestone (Ham and Wilson, 1967, p. 355; Sanford, 1969; Rexroad, 1980, p. 71) and probably several others of lesser magnitude. Along the east flank of the Cincinnati Arch differential uplift was greatest to the north; unconformities bounding the Dayton become progressively less apparent southward into Kentucky.

Maximum transgression presumably coincided with deposition of the Estill and upper Rose Hill shales, which are somewhat unique in having direct lithostratigraphic equivalents on the west side of the Cincinnati Arch (ex. Osgood Shale). Evidence for the initiation of the Cincinnati Arch as a topographic entity, and its effectiveness as a barrier to westward sedimentation during Silurian time, however, remains unclear. Timing of the arch can only be postulated within rough limits - Early Silurian to Middle Devonian (McDowell, 1983, p. 24); the Brassfield Formation is the only Silurian unit preserved near the arch axis. In this study, several stratigraphic units of the Medina, Clinton and overlying groups thin and undergo facies changes westward toward the present arch; however these conform to overall trends toward the regionally expansive Wabash Platform and do not necessarily support the existence of the Cincinnati Arch. In addition, the strong trend in facies changes to the west and northwest across Ohio easily accounts for the apparent absence, or difficulty in recognizing stratigraphic equivalents over the distance from east to west flanks of the arch; providing a less dramatic and perhaps more substantive explanation than one invoking the arch as a westward barrier to sedimentation (Freeman, 1951, p. 9). As suggested by McDowell (1983, p. 24) and paleogeographic analyis, it is likely the positioning of the "tectonic" Cincinnati Arch coincides, or nearly so, with a hinge-line or margin of the midcontinent platform, which later served to localize structural movements. However, lithologic and stratigraphic evidence from rocks within the area of investigation do not indicate tectonic initiation of the arch or its existence as a subaerial positive topographic feature during Llandovery, Wenlock, or Ludlow time.

Decreased rate of regional subsidence coupled with basin infilling promoted a regressive episode following Estill-Rose Hill time, during which Keefer sandstones prograded westward into West Virginia and silty carbonates of the Bisher Formation were deposited in Ohio. Keefer clastics were derived largely from the same eastern landmass which sourced the Tuscarora, in addition to a source located in the Virginia area (Smosna and Patchen, 1978, p. 2316-2317; Dennison, 1970). In southeastern Kentucky and eastern West Virginia, proximal to the northeast-southwest trending shoreline postulated by Smosna (1983, p. 100, Fig. 1), the Keefer is interpreted as a littoral or sublittoral marine shelf sand (Dennison, 1970, p. 8). Folk (1962, p. 373, Fig. 12) proposed that the Keefer was deposited as a series of barrier bars in eastern West Virginia, behind which Rochester shales accumulated in a shallow embayment. To the west in the subsurface the Keefer appears to have been deposited in an environment of lower energy, perhaps as a series of submerged offshore bars initiated near wave base and built upward into shallower water (Smosna and Patchen, 1978, p. 2316-2317; Smosna, 1983, p. 106-107). In Ohio, bioclastic Bisher carbonates accumulated under similar conditions beyond the controlling influence of eastern clastics. Storm generated currents occasionally transported pulses of clastic material northwestward across the shelf into Ohio, where they were later reworked and incorporated into the Bisher sediments. Both the Keefer and Bisher were deposited under shoaling conditions, as indicated by upward coarsening in grain size and an upward increase in current generated bedforms,

The north-northeast oriented bodies of thick Keefer and Bisher sediments most likely represent the coalescence of numerous imbricate sand bodies into elongate banks or shoals, rather than singular sediment bodies (Smosna, 1983, p. 107). Topographic relief across the sand bodies was probably minor, although enough to influence local facies relations in the formations, in addition to effecting sedimentation in the overlying Lockport (Herring, 1987, p. 62-67; Smosna, 1983, p. 106-107). The generally uniform thickness distribution maintained by the two formations across the study area suggests a very subdued shelf topography, perhaps with little, or only very gradual change in water depth, and rather homogeneous environmental conditions. Proximity to the clastic source controlled overall lithologic character in large part. This is consistent with the observation of Smosna and Patchen (1978, p. 2314), that during or immediately prior to Keefer deposition, the configuration of the Appalachian Basin changed from a central trough flanked by shelf areas dipping toward the depocenter, to a broad shelf of fairly constant base level locally broken by small sedimentary basins.

Lockport Group. Water depth increased at the beginning of Lockport deposition as a significant transgression occurred which served to restrict the influx of coarse clastics into western West Virginia and Ohio. The gradational transition between the Lockport Dolomite with underlying Keefer sandstones suggests that sea level rise was gradual, although Smosna and Warshauer (1983, p. 30) recognize, at least locally, a very brief drop in sea level immediately following Keefer deposition. The decreased dilution by terrigenous clastics along with a slightly deeper, less turbulent environment of deposition, probably below tidal wave base, promoted conditions conducive to biogenic production and carbonate deposition prevailed. Crinoid communities were first to become well established, producing a thin sheet of well washed bioclastic calcarenite. As the transgression continued and sea floor was lowered below wave base, small patch reefs and bioherms developed across the carbonate shelf, platformed by the slight topographic highs of the underlying Keefer-Bisher sand shoals. Between the bioherms, argillaceous and shaly, less fossiliferous carbonates accumulated; this suite of lithologies being consistent with the distribution of facies in the Lilley and in biohermal portions of the Lockport Dolomite.

In West Virginia, growth of the mounds above wave base, along with a gradual marine regression, resulted in deposition of the middle sandy unit of the Lockport Dolomite which formed in a mixed clastic-carbonate intertidal environment; a southeastern source in Virginia providing the clastics (Smosna and Patchen, 1978, p. 2319, Fig. 12). This regressive episode is also marked by the westward projecting Rabble Run redbed tongue of the Bloomsburg in Pennsylvania and adjacent states (Patchen and Smosna, 1975, p. 2268, Fig. 2), and may additionally correspond to the erosional truncation of Gasport patch reefs in New York (Crowley, 1973; Dennison and Head, 1975, p. 1098). Following deposition of the middle sandy zone, a second marine transgression is indicated in the Lockport Dolomite by the overlying oolite bar sequence (Patchen and Smosna, 1975, p. 2276). This minor rise in sea level promoted shoaling conditions, with production of ooids outpacing the rate of subsidence and creating an overall coarsening upwards, or regressive trend within the sequence. The Niagaran-Cayugan boundary persists here within the oolite section, suggesting deposition was continuous across this stratigraphic boundary at least locally.

In Ohio, directly following Lilley deposition the supply of terrigenous muds was greatly diminished and accumulation of relatively pure Peebles bioclastic carbonates commenced in agitated, clear shallow waters of the marine platform; largely representing reef, bank, and interreef depositional environments. Similar conditions persisted over much of the midcontinent at this time, having developed earlier in areas to the north and west, which were removed from any clastic influence (Droste and Shaver, 1983, p. 20, Fig. 33). In southern Ohio subsidence of the platform apparently kept pace with carbonate production, allowing for accumulation of the thick, homogeneous Peebles sequence. To the southeast into West Virginia, subsidence was apparently slower and perhaps more sporadic. There the equivalent sequence is thinner, displays a wider range of depositional facies which represent environments influenced more by tidal and nearshore processes, and shows more clearly transgressive and regressive trends.

Paleogeographic reconstruction of southern Ohio during Middle Wenlockian time by Droste and Shaver (1983, p. 20, Fig. 33) indicates the Peebles buildup recognized in the study area is located along the northwest margin of a shallow marine carbonate platform and lies directly south of a basinal area where biogenic productivity was limited. This paleogeographic interpretation is supported by the thin nature of the Peebles (typically less than 60 feet) in counties north of the study area, as reported by Horvath (1964, p. 74), and the rapid northward thickening of lower Salina Group strata in the same area. The east-northeast orientation of the Peebles buildup in the study area directly corresponds to a "thick" in the McKenzie Formation which extends through West Virginia counties north and east of Meigs County, Ohio (Smosna and Warshauer, 1978, Fig. 3, p. 32). These are in turn aligned further with a "thick" in undifferentiated Lockport strata which extends northeastward through south-central Pennsylvania (Alling and Briggs, 1961, p. 175-187; Fergusson and Prather, 1968); although the latter is separated from those previous by a basinal area in north-central West Virginia and southwestern Pennsylvania which lacks organic buildups (Droste and Shaver, 1985, p. 86, Fig. 15; Patchen and Smosna, 1975, p. 2285, Fig. 22).

Salina Group. Rocks of the Salina Group record the sedimentological transition from the shallow open marine carbonate environments of the Lockport to progressively more restricted, shallow peritidal, supratidal, and hypersaline environments favoring deposition of primary and early diagenetic evaporites and dolomites. The base of the Cayugan is marked in southern Ohio, and locally elsewhere in the midcontinent, by a marine regression which resulted in temporary exposure of Niagaran reef and platform carbonates (Briggs et al., 1978, p. 117); this caused partial erosional truncation and extensive vadose alteration. Eustatic sea level lowering was perhaps only minor, however, with the extent of subaerial exposure or continued submergence controlled in large part by local subsidence or uplift on the shallow carbonate platform. In some areas deposition, including reef growth, was continuous across the Niagaran-Cayugan boundary (Droste and Shaver, 1977; 1985, p. 82, Fig. 10).

Following the initial Cayugan regression, water depth increased slightly, but remained quite shallow during deposition of Greenfield sediments in southern Ohio. These include shallow intertidal mudcracked, algal laminated, rippled and cross-bedded dolomites with restricted faunas, in addition to thin oolite shoals and small stromatolite dominated bioherms. The overlying Tymochtee strata record a similar depositional setting in part, but also show progressive shallowing, with the development of local supratidal conditions indicated by thin beds and nodules of evaporite minerals. The inverse thickness relation between Lockport and lower Salina strata suggests that Salina sediments preferentially accumulated in low areas lying between Lockport buldups until an ambient base level was established.

Minor influx of fine clastics from the south and east occurred during Tymochtee time, culminating in the westward spread of the Newburg sandstone and associated shales of the C unit. Dennison (1970, p. 12) suggests that the spread of clastics resulted from a unique eustatic sea level drop, which allowed reworking of eastern sandstones and their spread into the basin as a nearly isochronous unit.

ECONOMIC POTENTIAL

Silurian formations in the southern Ohio area contain a number of mineral resource commodities which have been or are economically significant. The following discussion provides a brief review of the quarrying and hydrocarbon potential of the units studied.

Quarrying - The Peebles, Greenfield, and Tymochtee Formations are the principle targets of surface mining in the study area, restricting quarry operations in large part to Adams County, Ohio and north, where they are well exposed. Aggregate materials constitute the primary product, but others include roadstone, ballast, agricultural lime, flux stone, and filler materials (Schmidt et al., 1961, p. 264). The underlying carbonate rocks of the Lilley, Bisher, and Brassfield Formations are less attractive for these products because they generally lack the chemistry, rock soundness, and abrasion properties required for commercial uses.

The regional approach of this study limits further determination of limestone and dolomite resources at any specific locality; each prospective quarry site must be evaluated individually to determine characteristics of the stone, which requires detailed field investigations. It is of interest, however, that quarries that mine a section from the Tymochtee through Peebles (ex. Plum Run, Loc. 15), generally encounter stone with contrasting calcium and magnesium contents and other properties which provides a source for materials used in a greater variety of applications (Bowman, 1988, pers. comm.).

Oil and Gas - Commercial hydrocarbon production has been from a wide range of reservoirs in Ohio, Kentucky, and West Virginia, and has been economically important in all three states.

In Ohio counties within the study area, commercial production is restricted to the Clinton sandstone, and includes both oil and gas. The map of oil and gas fields of Ohio (Debrosse and Vohwinkel, 1981) recognizes thirty two separate Clinton fields in the area, with the majority in Hocking, Vinton, and Athens counties. Discovery dates range from 1899 to 1963; however, the current production and drilling activity in these fields was not established.

Separation of gas and oil production in the Clinton, as a rule, is unique to each field or sandstone body and does not follow the regional structural trend. This is a result of the mutistory and laterally discontinuous nature of the Clinton sandstone bodies, which necessitates detailed studies to increase the success of exploratory and development drilling (Keltch et al., 1987).

Near the study area in Athens and Meigs Counties, commercial gas and rarely oil is produced from the Whirlpool Sandstone at the base of the Silurian. In addition, in easternmost Meigs County (Lebanon Township) and adjacent portions of Jackson County, West Virginia, natural gas is produced from the drillers Newburg ("Williamsport") sandstone (Cardwell, 1971). It is unlikely that either production trend will be extended into the study area owing to the pinch-out of the sandstones to the west and south. Oil and gas production from the Clinton sandstone in the area, however, is far from exhausted.

In counties near the Ohio outcrop, gas shows are common at the base of the Devonian Ohio Shale where it overlies Bisher and younger Silurian carbonates, although commercial quantities have not been encountered to date. It would be interesting to further study this unconformity and the underlying section with regard to potential for gas storage or subsurface waste disposal. Gas shows are also common in Ohio at the drillers' Newburg porosity zone, which is typically recorded closely below the Lockport-Greenfield contact. No commercial hydrocarbons have been encountered in the Newburg in southern Ohio, although the interval is productive elsewhere in the state (Multer, 1963; Santini and Coogan, 1983) and should continue to be tested.

In Kentucky counties in the study area, most recent hydrocarbon production is from the Ashland and Mavity Clinton gas fields in Boyd County (Watson, 1979), and also a few wells producing from the "Big Six sand" (combined Keefer and lower Lockport Dolomite) also in Boyd County (Leach Station pool).

Several shallow oil and gas pools from near the Kentucky outcrop are of historical importance, although they are now abandoned. These include the Bluestone, Ragland, Hardeman School, Oldtown West, Scott Creek, North Triplett, and Hawken Branch fields in Rowan, Lewis, and Bath Counties

(Wilson and Sutton, 1976). Production was from Bisher Formation and undifferentiated Lockport reservoirs, which subcrop beneath the Devonian Ohio Shale, dated from about 1900 to the 1970's, and from depths of less than 150 feet to about 650 feet. Gas and oil, including some heavy black crude or asphaltic oil, was produced from the various fields as described by McGrain and Noger (1982, p. 15-19). It is interesting to note that asphaltic material locally fills porous Bisher, Lilley, and Peebles dolomites in Adams and Highland Counties, Ohio. It is unclear, however, why this heavy oil is not found as light, pumpable oil, down dip to the east.

Hydrocarbon production in West Virginia counties in the study area includes Keefer and "Big Six" gas fields in Wayne County (Patchen, 1968b), and a few scattered Tuscarora gas wells in Cabell and Wayne Counties (Cardwell, 1977). The Keefer and "Big Six" production is from the Whites Creek-Gragston and closely associated Herbert, Fort Gay-Hubbardstown, and Sidney fields. Principle drilling interest was in the 1950's and 1960's, with only limited activity in recent years (Cardwell and Avary, 1982). At present, the Tuscarora, Keefer, and lower Lockport Dolomite are considered only as secondary or tertiary targets, and further testing is needed to more fully understand their potential. Testing of the Keefer in adjacent Lawrence and Gallia Counties, Ohio, is especially encouraged.

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APPENDIX A - Summary of well data.

Abbreviations

ABS...absent by nondeposition
B.....bedrock
C.....core
DF....derrick floor
FR....fractional lot
GL....ground level
KB....kelly bushing
L.....lot
NA....not available owing to absence of bounding unit
NL....not logged
NP.....not penetrated
NR.....not recognized
NS.....not sampled
SD.....sample description on file at the Ohio Geological Survey
T......topo. elevation
TR.....truncated by erosional unconformity
UNK....unknown
VMS....Virginia Military Survey Lot
?......identification uncertain

N.B. 1) Sample numbers in West Virginia correspond to permit numbers.

2) Available well sample descriptions for West Virginia occur as unpublished open-file reports (File), and in volumes (v.), bulletins (B.), and circulars (c.) of the West Virginia Geological Survey.

3) In areas where both the Dayton Limestone and the Cacapon Sandstone are present, only thickness of the Dayton is given.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

ADAMS COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
11	3550	X	FRANKLIN	V7372	J.R. TENER #1	852 KB	3868
4		X	JEFFERSON	V2262	BAILEY #1-A	714 KB	3790
4		X	JEFFERSON	V4040	G. COVERT #1	624 KB	3829

ATHENS COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
1769	3095	X	ALEXANDER	17	A. FRENCH #1	708 KB	4096
3008		X	AMES	11	C. SCHWALBAUCH #1	935 DF	4666
3007		X	AMES	17	A. JAGO #1	780 DF	4552
2575		X	AMES	34	SUGAR CREEK COAL #4	1011 KB	4347
3186		X	AMES	36	SAYERS #1	886 KB	4237
3031		X	ATHENS	L72	OHIO MINING #35A	845 GL	4198
3106		X	ATHENS	L101	HOPE ET. AL. #2	643 GL	3989
3111		X	ATHENS	L113	OHIO MINING #46A	785 GL	4090
3105		X	ATHENS	L119	BALL #3	645 GL	3983
3020		X	ATHENS	L151	OHIO MINING #42A	755 GL	3985
3024		X	ATHENS	L151	OHIO MINING #43A	728 GL	4008
3040		X	ATHENS	L152	OHIO MINING #40A	805 GL	4062
3021		X	ATHENS	L153	OHIO MINING #41A	845 GL	4056
1916		X	CANAAN	7	R. DYBIEC #1	748 DF	4961
2868		X	DOVER	FR1N	PEABODY COAL CO. #22D	700 GL	3929
2887		X	DOVER	FR1N	PEABODY COAL CO. #15D	690 GL	3888
2893		X	DOVER	FR1N	PEABODY COAL CO. #29D	810 GL	4046
1764		X	DOVER	FR3	SUGAR CREEK COAL #1	927 DF	4154
1670		X	DOVER	FR4	R. SHIELDS #1	805 DF	4025
1688		X	DOVER	FR4	MILLFIELD COAL CO. #3	887 DF	4147
2066		X	DOVER	FR5	MILLFIELD COAL CO. #10	680 GL	3894
2867		X	DOVER	FR7N	PEABODY COAL CO. #28D	820 GL	4024
2869		X	DOVER	FR7N	PEABODY COAL CO. #20D	890 GL	4041
2892		X	DOVER	FR7N	PEABODY COAL CO. #21D	750 GL	3936
2031		X	DOVER	FR11E	SUGAR CREEK COAL #7	673 KB	3865

D E P T H T O T O P													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
		46BR	104 ?	162	214	338	TR	TR	351	ABS	NA	368	414
TR	97TR	105	175	214	244	393	400	403	408	ABS	NA	430	467
TR	124TR	145	208	247	280	425	433	436	444	ABS	NA	467	505
3400	3462	3520	3638	3683 ?	3706	3870	3881	3927	3944	3963	4004	?	NP
NL	3940	3996 ?	4136	4203 ?	4223	4384	4400	4438	4453	4472	4522	4558	4600
3740	3814	3885 ?	4015 ?	4072 ?	4097	4259	4268	4313	4328	4342	4368	4433	4472
3678	3752	3804	3940 ?	4004 ?	4024	4227	4240	4285	4296	4312	4335	NL	
3488	3562	3624	3764 ?	3812 ?	3849	4001	4012	4046	4060	4078	4107	4168 ?	4205
3394	3471	3534 ?	3652 ?	3703 ?	3736	3895	3908	3943	3959	3975	4013	4058	4096
3204	3258	3310	3422	3487 ?	3525	3683	3692	3732	3747	3764	3812	3846 ?	3886
3297	3372	3432 ?	3561	3607 ?	3640	3799	3812	3847	3864	3880	3913	3963 ?	4002
3182	3246	3312 ?	3428	3467 ?	3501	3667	3676	3717	3733	3751	3786	3836	3873
?	?	?	3460 ?	3514 ?	3543	3700	3714	3746	3762	3778	3812	3859 ?	3898
3200	3274	3344 ?	3458	3516 ?	3549	3705	3718	3753	3768	3782	3820	3863	3902
3263	3336	3410 ?	3514	3564 ?	3597	3756	3768	3801	3817	3827	3865	3914	3952
3304	3377	?	3564	3614 ?	3648	3808	3820	3853	3868	3885	3915	3966	4004
3888	3966 ?	4046 ?	4156	4180 ?	4220	4388	4397	4451	4470	4486	4526	4583	4620
3130	3206 ?	3290 ?	3394	3442 ?	3478	3632	3643	3676	3692	3707	3740	3790 ?	3825
3088	?	3250 ?	3370	3401 ?	3435	3588	3597	3632	3648	3663	3695	3746 ?	3784
3248	?	3378 ?	3514 ?	3563 ?	3595	3749	3762	3793	3809	3824	3870	3904 ?	3944
3496	3567	3628 ?	3810	3827 ?	3850	4005	4017	4052	4064	4084	4128	NP	
			NL	3684 ?	3721	3872	3886	3924	3938	3946	3995	NP	
3497	3568	3643	3760	3816 ?	3848	4008	4021	4054	4069	4087	4130	NP	
		NL	3509	3546 ?	3581	3738	3752	3784	3796	3810	3854	NP	
3246	3320	?	3504	3548 ?	3586	3740	3750	3784	3798	3810	3859	3890 ?	3930
3270	3344	3434 ?	3540	3580 ?	3614	3770	3782	3811	3827	3842	3876	3925 ?	3961
3144	3218 ?	3284 ?	3405	3454 ?	3488	3644	3654	3685	3701	3716	3762	3798	3836
3156	3228 ?	3318 ?	3418	3463 ?	3500	3654	3668	3700	3714	3732	3776	3810 ?	3853 ?

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

ATHENS COUNTY CONT'D.

2327		X	DOVER	FR11E	SUGAR CREEK COAL #9	666 KB	3848
2808		X	DOVER	FR11N	SUNDAY CREEK COAL #7E	860 GL	4039
2812		X	DOVER	FR11N	SUNDAY CREEK COAL #8E	805 GL	4019
2813		X	DOVER	FR11N	SUNDAY CREEK COAL #6E	847 KB	3977
2837		X	DOVER	FR11N	SUNDAY CREEK COAL #24B	693 DF	3916
3059		X	DOVER	FR24	SUNDAY CREEK COAL #15E	747 GL	3896
2818		X	DOVER	FR30	SUNDAY CREEK COAL #5E	890 GL	4051
2841		X	DOVER	FR30	SUNDAY CREEK COAL #23B	670 GL	3886
2850		X	DOVER	FR33	PEABODY COAL CO. #13D	855 GL	3988
2871		X	DOVER	FR33	PEABODY COAL CO. #19D	920 GL	4076
2879		X	DOVER	FR33	PEABODY COAL CO. #27D	885 GL	4072
2889		X	DOVER	FR33	PEABODY COAL CO. #26D	885 GL	4040
2849		X	DOVER	FR34	PEABODY COAL CO. #14D	860 GL	4000
2851		X	DOVER	FR34	PEABODY COAL CO. #12D	860 GL	3964
2853		X	DOVER	FR34	PEABODY COAL CO. #8D	695 GL	3840
2807		X	DOVER	FR35	SUNDAY CREEK COAL #4E	860 GL	3948
2857		X	DOVER	FR35	PEABODY COAL CO. #3D	875 GL	3969
2864		X	DOVER	FR35	PEABODY COAL CO. #2D	925 GL	4014
2866		X	DOVER	FR36	PEABODY COAL CO. #7D	880 GL	3970
2898		X	DOVER	L339	ATHENS COMMISSION #1	UNK	3961
2829		X	DOVER	L352	SUNDAY CREEK COAL #31B	725 GL	3963
2430		X	DOVER	L364	MC LAIN #1	700 GL	3643
3054		X	DOVER	2	SUGAR CREEK COAL #5	920 GL	4432
1681	2273	X	DOVER	4	SUGAR CREEK COAL #2	1062 DF	4229
1763		X	DOVER	4	MILLFIELD COAL CO. #4	782 DF	4010
2576		X	DOVER	4	SUGAR CREEK COAL #2	876 KB	4274
3062		X	DOVER	4	MILLFIELD COAL CO. #2	895 KB	6499
1684		X	DOVER	5	MILLFIELD COAL CO. #2	791 DF	3938
1780	3274	X	DOVER	5	MILLFIELD COAL #5	721 KB	4010

DEPTH TO TOP													
C SHALE	GREENFIELD	LOCKPORT/PEEBLE	LILLEY	BISHER / KEEFER	ROSEHILL/ ESTILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON / TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN/ JUNIATA
	LOCKPORT DOLOMITE												
		NL	3412	3456 ?	3492	3648	3660	3692	3706	3717	3770	3808 ?	NP
3244	3320	3391	3516	3562 ?	3596	3750	3762	3792	3809	3824	3866	3910	3945
3245	3318	3394 ?	3514	3554 ?	3591	3745	3759	3788	3806	3814	3860	3903	3940
3204	?	?	?	3518 ?	3552	3706	3719	3750	3769	3776	3811	3860	3899
3125	3199 ?	?	3402 ?	3435 ?	3476	3629	3642	3672	3688	3705	3743	3888 ?	3824
3108	3164 ?	3256 ?	3365	3421 ?	3457	3609	3621	3649	3665	3680	3725	3764	3798 ?
3270	3343	3418 ?	3533	3583 ?	3618	3767	3781	3812	3828	3843	3887 ?	3929	3954
3067	3189	3200 ?	3334	3374 ?	3409	3564	3576	3607	3624	3638	3677	3722	3763
3206	3278	3380 ?	3465	3514 ?	3549	3704	3715	3745	3762	3771	3811	3864 ?	3896
3292	3367	?	3554	3605 ?	3642	3796	3807	3836	3853	3866	3902	3956 ?	3990
3287	3358	?	3550	3598 ?	3631	3786	3799	3828	3845	3854	3904	3938 ?	3978
3270	3342	3403 ?	3538	3579 ?	3613	3768	3780	3811	3826	3837	3873	3927 ?	3960
3210	3284 ?	3370 ?	3468	3520 ?	3555	3708	3721	3750	3767	3782	3828	3868 ?	3903 ?
3181	?	?	3449	3493 ?	3529	3675	3697	3727	3743	3754	3786	3836 ?	3875
3042	3120	3200 ?	3314	3359 ?	3396	3549	3562	3592	3608	3616	3652	3706 ?	3738 ?
3164	3235	3296 ?	3420 ?	3476 ?	3509	3661	3672	3701	3716	3733	3782	3822	3855
3167	3242 ?	3327 ?	?	3476 ?	3514	3667	3679	3708	3728	3736	3774	3824	3857
3216	?	?	3474	3524 ?	3561	3714	3726	3755	3776	3788	3828	3856 ?	3908
3186	3260	3324	3454	3498 ?	3535	3688	3696	3730	3747	3760	3792	?	3877
		NL	3446	3499 ?	3521	3677	3689	3723	3742	3755	3785	3834	3871
3221	?	?	3443	3484 ?	3513	3670	3683	3716	3733	3746	3778	3829	3864
		NL	3302	3338 ?	3372	3525	3534	3568	3583	3594	3632	NP	
3554	3628	3710 ?	3823	3850 ?	3902	4063	4075	4109	4122	4136	4178	4224 ?	4264
		NL	3850	3892 ?	3934	4090	4104	4137	4150	4164	4212	NP	
			NL	3682 ?	3713	3870	3883	3918	3937	3950	3992	NP	
3534	3605	3665	3788	3840 ?	3890	4048	4061	4095	4109	4123	4167 ?	4208	4246
3508	3580	3656 ?	3770	3813 ?	3867	4020	4035	4069	4088	4103	4145	4187 ?	4223
		NL	3555	3614 ?	3646	3801	3814	3847	3862	3880	3916	NP	
3323	3386	3446 ?	3586	3640 ?	3663	3820	3834	3866	3885	3893	3940	3983 ?	NP

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

ATHENS COUNTY CONT'D.

2282		X	DOVER	5	MILLFIELD COAL CO. #1	891 KB	4202
2328		X	DOVER	6	SUGAR CREEK COAL #10	800 KB	4022
2801		X	DOVER	11	PHILLIPS ET. AL. #1	830 GL	4165
3051		X	DOVER	11	SIMPKINS #1	918 GL	4270
3092		X	DOVER	11	MILLFIELD PART. #1	935 GL	4240
3093		X	DOVER	11	MILLFIELD PART. #2	867 GL	4224
1507		X	DOVER	16	SUGAR CREEK COAL #1	885 DF	4065
2029		X	DOVER	16	MILLFIELD COAL CO. #8	680 KB	3869
2030		X	DOVER	16	MILLFIELD COAL CO. #9	688 KB	3876
1675		X	DOVER	17	DRY DOCK COAL #2	671 DF	3758
2814		X	DOVER	17	SUNDAY CREEK COAL #9E	800 GL	4114
1664	2104	X	DOVER	18	HELLER-DRY DOCK #1	719 DF	3800
2757		X	DOVER	18	GIBSON #1	665 GL	3952
2778		X	DOVER	18	DRYDOCK COAL CO. #35D	905 GL	4140
2519		X	DOVER	24	DRYDOCK COAL CO. #1D	945 GL	4042
2525		X	DOVER	24	DRYDOCK COAL CO. #7D	902 GL	4028
2662		X	DOVER	24	DRYDOCK COAL CO. #21D	758 GL	3890
2698		X	DOVER	24	DRYDOCK COAL CO. #32D	890 GL	4070
2699		X	DOVER	24	DRYDOCK COAL CO. #40D	875 GL	3999
2731		X	DOVER	24	DRYDOCK COAL CO. #50D	945 GL	4083
2733		X	DOVER	24	DRYDOCK COAL CO. #47D	850 GL	3979
3076		X	DOVER	24	DRYDOCK COAL CO. #53D	740 GL	3916
2888		X	DOVER	25	SUNDAY CREEK COAL #13E	790 GL	4023
2701		X	DOVER	29	DRYDOCK COAL CO. #30D	740 GL	3789
2804		X	DOVER	29	SUNDAY CREEK COAL #3E	922 GL	3999
2806		X	DOVER	29	SUNDAY CREEK COAL #1E	962 GL	4008
2836		X	DOVER	29	SUNDAY CREEK COAL #19B	965 GL	4031
2520		X	DOVER	30	DRYDOCK COAL CO. #2D	961 KB	3944
2521		X	DOVER	30	DRYDOCK COAL CO. #3D	985 GL	3982

D E P T H T O T O P													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
3510	3583	3632	3768	3828 ?	3860	4018	4032	4065	4084	4094	4136	NP	
		NL	3614	3663 ?	3697	3856	3868	3902	3916	3934	3971	NP	
3354	3426	3510 ?	3636	3672 ?	3708	3862	3874	3906	3924	3932	3980	4023 ?	4058
3470	3542 ?	3624 ?	3746	3792 ?	3824	3978	3991	4022	4040	4053	4096	4143 ?	4181
3466	3542	3598 ?	3737	3776 ?	3812	3965	3978	4010	4028	4040	4082	4126 ?	4164
3424	3500	3582 ?	3694	3748 ?	3779	3932	3946	3977	3996	4009	4050	4094 ?	4132
			NL	3734 ?	3770	3926	3939	3973	3987	4005	4047	NP	
3198	3270	3347 ?	3484 ?	3515 ?	3551	3702	3715	3747	3761	3778	3818	NP	
		NL	3494	3526 ?	3561	3716	3727	3759	3773	3790	3836	NP	
		NL	3368	3422 ?	3460	3612	3623	3653	3671	3684	3731	NP	
3310	3384	3468 ?	3595	3634 ?	3664	3820	3834	3863	3877	3894	3940	3980	4016
3146	3206	3272	3400 ?	3452 ?	3483	3635	3646	3676	3694	3708	3754	NP	
3110	3182	3246	3369	3425 ?	3461	3612	3625	3654	3672	3686	3729	3768	3815
3335	3408	3484	3599	3652 ?	3686	3832	3847	3876	3893	3908	3953	3992	4030
3310	3381	3440	3567	3626 ?	3660	3810	3823	3851	3869	3883	3927	3967 ?	4003 ?
3277	3350	3410	3538	3595 ?	3626	3776	3789	3816	3834	3848	3896	3937	3976
3154	3229	3298	3419	3471 ?	3507	3658	3671	3700	3717	3731	3775	3809	3850
3280	3353	3430	3544	3486 ?	3630	3780	3791	3820	3836	3851	3900	3934	3976
3214	3287	3370 ?	3482	3537 ?	3569	3719	3731	3759	3777	3785	3841	3881 ?	3915
3300	3374	3458 ?	3564	3620 ?	3654	3804	3816	3845	3853	3871	3924	3964	3999
3206	3280	3356 ?	3470	3526 ?	3559	3708	3719	3748	3765	3774	3828	3867	3903
3118	3192 ?	3273 ?	3382	3434 ?	3472	3624	3636	3665	3683	3696	3741	3780	3818
3220	3296	3380 ?	3486	3536 ?	3563	3718	3730	3762	3781	3794	3826	3878	3911
3068	3140	3216	3327	3386 ?	3420	3571	3583	3612	3630	3642	3668	?	3764
3193	3266	3350 ?	3460	3510 ?	3544	3695	3707	3735	3753	3765	3809	3855	3888
3226	3298	?	3486	3540 ?	3577	3726	3738	3767	3784	3792	3830	3893	3924 ?
3280	3352	3434 ?	3542	3596 ?	3630	3781	3793	3821	3838	3852	3896	3936	3970
3214	3286	3370 ?	3476	3534 ?	3565	3714	3725	3753	3771	3784	3818	3870	3903
3247	3321	3401	3510	3567 ?	3605	3752	3764	3791	3809	3822	3857	3910	3943

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

ATHENS COUNTY CONT'D.

2658		X	DOVER	30	DRYDOCK COAL #18D	925 KB	3982
2694		X	DOVER	30	DRYDOCK COAL CO. #28D	860 GL	3988
2719		X	DOVER	30	DRYDOCK COAL CO. #49D	900 GL	4042
2734		X	DOVER	30	DRYDOCK COAL CO. #52D	890 GL	3950
2735		X	DOVER	30	DRYDOCK COAL CO. #46D	UNK	3945
2736		X	DOVER	30	DRYDOCK COAL CO. #51D	907 GL	3933
2737		X	DOVER	30	DRYDOCK COAL CO. #48D	940 GL	4012
2852		X	DOVER	33	PEABODY COAL CO. #9D	925 GL	3938
2858		X	DOVER	33	PEABODY COAL #10D	950 KB	4003
2860		X	DOVER	33	PEABODY COAL CO. #24D	958 GL	4059
2872		X	DOVER	33	PEABODY COAL CO. #18D	795 GL	3880
2873		X	DOVER	33	PEABODY COAL CO. #16D	885 GL	3951
2885		X	DOVER	33	PEABODY COAL CO. #25D	870 GL	3993
2844		X	DOVER	34	PEABODY COAL CO. #1D	980 GL	4002
2845		X	DOVER	34	PEABODY COAL #4D	933 KB	3974
2992		X	DOVER	34	PEABODY COAL CO. #36D	965 GL	3993
2805		X	DOVER	35	SUNDAY CREEK COAL #2E	940 GL	3964
1777	3270	X	DOVER	36	E.M. POSTON #1	974 KB	3888
1818		X	DOVER	36	E.M. POSTON #3-0-2573	822 DF	3689
1821		X	DOVER	36	E.M. POSTON #2-0-2573	772 DF	3573
1874		X	DOVER	36	E.M. POSTON #4-0-2573	870 GL	3677
1966	3568	X	DOVER	36	E.M. POSTON #5	1008 DF	3868
1768	3094	X	LEE	1	DIAMOND STONE #1	757 KB	3890
2043		X	WATERLOO	F30	G.H. ADAMS #1	786 DF	3693
2049		X	WATERLOO	3	D. TAULBEE #1	754 DF	3841
2045		X	WATERLOO	7	E.M. BROOKS #1	881 DF	3878
2046		X	WATERLOO	12	J.D. LEE #1	734 DF	3734
1431	1077SD	X	WATERLOO	16	KISOR POOL #1	959 DF	3874
2097		X	WATERLOO	30	DRY DOCK COAL #2	870 KB	3509

DEPTH TO TOP													
C SHALE	GREEN-FIELD (Lockport Dolomite)	LOCK-PORT/PEEBLE (Lockport Dolomite)	LILLEY (Lockport Dolomite)	BISHER/KEEFER	ROSE-HILL/ESTILL	DAYTON/CASING	LULBE-GRUD SHALE	OLDHAM/PACKER	UPPER CABOT HEAD SHALE	CLINT-ON/TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/JUN-IATA
3253	3313	3363	3504	3554 ?	3594	3743	3754	3782	3800	3812	3854	3903 ?	NP
3172	3246	3322 ?	3436	3494 ?	3524	3674	3686	3716	3732	3746	3779	3833	3868
3222	3294 ?	3370	3484	3534 ?	3574	3723	3736	3764	3783	3796	3844	3884 ?	3918
3166	3238	3322 ?	3451	3484 ?	3517	3667	3678	3706	3724	3736	3776	3826	3858
3215	3290	3376	3482	3540 ?	3571	3718	3728	3757	3775	3788	3835	3875	3911
3173	?	?	3437	3491 ?	3523	3672	3684	3713	3730	3743	3790	?	3868
3230	3302	3362 ?	3498	3553 ?	3584	3733	3745	3773	3792	3803	3853	3888	3926
3155	?	?	3427	3472 ?	3507	3658	3669	3698	3714	3728	3763	?	3849
3230	3288	3350 ?	3490	3532 ?	3563	3720	3732	3760	3776	3790	3824	3856 ?	3907
?	?	?	3554	3588 ?	3626	3777	3790	3819	3833	3847	3896	?	3970
3110	?	?	3367	3419 ?	3455	3610	3622	3651	3667	3676	3713	?	3802
3165	3236	3316	3426	3468 ?	3505	3658	3668	3698	3713	3722	3760	3809 ?	3847
3235	3307	?	3504	3542 ?	3578	3734	3746	3776	3791	3807	3850	?	3923
3218	3290	?	3477	3531 ?	3567	3718	3730	3759	3777	3786	3828	?	3911
3196 ?	3254	3314 ?	3424	3493 ?	3526	3680	3690	3720	3736	3750	3784	3818 ?	3877
3185	3256	?	3454	3495 ?	3533	3684	3696	3725	3743	3751	3791	3842 ?	3877
3188	3261 ?	3340 ?	3456	3501 ?	3538	3688	3700	3728	3746	3759	3792	3844	3877 ?
3181	3240	3300 ?	3430	3496 ?	3520	3667	3678	3706	3724	3738	3772	3806 ?	3858
3035	3106	3197 ?	3305	3355 ?	3383	3530	3541	3570	3587	3596	?	NP	
2965	3024	3086	3200	3250 ?	3302	3449	3462	3487	3507	3514	3557	NP	
3065	3135	3216 ?	3350	3386 ?	3416	3562	3573	3600	3617	3632	3665	NP	
3264	3326	3386	3517	3572 ?	3608	3757	3768	3796	3813	3825	NP		
3228	3289	3342	3470	3490 ?	3529	3692	3701	3745	3764	3782	3811	?	NP
		NL	3161	3220 ?	3240	3396	3404	3436	3450	3464	3483	3529 ?	3580
		NL	3366	3424 ?	3447	3598	3614	3650	3670	3686	3718	3750	3802
		NL	3412 ?	3460 ?	3488	3650	3664	3698	3720	3732	3760	3796	3846
NL	3086	3144 ?	3266	3325 ?	3347	3504	3516	3547	3563	3574	3602	3642	3693
3168	3251	3302	3430	3475 ?	3507	3661	3670	3704	3724	3736	3765	3800	3850
			NL	?	3138	3336	3350	3377	3391	3405	3434	3470 ?	NP

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

ATHENS COUNTY CONT'D.

1656		X	YORK	FR11	E. COTTINGHAM #1	769 DF	3349
1674		X	YORK	FR11	OHIO MINING #2	713 DF	3460
2809		X	YORK	FR26E	OHIO MINING #1	990 GL	3765
2591		X	YORK	3	J. EDWARDS #1	673 DF	3636
2972		X	YORK	3	PEABODY COAL #32Y	695 GL	3718
3035		X	YORK	3	PEABODY COAL #30YA	762 GL	3746
3094		X	YORK	3	PEABODY COAL #31Y	898 GL	3876
3095		X	YORK	4	STONE #1	922 GL	3852
107		X	YORK	5	E. STRATTON #2	750 T	3529
1972		X	YORK	6	R.V. OAKLEY #1	700 DF	3449
2115		X	YORK	6	DRY DOCK COAL #2	872 DF	3627
2567		X	YORK	6	DRY DOCK COAL #3	682 DF	3432
2929		X	YORK	16	OHIO MINING #11Y	686 GL	3524
2672		X	YORK	17	HOCKING TECHNICAL #2	662 DF	3361
3099		X	YORK	17	HOCKING TECHNICAL #4	664 DF	3390
1776		X	YORK	25	DRY DOCK COAL #4	971 DF	3616
1783		X	YORK	25	OHIO MINING #1	988 DF	3621
1705		X	YORK	30	D.P. & M.A. WHATIN #1	802 DF	3236
1723		X	YORK	30	R.V. & H. OAKLEY #2	694 DF	3238
1746		X	YORK	30	C. & M.M. GASTIN #1	753 DF	3225
2130		X	YORK	30	SIMMS #2	702 DF	3250
2523		X	YORK	31	DRY DOCK COAL #5Y	895 DF	3609
2524		X	YORK	31	DRY DOCK COAL #6Y	960 DF	3634
2645		X	YORK	31	DRY DOCK COAL #14Y	943 DF	3617
2053		X	YORK	35	STEWART BROTHERS #1	692 DF	3130
2235		X	YORK	35	BAIRD BROTHERS #4	942 DF	3468
1730		X	YORK	36	E. WOLFE #1	844 DF	3498
1750		X	YORK	36	B. WOLFE LTD. #3	822 DF	3222

D E P T H T O T O P													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
		NL	3023	3068 ?	3102	3245	3254	3279	3292	3309	3337	NP	
?	?	?	3032	3084 ?	3110	3256	3263	3289	3304	3313	3346	3380	3430
3030	3098	3150 ?	3284	3333 ?	3368	3516	3526	3551	3564	3575	3609	3656	3695
2982	2962	3018 ?	3135	3196 ?	3225	3376	3387	3417	3434	3448	3476	3502 ?	3565
2924	2994	3048 ?	3194	3231 ?	3267	3418	3427	3458	3475	3482	3517	3552 ?	3604
3000	3070	3130	3256	3307 ?	3336	3486	3497	3528	3546	3558	3590	3612	3678
3092	3162	3220 ?	3343	3400 ?	3426	3577	3588	3616	3634	3641	3675	3698	3762
3156	3228	3283 ?	3420	3474 ?	3498	3650	3662	3689	3707	3720	3752	3807	3841 ?
2924	2992	3052 ?	3181	3245 ?	3267	3416	3428	3455	3472	3486	3510	NP	
2834	?	?	3102	3158 ?	3184	3332	3345	3368	3383	3394	3418	NP	
3024	3091	?	3280 ?	3346 ?	3369	3516	3526	3554	3572	3586	NP		
2805	2871	2932 ?	3060	3112 ?	3150	3296	3306	3333	3351	3366	3397	NP	
2770	2836	2892 ?	3022 ?	3072 ?	3108	3254	3266	3294	3308	3324	3353	3388	3440
2744	?	2876 ?	3006	3059 ?	3089	3236	3245	3271	3286	3303	3330	NP	
?	?	?	2968	3028 ?	3055	3201	3210	3237	3252	3267	3296	3331 ?	3383 ?
3022	3088	3145 ?	3264 ?	3317 ?	3357	3505	3513	3540	3554	3568	3598	NP	
?	?	?	3292	3337 ?	3376	3524	3532	3559	3573	3588	NP		
2665	2731	2796	2906 ?	2987 ?	3012	3153	3162	3186	3202	3216	NP		
?	?	?	2872	2915 ?	2951 ?	3090	3098	3123	3136	3160	3184	NP	
2632	2702	2762 ?	2903	2946 ?	2981	3120	3128	3152	3164	3174	3210	NP	
?	?	?	2935 ?	2965 ?	3002	3143	3152	3176	3190	3208	3230	NP	
2910	2975	3054 ?	3155	3196 ?	3241	3388	3397	3423	3436	3450	3483	3518 ?	3570
2923	2994	3054	3176 ?	3225 ?	3264	3410	3418	3444	3458	3468	3504	3539 ?	3591
2908	2973	3032	3144 ?	3194 ?	3238	3387	3396	3421	3434	3448	3478	3504 ?	3566
?	?	?	2824	2867 ?	2897 ?	3036	3048	3070	3084	3108	NP		
?	?	?	3132	3180 ?	3211	3353	3362	3384	3397	3420	3442	NP	
2737	2808	?	3006 ?	3058 ?	3084	3224	3232	3256	3267	3278	3312	3358 ?	3402
2635	2710	2772 ?	2910	2956 ?	2988	3124	3134	3158	3171	3186	3212	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

CLINTON COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
2A	482SD		GREEN	L4397	NEW VIENNA #2	1126 GL	1788
4	810SD		WASHINGTON	L1458	N. & L. IGO #1	1069 GL	3351
1	757SD	X	WAYNE	V1027	LUTTRELL #1	1114 DF	1983
2	772SD		WAYNE	V1065	P. ADAMS #1	1081 GL	3457
5	813SD		WAYNE	V1065	VAN PELT #1	1084 GL	3259
-	837SD		WAYNE	V808	H.W. & M. MC VEY	1087 GL	3465

FAYETTE COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
2	751SD	X	CONCORD	L1002	E. WILSON #1	1017 GL	3494
6	830SD		PERRY	V5431	M. HOPPES #1	998 GL	1879
10	3552	X	WAYNE	V1058	J.H. BRAUN #1	980 GL	3750

GALLIA COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
55	2399		GREENFIELD	18	CAMBRIA CLAY PROD. #14	UNK	3057
679		X	GUYAN	35	CROWN CITY MINING #1	932 KB	4252
181	3410	X	HARRISON	12	J. BANE #1	555 KB	4072
149		X	HARRISON	16	L.P. HASKINS #1	657 DF	4072
150		X	HARRISON	30	T. COLEMAN #1	578 DF	3783
769	3654		PERRY	10	BOB EVANS HIDDEN VALLEY	727 DF	4200
148	2609SD	X	PERRY	11	R. & E. COOK #1-0-1040	592 DF	3556
110	915SD	X	PERRY	28	A.P. GILLS #1	636 DF	3447
145	3387	X	PERRY	28	H.B. WOOD #1	762 DF	3617
151		X	PERRY	28	GILLS & GREEN #1-1101	793 DF	3624
146	2610	X	PERRY	33	W. CARTER ET. AL. #1	640 DF	3549
112	935		PERRY	34	D. DAVIS #1	635 DF	3643
597		X	RACCOON	9	VARNEY #1-31	799 KB	3529
480	3557		RACCOON	15	CENNAMO-BLAKENSHIP #1	615 DF	3550
220	3452	X	RACCOON	25	H. & O. HAGER #1	611 KB	3598

C SHALE	GREEN-FIELD	LOCK-PORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
D E P T H T O T O P													
				90BR ?	114 ?	160 ?	TR	TR	?	ABS	NA	170 ?	195 ?
												54B ?	95 ?
		82BR	151	170	180 ?	228	TR	TR	234	ABS	NA	245	290
		54BR ?	?	86 ?	107 ?	147 ?	TR	TR	?	ABS	NA	160 ?	201 ?
		50BR ?	?	80 ?	90 ?	130 ?	TR	TR	?	ABS	NA	145 ?	188 ?
		7BR ?	?	78 ?	100 ?	159 ?	TR	TR	?	ABS	NA	168 ?	218 ?
		30BR	132	150	166	210	TR	TR	218	ABS	NA	229	272
		50BR	?	?	220	295	TR	TR	?	ABS	NA	310 ?	366 ?
100 ?	205	260 ?	364 ?	380 ?	411	470	TR	?	484	ABS	NA	496	544
?	?	2630 ?	NR	2714 ?	2788 ?	?	?	2987 ?	2998 ?	3009 ?	3028 ?	NP ?	
3652	3718	3756	NR	3830	3869	4044	4050	4120	4152	4161	4195 ?	NP	
3436	3512	3550	NR	3631	3680	3853	3858	3928	3960	3970	4006	NP	
3482	3552	3589 ?	NR	3666	3719	3892	3896	3969	3994	4009	4052 ?	NP	
3218	3288	3326	NR	3406	3460 ?	3631	3636	3702	3728	3740	3768	NP	
?	?	?	NR	?	3650 ?	?	?	3934 ?	3958 ?	3980 ?	4005 ?	?	?
2972	3042	3080	NR	3159	3220	3391	3398	3456	3480	3495	3525	NP	
2912	2980	3010	NR	3091	3143	3313	3322	3377	3401	3407	3434	NP	
3036	3102	3135 ?	NR	3216 ?	3274 ?	3444	3453	3509	3532	3545	3571	3592 ?	NP
3065	3133	3168	NR	3249	3303	3472	3480	3536	3556	3564	3596	NP	
2947	3012	3050	NR	3133	3188	3360 ?	3365	3419	3442	3454	3481	3524 ?	NP
?	?	?	NR	?	3220 ?	?	?	3413 ?	3438 ?	3463 ?	?	?	3626 ?
2910	2978	3022 ?	NR	3112 ?	3170	3336	3343	3392	3408	3420	3458	3474 ?	NP
?	?	?	NR	?	3067 ?	?	?	3295 ?	3316 ?	3322 ?	3354 ?	?	?
2948	3015	3060	NR	3142	3201	3370	3377	3433	3454	3464	3500 ?	3515	3595

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

GALLIA COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
476	3560		RACCOON	29	STOUT-BALLMAN #1-12	698 DF	3451
248	3471	X	RACCOON	36	F. WILLIAMS #1	605 KB	3585
221	3454	X	SPRINGFIELD	19	J.T. & B.R. EVANS #1	718 KB	3957
224		X	SPRINGFIELD	21	BOB EVANS RANCH #1	718 KB	3940
583		X	SPRINGFIELD	22	E.K. PICKENS #1-38	651 KB	3874
586		X	SPRINGFIELD	23	CAINS #1-29	709 KB	3880
475	3562	X	SPRINGFIELD	34	DOUGLAS-DENNY-MOUNT #1	669 KB	3745
598		X	SPRINGFIELD	36	DAVIS #1-28	628 KB	3702
117		X	WALNUT	6	J.D. WAGONER #1	644 GL	3347
107	903	X	WALNUT	9	R. BAKER #1	681 GL	3630
828		X	WALNUT	32	T. SHEPHARD #1	892 KB	3794

HIGHLAND COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
9	2799C		BRUSH CREEK		HUMPHREY CA-110	749 T	313
6	2499C		FAIRFIELD	L1027	E. SWINGLEY CA-54	1056 T	270
3		X	PAINT	2	PEABODYS #1	880 T	3182
4		X	PENN	L2326	W.WRIGHT #1	1139 KB	2392

HOCKING COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
146	664		BENTON	19	M.D. MATTOX #1-8395	713 GL	2017
611	738	X	BENTON	33	AMERINE #1	1061 KB	2639
1490		X	STARR	3	SUNDAY CREEK COAL #1	972 DF	3512
1796		X	STARR	4	M. CAMPBELL #1	1002 DF	3426
2414		X	STARR	4	SEEL GRAVES UNIT #1	1012 DF	3438
497	679		STARR	5	S. KAPPEL #1	UNK	3295
1598		X	STARR	5	E.H. NORMAN ET. AL. #1	693 DF	3154
2520		X	STARR	5	NORMAN-CASSELLS #1	693 DF	3184
1293		X	STARR	6	NATCO CORP. #13	727 DF	3152
1693	3251		STARR	6	BELL WOLFE LTD. #6	800 T	3258

DEPTH TO TOP													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
?	?	?	NR	?	3052 ?	?	?	3274 ?	3298 ?	3302 ?	3346 ?	?	?
2960	3030	3063	NR	3152	3211	3380	3388	3443	3465	3475	3508	3526	NP
3325	3394	3434	NR	3520	3577	3746	3754	3817	3843	3857	3888	3920 ?	NP
3320	3393	3434	3518	3532 ?	3582	3758	3764	3826	3853	3866	3896	NP	
3211	3282	3322	3408	3423 ?	3475	3643	3652	3713	3739	3755 ?	3779	3805	NP
3225	3296	3335	3423 ?	3440 ?	3493	3663	3671	3730	3756	3769	3796	3820 ?	NP
3120	3190	3230	3316 ?	3336 ?	3384	3554	3561	3618	3640	3655	3683 ?	3710 ?	NP
3026	3096	3140	3233	3245 ?	3294	3462	3470	3525	3550	3562	3595	3627 ?	NP
2797	2858	2892	NR	2975	3032	3200	3206	3261	3281	3290	3310	NP	
3015	3080	3114	NR	3195	3250	3418	3425	3483	3508	3520	3546 ?	3565 ?	NP
3177	3241	3276	NR	3350	3404 ?	3572	3576	3635	3657	3672	3700	3734 ?	NP
		20BR	50	92	137	251	TR	TR	257	ABS	NA	277	NP
		24BR	91	116	142	207	TR	TR	219	ABS	NA	221	262
		26BR	108 ?	144 ?	179	262	TR	TR	271	ABS	NA	292	332
		54BR ?	108 ?	142 ?	188	248	TR	TR	253	ABS	NA	260	295
?	?	?	?	?	1830 ?	?	?	1951 ?	1954 ?	1993 ?	1998 ?	NP	
2040 ?	2105	2176	2300	2367 ?	2396	2524	2531	2543	2550 ?	2570	2578	2614	NP
2920	2996	3056 ?	3183 ?	3236 ?	3266	3414	3420	3444	3456	3471	3503	NP	
2834	2911	2978 ?	3098	3164 ?	3190	3333	3339	3361	3374	3387	3417	NP	
		NL	3150	3180 ?	3206	3346	3354	3376	3381	3403	3433 ?	NP	
?	?	?	?	?	?	3174 ?	3178 ?	3200 ?	3210 ?	3233 ?	3258 ?	NP	
2494	2570	2623 ?	2764 ?	2794 ?	2847 ?	2986	2994	3016	3030	3043	3072	3102	NP
2486	2566	2642 ?	2756	2790 ?	2840	2979	2986	3009	3022	3030	3066	3095 ?	NP
2521	2600	2660 ?	2795	2826 ?	2875	3014	3022	3044	3058	3067	3100	3132 ?	NP
?	?	?	?	?	3020 ?	?	?	3194 ?	3204 ?	3220 ?	3251 ?	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

HOCKING COUNTY CONT'D

2063	3545	X	STARR	6	GLEN-GARY CORP. #26	932 DF	3335
2669		X	STARR	10	STATLER/OLIVER #1	1030 KB	3517
2733		X	STARR	10	GROVES #2	1028 DF	3466
1702		X	STARR	11	J. TANSKY #1	693 DF	3034
2788		X	STARR	11	E. & C. WOOD #1	912 DF	3220
2857		X	STARR	11	VEIDT ET. AL. #1	842 DF	3140
1291		X	STARR	12	NATCO CORP. #12	703 DF	3008
1327		X	STARR	12	V. PRICE HEIRS #1	703 DF	3010
2753		X	STARR	15	SOWERS #1	983 DF	3421
1443		X	STARR	16	PEABODY COAL CO. #1	902 DF	3187
2452		X	STARR	16	C. CARSON #1	1022 DF	3344
2288		X	STARR	18	C.R. MASON #1	942 DF	3236
2297		X	STARR	18	DOZER #4	927 DF	3158
1394		X	STARR	21	LOGAN SAND CO. #1A	953 DF	3192
2632		X	STARR	22	WATT #1	1002 DF	3198
2139		X	STARR	23	C. LOOMIS #1	861 DF	3044
2321		X	STARR	24	ATHENS PRESBYTERIAN #2	922 DF	3097
1402		X	STARR	26	LOGAN SAND CO. #2A	993 DF	3132
1333		X	STARR	27	LOGAN SAND CO. #1	1027 DF	3187
1455		X	STARR	28	E. HORWELL #2	952 DF	3071
330A		X	STARR	29	VICKERS-ANDERSON #1	952 DF	3078
1414		X	STARR	29	J. BICKLE #1	962 DF	3062
1481		X	STARR	29	J. BICKLE #2	887 DF	2980
2224		X	STARR	29	C.R. BEATTY	952 DF	3100
2529		X	STARR	29	C.R. BEATY #2	968 KB	3090
1504		X	STARR	30	MOODY INSTITUTE #1	893 DF	2993
1757		X	STARR	30	AMER. BIBLE INST. #2	903 DF	3045
1222	1948SD	X	STARR	31	M.F. & H. HOCKMAN #1	970 KB	6488
1451		X	STARR	35	R. STONE & C. SMITH #1	993 DF	3067

DEPTH TO TOP													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
2704	2784	2847	2990	3030 ?	3066	3205	3214	3235	3248	3260	3284	3323 ?	NP
					NL	3324	3333	3355	3367	3380	3414	3438	3502
2770	2843	2900	3026	3091 ?	3122	3260	3268	3289	3300	3309	3348	3371	3430
2430	2512	2574 ?	3712	2753 ?	2785	2922	2930	2951	2965	2972	3000	NP	
			NL	2902 ?	2982	3122	3130	3154	3165	3176	3202 ?	NP	
2561	2640	2702 ?	2831	2880 ?	2910	3050	3058	3078	3091	3102	3138	NP	
2413	2488	2550	2693	2733 ?	2764	2899	2907	2928	2841	2952	2984	NP	
2420	2500	2565	2701	2741 ?	2772	2910	2917	2939	2951	2962	2990 ?	NP	
2724	2794	2860	2980	3035 ?	3066	3208	3216	3238	3249	3262	3294	3316	3380
2587	2612	2724	2854	2902 ?	2932	3070	3078	3099	3111	3120	3144	3178	NP
2725	2802 ?	2865 ?	3002	3046 ?	3076	3215	3223	3244	3255	3264	3303	3330	NP
2591	2665 ?	2730	2858	2904 ?	2939	3074	3082	3103	3114	3124	3154	3182	NP
		NL	2836	2881 ?	2914	3050	3058	3079	3088	3100	3128	NP	
2610	2675	2705	2805	2931 ?	2954	3090	3098	3118	3128	3139	3175	NP	
		NL	2890	2932 ?	2968	3098	3112	3131	3142	3152	3176	NP	
2469	2542	2604 ?	2742	2784 ?	2815	2948	2954	2975	2985	2994	3036	NP	
		NL	2786	2826 ?	2865	2996	3004	3023	3033	3042	3080	NP	
2558	2624	2681	2800 ?	2874 ?	2895	3029	3037	3056	3065	3075	3099	NP	
2600	2666	2728	2842 ?	2914 ?	2942	3077	3085	3103	3113	3122	3151	NP	
2506	2575	2637	2766	2807 ?	2843	2974	2982	3000	3009	3018	3048	NP	
		NL	2768	2810 ?	2845	2979	2986	3005	3015	3124	3052	NP	
2508	?	2607 ?	2772	2811 ?	2847	2975	2984	3002	3013	3021	3058	NP	
2430	2500	2560 ?	2694	2732 ?	2768	2899	2907	2925	2935	2944	NP		
2527	2596	2667 ?	2778 ?	2853 ?	2868	3002	3010	3028	3038	3048	3076	NP	
2513	2585	2647	2782	2823 ?	2855	2988	2996	3014	3024	3034	3062	NP	
2432	2505	?	2702	2746 ?	2782	2914	2922	2940	2950	2960	2978 ?	NP	
2484	2553 ?	2616 ?	2752	2796 ?	2831	2964	2972	2990	3002	3010	3039 ?	NP	
2595	2661	2720	2835 ?	2900 ?	2921	3058	3067	3085	3095	3104	3130	3155	3224
2505	2573	2635 ?	2766	2808 ?	2840	2973	2981	2999	3008	3018	3047	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

HOCKING COUNTY CONT'D.

2503		X	STARR	35	BURNS #1	924	DF	3038
1461		X	STARR	36	F. CONKLE #2	851	DF	2927
1429		X	WASHINGTON	1	COLUMBUS BEAGLE #3	1002	DF	3014
1483	2593	X	WASHINGTON	1	R.D. LEAMAN #1-2771	942	DF	2921
2314		X	WASHINGTON	1	G. LARKIN #1	960	KB	2994
2817		X	WASHINGTON	1	COLUMBUS BEAGLE #7	942	DF	2922
289	485		WASHINGTON	4	H.W. DAVIS #1	972	T	2774
2434		X	WASHINGTON	4	EMENS #7	1008	DF	2850
2435		X	WASHINGTON	4	EMENS #8	926	DF	2750
2444		X	WASHINGTON	8	EMENS #6	986	DF	2820
2445		X	WASHINGTON	8	EMENS #5	1006	DF	2950
2431		X	WASHINGTON	9	EMENS #2	1024	DF	3092
2432		X	WASHINGTON	9	EMENS #3	1076	DF	2930
2433		X	WASHINGTON	9	EMENS #4	1104	DF	2977
1477		X	WASHINGTON	10	F. RIGGS #1	982	DF	2812
2436		X	WASHINGTON	10	HAWK #1	804	DF	2726
2437		X	WASHINGTON	10	HAWK #3	796	DF	2746
1521		X	WASHINGTON	11	M. RAUBER ET. AL. #3	1032	DF	2980
2708		X	WASHINGTON	11	STRAIT #2	992	DF	2944
2709		X	WASHINGTON	11	STRAIT #1	981	DF	2932
2719		X	WASHINGTON	11	STRAIT #4	1004	DF	2944
2720		X	WASHINGTON	11	STRAIT #3	1022	DF	2963
2745		X	WASHINGTON	11	STRAIT #7	988	DF	2964
2666		X	WASHINGTON	12	R. MOSURE #2	960	DF	2907
824		X	WASHINGTON	13	C.E. GRIFFITH #1	UNK		2856
2228		X	WASHINGTON	13	F.A. & N.M. MOSURE #1	1007	DF	2988
2394		X	WASHINGTON	14	H.M. SMITH ET. AL. #1	1080	GL	3048
2680		X	WASHINGTON	14	BOWERS HEIRS #1	1052	DF	3017
2721		X	WASHINGTON	14	STRAIT #5	1032	DF	2972

D E P T H T O T O P

C SHALE	GREEN-FIELD	LOCK-PORT/PEEBLE	LILLEY	BISHER/KEEFER	ROSE-HILL/ESTILL	DAYTON/CASING	LULBE-GRUD SHALE	OLDHAM/PACKER	UPPER CABOT HEAD SHALE	CLINT-ON/TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/JUN-IATA
	LOCKPORT DOLOMITE												
		NL	2734 ?	2778 ?	2810	2942	2950	2967	2978	2987	3008	NP	
2368	2436	2500	2633	2670 ?	2707	2838	2846	2864	2874	2883	2911	NP	
		NL	2711	2757 ?	2794	2923	2930	2946	2956	2967	2995	NP	
2353	2426	2484	2621	2682 ?	2704	2830	2838	2854	2863	2873	NP		
2341	2413	2471	2614	2658 ?	2697	2821	2829	2845	2854	2864	2886	2920	NP
?	?	2486 ?	2636	2675 ?	2709	2838	2846	2862	2872	2882	2904	NP	
?	?	?	?	?	2601 ?	2720 ?	2724 ?	2736 ?	2747 ?	2761 ?	2774 ?	NP	
2227	2294	2356	2498	2554 ?	2585	2708	2714	2728	2736	2750	2775	2803	NP
2149	2216	2276	2420	2482 ?	2510	2631	2640	2654	2661	2669	2698	2726	NP
2202	2258	2328	2475	2539 ?	2565	2685	2695	2709	2716	2724	2753	2781	NP
2338	2409 ?	2468	2618	2677 ?	2706	2831	2837	2851	2859	2865	2898	2928	NP
2441	2520	2584	2734	2792 ?	2823	2954	2962	2976	2984	2994	3026	3051 ?	NP
2322	2390	2448	2594	2653 ?	2679	2804	2811	2825	2833	2856	3868	2896	NP
2348	2418	2478	2626	2683 ?	2712	2838	2846	2860	2868	2875	2881	2932	NP
2282	2351	2409	2553	2598 ?	2634	2760	2767	2782	2790	2799 ?	2828	NP	
?	?	?	2375	2416 ?	2456	2580	2588	2603	2609	2615	2652	2678	NP
2128	2196	2258	2398	2442 ?	2478	2605	2613	2627	2636	2645	2673	2698 ?	NP
2426	2500 ?	2558	2693	2743 ?	2772	2896	2908	2923	2932	2941	2966	NP	
2368	2436	2498	2631 ?	2698 ?	2716	2845	2853	2868	2878	2886	2920	NP	
2365	2433	2495	2625	2678 ?	2707	2834	2842	2857	2866	2875	2907	NP	
		NL	2636	2699 ?	2716	2843	2851	2865	2875	2889	2901	NP	
		NL	2643	2690 ?	2721	2846	2853	2868	2878	2886	2920 ?	2944 ?	NP
2384	2452	2512	2652	2701 ?	2732	2856	2870	2884	2893	2903	2920 ?	NP	
2348	2410	2470	2612 ?	2652 ?	2688	2816	2824	2839	2848	2858	2883	NP	
2306	2370	2430	2549	2619 ?	2642	2771	2780	2797	2806	2815	2842	NP	
2434	2506	2574 ?	2692	2740 ?	2772	2902	2910	2925	2935	2943	2976	NP	
		NL	2700	2752 ?	2798	2928	2936	2952	2961	2969	2993	3021	NP
		NL	2718	2764 ?	2812	2942	2950	2965	2974	2983	3004 ?	NP	
		NL	2652 ?	2694 ?	2754	2882	2891	2904	2914	2923	2950 ?	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

HOCKING COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
2426		X	WASHINGTON	15	ENDERLE #1	904 DF	2975
2427		X	WASHINGTON	15	ENDERLE #2	924 DF	2914
2428		X	WASHINGTON	15	ENDERLE #3	1011 DF	2971
2430		X	WASHINGTON	15	ENDERLE #5	864 DF	2844
2447		X	WASHINGTON	15	ENDERLE #6	884 DF	2918
2513		X	WASHINGTON	15	ENDERLE #4A	956 DF	2941
2561		X	WASHINGTON	15	M. ZIEGLER #1	982 KB	2828
720		X	WASHINGTON	16	J.A. FORAKER #1	970 GL	2820
1484		X	WASHINGTON	16	W.J. BOZETT #1	1103 DF	2963
1575		X	WASHINGTON	16	BENSONHAVER #1	1039 DF	2870
1738		X	WASHINGTON	16	K. FOX #1B	942 DF	2735
1783		X	WASHINGTON	16	R. WARTHMAN #1	982 DF	2791
2500		X	WASHINGTON	16	R. LAMPMAN #2	1062 DF	2840
327	515		WASHINGTON	17	E. GRIFFITH #1	1000 T	2800
1476		X	WASHINGTON	17	E. GRIFFITH #1	1037 DF	2810
1500		X	WASHINGTON	17	E. GRIFFITH #2	907 DF	2682
2033		X	WASHINGTON	17	R.J. CASSADY #1	1001 DF	2718
2168		X	WASHINGTON	17	W. ROBSON #1	1012 DF	2785
2290		X	WASHINGTON	17	C. MAPLE #1	1012 DF	2774
1604		X	WASHINGTON	19	G.B. HULL #4	962 DF	2770
1627		X	WASHINGTON	19	G.B. HULL #5-0	1002 KB	2730
1644	3071	X	WASHINGTON	19	G.B. HULL #7-0	968 DF	2710
1649	3068	X	WASHINGTON	19	G.B. HULL #8-0	937 DF	2655
1703		X	WASHINGTON	19	MAHONEY ET. AL. #1-0	1001 DF	2710
1685		X	WASHINGTON	20	G.B. HULL #10-0	1062 DF	2810
2441		X	WASHINGTON	20	PRIMMER #2	946 DF	2828
2442		X	WASHINGTON	20	PRIMMER #4	1034 DF	2867
2446		X	WASHINGTON	20	PRIMMER #3	1034 DF	2980
2695		X	WASHINGTON	20	ROBSON #2	1021 DF	2788

DEPTH TO TOP													
C SHALE	GREEN-FIELD	LOCK-PORT/PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
2390	2456	2516	2636 ?	2735 ?	2756	2890	2898	2913	2922	2933	2963 ?	NP	
2302	2366	2427	2548	2619 ?	2642	2773	2780	2796	2804	2813	2846	2866	NP
2346	2413	2480 ?	2600	2670 ?	2692	2818	2829	2845	2852	2861	2888	2917	NP
2227	2292	2350	2472	2550 ?	2570	2698	2706	2722	2731	2740	2773	2796 ?	NP
2302	2368	2430	2556	2634 ?	2654	2788	2796	2813	2822	2831	2868	2888	NP
2337	2402	2471	2584	2666 ?	2681	2812	2820	2835	2843	2853	2888	2909	NP
2276	2338	2402	2544	2616 ?	2631	2756	2766	2777	2784	2794	2822	NP	
2250	2316	2375	2506	2583 ?	2599	2728	2736	2750	2758	2768	2791	NP	
2390	2457	2520	2664	2725 ?	2739	2867	2875	2888	2896	2906	2935	NP	
2334	2400	2460	2605	2670 ?	2684	2811	2819	2832	2839	2848	NP		
			NL	2515 ?	2533	2660	2668	2682	2689	2697	2730 ?	NP	
2250	2316	2380	2503 ?	2573 ?	2594	2718	2728	2741	2749	2758	NP		
2294	2360 ?	2436	2571	2636 ?	2646	2772	2779	2792	2800	2808	2835	NP	
?	?	?	?	?	2580 ?	?	?	2716 ?	2724 ?	2740 ?	2767 ?	NP	
2256	2322	2393	2514	2590 ?	2606	2732	2739	2752	2758	2769	2799	NP	
2128	2192	2254	2386	2464 ?	2479	2606	2613	2627	2634	2643	2658	NP	
2178	2243	2308	2434	2514 ?	2532	2656	2666	2679	2686	2691	2714	NP	
2211	2275	2340	2464	2540 ?	2555	2683	2690	2703	2708	2716	2738	2774 ?	NP
2202	2268 ?	2328	2458	2505 ?	2553	2681	2688	2701	2708	2713	2741	NP	
2140	2201	2263	2394	2464 ?	2482	2610	2617	2630	2640 ?	2651	2678	2706	2768 ?
2163	2224	2284	2415	2486 ?	2504	2631	2639	2651	2660	2662 ?	2704	NP	
2168	2229	2290	2418	2480 ?	2510	2638	2646	2659	2666	2670 ?	2698	NP	
2130	2190	2250	2381	2452 ?	2470	2598	2605	2618	2626	2632	2650	NP	
2153	2213	2272	2406	2476 ?	2495	2623	2630	2643	2651	2662	2684	NP	
2260	2322	2381	2510	2580 ?	2600	2728	2736	2749	2756	2772	2786	NP	
2222	2288	2348	2472	2542 ?	2513	2693	2701	2714	2722	2728	2742	2786	NP
2271	2333	2394	2518	2588 ?	2610	2740	2747	2761	2768	2774	2791	2833	NP
2380	2444	2512	2634	2708 ?	2728	2864	2871	2886	2894	2910	2923	2963	NP
			NL	2582 ?	2598	2728	2735	2749	2756	2775	NP		

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

HOCKING COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
816		X	WASHINGTON	21	R. WARTHMAN #1	UNK	2693
838	1022		WASHINGTON	21	J.L. FORAKER #1	UNK	2717
2380		X	WASHINGTON	21	E.G. PRIMMER #1	966 DF	2873
2454		X	WASHINGTON	21	HORN #1	984 DF	2940
2455		X	WASHINGTON	21	HORN #2	944 DF	3010
753		X	WASHINGTON	22	E. MILLSTED #1	1018 DF	2962
870		X	WASHINGTON	22	D. TURNER #2	970 T	2925
2389		X	WASHINGTON	22	FISHER ET. AL. #1	954 DF	2990
2471		X	WASHINGTON	22	THOMPSON #1	942 DF	2868
752		X	WASHINGTON	23	ERVIN #1	920 DF	2880
2388		X	WASHINGTON	23	FISHER ET. AL. #3	1014 DF	3066
2408		X	WASHINGTON	23	E. & D. BRICKEY #1	950 DF	3042
2648		X	WASHINGTON	24	A. BRIMNER #1	820 GL	2838
829		X	WASHINGTON	26	PIERPONT HEIRS #1	UNK	2898
831		X	WASHINGTON	27	HUGHES #1	880 T	2810
843		X	WASHINGTON	27	A. CHRISTEL #2	960 T	2832
1493		X	WASHINGTON	27	L.E. & E.G. HUGGINS #1	962 DF	2878
2175		X	WASHINGTON	27	R. GORDON #1	992 DF	2902
2794		X	WASHINGTON	27	ANTHONY #1	943 DF	2828
812		X	WASHINGTON	28	J. CRAWFORD #A-1	865 T	2693
2379		X	WASHINGTON	28	R. MORGAN #1	916 DF	2894
2439		X	WASHINGTON	28	BROOKS #2	976 DF	2850
2440		X	WASHINGTON	28	BROOKS #1	904 DF	2814
1679	3043	X	WASHINGTON	29	SO. OHIO ENTERPRISE #1	1047 KB	2832
1704		X	WASHINGTON	29	G. LEONARD ET. AL. #1	952 DF	2828
1530	2857SD	X	WASHINGTON	30	G.B. HULL #1-0	987 DF	2738
1561		X	WASHINGTON	30	G.B. HULL #3	912 DF	2650
1562		X	WASHINGTON	30	G.B. HULL #2	972 DF	2698
1628	3024	X	WASHINGTON	30	G.B. HULL #6-0	993 KB	2760

D E P T H	T O	T O P											
C SHALE	GREEN-FIELD (LOCKPORT DOLOMITE)	LOCK-PORT/ PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
		NL	2398 ?	2456 ?	2477	2605	2613	2626	2634	2644	2672	NP	
?	?	?	?	?	?	?	?	?	?	2682 ?	2706 ?	NP	
2256	2319	2380	2508	2574 ?	2598	2730	2738	2752	2758	2768	2787	2825	NP
2326	2390	2454	2580	2650 ?	2670	2802	2809	2826	2835	2845	2874	2908	NP
2396	2464	2531	2660	2706 ?	2758	2894	2902	2918	2926	2938	2965	2999 ?	NP
2402	2468	2531	2632	2719 ?	2741	2872	2878	2894	2903	2913	2941	NP	
2360	2424	2487	2600	2674 ?	2695	2827	2835	2851	2859	2869	2887	NP	
2328	2392	2455	2574	2652 ?	2670	2802	2809	2825	2833	2842	2866	2895	2962
2336	?	2447 ?	2562 ?	2636 ?	2657	2788	2796	2812	2822	2830	2848	NP	
2332	2396	2457	2574	2648 ?	2669	2800	2808	2823	2832	2840	2869	NP	
2394	2458	2514	2635 ?	2686 ?	2732	2863	2870	2887	2896	2905	2929	2961	3028
2344	2409	2470	2568	2650 ?	2675	2806	2814	2830	2840	2846	2875	2902	2967
		NL	?	2595 ?	2618	2752	2760	2777	2786	2794	2828 ?	NP	
NL	2409	2470	2586	2656 ?	2681	2812	2819	2835	2845	2853	2885	NP	
2262	2324	2386	2505	2573 ?	2594	2726	2734	2750	2758	2767	2785	NP	
2286	2350	2421 ?	2526	2590 ?	2614	2747	2754	2769	2777	2786	2814	NP	
		NL	2581 ?	2636 ?	2661	2792	2798	2814	2823	2832	2862	NP	
2364	2429	2494	2611	2676 ?	2696	2828	2836	2851	2860	2868	2891	NP	
2278	2340	2406	2518 ?	2586 ?	2620 ?	2742	2750	2765	2773	2782	2806	NP	
2141	2204 ?	?	?	2458 ?	2481	2611	2619	2633	2641	2650	2676	NP	
				NL ?	2620 ?	2751	2759	2774	2782	2789	2820	2850	NP
2243	2306 ?	2368	2484	2548 ?	2587	2718	2726	2740	2748	2760	2784	2816	NP
2212	2274 ?	2334	2460	2532 ?	2554	2684	2691	2705	2713	2723	2749	2783	NP
2287	2348	2410	2540	2587 ?	2624	2757	2764	2778	2783	2787 ?	2816	NP	
2183	2243	2305	2430	2500 ?	2522	2652	2660	2673	2681	2701	2709	2744	2806
2160	2220	2280	2414	2483 ?	2503	2630	2636	2649	2658	2668	2698	NP	
2096	2158	2220	2350	2418 ?	2440	2568	2576	2589	2595	2618 ?	2632	NP	
2134	2196	2254	2393	2456 ?	2477	2604	2611	2624	2632	2639	2669	NP	
2204	2266	2323	2456	2523 ?	2545	2674	2681	2694	2702	2721	2730	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
HOCKING COUNTY CONT'D.							
1684	3069	X	WASHINGTON	30	G.B. HULL #9-0	923 DF	2652
1724		X	WASHINGTON	31	M.P. SAYERS #1-0	1028 DF	2750
2253		X	WASHINGTON	33	LANDREE ET. AL. #1	968 DF	2916
2654		X	WASHINGTON	33	R.E. LAPP #1	933 DF	2850
2682		X	WASHINGTON	33	SHEETS #1	975 DF	3014
2693		X	WASHINGTON	33	SHEETS #2	968 DF	2971
719		X	WASHINGTON	34	H. & L. STONE #1	850 T	2888
768		X	WASHINGTON	34	R.S. HOFFNER #1	912 DF	2940
844		X	WASHINGTON	34	E. OXLEY #1	UNK	2937
2418		X	WASHINGTON	34	O. & F. FUNK #2	927 DF	2947
764		X	WASHINGTON	35	Z. HOPKINS #1	812 DF	2874
1569		X	WASHINGTON	35	W.V. GRIFFITH #1	813 DF	2831
309	490		WASHINGTON	36	R. WILLIAMS #1	931 T	3104
946	1029SD	X	WASHINGTON	36	F. MOWREY #1	878 DF	2982
2864		X	WASHINGTON	36	R. CHERRY #3	993 DF	3118
JACKSON COUNTY, OHIO							
122		X	BLOOMFIELD	5	J.R. STEWART #1	856 KB	3040
124		X	BLOOMFIELD	6	P.R. JOHNSON #1	700 KB	2854
118		X	COAL	1	J. ADAMS LEASE #1	747 DF	2695
113		X	COAL	29	R.E. FRAZIER ET.AL. #1	681 DF	2495
108		X	FRANKLIN	4	T.H. BLANTON #1	797 KB	4569
104		X	FRANKLIN	5	B. GARRETT #1	798 KB	4468
110		X	FRANKLIN	5	T.H. BLANTON #2	791 KB	4494
102	3465SD	X	FRANKLIN	8	F.J. & C. TREPANIER #1	834 KB	6043
86	2517	X	FRANKLIN	21	V. & R. DASSEL #1	856 KB	4836
76	1625SD		FRANKLIN	23	G.D. & I. WOOD #1	816 KB	6320
79	1627SD		FRANKLIN	31	W.G. BROWN #1	841 KB	5991
78	1626SD		HAMILTON	28	S. SLAVENS ET. AL. #1	665 KB	5681

D E P T H T O T O P													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
2093	2155	2213	2349	2414 ?	2434	2564	2571	2584	2591	2596 ?	2624	NP	
2197	2259	2318	2454	2529 ?	2542	2673	2680	2692	2699	2706	2724	NP	
2274	2333	2398	2522	2580 ?	2606	2739	2748	2761	2769	2778	2803	2838	2901
2238	2300	2360	2485	2550 ?	2570	2705	2713	2726	2734	2757	2762	2796	NP
2372	2434	2495	2611	2678 ?	2698	2834	2841	2856	2864	2873	2898	2928	2990
2317	2380	2441	2559	2625 ?	2646	2778	2786	2800	2809	2824	2844	2875	2937
			NL	2561 ?	2581	2714	2722	2738	2746	2756	2788	2815	2877
			NL	2712 ?	2732	2862	2872	2886	2894	2905	2919	NP	
		NL	2510	2632 ?	2652	2781	2788	2803	2811	2818	2842	2874	NP
2378	?	2499	2611 ?	2683 ?	2702	2836	2844	2859	2868	2877	2907	2934	NP
2329	2392	2458	2510	2630 ?	2652	2786	2794	2810	2820	2829	2864 ?	NP	
2286 ?	?	2418 ?	2532	2600 ?	2620	2755	2763	2779	2787	2796	2831 ?	NP	
?	?	?	?	?	2847 ?	?	?	2989 ?	3000 ?	3033 ?	3048 ?	?	NP
2424	2486	2545 ?	2655	2728 ?	2748	2883	2890	2908	2917	2927	2962	2980	3047 ?
2546	?	2652	2775	2861 ?	2882	3020	3028	3044	3055	3064	3094 ?	NP	
2418	2488	2538 ?	NR	2636 ?	2692	2856	2863	2896	2907	2916	2936	2968	NP
2226	2292	2348 ?	NR	2430 ?	2488	2654	2662	2692	2704	2713	2734	2764	2825
2116	2188	2230	NR	2340	2395	2555	2563	2587	2596	2602	2623	2656	NP
1784	1854	1901	2004	2018	2071	2227	2235	2253	2260	2264	2279	2321	2378
1994	2056	2100	2198	2218	2258	2417	2427	2453	2464	2470	2486	2523	2580
1984	2045	2090	2178	2198	2237	2398 ?	2407	2432	2443	2453	2459	2504	2560
1990	2050	2092	2190	2212	2251	2409	2419	2444	2455	2464	2472	2515	2578
2018	2078	2124	2206	2232	2272	2432	2440	2466	2476	2484	2494	2536	2592
2148	2210	2253	NR	2340	2401	2548 ?	2572	2600	2611	2621	2628	2671	2726 ?
?	?	2212 ?	2320 ?	2400 ?	?	?	?	?	?	?	?	2791 ?	2821 ?
?	?	2062 ?	2152 ?	2208 ?	2223 ?	?	?	?	?	?	?	?	2540 ?
?	?	1770 ?	1855 ?	?	1943 ?	?	?	?	?	2110 ?	2118 ?	2208 ?	2239 ?

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

JACKSON COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
32	312SD		JEFFERSON	27	L. MEYERS #1	841 GL	2750
72	1023C		LIBERTY	19	C. GROVER #1	959 GL	2241
85		X	MADISON	5	G.E. LEWIS #1	693 DF	2940
168		X	MILTON	1	LEACH #1	948 KB	3403
165		X	MILTON	2	B. KRIEBEL #1	866 DF	3262
100		X	MILTON	3	J. ADAMS #1	860 KB	3180
166		X	MILTON	15	P. JOHNSON #1	678 DF	3008
98		X	MILTON	17	PITTENGER ET. AL. #1	865 KB	2995
61	740	X	MILTON	29	BUCKEYE #1	772 DF	2855
132		X	MILTON	29	W. MC KELL EST. #1	802 DF	4932
62	759	X	MILTON	33	F.C. MORROW ET. AL. #2	802 T	2986
126		X	MILTON	34(N)	LOCKARD LEASE #14	831 DF	3107
127		X	MILTON	34(N)	LOCKARD LEASE #15	926 DF	3210
128		X	MILTON	34(N)	LOCKARD LEASE #16	890 DF	3171
129		X	MILTON	34(N)	LOCKARD LEASE #17	826 DF	3125
130		X	MILTON	34(N)	LOCKARD LEASE #18	866 DF	3143
169		X	MILTON	36(N)	BIERHUP #1	956 DF	3347
48	569SD		SCIOTO	19	A.L. & A. MURRAY #1	646 GL	3800
4-5	358SD		WASHINGTON	17	G.H. YOUNG #1	915 GL	2808
119		X	WASHINGTON	26	J. ADAMS LEASE #2	872 DF	2830

LAWRENCE COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
235		X	AID	2	L. HILL #1	610 KB	3422
234		X	AID	12	R. & M. CRAWFORD #1	606 KB	3440
350		X	AID	13	C.E. WILSON #1	805 KB	3638
345		X	AID	25	C. ADKINS #1	585 GL	3429
264		X	AID	26	E. & E. DRUMMOND #1	605 KB	3399
347		X	AID	26	SHARON SILICA #7	643 KB	3398
340		X	AID	35	SHARON SILICA #5	830 KB	3601

DEPTH TO TOP													
C SHALE	GREEN-FIELD (LOCKPORT DOLOMITE)	LOCK-PORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
?	?	?	?	?	2484 ?	?	?	?	?	2724 ?	?	NP	
?	?	?	?	?	1900 ?	?	?	2050 ?	2060 ?	2090 ?	2100 ?	2125 ?	2175 ?
2417	2480	2524	NR	2613	2663	2827 ?	2840	2882	2894	2903	2922	NP	
2727	2803	2852	NR	2956	3023	3186	3195	3224	3235	3244	3280	3297	3360
2568	2643	2688	NR	2804	2862	3023	3032	3062	3073	3082	3111	3130	3196
		NL	NR	2730	2789	2949	2957	2986	2996	3006	3028	3056	NP
?	2388 ?	2437 ?	NR	2540	2600	2762	2769	2801	2811	2820	2848	2868 ?	2933 ?
		NL	NR	2632 ?	2687	2848	2856	2884	2894	2904	2921	2957	NP
2335	2407	2454	NR	2551	2608	2770	2778	2807	2819	2829	NP		
2374	2444	2493	NR	2590	2652	2814	2821	2852	2862	2872	2887	2926	2992 ?
2395	2470	2513	NR	2615	2670	2833	2842	2871	2884	2893	2918	2960	NP
2457	2530	2572	NR	2682	2750	2911	2919	2946	2956	2967	2990	3016	3078 ?
2533 ?	2606	2654 ?	NR	2764 ?	2829	2991	2998	3025	3035	3046	3072	3097	3164
2496 ?	2565	2608 ?	NR	2716 ?	2787	2949	2957	2984	2994	3006	3034	3054	3116 ?
2469	2543 ?	2590 ?	NR	2698 ?	2765	2927	2934	2961	2972	2983	3002	3029	NP ?
2491	2564 ?	2612	NR	2721 ?	2790	2953	2960	2989	2999	3010	3028	3054	3116 ?
2680	2755 ?	2802	NR	2918 ?	2975 ?	3136	3144	3175	3186	3195	3236	3256	NP
?	?	?	?	?	1620 ?	?	?	?	?	?	?	1805 ?	1946 ?
?	?	?	?	?	2608 ?	?	?	2669 ?	2689 ?	2716 ?	2722 ?	2762 ?	NP
2161	2233	2276 ?	NR	2387	2445	2602	2609	2631	2640	2644	2665	2705	2767
2770	2830	2867	NR	2935	2987	3155	3162	3217	3238	3246	3265	3298	3363
2788	2846	2884	NR	2954	3004	3170	3179	3234	3256	3270	3286	3316	3377
3058	3117	3155	NR	3223	3275	3440	3449	3507	3528	3542	3560	3590	NP
2857	2918	2957	NR	3020	3070	3232	3240	3299	3322	3335	3367	3385	NP
2794	2850	2888	NR	2953	3001	3164	3171	3229	3252	3266	3297	3314	NP ?
2820	2876	2915	NR	2980	3027	3190	3199	3256	3278	3292	3320	NP	
3040	3096	3130	NR	3200	3248	3410	3420	3477	3502	3515	3543	NP ?	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

LAWRENCE COUNTY CONT'D.

116	311		DECATUR	1	A. CULBERTSON #1	955 GL	3177
252		X	DECATUR	14	O.S. & C.R. COLLINS #1	695 KB	2962
265		X	DECATUR	34	PINKSTON #1	1002 KB	3186
263		X	ELIZABETH	1	SHARON SILICA #1	1048 KB	3389
162	566SD		ELIZABETH	4(E)	DOW CHEMICAL CO. #4	620 GL	2340
261		X	ELIZABETH	15(W)	P.& O. MONNIG JR. #1	590 KB	2604
219	2501	X	ELIZABETH	27	CAMBRIA CLAY #1-A	734 KB	5315
260		X	ELIZABETH	36	S. ANDREA #1	590 KB	3020
159	554SD		HAMILTON	5	DOW CHEMICAL CO. #2	552 GL	2031
231	3466	X	HAMILTON	11	H. JEFFREYS TRUSTEE #1	888 GL	2871
349		X	LAWRENCE	3	GREEN GATE FARMS #1	953 KB	3715
352		X	LAWRENCE	12	G. HUMPHREYS #1	838 KB	3660
153	591		LAWRENCE	14	G. HARTWIG #1	705 GL	3451
239		X	MASON	5	C.C. & C.M. MILLER #1	635 KB	3448
247		X	MASON	5	T. & R. BELVILLE #1	720 KB	3590
314		X	MASON	5	H. & A. ROACH #1	623 KB	3495
237		X	MASON	6	C. RENFRO #1	778 KB	3599
233		X	MASON	7	N. & R. TAYLOR #3	608 KB	3474
238		X	MASON	7	N. & R. TAYLOR #1	610 KB	3518
336		X	MASON	7	E. & M. TAYLOR #1	614 KB	3502
236		X	MASON	18	N. & R. TAYLOR #2	625 KB	3524
253		X	PERRY	17	F. PRATT #1	671 KB	3349
266		X	SYMMES	2	SHARON SILICA #1	665 KB	3300
217	2568	X	SYMMES	8	C. BURCH #1	930 DF	3259
174	927	X	SYMMES	13	A.J. PAYNE #1	608 KB	3271
251		X	SYMMES	34	E.W. & V.M. POSTON #1	640 KB	3210
243		X	SYMMES	36	J. & G. MILLER #1	610 KB	3357
170	900	X	WASHINGTON	11	CAMBRIA CLAY CO. #1	903 DF	2969
106	163		WASHINGTON	13	CAMBRIA CLAY CO. #2	890 GL	3205

DEPTH TO TOP

C SHALE	GREENFIELD	LOCKPORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSEHILL/ ESTILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON / TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN/ JUNIATA
	LOCKPORT DOLOMITE												
?	?	?	?	?	2870 ?	?	?	?	?	3127 ?	3149 ?	NP	
2364	2416 ?	2452	NR	2534	2582 ?	2742	2748	2793	2813	2817	2835	2872	2928
2584	2638	2676	NR	2746	2796	2956	2963	3008	3025	3032	3038	3084	3137
2786	2842 ?	2882	NR	2954 ?	3003	3162	3169	3217	3236	3243	3264	3297 ?	3351
?	?	2250 ?	NP										
1945	1992 ?	2032	NR	2097	2146	2308	2314	2360	2373	2376	2384	2428	2484
2476	2530 ?	2566	NR	2633	2680	2826	2860	2902	2908	2913 ?	2936	2982 ?	3036
2433	2484	2523	NR	2584	2630	2794	2802	2855	2875	2881	2903	2930	2993
?	?	?	?	?	?	?	?	1970 ?	1982 ?	2000 ?	2004 ?	NP	
2358	2404 ?	2443 ?	NR	2500	2554	2713	2730	2769	2786	2792	2797	2841	NP
		NL	NR	3276	3322	3486	3495	3554	3577	3588	3604	3640	3701
3150	3206	3238 ?	NR	3303	3346 ?	3508	3512	3577	3604	3615	3644	NP	
?	?	?	?	?	3130 ?	?	?	3360 ?	3365 ?	3377 ?	3405 ?	NP	
2962	3022	3056	NR	3130	3180	3346	3357	3416	3439	NP			
3013	3073	3110	NR	3184	3235	3404	3410	3470	3490	3505	3522	3551	NP
2924	2984	3020	NR	3096	3146	3316	3322	3382	3405	3419	3447	NP	
3005	3063	3100	NR	3172	3224	3393	3400	3458	3480	3494	3508	3541	NP
2874	2933	2970 ?	NR	3040	3088	3258	3265	3322	3345	3357	3388	3413	NP
2910	2968	3005 ?	NR	3070	3124	3287	3296	3354	3377	3390	3420 ?	3437	3504
2916	2975	3012	NR	3083	3133	3298	3307	3366	3388	3401	3432	3449 ?	NP
2916	2975	3013	NR	3085	3131	3300	3308	3364	3383	3401	3434	3450 ?	3515
2763	2809 ?	NR ?	NR	2900 ?	2940	3106	3112	3175	3203	3213	3230	3266	NP ?
2667	2727	2764	NR	2844 ?	2906 ?	3063	3073	3125	3144	3152	3170	3202	3260
2745	2804	2843	NR	2914	2978 ?	3136	3143	3191	3212	3216	3239	NP	
2689	2750	2782 ?	NR	2858	2913	3079	3083	3138	3156	3165	3192	3210 ?	NP
2642	2702	2740	NR	2812 ?	2862	3027	3038	3089	3107	3114	3136	3168	NP
2782	2844	2880 ?	NR	2948	3005	3171	3178	3235	3260	3270	3283	3315	NP
2466 ?	2530	2570	NR	2649	2704	2864	2882	2917	2932	2939	2953	NP	
?	?	?	?	?	2788 ?	?	?	3005 ?	3019 ?	3025 ?	3032 ?	3136 ?	NP ?

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

LAWRENCE COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
220	2506	X	WINDSOR	1	D. HIGGINS #1	620 KB	3604
221	2621	X	WINDSOR	1	R. & V. BURCHMAN #1	708 KB	4089
206	2150		WINDSOR	7	BUCKLEW FARM	570 GL	3490
197	1987		WINDSOR	18	P. & C. MOOTZ #1	562 GL	3507

MEIGS COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
1566		X	COLUMBIA	1	H. HARMON #1	725 KB	4062
2128		X	SCIPIO	FR17	WILLIAMS & YOUNG #1	755 KB	4172

PIKE COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
1	263SD		BEAVER	35	R. BAPST #1	708 GL	4227
23	1066	X	BEAVER	5	P.F. QUINSEL #1	667 KB	1620
25	1069	X	BENTON		T. FRANCIS #1	620 KB	581
35	1971SD	X	JACKSON	10	REISENGER ET. AL. #1	775 DF	3999
36	2086SD	X	JACKSON	10	L. FRICK #1	1001 KB	5146
22	1339C	X	PEBBLE		L. MILLER #1	681 GL	1089
29	1324SD		PEBBLE		E. CONLEY #1	915 GL	3614
D5	310SD		PEE PEE	L490	I. DONALDSON #1	580 GL	3360
30	1396	X	PEE PEE	V2863	G.D. NYE #1	672 DF	3636
33	1659SD	X	PEE PEE	V8942	W. EASTERDAY #1	762 KB	3365
21	1340C	X	PERRY		ATTINGER #1	939 DF	533
D6	287SD		SCIOTO	16	ARMINTROUT #1	682 GL	3429
24	1070	X	SEAL	13	C. ANDERSON #1	696 KB	1441
32	1395SD	X	SEAL	19	R. BURTON #1	885 DF	3386
34	1683SD	X	SEAL	15	G. GREGG #1	686 KB	3860
28	1154SD	X	SUNFISH		B.W. WILLIAMS #1	634 DF	2920
27	1121SD	X	UNION	26	W.A. WOODELL #1	773 DF	3845

DEPTH TO TOP													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
3370	3432	3466	NR	3536	3573	NP							
3448	3510	3545	NR	3612	3652	3822	3831	3904	3934 ?	3945 ?	3979	4017	4074
?	?	?	?	?	3170 ?	?	?	3410 ?	3436 ?	3452 ?	3490 ?	NP ?	
?	?	?	?	?	3190 ?	?	?	3427 ?	3431 ?	3480 ?	3507 ?	NP ?	
3228	3304	3350	3476 ?	3488 ?	3526	3696	3704	3753	3773	3790	3810	3868	3911
3405	3490 ?	3535	3650 ?	3680 ?	3720	3890	3900	3953	3971	3990	4027	4070	4108
?	?	1381 ?	1458 ?	1476 ?	1505 ?	?	?	?	?	ABS	NA	1792 ?	1830 ?
1104	1158	1202	1285	1310	1359	1509	1518	1531	1543	ABS	NA	1586	NP
130	182	230	330	365	412	530	TR	539 ?	548	ABS	NA	NP	
1277	1332	1377	1470	1484	1541	1691	1700	1712	1722	1730 ?	1740 ?	1765	1830
1490	1544	1590	1682	1707 ?	1754	1904	1912	1924	1936	ABS	NA	1978	2040 ?
530	580	625	702	728	794	928	935	940	950	ABS	NA	986	1033
?	?	682 ?	785 ?	852 ?	883 ?	?	?	?	?	ABS	NA	1040 ?	1096 ?
?	?	625 ?	?	?	895 ?	?	?	?	?	ABS	NA	?	1015 ?
590	653 ?	690	785	813 ?	860	995	1003	1009	1020	ABS	NA	1057	1105
717	773	820	890	940	995	1130	1135	1142	1151	ABS	NA	1191	1241
TR	134TR	153	259	293	362	464	TR	472 ?	474	ABS	NA	500	NP
?	?	960 ?	?	1070 ?	1092 ?	1245 ?	1248 ?	1256 ?	1264 ?	ABS	NA	1340 ?	1380 ?
914	968	1013	1102	1134	1180	1325	1330	1342	1354	ABS	NA	1396	1446
1012	1065	1108	1200	1230	1277	1420	1426	1416	1447	ABS	NA	1490	1538
783	836	881	965	995	1048	1188	1195	1206	1218	ABS	NA	1257	1304
304	356	402 ?	500 ?	520 ?	580 ?	704	712	715	724	ABS	NA	756	805
1105	1157	1200 ?	1280	1305	1346	1498	1507	1520	1531	ABS	NA	1575	1623

ROSS COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
5		X	BUCKSKIN		FULLER #1	922 DF	2566
21	3556	X	BUCKSKIN	V3074	R.M. IRVINE #1	985 KB	3880
10	1435SD	X	COLERAIN	9	SCHAAL #1	858 KB	3611
11	1512SD	X	COLERAIN	19	D.L. ZEIGLER #1	898 KB	3500
19	1537SD	X	COLERAIN	36	TAR HOLLOW STATE #1	820 KB	3800
9	1454SD	X	CONCORD		O.& O. CLARK #1	1033 KB	3863
10A	153SD		CONCORD	L407	W. PERIE #1	832 DF	2325
8	1397SD	X	GREEN	18	M. IMMEL #1	695 DF	4168
16	1516SD	X	GREEN	28	F.R. CONAWAY #1	871 KB	3310
6	1282SD	X	HARRISON	9	D. & N. COFFMAN #1	740 DF	3809
13	1502SD	X	HARRISON	30	H.L. CARPER #1	678 KB	3421
4	1072	X	HUNTINGTON	V4642	N. WENZEL #1	955 KB	1066
7	1348SD		JEFFERSON	34	M. & B. OYER #1	623 GL	4198
14	1513SD	X	LIBERTY	9	K.C. CRYDER #1	640 KB	3505
18	1524SD	X	SPRINGFIELD	1(E)	J.F. SCOTT #1	827 KB	3480

SCIOTO COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
1A	559		BLOOM	7E	V.V. ATKINS #1	683 GL	2485
195	1067	X	BRUSH CREEK		C.L. JONES #1	594 KB	500
212	2161C	X	GREEN		U.S. STEEL CORP. #1	557 KB	5617
202	1370		HARRISON	17	A.R. WILL #1	923 GL	4320
193	1045	X	MADISON	20E	DEVER #1	591 KB	2060
85	447		PORTER	13	A. HOCK #1	UNK	2174
257		X	RARDEN	L103	H. SMITH #1	1213 KB	4432
194	1068	X	VALLEY	5	C.D. SHISLER #1	531 KB	1075

VINTON COUNTY, OHIO

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
122P	540		BROWN	36	D.D. WARD #1	753 GL	3045
400		X	BROWN	36	LEMUEL & FULLER #3	750 DF	3024

DEPTH TO TOP

C SHALE	GREENFIELD	LOCKPORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSEHILL/ ESTILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON / TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN/ JUNIATA
	LOCKPORT DOLOMITE												
210	289 ?	347 ?	453 ?	490	524	595	TR	?	610	ABS	NA	628	673
190	280 ?	340	434	444	494	562	TR	?	576	ABS	NA	590	642
1140	1222	1280	1373	1400	1463	1560	1572	1576	1585	ABS	NA	1630	1686
1070	1147	1200	1289	1339 ?	1386	1480	TR	?	1504	ABS	NA	1548	1602
1278	1357	1405 ?	1512	1530 ?	1600	1715	1725	1729	1740	ABS	NA	1783	1842
242 ?	380 ?	416 ?	504	526	552	614	TR	?	634	ABS	NA	646	699
?	?	349 ?	439 ?	479	495 ?	535 ?	TR	?	543 ?	ABS	NA	?	710 ?
597	670	725	812	848	910	994	1007	1009	1017	ABS	NA	1055	1109
860	934	985	1072	1122	1177	1272	TR	?	1292	ABS	NA	1335	1383
990	1047	1093	1280	1323	1370	1483	1492	1496	1507	ABS	NA	1550	1605
894	950	1003	1133	1180	1222	1338	1348	1352	1362	ABS	NA	1404	1458
679	732	777	938	984 ?	1038	NP							
1073 ?	?	?	1268	1318 ?	1347	1502 ?	?	?	1521 ?	ABS	NA	1568	1619
955	1015 ?	1060	1150 ?	1202	1265	1392	1401	1408	1420	ABS	NA	1460	1517
916	972	1020	1205	1263	1300	1403	TR	?	1426	ABS	NA	1470	1524
?	?	?	?	?	2176 ?	?	?	2380 ?	2390 ?	2398 ?	2410 ?	?	NP
180	226	268	330 ?	375	402	NP							
1706	1752	1792 ?	NR	1862	1900	2050 ?	2054	2112	2132	2138 ?	2148 ?	2178	2234
?	?	?	?	?	?	?	?	?	?	?	?	?	?
1486	1540	1580	1660	1700 ?	1722	1885	1891	1917	1927	1930 ?	1936 ?	1978	2038
?	?	?	?	?	1780 ?	?	?	1973 ?	1985 ?	2000 ?	2005 ?	?	?
668	719	760 ?	848 ?	890	920	1055	TR	?	1072	ABS	NA	1098	1138
814	864	904	980 ?	1006 ?	1050	NP							
?	?	?	?	?	2805	?	?	2961	2969	2989	3014	NP	
2482	2546 ?	2600 ?	2715	2781 ?	2804	2944	2952	2970	2979	2989	3022	NP	

Permit Number	Sample Number	Log	Township	Section	Well Name	Elevation	Total Depth

VINTON COUNTY CONT'D.

594		X	CLINTON	5	G. HARPER #1	767 KB	2930
601		X	CLINTON	6	W. DEPUE #2	834 DF	2906
394		X	CLINTON	14	JAY MAR COAL CO. #4	869 DF	3062
715		X	CLINTON	14	JAY MAR #14-1	882 DF	3198
720		X	CLINTON	14	CHURCH FOUND. #14-1	880 DF	3228
744		X	CLINTON	14	JAY MAR #14-2	921 KB	3199
641		X	CLINTON	15	EBERTS LEASE #2	856 DF	3096
647		X	CLINTON	15	BOOTH LEASE #2	811 DF	3066
649		X	CLINTON	15	BOOTH LEASE #1	846 DF	3042
716		X	CLINTON	15	JAY MAR #15-1	860 KB	3123
742		X	CLINTON	15	JAY MAR #15-2	915 KB	3172
652		X	CLINTON	17	OBERHOLZER #1	908 DF	3052
653		X	CLINTON	17	OBERHOLZER #2	827 DF	2986
620		X	CLINTON	20	DIXON LEASE #4	826 DF	3004
630		X	CLINTON	20	DIXON LEASE #5	686 DF	2775
643		X	CLINTON	20	DIXON LEASE #3	690 DF	2804
644		X	CLINTON	20	MASSIE #1	908 DF	3107
650		X	CLINTON	20	DIXON #2	846 DF	2970
718		X	CLINTON	21	D.E. LEWIS #4	775 DF	3004
719		X	CLINTON	21	D.E. LEWIS #5	725 KB	2924
434		X	CLINTON	22	LOCKARD #1	852 DF	3018
556		X	CLINTON	22	LOCKARD LEASE #4	888 DF	3150
557		X	CLINTON	22	LOCKARD LEASE #5	831 DF	3048
619		X	CLINTON	22	T. WILLIS #1	833 DF	3086
659		X	CLINTON	22	J. EBERTS #1	865 DF	3157
555		X	CLINTON	23	LOCKARD LEASE #3	808 DF	3100
558		X	CLINTON	23	LOCKARD LEASE #6	808 DF	3138
395		X	CLINTON	24	MEAD CORP. #3	772 DF	3024
674		X	CLINTON	26	LOCKARD LEASE #13	886 DF	3194

D E P T H					T O				T O P				
	LOCKPORT DOLOMITE												
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
2170	2244	2292	2408	?	2468	2622	2630	2652	2660	2671	2687	2720	2784
2238	2313	2357 ?	2482	?	2542	2696	2705	2726	2734	2744	2769	2794	2858
2422	?	?	?	?	2790	2948	2956	2982	2992	3008	3030	NP	
2535	2612 ?	2656	2765	2821 ?	2834	2991	3000	3023	3033	3042	3064	3097	3165
2521	2597	2645	2748 ?	2808 ?	2822	2978	2987	3012	3022	3034	3058	3088	3154
2534	2609	2660	2760	2818 ?	2832	2990	2996	3020	3032	3038	3063	3100	3163 ?
2461	2536	2580	2690	2749 ?	2759	2918	2926	2950	2959	2970	2989	3024	3078 ?
2390	2466	2508	2618	2674 ?	2685	2844	2852	2875	2884	2895	2920	2945	3004
2392	2466	2510	2620	2678 ?	2690	2848	2855	2880	2889	2902	2917	2952	3006
2460	2536	2580	2692	2745 ?	2758	2916	2925	2949	2958	2970	2992	3024	3078
2523	2600	2640	2749	2810 ?	2822	2977	2985	3010	3020	3034	3058	3089	3152
2406	2479	2524	2642	2686 ?	2698	2856	2864	2886	2894	2904	2919	2954	3013
2333	2408	2456	2566	2618 ?	2628	2786	2794	2818	2827	2837	2851	2882	2954 ?
?	?	?	?	?	2585	2742	2750	2774	2782	2792	2804	2840	2906
2144	2219	2268	2370	2431 ?	2438	2596	2604	2627	2636	2646	2664	2702	2760
2141	2216	2261	2360 ?	2426 ?	2436	2594	2602	2624	2633	2642	2656	2691	2753
2414	2490	2530 ?	2640	2704 ?	2712	2872	2880	2904	2912	2922	2934	2972	3034 ?
2328	2404	2448 ?	2554	2618 ?	2626	2783	2791	2815	2823	2834	2846	2881	2944
2328	2403	2447	2558	2610 ?	2621	2780	2788	2813	2821	2829	2851	2880	2942
2300	2374	2420 ?	2530	2584 ?	2593	2750	2760	2784	2793	2802	2825	2855	NP
2417	2490	2532 ?	2646	2694 ?	2707	2866	2874	2899	2908	2918	2937	2968	NP
2495	2572	2616 ?	2726 ?	2782 ?	2794	2955	2963	2989	2999	3008	3028	3063	3124
2406	2478	2528	2630	2688 ?	2700	2858	2867	2893	2902	2912	2932	2965	3024
2412	2487	2534	2638 ?	2698 ?	2707	2866	2874	2899	2908	2918	2936	2965	NP
?	?	?	?	?	2768	2926	2932	2958	2967	2975	3006	3026	3084 ?
2451	2528	2573 ?	2680	2738 ?	2749	2909	2918	2944	2954	2963	2982	3020	3080
2440	2518 ?	2564	2666	?	2739	2898	2907	2934	2943	2954	2970	3010	3068
2476	2548 ?	2602 ?	2710	2766 ?	2776	2937	2946	2972	2982	2991	NP		
2557	?	?	?	?	2837	2998	3006	3034	3044	3054	3080	3104	3166

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

VINTON COUNTY CONT'D.

442		X	CLINTON	27	LOCKARD LEASE #1	942 DF	3232
551		X	CLINTON	27	LOCKARD LEASE #12	866 DF	3198
682		X	CLINTON	27	D.E. LEWIS #1	876 KB	3080
717		X	CLINTON	28	D.E. LEWIS #3	860 KB	3055
721		X	CLINTON	28	D.E. LEWIS #2	800 DF	3006
618		X	CLINTON	29	A. WILBUR #1	686 DF	2750
661		X	CLINTON	29	L. DIXON LEASE #6	805 DF	2942
654		X	CLINTON	30	TRAINER #1	726 DF	2858
290		X	EAGLE	10	MEAD CORP. #1	787 DF	1968
370	2616	X	ELK	3	ENGLE ET.AL. #1-0-1223	752 DF	2859
259		X	ELK	4	E.R. KING #1	770 T	2776
369	2508	X	ELK	18	J.S. WALDRON #1-0-1212	884 DF	2738
254		X	ELK	19	D. PERRY #2	970 T	2784
260		X	ELK	30	D. PERRY #3	845 DF	2695
302	1347SD	X	HARRISON	6	V.R. & F.E. BROWN #1	628 DF	4072
476		X	JACKSON	3	L. MINTON ET. AL. #1	1020 KB	2661
471		X	JACKSON	4	CARPENTER ET. AL. #2	1018 DF	2719
544		X	JACKSON	4	E. & H. MINTON #1	1050 KB	2734
189		X	JACKSON	7	B. TATMAN #1-10183	763 DF	2123
202		X	JACKSON	7	E. TURNER #3-10194	945 DF	2293
489		X	JACKSON	10	T. &. L. SCANLAN #1	1075 KB	2744
491		X	JACKSON	11	C.E. & R. FOUT #1	1060 KB	2868
381		X	JACKSON	12	A. & M. PERRY #1	1007 DF	2777
214		X	JACKSON	18	E.W. TURNER #10200	709 DF	2058
266		X	JACKSON	18	G.R. SOWERS #1-10237	920 DF	2327
563		X	JACKSON	20	G. HART #1	955 KB	2511
488		X	JACKSON	24	A. & D. BROADSTONE #1	930 KB	2764
500		X	JACKSON	24	C. & O. FREELAND #1	1010 DF	2888
637		X	JACKSON	24	E. COX #1	1010 KB	2758

DEPTH TO TOP													
C SHALE	GREENFIELD	LOCKPORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSEHILL/ ESTILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON / TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN/ JUNIATA
	LOCKPORT DOLOMITE												
2511	2586	2636 ?	2738	2796 ?	2807	2965	2974	2999	3008	3019	3044	3090	3134
2524	2600 ?	2642 ?	2750	2813 ?	2826	2986	2994	3021	3032	3042	3072	3090	3159
2424	2498	2541	2648	2705 ?	2717	2876	2884	2910	2918	2927	2943	2978	3038
2400	2475	2522	2622	2680 ?	2692	2850	2858	2883	2892	2909	2922	2955	3014 ?
2372	2446	2489	2595 ?	2653 ?	2664	2823	2831	2856	2865	2875	2892	2925	2983
2153	2226	2274	2373	2428 ?	2445	2604	2611	2634	2643	2656	2673	2703	NP
2279	2352	2395 ?	2498	2565 ?	2577	2735	2744	2768	2777	2786	2799	2838	2897
2161	2234	2280 ?	2382	2442 ?	2452	2609	2618	2641	2650	2660	2677	2712	2772
1458	1528 ?	1582	1690	?	1766	1892	1899	1909	1915	1920 ?	1926 ?	NP	
2280	2356	2408	2525	2590 ?	2600	2747	2755	2774	2782	2795	2819	2845 ?	NP
2216	2293 ?	?	2466	2530 ?	2538	2676	2692	2708	2716	2726 ?	2749	NP	
2173	2250	2300	2410	2436 ?	2485	2632	2640	2658	2665	2676	2700	NP	
2240	2316	2367	2478	2528 ?	2552	2700	2709	2726	2733	2744	2763	NP	
2156	2230	2280	2388	2440 ?	2463	2610	2618	2636	2644	2655	2683	NP	
1176	1247 ?	1294	1420 ?	1477 ?	1513	1642	1649	1660	1670	ABS	NA	1713	1776
2080	2098	2149	2320	2384 ?	2402	2533	2540	2553	2570 ?	2578	2582	2619	NP
			NL	2342 ?	2370	2503	2510	2523	2528	2538	2546	2593	2653
?	?	?	?	?	?	2532	2540	2552	2558	2562	2580	2620	2679
		NL	1880	1932 ?	1946	2075	2082	2092	2097	2100	2108	NP	
1750	1810	1860	2037	2090 ?	2107	2235	2242	2253	2270	2272 ?	2280 ?	NP	
2058	2124	2176	2342	2416 ?	2442	2573	2580	2592	2598	2606	2616	2659	2720
2194	2264	2314	2460	2526 ?	2540	2677	2686	2698	2704	2712	2728	2764	2826
2222	2297	2350	2480	2543 ?	2558	2697	2705	2718	2726	2734	2740	2784	2847
1510	1577	1623	1815	1873 ?	1884	2012	2020	2030	2047	NP ?			
1747	1814	1862	2051	2107 ?	2122	2252	2259	2270	2281	2286	2290	NP	
1912	1982	2030	2170 ?	2236 ?	2250	2387	2394	2406	2414	2419	2432	2474	NP
2166	2238	2290	2418	2478 ?	2494	2635	2643	2657	2664	2674	2692	2726	NP
2253	?	?	?	?	2564	2706	2713	2729	2736	2746	2766	2796	2860 ?
2164	2238	2292	2418	2483 ?	2496	2634	2640	2655	2662	2674	2688	2725	NP

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

VINTON COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
482		X	JACKSON	25	C. & G. GRAY #1	1070 DF	2783
499		X	JACKSON	25	C. & G. GRAY #2	831 KB	2724
746		X	JACKSON	27	HAECKER #1	898 DF	2610
493		X	JACKSON	28	I. ANKROM #1	740 KB	2454
496		X	JACKSON	33	D.M. BARNETT #1	740 DF	2382
629		X	JACKSON	35	F. ANKROM #1	1015 DF	2787
497		X	JACKSON	36	L. & F. DAFT #1	1005 KB	2896
605		X	JACKSON	36	J. HENTHORN #1	956 KB	2778
585		X	MADISON	32	J. BETHEL #2	746 DF	3182
378	2915		RICHLAND	4(S)	F.T. VERKAMP #1-A	750 GL	2366
306A	1285SD		SWAN	1	E. WHITE #1-A	900 GL	3078
404		X	SWAN	1	E. WHITE #2	780 DF	2938
405		X	SWAN	1	LEMUEL & FULLER #2	815 DF	2951
406		X	SWAN	1	D.E. & A.M. STUMP #1	811 KB	2956
407		X	SWAN	1	H.M. TURNER #1	788 DF	2909
408		X	SWAN	1	E. WHITE #3	771 KB	2981
76		X	SWAN	2	Z. HOPKINS #1	748 T	2826
207		X	SWAN	2	W. MAXWELL #1	783 T	2872
402		X	SWAN	2	E. WHITE #1	787 DF	2946
481		X	SWAN	2	BASEL FARMS INC. #1	793 DF	2872
203		X	SWAN	3	PITTMAN (WILLS) #1	982 GL	2915
349	2153SD	X	SWAN	3	O.E. CHERRY #1	972 DF	2959
451		X	SWAN	3	O. & F. FUNK #1	897 GL	2983
665		X	SWAN	3	D. DAVIS #6	943 DF	3019
383		X	SWAN	4	G. LEONARD ET. AL. #1	924 DF	2898
432		X	SWAN	4	B. DAVIS #3	848 DF	2833
658		X	SWAN	4	D. DAVIS #4	966 DF	3031
668		X	SWAN	4	B. DAVIS #5	928 DF	2964
690		X	SWAN	4	D. DAVIS #7	906 DF	2952

DEPTH TO TOP													
C SHALE	GREEN-FIELD	LOCK-PORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
2164	?	?	?	?	2468	2608	2616	2631	2638	2648	2672	2700	2761
2070	2146	2200	2318	2386 ?	2392	2533	2541	2556	2562	2574	2592	2628	2692
1949	2026	2078	2204	2266 ?	2282	2421	2429	2443	2450	2456	2468	2510	2569
1792	1864	1912	2044	2110 ?	2124	2262	2270	2284	2290	2297	2312	2348	2410
1736	1808	1856	1986	2050 ?	2064	2205	2213	2225	2232	2241	2253	2292	2352
?	?	?	?	?	2523	2666	2677	2688	2696	2699	2726	2757	NP
2211	2284	2334	2446 ?	2518 ?	2525	2668	2678	2692	2698	2708	2731	2760	2824
2172	2247	2297	2407	2480 ?	2487	2630	2638	2653	2660	2670	2693	2723	NP
2474	2555	2601	2710	2767 ?	2782	2941	2950	2973	2986	2995	3026	3050	3137 ?
?	?	?	?	?	2145 ?	?	?	?	?	2346 ?	2355 ?	NP	
?	?	?	?	?	2816 ?	2950 ?	2960 ?	2978 ?	2987 ?	2998 ?	3025 ?	NP	
?	?	?	?	?	2674	2815	2822	2840	2850	2860	2882	2911	NP
2396	2466	2527	2640	2704 ?	2728	2867	2876	2894	2904	2913	2942	NP	
2341	2408	2460	2579	2657 ?	2678	2817	2825	2843	2853	2863	2889	2915	NP
2344	2413	2472	2580	2649 ?	2672	2814	2822	2839	2849	2858	2878	NP	
2348 ?	2416	2474	2584	2654 ?	2675	2815	2823	2841	2852	2860	2887	2912	NP
2270	?	2408 ?	2508 ?	2580 ?	2600	2736	2745	2760	2769	2779	2813	NP	
2314	2382	2440	2516 ?	2621 ?	2654	2791	2799	2815	2823	2833	2862	NP	
2305	2374	2434	2544	2622 ?	2641	2779	2787	2804	2814	2823	2847	2876	2936 ?
		NL	2526	2596 ?	2614	2751	2758	2775	2784	2792 ?	2823	2848	NP
		NL	2640 ?	2692 ?	2711	2847	2855	2871	2878	2888	2904 ?	NP	
2435	2507	2565	2682	2748 ?	2768	2906	2913	2930	2938	2946	NP		
2348	2417	2470	2561 ?	2663 ?	2682	2816	2824	2839	2847	2856 ?	2889	NP	
2364	2434	2496	2609	2682 ?	2698	2833	2841	2857	2865	2875	2899	2928	2993
2322	2390	2442	2563 ?	2646 ?	2659	2793	2801	2816	2822	2831	2858	2887	NP
2228	2300	2358	2477	2542 ?	2562	2700	2708	2722	2731	2739	2759	2794	NP
2350	2418	2478	2582	2670 ?	2685	2818	2826	2839	2847	2857	2902	2920	2984
2296	2364	?	2544	2604 ?	2626	2762	2769	2784	2792	2801	2822	2857	2921
2287	2354	2414	2533	2609 ?	2622	2755	2762	2777	2784	2792	2827	2852	2914

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

VINTON COUNTY CONT'D.

734		X	SWAN	4	B. DAVIS #9	918 DF	2954
782		X	SWAN	4	MC AFEE #1	959 DF	2976
274		X	SWAN	5	C. PETTIBONE #1	962 DF	2784
687		X	SWAN	5	WOODGEARD #1	955 DF	2948
688		X	SWAN	5	WOODGEARD #2	865 DF	2814
692		X	SWAN	5	WOODGEARD #3	978 DF	2938
732		X	SWAN	5	WOODGEARD #4	1015 DF	2964
764		X	SWAN	5	LOCKWOOD #1	890 DF	2820
70	635		SWAN	6	C. BURROUGHS #1	UNK	2772
415		X	SWAN	6	K.E. HUGGINS	931 DF	2856
73	640	X	SWAN	7	J. HUETT #1	971 GL	2756
655		X	SWAN	8	BENEDICT INC. #3	1016 DF	2975
656		X	SWAN	8	BENEDICT INC. #2	1015 DF	2994
691		X	SWAN	8	ENGLE #1	1034 DF	2963
693		X	SWAN	8	BENEDICT INC. #4	1008 DF	2989
694		X	SWAN	8	BENEDICT INC. #5	1048 DF	3031
695		X	SWAN	8	ARMSTRONG #1	853 DF	2832
730		X	SWAN	8	CASTLE #1	872 DF	2818
769		X	SWAN	8	CROSON #1	1003 DF	2970
772		X	SWAN	8	MC VEY #4	948 DF	2912
401		X	SWAN	9	F.M. & K.M. WRIGHT #2	937 DF	2990
657		X	SWAN	9	BENEDICT INC. #1	840 DF	2857
700		X	SWAN	9	HEWITT #1	952 DF	2982
729		X	SWAN	9	D. DAVIS #8	945 DF	2968
733		X	SWAN	9	HAAS #1	948 DF	2950
403		X	SWAN	10	F.M. & K.M. WRIGHT #1	908 KB	2888
387		X	SWAN	13	COMMUNITY CAMP #1	826 DF	3037
195		X	SWAN	14	I. SCHURTZ #1	912 DF	2957
231		X	SWAN	14	I. SCHURTZ #3	UNK	2879

DEPTH TO TOP													
C SHALE	GREEN-FIELD	LOCK-PORT/PEEBLE	LILLEY	BISHER / KEEFER	ROSE-HILL/ESTILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDOV-ICIAN/ JUN-IATA
	LOCKPORT DOLOMITE												
2278	2348	2408	2528	2600	? 2615	2749	2757	2772	2779	2788	2814	2845	2907
2366	2436	2496	2615	2692	? 2704	2839	2847	2862	2869	2878	2901	2934	NP
2265	2333	2392	2510	2590	? 2608	2742	2750	2762	2769	NP			
2279	2346	2404	2528	2607	? 2622	2754	2762	2776	2783	2792	2825	2848	2910
2178	2242	2304	2433	2508	? 2525	2657	2666	2678	2686	2696	2719	2752	NP
2272	2336	2396	2538	? 2598	? 2616	2748	2755	2769	2776	2782	2816	2843	2907
2315	2376	2438	2568	? 2637	? 2652	2786	2794	2808	2814	2822	2839	2876	2939
2208	2274	2335	2462	2532	? 2551	2685	2693	2707	2714	2722	? 2736	2778	NP
?	?	?	?	?	?	?	?	?	?	?	?	?	?
?	?	?	?	?	2570	2704	2712	2726	2732	2741	2764	2796	NP
2205	?	?	?	2527	? 2534	2665	2673	2684	2692	2711	2729	NP	
2313	2378	2440	2564	2624	? 2648	2782	2790	2804	2810	2817	2840	2874	2936
2325	2392	2454	2576	2644	? 2665	2800	2807	2821	2826	2836	2853	2892	2954
2310	2374	?	2554	2634	? 2653	2786	2794	2808	2814	2820	2837	2876	2938
2321	2387	2448	2568	2636	? 2663	2799	2806	2820	2826	2836	2856	2890	? 2952
2364	2432	2492	2612	2675	? 2700	2839	2847	2861	2868	2874	2892	2930	2992
2182	2248	2308	2433	2495	? 2521	2658	2666	2680	2686	2694	2716	2751	? 2814
2174	2241	2302	2426	2494	? 2514	2650	2658	2672	2678	2686	2707	2738	2802
2318	? 2368	2430	2556	2618	? 2640	2777	2784	2798	2804	2814	2830	2868	2928
2248	2314	2373	2494	2558	? 2586	2725	2733	2746	2752	2758	2781	2817	2878
2318	2386	2447	2562	2632	? 2654	2794	2802	2818	2826	2831	2855	2889	2952
2178	2244	2304	2424	2496	? 2520	2657	2664	2678	2686	2695	2715	2750	2814
2329	2398	2458	2576	2636	? 2658	2798	2806	2822	2830	2840	2865	2895	2960
							NL	2794	2800	2808	2829	2866	2930
2295	2371	2426	? 2540	2604	? 2629	2767	2775	2790	2796	2806	2824	2856	2920
2332	2402	2462	2578	2640	? 2662	2799	2807	2823	2830	2840	2862	NP	
2455	2525	2586	2695	2758	? 2784	2921	2933	2951	2962	2972	3006	NP	
?	?	2552	? 2655	2716	? 2737	2880	2888	2906	2916	2927	NP		
					NL	2790	2798	2816	2825	2835	2872	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	TOWNSHIP	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH

VINTON COUNTY CONT'D.

264	922		SWAN	14	H.F.R. SCORLES #1	935 GL	2980
184		X	SWAN	15	H. STEELE #1	UNK	2730
210		X	SWAN	15	M. SCHURTZ #3	UNK	2855
737		X	SWAN	17	BENEDICT INC. #6	980 DF	2950
738		X	SWAN	17	BENEDICT INC. #7	1033 DF	2978
767		X	SWAN	17	MC VEY #1	881 DF	2894
795		X	SWAN	17	MC VEY #2	1015 DF	3016
804		X	SWAN	17	J. EAGLE #1	988 DF	2956
379		X	SWAN	18	C.E. CONNER #1	946 KB	2835
616		X	SWAN	19	HOCKING VALLEY #2034	1000 KB	2906
615		X	SWAN	20	HOCKING VALLEY #2029	1015 KB	2908
263		X	SWAN	24	H. FRANTZ #1	940 T	3179
593		X	SWAN	34	BENEDICT LEASE #2	808 DF	2984
331	2015SD		VINTON	FR35	STATE OF OHIO #1	722 DF	3225
588		X	WILKESVILLE	11	PUCKETT #1	766 KB	3541
276	960SD		WILKESVILLE	15	F.L. PENN #1	716 GL	3440
278	962C		WILKESVILLE	23	M. HALL #1	639 GL	3177
279	976SD		WILKESVILLE	36	O.J. LEACH #1	977 GL	3402
752		X	WILKESVILLE	36	O.J. LEACH #1	948 DF	3440

DEPTH TO TOP													
C SHALE	GREENFIELD	LOCKPORT/ PEEBLE	LILLEY	BISHER / KEEFER	ROSEHILL/ ESTILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON / TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN/ JUNIATA
	LOCKPORT DOLOMITE												
?	?	?	?	?	2787 ?	?	?	2945 ?	2955 ?	2971 ?	2979 ?	NP	
2203	2272	2332	2425	2512 ?	2535	2676	2683	2701	2710	NP			
2305	2370 ?	2435	2542	2605 ?	2629	2767	2775	2792	2800	2809	2841	NP	
2288	2354	2415	2534 ?	2605 ?	2628	2766	2773	2787	2794	2804	2824	2859	2920
2392	2465	2518	2638	2708 ?	2730	2868	2876	2890	2897	2906	2925	2952	NP
2224	2300	2352	2466	2543 ?	2558	2698	2706	2720	2728	2738	2760	2792	2854
2351	2426	2476	2596	2672 ?	2685	2822	2830	2846	2853	2864	2885	2918	2979
		NL	2554	2622 ?	2638	2775	2783	2797	2803	2814	2835	2870	2932
2190	2258	2315	2440	2510 ?	2526	2663	2667	2680	2688	2696	2715	2748	2810
			NL	2614 ?	2628	2766	2773	2788	2795	2806	2827	2863	NP
			NL	2632 ?	2648	2788	2796	2810	2816	2826	2848	2884	NP
?	?	?	?	?	2847	?	?	3024	3034	3051	3070	?	?
2302	2376	2426	2548	2616 ?	2628	2773	2782	2800	2808	2820	2846	2873	2940
?	?	?	?	?	2879 ?	3044 ?	3052 ?	3075 ?	3086 ?	3096 ?	3134 ?	?	3234 ?
2884 ?	2954	3008	3112 ?	3160 ?	3178	3350	3358	3399	3412	3426	3446	3470	NP
?	?	?	?	?	3070 ?	?	?	3286 ?	3301 ?	3318 ?	3343 ?	?	NP ?
?	?	?	?	?	2905 ?	3079 ?	3085 ?	?	?	3144 ?	3176 ?	NP	
?	?	?	?	?	3007 ?	3198 ?	3202 ?	3231 ?	3242 ?	3257 ?	3270 ?	3309 ?	NP
2738 ?	2805	2862 ?	2956	3014 ?	3026	3189	3197	3228	3240	3248	3290	3313	3380

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH

BATH COUNTY, KENTUCKY

5292			02 T 70	2200N-0050E	ROSE RUN IRON #1	765 GL	2001

BOYD COUNTY, KENTUCKY

20459	10499	X	11 V 81	1030N-1310W	INLAND GAS CO. #533	862 KB	9595
8521	7291		01 W 82	1080N-2030W	INLAND GAS CO. #K-106	651 GL	2955
29996		X	10 W 82	2550S-1200W	J.E. ROSS #560(G)	731 KB	3190
23546	11434	X	20 W 82	1890S-1130E	J.T. MAGGARD #539	724 DF	3162
18327	9634	X	21 W 82	0750S-1390E	L.O. WHITE HEIRS #529	652 KB	7634
21652	10923	X	22 W 82	1200N-1490E	G.E. FANNIN EST. #537	709 KB	7798
19454	10002	X	05 W 83	1850S-0650W	CLINTON TRACT #532	695 DF	3059
29858		X	05 W 83	2050S-1050E	M. DANIELS #559	822 KB	3246
16321	9234	X	06 W 83	0600N-0425E	I. GIFFITH #527-G	902 DF	3318
10307	7643		12 W 83	1750N-1100W	E.T. AMBURGEY #1	640 T	3402
14706	8785		15 W 83	0050N-0340W	L. WEBB #524	730 T	3274
27765	13052	X	19 W 83	0520N-1280E	LEACH REFINERY #1-G	596 DF	3407
20876	10467	X	25 W 83	1790S-1700E	S. MC KEAND #535	868 KB	9445
27870		X	25 W 83	1700S-1380E	SMALLRIDGE #551-0	719 KB	8419

CARTER COUNTY, KENTUCKY

25730	12605	X	22 U 79	2580S-0900W	E. MC DAVID #546	808 KB	9938
26445	12879	X	23 U 79	2300N-1340E	W.E. ROBINSON #1	675 KB	2465
398E9	4672	X	03 V 77	2050N-1600E	L. STAMPER #8807T	857 DF	1825
16235	10451	X	12 V 77	2450N-1525W	W. STAPLETON #11-1	956 KB	5251
10443	7644		13 V 81	1925S-1050W	INLAND GAS CO. #510	756 GL	2605
22935	12342	X	14 V 81	2430S-0010E	INLAND GAS CO. #538	796 KB	7262
6285	7582		23 W 76	0000S-0400E	O. COLEMAN #4	863 DF	3585
26995		X	25 W 77	0400S-2150E	T.H. DUNCAN #547	985 KB	5062
19-E8	3743		11 W 78	0650S-2800E	J. SIMMONS #1	647 GL	3642
23511	10713	X	12 X 77	1600N-2300W	H. WALGREN #1	682 KB	1200

D E P T H T O T O P

C SHALE	GREENFIELD (LOCKPORT DOLOMITE)	LOCKPORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ESTILL /ROSE HILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON/ TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN / JUNITA
												OBR	30
2689	2730	NR	NR	2815	2845	3008	3018 ?	3084	3117	3022	3030	3192	3230
?	?	NR	NR	2624 ?	2658 ?	?	?	?	?	2928 ?	2939 ?	NP	
2588	2629	NR	NR	2722	2756	2920	2926	2990	3018	3026	3041	NP	
2660	2703	NR	NR	2788	2821	2981	2987	3058	3086	3095	3115	NP	
2714	2759	NR	NR	2847	2879	3030	3066 ?	3120	3150	3157	3177	3229	3264
2581	2623	NR	NR	2710	2753	2901	?	2976	3004	3011	3028	3081	3118
2577	2620	NR	NR	2712	2750	2913	2920	2983	3010	3019	3035	NP	
2749	2792	NR	NR	2883	2915	3079	3085	3150	3178	3185	3204	NP	
2832	2874	NR	NR	2966	3004	3166	3172	3238	3265	3274	3292	NP	
?	?	NR	NR	?	3190 ?	?	?	?	?	3245 ?	3256 ?	3348 ?	3390 ?
?	?	NR	NR	2821 ?	2858 ?	?	?	?	?	3123 ?	3130 ?	3185 ?	3220 ?
2742	2782	NR	NR	2869	2903	3062	3067	3142	3176	3185	3215 ?	3260	3295
3052	3098	NR	NR	3182	3223	3363	3375	3463	3494	3503	3519	3582	3614
2848	2893	NR	NR	2978	3014	3175	3181	3252	3283	3291	3309	3363	3400
2307	2345	NR	NR	2432	2490 ?	2635	2643	2720	2746	ABS	NA	2804	2856
2112	2150	NR	NR	2237	2296	2408	?	NP					
1270	1305	NR	NR	1394	1449	1585	1594	1628	1646	ABS	NA	1685	1728
1415	1450	NR	NR	1524	1580	1718	1730	1763	1780	ABS	NA	1817	1857
?	?	NR	NR	2534 ?	2570 ?	NP							
2405	2445	NR	NR	2535	2575	2721	2730	2796	2824	ABS	NA	2900	2940
TR	TR?	NR	NR	1096 ?	1137 ?	?	?	?	?	ABS	NA	1360 ?	1400 ?
TR	1305 ?	1330 ?	NR	1400	1446	1587	1600	1624	1642	ABS	NA	1680	1720
?	?	?	NR	1523 ?	1559 ?	?	?	?	?	ABS	NA	1754 ?	1802 ?
984	1031	1058	NR	1137	1176	NP							

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH

CARTER COUNTY CONT'D.

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH
23118		X	13 X 77 0300N-1600E	H.W. WALGREN #4	717 KB	1462
23227		X	16 X 77 0850N-1700E	H.W. WALGREN #6	787 GL	1200
UNK	2060		25 X 78 2000S-0900W	V.H. RAMEY #1	950 GL	3840

ELLIOTT COUNTY, KENTUCKY

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH
1555	5504	X	21 T 76 0750N-1750E	PENNINGTON #9021-T	921 DF	1510
271E0	5537	X	22 T 76 1900N-0950W	O. LITTON #8802-T	968 KB	5263
29843	13076	X	15 T 78 2000S-1350W	A. GILLUM #1	816 KB	4163
898	2504		23 T 78 4775S-0350W	J.H. FRALEY #1-215	796 KB	3600
25781	12423	X	07 T 79 2200S-1930E	J. KAUFMAN #1	710 KB	5156
23542	11445	X	08 T 79 0745S-1665W	C. ISON #1	686 KB	9652
27685	12878	X	09 T 79 0295N-2030W	D. JOHNSON #1	696 KB	5246
26619	12871	X	13 T 79 1405S-1710E	STEPHENS #2-G	793 KB	9458
28289	12929	X	19 T 79 1060N-1860E	L. MADDOX #1-G	1032 DF	2895

GREENUP COUNTY, KENTUCKY

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH
645E9	5143	X	03 W 79 0050N-0300E	F. FELTY #1	709 DF	4176
21256	10231	X	07 Z 78 3850N-0420E	D.P. NEWELL #1	1054 KB	5193
22214		X	07 Z 78 1750S-0140E	D.P. NEWELL #1-A	1031 DF	3481
30078	13149	X	16 Z 78 0775S-0125E	W. GILLIAM #1	1081 KB	3824
20187	10029	X	25 Z 78 0250S-0100W	J.N. HUBER CORP. #1	1100 KB	3905

LAWRENCE COUNTY, KENTUCKY

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH
43004		X	02 T 81 3560N-0420E	H. NEAL #1	744 KB	3279
53143		X	13 T 81 1430N-1640E	D.G. HILLMAN #1-R	852 KB	3320
UNK		X	21 T 81 0350N-1950W	L. HAMMOND #1	673 KB	3308
30278		X	09 T 82 0900N-0750W	M. KRANTZ #20061	703 KB	3178
22432	10975	X	24 T 82 2775S-2190W	G. ROBERTS #1420	731 DF	3457

D E P T H T O T O P													
C SHALE	GREEN-FIELD (LOCKPORT DOLOMITE)	LOCK-PORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ESTILL /ROSE HILL	DAYTON / CASING	LULBE-GRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINT-ON/ TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	ORDO-VICIAN / JUNITA
998	1035	1064	1111 ?	1142	1155	1305	1311	1339	1349	ABS	NA	1387	1426
986	1022	1050 ?	NR	1121	1164	NP							
?	1514 ?	?	NR	1602 ?	1659 ?	?	?	?	?	ABS	NA	1915 ?	1945 ?
1344	1373	NR	NR	1444	1497	NP							
1347 ?	1375 ?	NR	NR	1450	1495	ABS	NA	1644	1687	ABS	NA	1725	1765
1486	1515	NR	NR	1591	1654	1776	1800	1837	1861	ABS	NA	1904	1946
?	1613 ?	NR	NR	1713 ?	1762 ?	?	?	?	?	ABS	NA	1997 ?	2020
2086	2124	NR	NR	2212	2268	2408	2414	2493	2523	2540	2550	2580	2628
2044 ?	2080 ?	NR	NR	2165 ?	2235 ?	2393	2399	2453	2482	?	?	2543	2590
2136	2173	NR	NR	2260	2320	2493	2497	2550	2584	2605	2610	2641	2690
2119	2156	NR	NR	2248	2298	2472	2477	2533	2564	2587 ?	2593	2625	2675
2374	2413	NR	NR	2500	2553	2732	2736	2793	2824	2848	2866	NP	
1580	1620	1645	NR	1711	1768	1928	1932	1966	1991	ABS	NA	2030	2080
1357	1400	1438	NR	1508	1560	1718	1722	1746	1767	ABS	NA	1799	1844
1332	1374	1412	NR	1480	1532	1690	1694	1719	1738	ABS	NA	1773	1816
1398	1440	1476	NR	1548	1593	1748	1754	1778	1797	ABS	NA	1831	1876
1396	1435	1463 ?	NR	1539	1578	1734	1738	1760	1778	ABS	NA	1812	1856
2705	2749	NR	NR	2840	2880	3036	3046	3140	3177	3187	3221	NP	
2731	2771 ?	NR	NR	2862	2910	3058	3065	3166	3196	3206	3240	3283	NP
2680	2720	NR	NR	2803	2853	3003	3009	3112	3152	3161	3187	3217	3276
2942	2986	NR	NR	3072	3115	NP							
2888	2928	NR	NR	3017	3051	3202	3206 ?	3315	3358	3367	3402	NP	

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION	WELL NAME	ELEVATION	TOTAL DEPTH
LAWRENCE COUNTY CONT'D.						
24502	12606	X	06 U 82 2320N-1550W	W.P. YOUNG #542	884 KB	4189
UNK		X	07 U 82 2500N-2050W	C. HALL ET. AL. #1	688 KB	3523
52727		X	23 U 82 2120N-2170W	P. HOLBROOK #1	635 KB	3456
LEWIS COUNTY, KENTUCKY						
332	2968		2 W 73 CSL NW	R.W. STIDAM #1	998 GL	475
1159	1783		21 W 74 0400S-2100W	R. LOGAN #1	939 GL	939
2579	5503	X	19 W 75 1050N-2050E	A. SHEPHERD #9060-T	915 KB	4445
1160	3037		20 X 73 C NW SE	R.W. THOMPSON #1	966 GL	460
1166	2951		3 X 74 SE NE SE	F. JONES #1	717 GL	350
20314	9958	X	07 X 74 0200N-0100W	J.H. CURTIS #1	734 KB	2604
1161	2983		12 X 74 NE NE NE	BUDDE #1	919 GL	609
334	2992		02 X 75 0750N-1300E	T.J. KIDWELL #1	624 GL	588
331	2999		18 Y 74 C SW	F. CLARK #1	763 GL	565
1165	3005		19 Y 74 CN/2 NW	MC DANIEL HEIRS #1	770 GL	400
1164	2976		20 Y 74 SE NW SE	L. JONES #1	684 GL	420
1162	3030		25 Y 74 SE NW	H. KNAPP #1	776 GL	380
20436	9959	X	13 Y 75 2800N-0200W	J.C. BUCKNER #1	879 KB	3359
31757	4484	X	13 Y 76 4250S-0200W	D. ADAMS #1	555 GL	2900
1190	5573		05 Y 77 1950N-0950W	E. MUSTARD #1	750 GL	990
21132	10112	X	13 Y 77 1000S-0820W	D. WOLFE ET. AL. #1	1113 KB	5075
31428	14132	X	20 Z 77 0750S-0470W	MEAD CORP. #1	662 KB	3389
ROWAN COUNTY, KENTUCKY						
145	1377		09 T 71 SE NW SE	B. HOWARD #1	667 GL	1040
1422	1363		09 T 72 NW SE NW	J.W. JONES #1	677 GL	417
342	2485		14 T 73 NCL SW SW	BALDWIN #1	UNK	550
1284	570		03 T 74 SW NE NE	N. MANIER #1	901 GL	1055
1287	569		12 T 74	E. RIDDLE #1	1005 GL	964

DEPTH TO TOP													
C SHALE	GREENFIELD (LOCKPORT DOLOMITE)	LOCKPORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ESTILL /ROSE HILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON/ TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN / JUNITA
3103	3150	NR	NR	3245	3286	3450	3460 ?	3544	3582	3592	3621	3642	3700
2995	3043	NR	NR	3137	3176	3340	3347	3437	3476	3485	3516 ?	NP	
2904	2950	NR	NR	3038	3077	3238	3242	3340	3377	3389	3417	3432 ?	NP
TR	TR	TR	390TR ?	405 ?	445 ?	NP							
TR	TR	678TR ?	NP										
TR	TR	822TR	NR	927	974	1117	1125	1148	1162	ABS	NA	1192	1236
TR	TR	TR	TR	380TR ?	420 ?	NP							
TR	TR	TR	?	280TR ?	320 ?	NP							
TR	TR	TR	231TR	242	279	419	424	439	449	ABS	NA	469	505
TR	TR	530TR ?	?	571 ?	NP								
TR	435TR ?	450 ?	500 ?	515 ?	562 ?	NP							
TR	TR	270TR ?	280 ?	290 ?	345 ?	480 ?	485 ?	495 ?	505 ?	ABS	NA	515 ?	555 ?
TR	TR	315TR ?	338 ?	374 ?	NP								
TR	265TR ?	288 ?	355 ?	380 ?	417 ?	NP							
TR	TR	275TR ?	325 ?	345 ?	365 ?	NP							
TR	537TR	546	610	635	662	813	817	835	856	ABS	NA	869	909
459	493	512 ?	558 ?	583	633	?	?	?	?	ABS	NA	?	?
?	?	?	?	?	932 ?	NP							
1274	1313	1350 ?	1411	1434	1457	1591	1609	1635	1654	ABS	NA	1684	1723
883	923	957	NR	1021	1078	1235	1242	1264	1283	ABS	NA	1315	1356
					458 ?	ABS	NA	80 ?	?	ABS	NA	?	?
TR	TR	151TR ?	NR	173 ?	197 ?	ABS	NA	352 ?	360 ?	ABS	NA	371 ?	407 ?
TR	TR	398 ?	NR	420 ?	472 ?	NP							
TR	TR	710TR ?	NR	?	814 ?	ABS	NA	975 ?	989 ?	ABS	NA	1020 ?	1050 ?
TR	TR	846TR ?	905 ?	930 ?	NP								

PERMIT NUMBER	SAMPLE NUMBER	LOG	CARTER COORDINATE LOCATION		WELL NAME	ELEVATION		TOTAL DEPTH

ROWAN COUNTY CONT'D.

1268	571		15 T 74		LEE CLAY PROD. #2	948	GL	740
25356	12408	X	21 T 74	0875N-0750W	R. PERKINS #1	1240	KB	4974
14647	8456	X	04 T 75	0450N-3600W	C. JONES #1	1199	KB	4991
22478		X	19 U 72	0910N-1315W	W.Y. BAILEY #1	737	KB	3800
1286	590		11 U 74	1750S-0200W	CARNEGIE TECH. #3	951	GL	1155
1289	1734		15 U 74	E	CHRISTIAN #1	804	GL	811
144	1091		19 U 74	2990S-0800E	J. CAUDILL #1	837	GL	3721
UNK	926		16 U 75	1965S-1215E	J. LEWIS #1	877	GL	2778
9123	7484		16 U 75	1965S-1215E	J.A. LEWIS #1	872	GL	2855
147	935		16 U 75		WITHROW #1	1024	GL	3100
18028	9114	X	25 U 75	1750S-1590W	F. MAYS #1	905	KB	3353
1420	1389		09 V 73	SE NW	F. EASTON #1	865	GL	403
1425	1391		09 V 73	SE NW NW	T.H. CAUDILL #1	865	GL	412
1423	1385		11 V 73	NW	H.A. BATES #1	848	GL	432
333	591		07 V 74		S. BROWN #1	816	GL	817
1272	11625		18 V 74		CARNEGIE TECH #1	1172	GL	924
1283	2726		20 V 74	EL	R.L. PARKER #1	942	GL	900
1288	572		24 V 74		CARNEGIE TECH #2	900	GL	934
1428	1388		11 W 73	SE NW NW	B.H. BUCKNER #1	1029	GL	548

C SHALE	GREENFIELD (LOCKPORT DOLOMITE)	LOCKPORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ESTILL /ROSE HILL	DAYTON / CASING	LULBEGRUD SHALE	OLDHAM / PACKER	UPPER CABOT HEAD SHALE	CLINTON/ TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	ORDOVICIAN / JUNITA
DEPTH TO TOP													
TR	TR	685TR ?	NP										
TR	TR	1178TR	NR	1266	1303	ABS	NA	1466	1487	ABS	NA	1520	1546
TR	TR	1174TR	NR	1250	1293	1423 ?	1435 ?	1455	1472	ABS	NA	1508	1536
TR	TR	TR	NR	151TR	193	ABS	NA	344	356	ABS	NA	375	412
TR	TR	808TR ?	NR	892 ?	916 ?	ABS	NA	1075 ?	1098 ?	ABS	NA	1137 ?	NP
TR	TR	495TR ?	NR	548 ?	588 ?	ABS	NA	?	?	ABS	NA	795 ?	NP
TR	TR	689TR ?	NR	740 ?	798 ?	ABS	NA	956 ?	979 ?	ABS	NA ?	1037 ?	1037
TR	TR	799TR ?	NR	?	915 ?	ABS	NA	?	?	ABS	NA	?	?
TR	TR	790TR ?	NR	?	900 ?	ABS	NA	?	?	ABS	NA	1090 ?	1130 ?
TR	TR	935TR ?	NR	992 ?	1035 ?	ABS	NA	?	?	ABS	NA	?	?
TR	TR	821TR	NR	883 ?	925	ABS	NA	1090	1105	ABS	NA	1137	1165
TR	TR	TR	NR	389TR ?	NP								
TR	TR	TR	NR	371TR ?	NP								
TR	TR	393TR ?	NR	408 ?	NP								
TR	TR	500TR ?	NR	553 ?	597 ?	?	?	755 ?	763 ?	ABS	NA	796 ?	NP
TR	TR	899TR ?	NR	911 ?	NP								
TR	TR	792TR ?	NR	860 ?	NP								
TR	TR	620TR ?	NR	672 ?	715 ?	?	?	880 ?	904 ?	ABS	NA	923 ?	NP
TR	TR	TR	NR	494TR ?	NP								

PERMIT NUMBER	SAMMPLE	SAMPLE DESCRIPT	LOG	15 MINUTE QUADRANGLE	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
CABELL COUNTY, WEST VIRGINIA								
464	X	FILE		MILTON	SW	G. PORTER #5	603 GL	4790
532			X	GUYANDOT	NE	H.L. PERRY #1	728 KB	4694
534			X	GUYANDOT	NE	I. WARDEN #1	887 KB	4856
537	X		X	ATHALIA	SE	E. KINGERY #1	667 KB	8552
558			X	MILTON	SW	C. BIAS #1	747 KB	4931
709			X	GUYANDOT	NW	R. ASHWORTH #1	547 KB	3580
LINCOLN COUNTY, WEST VIRGINIA								
1625			X	MILTON	SW	G. MESSENGER #2	638 GL	4763
MASON COUNTY, WEST VIRGINIA								
69	X	B.23	X	GLENWOOD	NC	ARRINGTON #8803	597 KB	8635
310			X	GLENWOOD	NC	K.L. PRICE #1	808 KB	4906
PUTNAM COUNTY, WEST VIRGINIA								
737			X	GLENWOOD	SE	I. FRAZIER #1	694 KB	5620
773			X	GLENWOOD	SE	GILLISPIE-JACOBS #7	739 KB	5034
776			X	GLENWOOD	SE	A. HOLLY #N9	680 KB	5516
WAYNE COUNTY, WEST VIRGINIA								
138	X	V.11		WAYNE	NW	G.T. SAUNDERS #2	697 GL	3757
146	X	V.17		WAYNE	NW	H.S. JACKSON #1	620 GL	4167
199	X	V.17		WAYNE	NW	A.P. BOOTH #1	762 GL	3883
271	X	V.17		GUYANDOT	SW	BARBOUR & DUNKLE #1	639 GL	4042
277	X	V.17		CEREDO	SE	MC COMAS ET.AL.#1	668 GL	4168
346	X			WAYNE	C	HOARD-BALDWIN #34	632 GL	3850
393	X			LOUISA	NE	HUNTINGTON #A2	760 GL	3729
906	X	FILE		GUYANDOT	SW	D.M. PERDUE #1	640 GL	3875
996	X			LOUISA	EC	L.F. JARRELL #1	756 T	4198
1217			X	GUYANDOT	SW	O.J. SPURLOCK #3	818 DF	3993

DEPTH TO TOP

C SHALE	GREENFIELD (LOCKPORT DOLOMITE)	LOCKPORT/ PEEBLE (LOCKPORT DOLOMITE)	LILLEY	BISHER / KEEFER	ROSEHILL/ ESTILL	CACAPON SS.	LULBEGRUD SHALE	PACKER / OLDHAM	UPPER CABOT HEAD SHALE	CLINTON / TUSCARORA	LOWER CABOT HEAD SHALE	BRASSFIELD	JUNIATA / ORD.
?	4035 ?	NR	NR	4133 ?	4195	?	?	4505 ?	?	4550 ?	4587 ?	4635 ?	4668 ?
3954	4016	NR	NR	4114	4156	4360	4366	4423	4464	4492	4523	4560	4590
4216	4280 ?	NR	NR	4382	4423	4632	4636	4693	4742	4760	4796	NP	
3872	3936	NR	NR	4034	4078	4277	4281	4337	4377	4396	4429	4472	4500
4226	4300	NR	NR	4393	4424	4658	4672	4736	4788	4810	4852	4896	4918 ?
?	?	NR	NR	3258	3406	NP							
4094	4167	NR	NR	4267	4300	4525	4546	4605	4660	4688	4726	NP	
3915	3990	NR	NR	4110	4159	4330 ?	4342 ?	4420	4454	4478	4500	4550	4582
4152	4226	NR	NR	4348	4390	4564 ?	4572 ?	4655	4692	4716	4746	4790	4820
4880	4972	NP											
4818	4908	NP											
4732	4820 ?	NR	NR	4934	4968	5198	5204	5271	5317	5352	5386	5424	5462
?	?	?	?	?	?	NP							
					NS	?	?	4018 ?	?	4057 ?	4076 ?	?	NP
?	?	?	?	3861 ?	3891 ?	NP							
?	3868 ?	NR	NR	3953 ?	3992 ?	NP							
?	3572 ?	NR	NR	3674 ?	3702 ?	NS							
			NS	3821 ?	3848 ?	NP							
?	?	NR	NR	?	3690 ?	NP							
?	?	NR	NR	?	3875 ?	NP							
?	?	NR	NR	3643 ?	3699 ?	NP							
3788	3850	NR	NR	3932	3978 ?	NP							

WAYNE COUNTY CONT'D.

PERMIT NUMBER	SAMPLE	SAMPLE DESCRIPT	LOG	15 MINUTE QUADRANGLE	SECTION	WELL NAME	ELEVATION	TOTAL DEPTH
1230			X	GUYANDOT	SW	O.J. SPURLOCK #4	831 DF	3919
1252			X	LOUISA	NE	M. MC GEE #662	628 DF	3574
1255			X	WAYNE	NW	E. PRICHARD #8	645 DF	3793
1336			X	GUYANDOT	SW	G.M. BURGESS #5	772 DF	4021
1394			X	WAYNE	NW	O.J. SPURLOCK #6	868 DF	3967
1427	X			LOUISA	NE	A.B. FULLER #1	674 GL	3609
1549	C	C.14	X	LOUISA	EC	U.F.G. FEE #9509	601 DF	3937
1572			X	LOUISA	NE	J.P. SMITH #1	622 KB	14594
1576			X	WAYNE	NW	COLUMBIA GAS #20060	647 KB	3598

DEPTH TO TOP													
C SHALE	GREEN-FIELD (LOCKPORT DOLOMITE)	LOCK-PORT/PEEBLE (LOCKPORT DOLOMITE)	LILLEY (LOCKPORT DOLOMITE)	BISHER / KEEFER	ROSE-HILL/ ESTILL	CACAP-ON SS.	LULBE-GRUD SHALE	PACKER / OLDHAM	UPPER CABOT HEAD SHALE	CLINT-ON / TUSCA-RORA	LOWER CABOT HEAD SHALE	BRASS-FIELD	JUN-IATA / ORD.
3722	3782 ?	NR	NR	3864	3909 ?	NP							
3376	3437	NR	NR	3522	3563	NP							
3597	3656 ?	NR	NR	3744	3776	NP							
3810	3866 ?	NR	NR	3958	4002 ?	NP							
3760	3820 ?	NR	NR	3904	3960	NP							
?	?	NR	NR	?	?	NP							
3352	3408	NR	NR	3496	3526	3728	3733	3811 ?	3858 ?	3878	3900	NP	
3396	3448	NR	NR	3542	3585 ?	3790	3796	3864	3910	3926	3948	3998	4044
3370	3416 ?	NR	NR	3504 ?	3546 ?	NP							

APPENDIX B. - Sample descriptions.

Well sample and core descriptions are organized in the appendix according to the order of the following table.

OHIO

County	Township	Permit No.	Sample No. & Type	Interval Described
Adams	Franklin	*	162 Core	Tymochtee-Lilley
Adams	Franklin	*	1001 Core	Peebles-Bisher
Adams	Franklin	*	1002 Core	Peebles-Bisher
Athens	Waterloo	1431	1077 Cut.	C Unit-Ordovician
Clinton	Wayne	1	757 Cut.	Peebles-Ordovician
Fayette	Concord	2	751 Cut.	Peebles-Ordovician
Gallia	Harrison	181	3410 Cut.	C Unit-Cabot Head
Highland	Brush Creek	9	2799 Core	Peebles-Estill
Highland	Fairfield	6	2499 Core	Peebles-Ordovician
Hocking	Benton	611	738 Cut.	C Unit-Brassfield
Hocking	Washington	1679	3043 Cut.	Greenfield-Estill
Jackson	Milton	62	759 Cut.	C Unit-Brassfield
Lawrence	Hamilton	231	3466 Cut.	C Unit-Brassfield
Pike	Pebble	22	1339 Core	C Unit-Ordovician
Pike	Perry	21	1340 Core	Ohio Sh.-Brassfield
Ross	Harrison	6	1282 Cut.	C Unit-Ordovician
Scioto	Green	212	2161 Core	Peebles Formation
Scioto	Madison	193	1045 Cut.	C Unit-Ordovician
Vinton	Wilkesville	278	962 Core	Clinton sandstone

WEST VIRGINIA

County	Quadrangle	Permit No.	Sample No. & Type	Interval Described
Cabell	Athalia	537	537 Cut.	C Unit-Ordovician

* Cores from Adams County provided courtesy of Plum Run Stone Division of Davon Inc.

Adams County, Ohio
Franklin Township
Plum Run Stone Division, Davon Inc.
Core 162

TYMOCHTEE FORMATION

8.0-15.6	Dolomite, grayish yellow, finely crystalline, algal laminated, scattered rip-up clasts, few shale partings to 0.1 feet thick; some thin beds gray, finely to very finely crystalline, argillaceous to shaly, faintly laminated.
15.6-32.2	Dolomite, medium gray, tan gray, and brown, variably mottled and interbedded, numerous stylolites. Gray dolomite is argillaceous, dull, dense, faintly laminated, rippled, and bioturbated; tan dolomite is finely to microcrystalline, with poor pin-point porosity; brown dolomite is finely to medium crystalline, faintly laminated, contains a few unidentified clasts, and has moderate to good vug porosity. Upper three feet of interval is gray, dense, laminated, lithographic dolomite gradational with above lithology; lower two feet is primarily medium gray argillaceous dolomite.

GREENFIELD FORMATION

32.2-34.5	Dolomite, variably medium gray, tan gray, and light bluish gray, with discontinuous and contorted algal lamination, stylolites common, scattered vug porosity.
34.5-37.0	Dolomite, mottled dusty yellow and light gray, finely to microcrystalline, irregular to faint horizontal lamination; contains light brown, dense, faintly laminated clasts in two thin breccia zones.
37.0-53.8	Dolomite, variably mottled light gray, tan, and tan gray, finely to microcrystalline, poorly bedded with some faint contorted lamination, mostly dense with occasional beds having good vug porosity, scattered stylolites. A 0.3 feet thick oolite bed occurs at 50.5 feet and overlies a 0.5 feet thick breccia composed of tan gray, lithographic dolomite. A second dolobreccia is present at 53.5-53.8 feet with heavy oxide stain and asphalt impregnation.
53.8-59.2	Dolomite, white to very light gray, micritic, chalky, with few stylolites. Heavy asphalt

stain in porous zones suggests cross bedding.

PEEBLES FORMATION

59.2-94.0	Dolomite, light gray, cream, and light tan, medium to finely crystalline, brecciated(?) with unidentified clasts of fossil debris, bedding massive to structureless, excellent porosity with wide range in vug sizes (pin-point to 3 inches). Gradational to underlying lithology.
94.0-104.0	Dolomite, light gray, finely to medium crystalline, some irregular patches sucrosic, scattered fossil molds, few stylolites, porous, homogeneous.
104.0-105.0	Dolomite, gray brown, micro- to finely crystalline, very compact, dense and heavy, contains much pyrite.

LILLEY FORMATION

105.0-107.8	Dolomite, irregularly mottled light- and medium gray, and tan, finely crystalline, argillaceous in part, poorly bedded, bioturbated, moderate to poor vug and pin-point porosity. Contains scattered, fine to medium grained skeletal debris and a few large light yellow-gray coral swirls.

Adams County
Franklin Township
Plum Run Stone Division, Davon Inc.
Core 1001

PEEBLES-LILLEY TRANSITION

2.4-13.0	Dolomite, tan to gray tan, finely to medium crystalline, variably pure to argillaceous, appears massively bedded and homogeneous, no recognizable fossils, good vug porosity. Dolobreccia at 12.5 feet consists of medium gray and light tan clasts in an argillaceous, gray dolomite matrix.

LILLEY FORMATION

13.0-20.5	Dolomite, medium gray, argillaceous, faintly laminated to bioturbated, few whispy shale laminae, moderate vug and pin-point porosity; with sparse to abundant, medium to fine grained

skeletal debris (crinoidal) and several large light yellow-gray coral swirls. Gradational with underlying lithology.

20.5-39.0	Dolomite, medium gray, argillaceous to shaly, dull, poorly bedded to faintly laminated, with scattered fine grained fossil debris (crinoidal) and unidentified irregular cream colored (coral?) masses, dense. Intraformational breccia at 22-22.5 feet composed of large, angular to subround clasts of light gray, finely crystalline, slightly argillaceous dolomite in a matrix of medium gray argillaceous dolomite.
39.0-42.5	Dolomite, gray to tan gray, brownish, medium to finely crystalline, slightly argillaceous, abundant medium grained well sorted crinoidal debris scattered vug and pin-point porosity. Gradational with lithologies above and below; becomes less fossiliferous, more dense, and more argillaceous toward base.
42.5-44.8	Dolomite, tan gray to tan, very finely to finely crystalline, faintly bioturbated to homogeneous; irregularly interbedded with medium- to dark gray, argillaceous to shaly dolomite containing scattered fine grained fossil debris. Texture is highly irregular and appears brecciated, clotted, disturbed. Bedding may be algal in nature.
44.8-48.0	Dolomite, as in 39.0-42.5 feet, with abundant thin shale partings in top 1.5 feet, faintly cross bedded.
48.0-49.5	Dolomite, as in 42.5-44.8 feet.
49.5-52.5	Dolomite, mottled light- and medium gray, finely to medium crystalline, oolitic, trace crinoidal debris, faintly cross bedded and parallel laminated, good vug and pin-point porosity.
52.5-61.0	Dolomite, light- to medium gray, tan gray, finely to medium crystalline, slightly argillaceous, fine to very fine grained crinoidal debris abundant, good vug porosity, scattered ooids in upper 3 feet. Less argillaceous and lighter colored toward base.

BISHER FORMATION

61.0-86.6	Dolomite, medium- to light gray, faintly brownish, finely to medium crystalline,

slightly argillaceous, faintly laminated and rippled, most appears massively bedded; with scattered, very fine grained fossil debris, trace quartz silt, trace pyrite. Several thin beds with concentrated fine to medium grained fossil debris and quartz silt.

Adams County, Ohio
Franklin Township
Plum Run Stone Division, Davon Inc.
Core 1002

PEEBLES FORMATION

2.2- 8.2	Dolomite, mottled light- to medium gray and tan, finely crystalline, very slightly argillaceous, dull in part, fine grained skeletal debris abundant, sparse vug porosity; with thin, irregular argillaceous partings, slightly oolitic(?) and silty(?).
8.2-23.0	Dolomite, light tan to tan gray, purer than above, medium to finely crystalline, fossiliferous (coralline) with a fossil-breccia zone at 11-12 feet, good vug porosity, some dense.

LILLEY FORMATION

23.0-27.5	Dolomite, medium gray, argillaceous; with disseminated light gray, fine to medium grained skeletal debris (crinoidal) and several large, light yellow-gray coral swirls which are angular to corroded and very porous. Gray argillaceous matrix bioturbated, dense, with many whispy carbonaceous partings.
27.5-39.8	Dolomite, medium gray, argillaceous to shaly, bioturbated, faintly laminated; with sparsely disseminated, lighter colored skeletal debris. Increasingly shaly and less fossiliferous toward base.
39.8-55.0	Dolomite, medium tan to light tan gray, micritic, faintly bioturbated; irregularly interbedded with medium gray, argillaceous dolomite with a few irregular shaly seams and sparse coral and crinoidal fragments, dense. Boundaries between lithologies are highly irregular and penetrating; overall texture appears brecciated, clotted, disturbed. Bedding may be algal. Lithology is gradational with

overlying unit through a 1.5 foot thick zone containing a domal favositid coral overlain by gray, slightly argillaceous dolomite with abundant skeletal debris.

55.0-57.5 Dolomite, very light tan to light tan gray, finely crystalline, few medium gray shale whisps, good vug porosity. Contains several large clasts of above micritic lithology.

57.5-59.5 Dolomite, as in 39.8-55.0 feet.

59.5-70.0 Dolomite, light tan to very light tan gray, finely to medium crystalline, moderately pure with a few argillaceous zones, very poorly bedded, scattered fossil debris becoming finer grained toward base. Good vug porosity in upper two-thirds, denser toward base.

BISHER FORMATION

70.0-79.9 Dolomite, gray brown to tan gray, finely to medium crystalline, dense and heavy, faintly parallel bedded and bioturbated, scattered fine to very fine grained skeletal debris, slightly silty, very homogeneous.

Athens County, Ohio
Waterloo Township
Section 16
Sample No. 1077

El Paso Natural Gas
Kisor Pool Unit #1
Permit 1431
Elevation 959 DF

3157-3171 Dolomite, medium- to medium light gray, finely crystalline, argillaceous. Dolomite, tan, microcrystalline to lithographic. Shale, medium- to dark gray; heavy trace. Anhydrite, white, microcrystalline; trace.

3171-3194 Dolomite, light- and medium gray, finely to microcrystalline, argillaceous to very argillaceous, slightly silty. Shale, gray to green gray; 20%. Dolomite, tan, as above; trace. Anhydrite, trace. C UNIT AT 3168 FEET (GRN).

3194-3219 Dolomite, gray, as above. Anhydrite, white to very light gray, very finely to finely crystalline; 10%. Shale, medium gray; trace. TYMOCHTEE FORMATION AT 3192 FEET (GRN).

3219-3231 Dolomite, light medium gray and tan gray, finely to microcrystalline, some lithographic.

Anhydrite, white; trace. Shale, medium- to dark gray, soft; 15%.

3231-3244	Dolomite, tan gray and gray brown, finely to medium crystalline, slightly silty and argillaceous. Shale, medium gray; 10%.
3244-3258	Dolomite, tan gray as above, silty to very silty, interbedded with white anhydrite. Shale as above. GREENFIELD FORMATION AT 3251 FEET (GRN).
3258-3282	Dolomite, silty, as above. Heavy trace medium gray shale.
3282-3293	Dolomite, brown gray to tan gray, finely to medium crystalline, more crystalline than above; few medium gray, argillaceous. Shale, medium- to light gray, soft; 35%. Siltstone, gray, fine to very fine grained; trace.
3293-3300	Dolomite, brown gray, tan, and yellow gray, finely crystalline, pure to slightly argillaceous, slightly silty. Shale, medium gray; heavy trace.
3300-3309	Dolomite as above, mostly pure, very slightly silty. Shale as above, 35%.
3309-3341	Dolomite, yellow gray to very light tan, finely crystalline, few medium crystalline, pure, dense, homogeneous. PEEBLES FORMATION AT 3302 FEET (GRN).
3341-3358	Dolomite, light- to medium gray, tan, darker than above, finely to medium crystalline, silty. Trace gray shale.
3358-3371	Dolomite, light tan, light gray, and yellow gray, medium to finely crystalline, some coarse and sucrosic, slightly silty and pyritic. Heavy trace gray shale.
3371-3388	Limestone, white to light gray, fine grained, dolomitic in part, slightly silty. Siltstone, light tan gray, fine to medium grained, calcareous.
3388-3427	Limestone, medium gray and brown gray, fine grained, slightly argillaceous and silty. Limestone, mottled light gray, white, and cream, fine to medium grained, fossiliferous, variably silty. Siltstone as above, trace.
3427-3451	Shale, very silty, gradational to shaly

siltstone, medium- to dark gray, dolomitic. Limestone, silty, gray, with white megacrystals, fossiliferous; 20%. UNDIFFERENTIATED LILLEY AND BISHER FORMATIONS AT 3430 FEET (GRN).

3451-3477	Siltstone, calcareous, light gray to light tan gray, fine to medium grained, well sorted, subangular to subround, moderately hard. Limestone, fossiliferous, as above; heavy trace.
3477-3490	Shale, medium- and light gray, soft. Siltstone as above, trace. Dolomite, light gray, finely crystalline, argillaceous in part, dense; heavy trace.
3490-3540	Shale, reddish gray, soft. Dolomite as above, heavy trace. ESTILL SHALE AT 3508 FEET (GRN). Samples poorly lagged here.
3540-3621	Shale as above, some medium gray. Limestone, white, fine grained, silty; trace to 10%. Siltstone, gray, fine grained, very argillaceous, compact; trace.
3621-3652	Shale, limestone, and siltstone as above, slightly glauconitic.
3652-3660	Shale, light medium gray, soft. Limestone, gray tan, fine to medium grained, pure, hard.
3660-3668	Limestone, light gray, fine grained, argillaceous, moderately hard; and a few white, purer, fine to medium grained. Shale, light to medium gray, moderately soft. DAYTON LIMESTONE AT 3661 FEET (GRN).
3668-3677	Shale as above, 70%. Limestone, gray, as above. LULBEGRUD SHALE AT 3670 FEET (GRN).
3677-3682	Limestone, mottled cream, white, tan, and light gray, medium to fine grained, slightly silty, hard. Shale as above, 40%.
3682-3693	Limestone as above, more argillaceous, some very silty. Siltstone, light gray, fine grained, calcareous in part. Shale, gray, as above.
3693-3702	Shale, red gray, moderately soft to soft. Limestone, ferruginous, red brown mottled white, fossiliferous, oolitic or pelletal, silty. Siltstone, light gray, fine grained; trace.

3702-3708	Shale, medium gray, moderately soft. Limestone, medium gray, argillaceous, silty, hard. OLDHAM LIMESTONE AT 3704 FEET (GRN).
3708-3713	Limestone, mottled medium gray and tan, medium grained, argillaceous, silty in part; few white, pure, medium grained; few ferruginous. Shale as above, 30%.
3713-3717	Shale, light medium gray, soft. Siltstone, white to cream, average grain size 150 μ, subangular to subround, pure, hard; 15%. Limestone, silty, as above; heavy trace.
3717-3724	Siltstone as above; with some light- to medium gray, slightly calcareous, and finer grained. Shale, gray; 25%.
3724-3728	Siltstone, white, as above, compact; and a few red brown, ferruginous, oolitic; and few gray, shaly, poorly sorted. Shale, light medium gray; trace. UPPER CABOT HEAD SHALE AT 3724 FEET (GRN).
3728-3730	Siltstone, white, average grain size 200 μ, well sorted, subround to subangular, compact, hard; and a few light gray, argillaceous. Shale, medium gray; 15%. Dolomite, gray, finely crystalline, argillaceous, hard; trace.
3730-3736	Siltstone as above, disaggregated, with heavy trace iron cement and limonite stain. Shale, gray; 10%.
3736-3746	Siltstone, light gray, average grain size 100-125 μ, shaly in part, compact; and a few white, pure, as above. Shale, medium- to medium dark gray; 35%. Dolomite, gray tan, finely crystalline; trace. CLINTON SANDSTONE AT 3738 FEET (GRN).
3746-3752	Limestone, mottled brown, white, and gray, fine grained, slightly ferruginous, silty to very silty, argillaceous, fossiliferous. Siltstone, light gray, as above. Shale, medium gray, soft; heavy trace.
3752-3765	Siltstone, light gray and light tan, average grain size 100-125 μ, well sorted, subangular to subround, slightly calcareous. Limestone as above, trace to 10%. Shale, light medium gray, soft; 15%.
3765-3773	Siltstone, light medium gray, fine grained,

very argillaceous. Shale, silty, gray. Limestone, tan, medium grained, fossiliferous.

3773-3780	Shale, gray; 60%. Limestone, mottled brown, white, and light gray, fine to medium grained, argillaceous in part, fossiliferous. Siltstone, light tan, average grain size 150 µ, argillaceous, calcareous, compact; trace. LOWER CABOT HEAD SHALE AT 3765 FEET (GRN).
3780-3787	Shale, limestone, and siltstone as above. Limestone silty to very silty.
3787-3804	Shale, medium gray, soft. Limestone, light gray and tan, medium to coarse grained, argillaceous, silty, hard. Siltstone, light medium gray, fine grained, compact, calcareous.
3804-3822	Shale, medium gray. Limestone, mottled light- and medium gray, white, and tan, fine to medium grained, few sparry, fossiliferous, slightly silty. Siltstone, light gray to white, fine grained, compact, calcareous; 10%. BRASSFIELD FORMATION AT 3800 FEET (GRN).
3822-3828	Siltstone, medium gray, very argillaceous. Shale, gray and gray red, silty, dolomitic, moderately soft to moderately hard; 40%.
3828-3852	Shale, silty to very silty, red, calcareous. WHIRLPOOL SANDSTONE AT 3838 FEET (GRN). ORDOVICIAN JUNIATA AT 3850 FEET (GRN). Samples below Dayton Limestone poorly lagged.

Clinton County, Ohio
Wayne Township
VMSL 1027
Sample No. 757

Kewanee Oil Company
Luttrell #1
Permit No. 1
Elevation 1114 DF

Samples start at 82 feet in PEEBLES FORMATION.

82-113	Dolomite, pale brown to tan, finely to medium crystalline, fair porosity, most dense. Dolomite, yellow brown, coarsely crystalline, sucrosic; 10%.
113-151	Dolomite, yellow gray, white, and very light gray, finely crystalline, sparry, very pure, homogeneous, good to excellent porosity.
151-159	Dolomite, light medium gray, with scattered white megacrystalline rhombs, medium

crystalline, variably argillaceous matrix, fossiliferous, slightly pyritic. Dolomite as above, 15%. LILLEY FORMATION AT 151 FEET (GRN).

159-174	Dolomite, medium gray, argillaceous, slightly silty and pyritic, moderately hard; with a few light gray, finely crystalline, and pure.
174-190	Dolomite, tan gray and gray, medium crystalline, with scattered white megacrystalline rhombs, slightly argillaceous, crinoidal in part. Shale, light gray, soft; 20%. BISHER FORMATION AT 170 FEET (GRN).
190-195	Shale, light- to medium gray. Siltstone, light gray, fine grained, moderately hard, dolomitic; 10%. Dolomite as above, heavy trace. ESTILL SHALE AT 188 FEET (GRN).
195-231	Shale, medium gray, dolomitic. Dolomite, light gray, finely crystalline, slightly argillaceous; trace to 20%.
231-236	Limestone, ferruginous, red brown, mottled white and gray, fossiliferous, slightly to very argillaceous, hard. Shale, gray, as above, with glauconite; 10%. DAYTON LIMESTONE AT 229 FEET (GRN).
236-241	Dolomite, gray to whitish gray, finely crystalline, fossiliferous, poor vug porosity. Trace gray shale. CABOT HEAD SHALE AT 234 FEET (GRN).
241-250	Dolomite, very light gray, finely crystalline, some sparry, fair to good vug porosity in some, most dense. BRASSFIELD FORMATION AT 245 FEET (GRN).
250-255	Dolomite, yellow gray and brown gray, ferruginous in part, medium to coarsely crystalline, slightly argillaceous, fossiliferous.
255-261	Dolomite, light- to medium gray, finely to medium crystalline, some argillaceous, slightly silty, dense. Shale, gray, dolomitic; trace.
261-269	Limestone, light gray, as above dolomite, with glauconite.
269-277	Dolomite, light- to medium gray, finely crystalline, some very silty, slightly argillaceous. Siltstone, white, very fine

grained; trace. Chert, white, trace.

277-290	Siltstone, dolomitic, medium gray, fine grained, argillaceous. Shale, medium gray, dolomitic; 10%. Trace white chert. ORDOVICIAN AT 286 FEET (GRN).
290-295	Shale, reddish gray, moderately soft, calcareous. Limestone, light gray, fine grained, argillaceous, fossiliferous; 30%.

Fayette County, Ohio
Concord Township
Lot 1002
Sample No. 751

Kewanee Oil Company
E. Wilson #1
Permit No. 2
Elevation 1017 T

0- 30	Glacial drift.
30- 50	Dolomite, light tan gray and very pale brown, finely to microcrystalline, good to excellent vug porosity in some, most dense. Dolomite, tan, lithographic; heavy trace. BEDROCK IN PEEBLES FORMATION.
50- 75	Dolomite, light gray and light tan gray, finely crystalline, slightly calcareous, dense to good vug porosity, few stylolites; 85%. Dolomite, yellow gray, finely sucrosic, fair to poor vug porosity.
75-135	Dolomite as above. Dolomite, white and cream, medium to coarsely crystalline, very pure; 20%.
135-140	Dolomite as above, 75%. Limestone, light medium gray, fine grained, slightly argillaceous, dolomitic in part, fossiliferous. LILLEY FORMATION AT 135 FEET (GRN).
140-150	Limestone, medium- to light gray, fine grained, slightly to very argillaceous; 40%. Limestone, mottled white and gray, coarse grained, fossiliferous; 30%. Dolomite as above, 20%. Heavy trace gray shale.
150-160	Dolomite, calcareous, gray brown, medium to coarsely crystalline, crinoidal, silty to very silty, some purer; 75%. Dolomite, light gray, less calcareous, medium crystalline, slightly argillaceous and silty. Heavy trace medium gray shale. BISHER FORMATION AT 150 FEET (GRN).
160-170	Limestone, dolomitic, medium gray, medium to

coarse grained, argillaceous in part, silty; interbedded with limestone, mottled light gray, tan and white, coarse grained, fossiliferous. Shale, medium gray; 20%. ESTILL SHALE AT 165 FEET (GRN).

170-175	Shale, dolomitic, gray, very slightly silty. Dolomite, light gray to buff, finely crystalline, silty; 15%.
175-204	Shale, light- to medium gray, soft, dolomitic; 85%. Dolomite, calcareous, and limestone, mottled light gray and white, medium to coarse grained, fossiliferous, some argillaceous.
204-210	Limestone, white to cream, medium to fine grained, some sparry, with a trace of glauconite and quartz sand grains. DAYTON LIMESTONE AT 210 FEET (GRN).
210-220	Limestone, as above, no glauconite or sand grains. Shale, medium gray; 20%. Heavy trace ferruginous limestone. CABOT HEAD SHALE AT 218 FEET (GRN).
220-230	Limestone, medium- to dark gray, fine to medium grained, very argillaceous to shaly, fossiliferous and ferruginous in part. Limestone as above, heavy trace.
230-240	Limestone, gray, as above, glauconitic, some very fossiliferous and slightly silty. BRASSFIELD FORMATION AT 229 FEET (GRN).
240-250	Limestone, light gray, coarsely crystalline, argillaceous in part, crinoidal. Limestone, red brown, ferruginous, fossiliferous; 25%.
250-265	Limestone, mottled light gray, cream, buff, and tan, coarse to medium grained, fossiliferous. Heavy trace gray and white chert. Faint trace ferruginous limestone.
265-275	Dolomitic siltstone, light- to medium gray, fine grained, argillaceous, moderately friable; 90%. Limestone, mottled, as above; 5%. Shale, gray, silty, dolomitic; 5%. ORDOVICIAN AT 272 FEET (GRN).
275-280	Shale, medium gray, moderately soft, slightly silty, calcareous; 75%. Limestone, light gray, argillaceous, fine grained, fossiliferous.

Gallia County, Ohio
Harrison Township
Section 12
Sample No. 3410

Columbia Gas Company
J. Bane #1
Permit No. 181
Elevation 555 KB

3410-3430	Dolomite, tan, finely crystalline, laminated. Shale, medium dark gray; 20%. Anhydrite, white, very finely crystalline; trace. C UNIT AT 3422 FEET (GRN).
3430-3440	No sample.
3440-3450	Dolomite, medium- and light gray, micro- to finely crystalline, argillaceous. Dolomite, tan, microcrystalline to lithographic; 15%. Siltstone, gray, fine grained; heavy trace.
3450-3490	Dolomite, light tan and tan gray, lighter than above, micro- to finely crystalline, some lithographic, argillaceous in part. Anhydrite, white, very finely crystalline; trace. Heavy trace gray shale. TYMOCHTEE FORMATION AT 3458 FEET (GRN).
3490-3500	Dolomite, tan and light tan gray, micro- to finely crystalline, dense, homogeneous.
3500-3510	Dolomite, gray, micro- to finely crystalline, argillaceous.
3510-3520	No sample.
3520-3530	Dolomite, light gray and brown gray, finely crystalline, less argillaceous than above, homogeneous. GREENFIELD FORMATION AT 3512 FEET (GRN).
3530-3570	No sample.
3570-3580	Dolomite, light- and medium gray, finely crystalline, slightly silty. Dolomite, brown gray, darker than above, finely crystalline, variably silty. LOCKPORT GROUP AT 3555 FEET (GRN).
3580-3590	Dolomite, light gray and light brown gray, as above. Siltstone, white, fine grained, pure; trace.
3590-3610	Dolomite, brown gray, finely crystalline, some argillaceous; 60%. Dolomite, light gray, as above; 15%. Siltstone, dolomitic, white and gray, medium to coarse grained; heavy trace.

3610-3620	No sample.
3620-3630	Dolomite, brown gray, finely to medium crystalline, with some white megacrystalline rhombs, fossiliferous, slightly silty. Dolomite, light gray, finely to microcrystalline, dense; 30%.
3630-3650	Siltstone, dolomitic, gradational to silty dolomite, tan and brown gray, medium to coarse grained. Trace medium gray shale. KEEFER SANDSTONE AT 3631 FEET (GRN).
3650-3660	No sample.
3660-3680	Siltstone, mottled light gray and light tan, dolomitic, average grain size 125 μ, moderately well sorted, subangular to subround; few medium gray, argillaceous.
3680-3700	Shale, medium- to dark gray, moderately soft. Siltstone, dolomitic, as above; 15%. ESTILL SHALE AT 3680 FEET (GRN).
3700-3860	Shale, medium- to dark gray, some reddish gray. Trace siltstone as above. Trace dolomite, tan, finely crystalline. Shale becomes increasingly red gray below 3760 feet, with heavy trace of siltstone and dolomite.
3860-3870	Shale as above. Dolomite, medium gray, finely crystalline, argillaceous, slightly glauconitic; 10%. DAYTON LIMESTONE AT 3853 FEET, LULBEGRUD SHALE AT 3858 FEET (GRN).
3870-3880	Shale, medium light gray, micaceous; 80%. Dolomite, light gray and tan, finely crystalline. Siltstone, white, very fine grained, friable; heavy trace. CACAPON SANDSTONE AT 3873 TO 3878 FEET (GRN).
3880-3890	Shale, light- and medium gray. Dolomite, light gray, finely crystalline, argillaceous, slightly glauconitic; 20%.
3890-3900	Shale as above, slightly glauconitic. Dolomite as above; with a few tan.
3900-3920	Shale and dolomite as above, no glauconite, trace of silt in dolomite.
3920-3940	Shale, reddish gray. Dolomite, mottled gray and tan, finely crystalline, slightly argillaceous and silty, hard. OLDHAM LIMESTONE

AT 3929 FEET (GRN).

3940-3950	Shale, light gray. Dolomite, mottled medium dark gray and tan, finely to medium crystalline, argillaceous, silty, some slightly ferruginous; 35%. Siltstone, white, fine grained, friable; trace.
3950-3960	Shale as above, some reddish gray, very soft. Dolomite as above, 10%. Dolomite, tan and white, sparry, fossiliferous; heavy trace.
3960-3970	Shale, gray and reddish gray, very soft; 60%. Dolomite, tan, as above. UPPER CABOT HEAD SHALE AT 3959 FEET (GRN).
3970-3980	Shale, medium gray. Dolomitic siltstone, brown, ferruginous, oolitic. Dolomite, gray and tan, medium crystalline, argillaceous. CLINTON SANDSTONE AT 3970 FEET (GRN).
3980-3990	Siltstone, white to light tan, impure, average grain size 177 μ, moderately well sorted, subangular to subround, pyritic. Shale as above, 30%. Dolomitic siltstone, ferruginous, as above; heavy trace.
3990-4000	No sample.
4000-4010	Siltstone, white, pure, well sorted, average grain size 177 μ. Shale, medium dark gray; 30%. Limestone, gray, fine grained; trace. LOWER CABOT HEAD SHALE AT 4006 FEET (GRN).
4010-4020	Shale, gray; 80%. Dolomite, medium light gray, finely crystalline, argillaceous and silty, hard. Siltstone, white, fine grained, pure; trace.
4020-4030	Shale as above. Limestone, ferruginous, brown and red brown, mottled white, oolitic, fossiliferous, moderately hard; 20%. Dolomite, tan and gray, finely crystalline; heavy trace.
4030-4040	Shale, gray; 95%. Trace dolomite and ferruginous limestone as above.
4040-4050	Shale as above, 70%. Dolomite, gray, finely crystalline, argillaceous, silty, hard; with a few tan, medium to finely crystalline, fossiliferous.

TD 4080 in Lower Cabot Head Shale.

Highland County, Ohio
Brush Creek Township
Sample No. 2799

Cominco American Inc.
J. Humphrey CA-110
Permit No. 9
Elevation 749 T

Core starts at 20 feet in PEEBLES FORMATION.

20- 47	Dolomite, light yellowish gray (5 Y 7/2), medium to coarsely crystalline, good vug porosity, minor asphalt impregnation in upper 5 feet, abundant corals in lower 2 feet. Core strongly broken and fractured.

PEEBLES-LILLEY TRANSITION

47- 50	Dolomite, medium- to light gray, argillaceous to shaly; containing irregular patches of yellow gray, medium to finely crystalline, porous dolomite as above. Several gray shale partings and a few thin zones of coarse crinoidal debris are present.

LILLEY FORMATION

50- 67	Dolomite, medium gray, finely crystalline, argillaceous to shaly, fine grained crinoidal debris disseminated throughout with some coarse grained debris irregularly scattered, contorted shale partings uncommon, silty, faintly cross bedded and bioturbated.
67- 77	Dolomite, as above, with a few whitish limestone (coral?) swirls, and several inch-thick beds of yellow gray, pure, cross bedded, porous dolomite.
77- 92	Dolomite, mottled gray and brownish gray, argillaceous, bioturbated, faint hummocky cross lamination common, shale laminae common, with several thin fossil-rich calcareous beds.

BISHER FORMATION

92-125	Dolomite, light gray and light brown gray, finely to medium crystalline, slightly argillaceous, silty, dense, rather homogeneous, faintly cross bedded, with many light gray shale whisps and partings. Milky gray chert nodules at 102 and 115 feet.
125-127	Dolomite, similar to above, darker gray, shaly to very argillaceous.

127-137 Dolomite, brown gray, medium to finely crystalline, less argillaceous than above, silty, medium grained crinoidal debris abundant, bioturbated, faintly cross bedded, pyritic.

ESTILL SHALE

137-153 Shale, green gray, soft, splintery; with a few thin, yellow gray, cross bedded dolomite stringers in upper 2 feet.

Highland County, Ohio	Cominco American Inc.
Fairfield Township	E. Swingley CA-54
Lot 1027	Permit No. 6
Sample No. 2499	Elevation 1056 T

Core starts at 24 feet in PEEBLES FORMATION.

24- 28 Dolomite, yellow gray and light brown, finely to medium crystalline, pure, excellent vug porosity, irregularly stained with limonite, no recognizable fossils.

28- 84 Dolomite, yellow gray, very light gray, and light brown gray, medium to finely crystalline, pure, fair to poor vug porosity with a few zones of excellent porosity as a 79 to 84 feet, scattered corals, rare whispy shale laminae, stylolites common from 32 to 42 feet.

PEEBLES-LILLEY TRANSITION

84- 92 Dolomite, light- to medium gray, micro- to finely crystalline, argillaceous, very fossiliferous, excellent vug porosity in association with fossil zones.

LILLEY FORMATION

92- 93 Shale, light greenish gray.

93- 98 Dolomite, gray, very argillaceous to shaly; interbedded with dolomite, yellow gray, finely crystalline, purer, crinoidal and coralline, with a trace of pyrite and asphalt.

98-115 Dolomite, very light gray, finely crystalline, argillaceous, with several thin beds of gray shale, very fossiliferous (crinoidal and coralline), fair to good vug porosity, pyrite common in vugs.

BISHER FORMATION

115-122 Dolomite, medium gray to brown gray, finely crystalline, argillaceous, faintly cross bedded, poor vug porosity, few shale partings, scattered crinoidal debris, slightly silty. Gradational with above lithology.

122-131 Dolomite as above, medium gray to brown gray, bioturbated, mottled, hummocky cross lamination common, several dark gray clay whisps and light gray silty interbeds, dense.

131-142 Dolomite, calcareous in part, brown gray to buff, finely crystalline, some very slightly argillaceous, most pure, crinoidal in part, scattered zones of fair vug porosity, rare shale whisps. Cryptothyrella zone at 139 to 140 feet. Gradational with Estill Shale.

ESTILL SHALE

142-207 Shale, medium- to light gray, greenish gray, dolomitic; progressively more reddish gray and maroon below 175 feet.

DAYTON LIMESTONE

207-219 Limestone, yellowish gray to white with a greenish tinge, medium to coarse grained and sparry, nodular bedded, glauconitic especially in upper 0.5 feet. From 209-213 feet limestone is red, ferruginous, oolitic, fossiliferous, dense.

CABOT HEAD SHALE (?)

219-220 Shale, light greenish gray, poorly indurated.

BRASSFIELD FORMATION

220-229 Limestone, light gray to greenish gray, medium to coarse grained, glauconitic, mottled throughout with iron staining, A 2-inch thick oolitic, ferruginous limestone bed occurs at 224 feet.

229-243 Limestone, gradational with above, light gray to whitish gray, some yellow gray, fine to coarse grained, relatively shale free except for a few shale partings, slightly glauconitic, bedding irregular, rare milky white and gray chert interbedded below 236 feet.

243-255	Dolomite, slightly calcareous, mottled medium gray and brown gray, argillaceous to shaly, silty in part, bioturbated, dense.
255-262	Dolomite, as above, very argillaceous; interbedded with laminated dolosiltite and green gray shale. At 262 feet rip-up clasts of red shale in fragmental silty limestone.

ORDOVICIAN

262-270	Shale, grayish red (10 R 4/2), silty, moderately hard, calcareous. Gradational upward into above lithology.

Hocking County, Ohio
Benton Township
Section 33
Sample No. 738

Kewanee Oil Company
Amerine #1
Permit No. 611
Elevation 1061 KB

2015-2083	Dolomite, tan, microcrystalline to lithographic, with black carbonaceous partings; 75%. Dolomite, medium- to dark gray, argillaceous; interbedded with white, finely crystalline anhydrite. C UNIT AT 2010(?) FEET, TYMOCHTEE FORMATION AT 2032 FEET (GRN).
2083-2101	Dolomite, medium- to light gray, finely crystalline, slightly argillaceous and silty. Dolomite, brown gray, finely to microcrystalline, slightly silty; 10%.
2101-2132	Dolomite, tan, gray, and gray brown, finely crystalline, harder and more crystalline than above. GREENFIELD FORMATION AT 2105(?) FEET (GRN).
2132-2163	Dolomite as above; and a few yellow gray, finely crystalline, pure, dense.
2163-2180	Dolomite, tan and yellow gray, finely crystalline, pure, dense. Shale, medium- to dark gray; 5-10%. Siltstone, medium gray, very fine grained; trace.
2180-2239	Dolomite, yellow gray, finely crystalline, some medium crystalline and sucrosic, very pure, homogeneous. PEEBLES FORMATION AT 2176 FEET (GRN).
2239-2267	Dolomite, very light gray and yellow gray,

finely to microcrystalline, dense; sparsely interbedded with gray, fine grained siltstone.

2267-2277	Dolomite as above. Siltstone, dolomitic, light gray, fine to medium grained; 15%.
2277-2300	Dolomite, light gray and yellow gray, finely to medium crystalline, fair vug porosity. Faint trace siltstone as above.
2300-2325	Dolomite, mottled medium gray and tan, with white megacrystalline rhombs, medium to coarsely crystalline, fossiliferous, slightly silty and argillaceous. UNDIFFERENTIATED LILLEY AND BISHER FORMATIONS AT 2300 FEET (GRN).
2325-2373	Dolomite, very light gray to white, medium to finely crystalline, some coarser, fossiliferous, slightly to very silty. Siltstone, light gray, fine grained; heavy trace.
2373-2388	Siltstone, light gray, fine to medium grained, moderately well sorted, pure to moderately argillaceous. Dolomite as above, 20%, Heavy trace dark gray shale.
2388-2404	Siltstone, light gray, fine to very fine grained, compact. Shale, medium gray; heavy trace. ESTILL SHALE AT 2396 FEET (GRN).
2404-2421	Siltstone, light tan and light gray, very fine grained, compact; interbedded with medium gray shale. Shale, medium- to light gray, becomes more abundant toward base of interval.
2421-2514	Shale, medium gray and reddish gray, moderately soft. Dolomite, light gray and tan, medium to finely crystalline, fossiliferous, some silty; trace to 20%.
2514-2526	Shale, light- and medium gray, slightly micaceous. Dolomite, gray and tan, finely crystalline, glauconitic, slightly argillaceous, silty. Siltstone, light gray, very fine to fine grained; trace.
2526-2531	Shale as above. Dolomite, gray, finely crystalline, argillaceous, hard; heavy trace. DAYTON LIMESTONE AT 2525 FEET (GRN).
2531-2537	Dolomite, mottled tan, light gray, and white, finely to medium crystalline, pure, slightly glauconitic. Shale, gray; heavy trace.

LULBEGRUD SHALE AT 2532 FEET (GRN).

2537-2542 Dolomite as above. Shale, medium light gray; 30%.

2542-2546 Dolomite, gray and tan, medium crystalline, slightly argillaceous, hard, glauconitic. Shale, light gray mottled reddish gray, silty. OLDHAM LIMESTONE AT 2543 FEET (GRN).

2546-2551 Shale, light gray to reddish gray. Dolomite, argillaceous, as above. Shale, brown, silty, very soft; trace.

2551-2563 Dolomite, mottled tan, brown, gray, and white, medium to finely crystalline, silty, fossiliferous, pyritic, slightly ferruginous. Siltstone, light gray to white, fine to very fine grained, friable to moderately hard. Trace gray shale. UPPER CABOT HEAD SHALE AT 2561 FEET (GRN).

2563-2572 Siltstone, white, average grain size 200 μ, well sorted, subangular to subround, pure. Siltstone, gray and tan, argillaceous to shaly, dolomitic; 15%. CLINTON SANDSTONE AT 2570 FEET (GRN).

2572-2582 Siltstone, white and light gray, average grain size 100 μ, mostly pure, some limonite stain. Shale, light gray, slightly silty; 10%. LOWER CABOT HEAD SHALE AT 2578 FEET (GRN).

2582-2586 Shale, light medium gray, soft. Siltstone, light medium gray, very fine to fine grained, argillaceous; trace.

2586-2591 No sample.

2591-2604 Shale as above, slightly silty. Siltstone as above, 25%.

2604-2616 Siltstone, light gray, very fine grained, argillaceous. Dolomite, mottled tan, gray, and white, medium to finely crystalline, silty; 30%. Shale, light gray; 25%. Trace ferruginous limestone.

2616-2631 Siltstone, dolomitic, medium gray and tan, medium to fine grained; a few white, pure. Shale, light gray; 15%. BRASSFIELD FORMATION AT 2615 FEET (GRN).

2631-2640 Siltstone as above, less dolomitic, medium to coarse grained and slightly ferruginous.

Shale, light medium gray; 10%.

2640-2648	Siltstone, light gray and tan, average grain size 150 µ, angular to subround, poorly sorted. Shale, gray; 35%.

TD at 2648 in Brassfield Formation.

Hocking County, Ohio
Washington Township
Section 29
Sample No. 3043

Quaker State Oil Co.
Southern Ohio Ent. #1
Permit No. 1679
Elevation 1047 KB

2350-2365	Dolomite, medium to light gray, finely crystalline, a few microcrystalline, slightly argillaceous. Anhydrite, white, very finely crystalline; trace. Trace light gray, fine grained siltstone. GREENFIELD FORMATION AT 2348 FEET (GRN).
2365-2385	Dolomite, medium gray, argillaceous, as above. Dolomite, tan and tan gray, microcrystalline to lithographic, dense. Trace white anhydrite.
2385-2415	Dolomite, medium gray, microcrystalline, argillaceous; few tan gray as above. Shale, medium- to dark gray; 20%. Trace light gray chert.
2415-2550	Dolomite, white, yellow gray, and very light gray, finely crystalline, pure, homogeneous, fair to good intercrystalline and vug porosity. PEEBLES FORMATION AT 2410 FEET (GRN).
2550-2560	Dolomite, light- to medium gray, argillaceous to shaly, much darker and less pure than above. Shale, medium gray; 20%. UNDIFFERENTIATED LILLEY AND BISHER FORMATIONS AT 2540 FEET (GRN).
2560-2570	Shale, medium gray, soft. Dolomite, white and yellow gray, finely crystalline, slightly argillaceous, dense; 30%. Siltstone, gray, fine grained, argillaceous to shaly, dolomitic; trace.
2570-2600	Dolomite, white and yellow gray, finely to medium crystalline, with white megacrystalline rhombs, fossiliferous. Siltstone, medium gray, fine grained, argillaceous, dolomitic; 20%. Trace gray shale. Anhydrite, white, very finely crystalline; trace.

2600-2630	Siltstone, light gray to light tan gray, fine grained, moderately to poorly sorted, argillaceous in part, some pure Shale, medium gray, slightly micaceous; 20%.
2630-2635	Dolomite, white, finely crystalline, pure to very pure, homogeneous.
2635-2650	Shale, medium gray; interbedded with a few gray and tan, fine grained, compact siltstone. ESTILL SHALE AT 2625 FEET (GRN).

Jackson County, Ohio
Milton Township
Section 33
Sample No. 759

Kewanee Oil CO.
Buckeye #2
Permit No. 62
Elevation 802 T

2412-2440	Dolomite, medium gray, microcrystalline, argillaceous, sandy in part. Dolomite, tan, microcrystalline to lithographic, faintly laminated. Trace gray shale. Trace white, finely crystalline anhydrite. C UNIT AT 2390 FEET, TYMOCHTEE FORMATION AT 2413 FEET (GRN).
2440-2446	Shale, medium gray; 60%. Dolomite, gray, microcrystalline, silty.
2446-2451	Dolomite, tan gray and medium gray, finely to microcrystalline, some lithographic. Heavy trace white, finely crystalline anhydrite. Slight trace gray, fine grained siltstone.
2451-2463	Dolomite, gray and tan gray, as above; mottled with anhydrite. Trace medium gray shale.
2463-2480	Dolomite, medium gray and tan gray, finely to microcrystalline, some very argillaceous and silty. Dolomite, light tan, microcrystalline to finely crystalline, lighter than above; 40%. GREENFIELD FORMATION AT 2470 FEET (GRN).
2480-2503	Dolomite, light gray and tan, as above, less argillaceous. Trace medium gray shale.
2503-2513	Dolomite as above. Dolomite, light tan to yellow gray, microcrystalline, dense; 15%.
2513-2544	Dolomite, yellow gray to very light tan, finely to medium crystalline, some sucrosic, pure, fair to good vug porosity, homogeneous. LOCKPORT GROUP AT 2513 FEET (GRN).

2544-2563	Dolomite, tan gray, and medium- to light gray, darker than above, finely crystalline, slightly argillaceous, silty. Trace medium gray shale.
2563-2596	Dolomite, yellow gray, as in 2513-2544, finely crystalline with a few medium crystalline, slightly sucrosic, fair intercrystalline porosity.
2596-2615	Dolomite, light tan to tan gray, finely crystalline, slightly silty, homogeneous, dense.
2615-2642	Dolomite, medium gray and tan gray, darker than above, finely crystalline, some very argillaceous, slightly to very silty. BISHER FORMATION AT 2615 FEET (GRN).
2642-2665	Siltstone, dolomitic, light gray and tan, average grain size 125 μ, moderately sorted; some medium gray, very argillaceous. Heavy trace to 10% medium gray shale.
2665-2674	Siltstone as above, average grain size 150 μ, well sorted. Shale, medium gray; 20%. ESTILL SHALE AT 2670 FEET (GRN).
2674-2684	Siltstone, gray, fine grained, argillaceous to shaly, compact. Shale as above.
2684-2706	Shale, light- to medium gray, moderately soft, slightly silty; 80%. Siltstone, argillaceous, as above.
2706-2746	Shale, medium gray to reddish gray. Trace siltstone and silty dolomite.
2746-2831	Shale, medium gray to reddish gray, dolomitic. Heavy trace dolomite, gray, argillaceous and silty. Trace siltstone, light gray, fine to very fine grained, argillaceous.
2831-2839	Dolomite, medium to light gray, finely crystalline, argillaceous, hard, dense. Shale as above, 20%. DAYTON LIMESTONE AT 2833 FEET (GRN).
2839-2850	Dolomite as above, slightly silty; and few tan, medium crystalline. Shale as above, glauconitic. LULBEGRUD SHALE AT 2842 FEET (GRN).
2850-2881	Shale, medium light gray. Dolomite, gray, finely crystalline, argillaceous; trace.

OLDHAM LIMESTONE AT 2871 FEET (GRN).

2881-2889 Limestone, mottled light gray, white, and tan, medium grained, silty, oolitic, hard. Shale as above, 20%. UPPER CABOT HEAD SHALE AT 2884 FEET (GRN).

2889-2899 Shale, medium gray to dark reddish gray; 70%. Limestone, brown and reddish gray, ferruginous, oolitic. Siltstone, white, fine grained, moderately sorted, subangular to subround; trace. CLINTON SANDSTONE AT 2893 FEET (GRN).

2899-2911 Limestone, ferruginous, and shale as above; 75%. Siltstone, white and tan, fine grained, pure, calcareous, compact.

2911-2915 Shale, light- to medium gray, soft; 60%. Siltstone, white to gray, average grain size 150 μ, argillaceous, compact, noncalcareous; 25%.; and a few light tan, very fine grained. Limestone, ferruginous; heavy trace.

2915-2924 Siltstone, light gray to white, average grain size 125 μ, slightly argillaceous, compact. Shale, gray; heavy trace. LOWER CABOT HEAD SHALE AT 2918 FEET (GRN).

2924-2928 Sandstone, white, average grain size 250 μ, subangular to subround, well sorted, pure. Shale, gray; heavy trace.

2928-2933 Siltstone, white to light gray, average grain size 177 μ, well sorted, subangular to subround. Shale, gray; 40%.

2933-2938 Shale, medium gray; 70%. Siltstone as above.

2938-2945 Shale as above. Limestone, mottled light gray and tan, fine grained, fossiliferous, dense; heavy trace.

2950-2959 Shale as above, 90%. Limestone, and a few similar dolomite, as above. Siltstone, white, fine grained, pure; trace.

2959-2966 Siltstone, white and tan, fine grained, well sorted, argillaceous, compact; 60%. Limestone, light gray and tan, finely crystalline, silty and argillaceous; 30%. Shale, gray. BRASSFIELD FORMATION AT 2960 FEET (GRN).

2966-2999 Limestone, mottled gray, tan, cream and white, medium to fine grained, some coarse and sparry, fossiliferous; 75%. Shale, medium to light gray, moderately soft. Siltstone, light gray and tan, very fine grained; trace.

TD at 2999 in Brassfield Formation.

Lawrence County, Ohio	Fortune Gas & Oil Co.
Hamilton Township	Jefferys Trustee #1
Section 11	Permit No. 231
Sample No. 3466	Elevation 901 KB

2330-2340 Dolomite, tan, light gray tan, and yellow gray, finely to microcrystalline, pure, dense. Shale, black; 5%. Anhydrite, white, very finely crystalline; trace.

2340-2360 Dolomite as above. Shale, dark green gray; 25%. Siltstone, light gray, fine grained, well sorted; 5%. C UNIT AT 2344 FEET (GRN).

2360-2400 Dolomite, tan gray, finely to microcrystalline, silty, laminated. Shale, light medium gray; 15%. Anhydrite, light gray and white, very finely crystalline; heavy trace. TYMOCHTEE FORMATION AT 2364 FEET (GRN).

2400-2440 Dolomite, gray, tan, and brown gray, darker than above, micro- to finely crystalline, slightly silty. Siltstone, dolomitic, light medium gray, fine grained, argillaceous; 15%. Trace anhydrite. GREENFIELD FORMATION AT 2404 FEET (GRN).

2440-2460 Dolomite, light tan to light gray, finely crystalline, few medium crystalline, fair intercrystalline porosity to dense. LOCKPORT GROUP AT 2443 FEET (GRN).

2460-2470 Dolomite, light gray to yellow gray, finely crystalline, sucrosic in part. Trace gray shale.

2470-2500 No sample.

2500-2510 Dolomite, gray, finely crystalline, some very argillaceous to shaly, silty, dense. Siltstone, gray, fine to coarse grained, poorly sorted, dolomitic, shaly; few white, pure; 15%. Heavy trace gray shale. BISHER FORMATION AT 2500 FEET (GRN).

2510-2540 Dolomite, cream, finely to medium crystalline, silty and sandy. Heavy trace gray shale.

Increasingly silty toward base of interval, gradational to dolomitic siltstone.

2540-2570	No sample.
2570-2600	Siltstone, variably white, cream, and light tan, average grain size 125 μ, poorly sorted, dolomitic. Shale, medium dark gray; trace. ESTILL SHALE AT 2554 FEET (GRN). Samples poorly lagged here.
2600-2710	Shale, medium- to light gray, very slightly silty. Dolomite, silty, tan gray to gray, finely crystalline, some argillaceous; heavy trace to 10%.
2710-2730	Dolomite, light gray to white, medium crystalline, hard, dense; and a few argillaceous, as above. Shale, gray as above; 30%. Siltstone, white, very fine grained; trace. DAYTON LIMESTONE AT 2713 FEET, LULBEGRUD SHALE AT 2718 FEET, CACAPON SANDSTONE AT 2726-2730 FEET (GRN).
2730-2770	Shale, gray to reddish gray, moderately hard, dolomitic. Siltstone and argillaceous dolomite as above, trace to 20%. LULBEGRUD SHALE AT 2730 FEET (GRN).
2770-2780	Dolomite, mottled light gray, tan, and white, medium crystalline, silty, slightly pyritic. Shale as above, 40%. OLDHAM LIMESTONE AT 2769 FEET (GRN).
2780-2790	Dolomite as above, ferruginous in part. Shale as above, 50%. UPPER CABOT HEAD SHALE AT 2786 FEET (GRN).
2790-2800	Siltstone, gray to red brown, ferruginous, fossiliferous, hard to moderately friable. Shale, medium gray; 20%. CLINTON SANDSTONE AT 2792 FEET (GRN).
2800-2810	Shale as above, 75%. Dolomite, mottled gray and white, medium to finely crystalline, silty. LOWER CABOT HEAD SHALE AT 2797 FEET (GRN).
2810-2830	Shale, medium gray. Dolomite, medium gray, finely crystalline, argillaceous to shaly; 5 to 20%.
2830-2840	Shale as above, 75%. Siltstone, light to medium gray, fine grained, calcareous.
2840-2870	Shale and siltstone as above. Limestone, gray,

fine grained, slightly ferruginous, pyritic; 10%. BRASSFIELD FORMATION AT 2841 FEET (GRN).

2870-2900	Limestone, mottled tan, gray, and white, medium grained, fossiliferous, silty, dense. Shale, gray, with some reddish gray; 25%.

TD 2900 feet in Brassfield Formation.

Pike County, Ohio
Pebble Township
Sample No. 1339

Continental Oil Company
L. Miller #1
Permit No. 22
Elevation 681 GL

Core description begun at 500 feet in UNDIFFERENTIATED SALINA GROUP.

500- 520	Dolomite, yellowish gray to pale brown, finely to very finely crystalline, scattered small vugs and carbonaceous laminae, oolitic beds at 503, 509 and 513 feet associated with intraclast breccias, most bioturbated, some faintly laminated, fractured.
520- 529	Dolomite, greenish gray (5 G 5/2), mottled yellow gray in part, finely crystalline, slightly argillaceous, faintly laminated and cross bedded, some convoluted (algal?) bedding, bioturbated, very slightly oolitic.

C UNIT

529- 535	Shale and very shaly dolomite, grayish green (5 GY 3/2), laminated.

TYMOCHTEE FORMATION

535- 538	Dolomite, grayish green, finely crystalline, with many thin shale partings. Gradational with above lithology. Dolobreccias at 537 to 538 feet.
538- 577	Dolomite, yellow gray to pale brown, mottled greenish gray in part, finely to microcrystalline, carbonaceous partings and thin shale laminae common, stylolitic, bioturbated, slightly silty, few thin breccia zones, most dense. Bird's-eye structure(?) at 572-577 feet.
577- 580	No Sample.

GREENFIELD FORMATION

580- 596 Dolomite, dark yellow brown (10 YR 4/2) and medium gray, very finely crystalline to lithographic, carbonaceous partings and stylolites common, irregular zones of good vug porosity, bioturbated and algal laminated in part, ostracodes.

596- 625 Dolomite, yellowish gray (5 YR 6/4), similar to above, with good vug porosity through entire interval, faintly algal laminated, brecciated at 598 feet, oolitic at 610 feet.

PEEBLES FORMATION

625- 645 Dolomite, yellow gray, mottled light gray and gray green in part, finely to medium crystalline, fair to good intercrystalline porosity, very fossiliferous (corals, gastropods), bedding massive to structureless.

645- 650 Dolomite, gray to greenish gray, argillaceous to shaly, dense.

650- 685 Dolomite, light gray to yellow gray, finely to medium crystalline, pure, scattered large vugs, most dense, fossiliferous (corals, stromatoporoids, bryozoans), few stylolites, rare shale partings and laminae.

PEEBLES-LILLEY TRANSITION

685- 703 Dolomite, medium- to light gray, gray brown, finely crystalline, slightly argillaceous, poor to fair intercrystalline porosity; irregularly interbedded with pure, yellow gray dolomite as above. Rare shale partings and stylolites, slightly pyritic.

LILLEY FORMATION

703- 710 Dolomite, gray to brown gray, finely to medium crystalline, argillaceous, with scattered fine grained crinoidal debris, shale partings common.

710- 728 Dolomite, yellow gray to light gray, finely crystalline, slightly argillaceous, fossiliferous (crinoidal, Coenetes), few thin beds very shaly, bioturbated in part, slightly pyritic, poor vug porosity.

BISHER FORMATION

728- 746	Dolomite, variably light gray, yellow gray, and brown gray, finely to medium crystalline, less argillaceous than above, extremely bioturbated, most dense, irregularly spaced shale partings and whispy laminae common.
746- 773	Dolomite, very light gray to yellow gray, medium to finely crystalline, crinoidal, fair to good vug porosity, mostly pure, rare shaly mottles.
773- 791	Dolomite, pale yellow brown, finely crystalline, dense, slightly silty, more argillaceous than above, irregular whispy shale laminae common.

ESTILL SHALE

791- 926	Shale, greenish gray (10 G 4/2), soft, splintery, with a few thin, yellow gray, rippled dolomite stringers in upper 10 feet. Sharp contact with overlying Bisher. Shale becomes more grayish red (5 R 4/2) toward base.

DAYTON LIMESTONE

926- 931	Dolomite, light gray to yellow gray with a greenish tinge, medium crystalline, argillaceous, glauconitic, pyritic, bioturbated, nodular to irregular bedding, with a few thin shale breaks.

LULBEGRUD SHALE

931- 938	Shale, gray, greenish gray, moderately soft.

OLDHAM LIMESTONE

938- 939	Limestone, ferruginous, red to red brown, fine to medium grained, oolitic, fossiliferous.
939- 941	Dolomite, gray to green gray, finely crystalline, argillaceous to shaly, dense.
941- 943	Limestone, ferruginous, red brown, oolitic, fossiliferous, glauconitic, nodular bedded, bioturbated; gradational with overlying argillaceous dolomite and with a sharp lower contact.

CABOT HEAD SHALE

943- 986	Shale, medium to light gray, unfossiliferous, scattered pyritized burrows, with a few 1- to 2-inch thick stringers of shaly dolomite. Shale is interbedded in the lower 6 feet with argillaceous, grayish white, sparsely fossiliferous limestone.

BRASSFIELD FORMATION

986- 989	No sample.
989- 990	Limestone, ferruginous, red brown, medium grained, fossiliferous, with shale partings and a trace of silt. Gradational with lithology below.
990-1000	Limestone, light medium gray to greenish gray, medium grained, fossiliferous (crinoidal), nodular to irregular bedded, bioturbated; interbedded with gray shale as whisps, laminae and thin breaks. A 1.0 feet thick shale break occurs at 999 feet.
1000-1010	Limestone, greenish gray, argillaceous, as above, with light gray to white chert associated with thin beds of gray brown to tan, argillaceous, dolomite or dolomitic limestone. A few interbeds of shale up to 0.5 feet thick are present.
1010-1021	Limestone, gray to brown gray, fine grained, thin to nodular bedded, some very argillaceous to shaly, glauconitic at 1017 feet. Limestone is strongly interbedded with gray to greenish gray shale.
1021-1030	Limestone, medium gray, very argillaceous, poorly crystalline, bioturbated, silty, dolomitic in part, with thin interbeds of greenish gray shale. At base of interval is an 0.8 feet thick bed of fossil debris and green shale clasts in a gray, argillaceous matrix.

ORDOVICIAN

1030-1040	Shale, red gray, moderately soft, calcareous in part, with a few thin interbeds of light gray, fossiliferous limestone.

Pike County, Ohio
Perry Township
Sample No. 1340

Continental Oil Company
L. & W. Attinger #1
Permit #21
Elevation 939 DF

OLENTANGY SHALE

125-133	Shale, dark greenish gray, laminated, pyritic, soft.

DEVONIAN-SILURIAN UNCONFORMITY

133-133.5	Dolomite, brecciated; angular fragments of brown, finely crystalline dolomite in matrix of grayish green, finely crystalline, argillaceous dolomite.

GREENFIELD FORMATION

133.5-138	Dolomite, brown to gray brown (5 YR 3/4), finely to medium crystalline, fair vug porosity, limonite staining at top.
138-153	Dolomite, yellowish brown to gray brown, medium to finely crystalline, algal laminated in part, good vug porosity confined to irregularly spaced thin zones, rare carbonaceous laminae, few stylolites, trace asphalt stain, oolitic at 142 feet.

PEEBLES FORMATION

153-171	Dolomite, yellowish gray (5 Y 7/2), finely to medium crystalline, excellent vug porosity throughout interval, fossiliferous (corals and gastropods), minor asphalt staining, upper 2 feet extremely fractured.
171-202	Dolomite, mottled yellowish- and light gray, finely crystalline, some medium crystalline, pure, fair to poor vug porosity confined to discrete zones associated with fossils, bedding massive and structureless, fossiliferous (corals, gastropods).
202-241	Dolomite, light gray to gray yellow, finely crystalline, pure, mostly dense with fair vug porosity confined to thin scattered fossil zones, massively bedded, several vertical fractures.
241-253	Dolomite as above, with corals and excellent vug porosity.

253-258 Dolomite, light gray to gray yellow, some medium gray, finely crystalline; increasingly argillaceous downward through interval.

PEEBLES-LILLEY TRANSITION

258-264 Dolomite, medium- to light gray, argillaceous, dense matrix; containing scattered swirls (corals?) of pure, yellow gray, crystalline, vuggy dolomite as above.

LILLEY FORMATION

264-276 Dolomite, medium- to light gray, argillaceous, finely crystalline, with sparsely disseminated fine grained crinoidal debris, a few corals, and a few stylolites.

276-294 Dolomite, medium light gray, argillaceous, as above, minor intercrystalline and vug porosity, slightly silty, bioturbated, irregular carbonaceous laminae, irregularly bedded, some intervals very shaly.

BISHER FORMATION

294-311 Dolomite, brown gray to medium gray, finely crystalline, slightly argillaceous, faintly cross bedded and hummocky bedded, bioturbated, slightly silty, unfossiliferous, with a few 1-3 inch thick very silty beds and some shale partings.

311-334 Dolomite, light gray to light brown gray, finely crystalline, silty to very silty, crinoidal in part, less argillaceous than above, poor vug porosity, medium to thick bedded with faint cross stratification, rare chert nodules and a trace of pyrite.

334-338 Dolomite, calcareous, pale brown, finely crystalline, argillaceous, bioturbated, slightly silty.

338-347 Dolomite, light- to medium gray, and brown gray, poorly crystalline, argillaceous, shale laminae and partings common, faintly cross bedded, crinoidal debris sparsely disseminated throughout with a few calcareous beds up to 0.5 feet thick composed of coarse grained crinoidal debris.

347-361 Dolomite, much as above, increasingly crinoidal and calcareous, thick bedded, bioturbated.

Interval becomes more argillaceous and shaly below 356 feet.

ESTILL SHALE

361-465 Shale, greenish gray and reddish gray, with a few thin, gray, dolomite stringers and lenses interbedded, especially in upper few feet. Glauconitic zones at 463 to 464 feet.

DAYTON LIMESTONE

465-473 Limestone, buff to white with a greenish tinge, medium grained, nodular to irregular bedded, shale whisps and laminae common especially in upper 0.5 feet. Below 467 feet becomes more massive, purer, slightly glauconitic and pyritic with fewer shale partings.

OLDHAM LIMESTONE

473-474 Limestone, gray, fine grained, very argillaceous; interbedded with thin gray shales. Similar to Oldham Limestone of Core 1339.

474-475 Limestone, ferruginous, red brown, medium grained, fossiliferous, oolitic, with a few large shale intraclasts.

CABOT HEAD SHALE

475-490 Shale, greenish gray to gray, soft, with a few thin, gray, laminated limestone stringers. Slightly ferruginous limestones at 485 and 486 feet.

490-492 Limestone, ferruginous, reddish brown, medium grained, fossiliferous, well cross bedded, containing a few gray shale intraclasts.

492-499 Shale, greenish gray, with a few 3-4 inch thick beds of white limestone at 491, 493 and 496 feet.

BRASSFIELD FORMATION

499-501 Limestone, ferruginous, red, medium to fine grained, oolitic, dense, heavy.

501-505 Limestone, yellow gray to buff, medium to coarse grained, fossiliferous, dense.

505-506 Shale, greenish gray, with a few nodular beds of limestone as above.

506-507	Limestone, ferruginous, reddish brown, fine to medium grained, oolitic and fossiliferous. Contact with lithology below is sharp.
507-518	Limestone, yellow gray to buff, fine to medium grained, slightly argillaceous in upper part, and interbedded with green gray shale below 511 feet. A 1.5 feet thick shale break at base.
518-534	Limestone, light gray, fine to medium grained, slightly to very argillaceous, fossiliferous, poorly to nodular bedded, with thin, irregular shale laminae and breaks.

TD at 534 in Brassfield Formation.

Ross County, Ohio	Pure Oil Company
Harrison Township	Coffman #1
Section 9	Permit No. 6
Sample No. 1282	Elevation 740 KB

990-1000	Dolomite, tan gray, micro- to finely crystalline, argillaceous, slightly silty. Dolomite, yellow gray, lithographic; trace. C UNIT AT 995 FEET (GRN).
1000-1010	Dolomite, medium- to light gray, gray tan, finely to microcrystalline, slightly silty. Shale, dolomitic, medium gray to green gray, moderately soft; 25%. TYMOCHTEE FORMATION AT 1008 FEET (GRN).
1010-1032	Dolomite, light- and medium tan, gray, finely to microcrystalline, dense, slightly oolitic. Dolomite, yellow gray, microcrystalline to lithographic, with black shale laminae; 30%.
1032-1043	Dolomite, medium tan gray to medium gray, finely crystalline, silty to very silty.
1043-1053	Dolomite as above. Dolomite, light brown, finely to medium crystalline, slightly silty; 30%. GREENFIELD FORMATION AT 1047 FEET (GRN).
1053-1071	Dolomite, brown, finely to medium crystalline, homogeneous.
1071-1082	Dolomite as above. Dolomite, medium gray, finely crystalline, variably argillaceous; 50%.
1082-1093	Dolomite, gray and brown, as above. Dolomite

light tan gray to yellow gray, finely crystalline, dense; heavy trace.

1093-1103	Dolomite, yellow gray to very light tan, finely crystalline, some medium crystalline and sucrosic, pure. Dolomite, light gray, slightly argillaceous; 15%. PEEBLES FORMATION AT 1094 FEET (GRN).
1103-1120	Dolomite, yellow gray, as above, homogeneous, with fair to good vug porosity.
1120-1143	Dolomite as above. Dolomite, light- to medium gray, finely crystalline, slightly argillaceous; heavy trace.
1143-1239	Dolomite, yellow gray to very light gray tan, finely crystalline, a few medium crystalline, pure, homogeneous, fair porosity.
1239-1277	Dolomite as above. Dolomite, light- to medium gray, finely crystalline, slightly argillaceous; 20%.
1277-1290	Dolomite, gray brown, finely crystalline, argillaceous, slightly silty; 65%. Dolomite as above. LILLEY FORMATION AT 1280 FEET (GRN).
1290-1310	Dolomite, mottled medium- to light tan gray, and white, medium to finely crystalline, silty, fossiliferous; and a few microcrystalline, dense. Dolomite, gray brown, as above; 25%.
1310-1330	Dolomite, very silty, gradational to dolomitic siltstone, gray tan, fine grained, well sorted, slightly calcareous, laminated in part. BISHER FORMATION AT 1323 FEET (GRN).
1330-1337	Dolomitic siltstone as above.
1337-1343	Dolomitic siltstone as above. Shale, medium- to light gray, silty, moderately soft, slightly calcareous; 10%.
1343-1363	Dolomitic siltstone, light gray to medium tan gray, fine grained, slightly calcareous.
1363-1370	Siltstone, dolomitic, light gray, average grain size 125 μ, well sorted, slightly argillaceous, homogeneous. Dolomite, tan, medium crystalline; trace.
1370-1390	Siltstone as above, finer grained and more argillaceous. Dolomite as above, trace. Shale, light gray, soft; heavy trace. ESTILL SHALE AT

1370 FEET (GRN).

1390-1400	Shale, medium- to light gray, soft to moderately soft. Siltstone, very fine grained, as above; heavy trace.
1400-1410	Shale as above. Limestone, light gray, fine grained; heavy trace. Siltstone as above, more argillaceous; trace.
1410-1440	Shale, siltstone, and limestone as above. Dolomite, light tan and light gray, medium to finely crystalline, slightly silty; trace.
1440-1460	Shale, medium gray to reddish gray, soft. Limestone as above, heavy trace.
1460-1480	Shale, medium- to light gray, moderately soft to soft, dolomitic, slightly pyritic. Dolomite, medium gray, finely crystalline, slightly argillaceous, dense; heavy trace.
1480-1488	Limestone, light- to medium gray, fine grained, argillaceous. Shale as above, 40%. DAYTON FORMATION AT 1483 FEET (GRN).
1488-1492	Limestone, light gray and tan, fine grained, pure; 40%. Dolomite, light- to medium gray, finely crystalline, argillaceous; 20%. Shale, medium gray, moderately soft.
1492-1496	Shale, light- to medium gray, moderately soft, dolomitic; 80%. Limestone, medium gray, fine grained, argillaceous. LULBEGRUD SHALE AT 1492 FEET (GRN).
1496-1505	Limestone, mottled light- to medium gray, white, and tan, medium to fine grained, fossiliferous, slightly silty and glauconitic; a few ferruginous. Shale as above, 30%. OLDHAM LIMESTONE AT 1496 FEET (GRN).
1505-1515	Shale, medium- to light gray, moderately soft, dolomitic. Limestone and dolomite, light gray, finely crystalline, slightly argillaceous. CABOT HEAD SHALE AT 1507 FEET (GRN).
1515-1548	Shale, medium light gray, moderately soft to soft, dolomitic. Limestone and dolomite as above, glauconitic in part; 15% to trace.
1548-1554	Limestone, ferruginous, mottled brown, gray, and white, medium to fine grained, fossiliferous, oolitic, moderately friable. Shale as above, 30%. BRASSFIELD FORMATION AT

1550 FEET (GRN).

1554-1560	Limestone, light gray to white, medium grained, fossiliferous. Limestone, medium to light gray, very argillaceous, fossiliferous, slightly glauconitic; 30%.
1560-1571	Limestone, medium grained, as above; 80%. Limestone, ferruginous, mottled brown and gray; 10 %. Shale, gray; heavy trace.
1571-1577	Limestone, mottled light gray and white, fine to medium grained, fossiliferous, some slightly argillaceous. Shale as above, 35%.
1577-1589	Limestone, mottled cream, white, and light tan, medium to fine grained, fossiliferous, pure. Trace white chert.
1589-1594	Limestone as above, 50%. Limestone, medium to light gray, fine grained, argillaceous; 20%. Shale, light gray, soft; 25%. Siltstone, light gray and tan, very fine grained, calcareous; trace.
1594-1611	Limestone and shale as above. ORDOVICIAN AT 1610 FEET (GRN).
1611-1614	Shale, gray, moderately hard, calcareous. Limestone as above, trace.
1614-1634	Shale, variably reddish gray, red, and gray, moderately soft, calcareous. Siltstone, reddish gray to red, very fine grained, very argillaceous.

Scioto County, Ohio
Green Township
Sample No. 2161

Earlougher Engineering
U.S. Steel #1
Permit No. 212
Elevation 557 KB

Core slabs from 1809-1829 in PEEBLES FORMATION.

1809-1814	Dolomite, medium gray to brown gray, finely crystalline, argillaceous, dense, few carbonaceous laminae, bioturbated and mottled in part, horizontal burrows recognizable in more argillaceous zones, white stromatactis(?) structure at 1810.5.
1814-1818	Dolomite, mottled medium gray and gray brown, finely crystalline, argillaceous, slightly

silty. Rotated geopetal brachiopod at 1814.8; large vug filled with yellowish megacrystalline dolomite at 1816.5; coral fragment at 1818 feet.

1818-1820 Dolomite, medium light gray, slightly mottled gray brown, finely crystalline, argillaceous. Carbonaceous partings at 1819 feet; dolobreccia(?) at 1819.5 feet with dark gray dolomite fragments floating in gray brown matrix.

1820-1829 Dolomite, gray, mottled gray brown in part, argillaceous, carbonaceous partings and whispy laminae common, bioturbated. Algal laminated at 1823 feet; solution collapse(?) breccia at 1828-1829 feet.

Scioto County, Ohio	Continental Oil Co.
Madison Township	Dever #1
Section 20-E	Permit No. 193
Sample No. 1045	Elevation 591 KB

1470-1485 Dolomite, light tan gray to gray, micro- to finely crystalline, few medium crystalline and sucrosic, trace vug porosity, with black carbonaceous laminae. Shale, green gray to black; 10%. C UNIT AT 1476 FEET (GRN).

1485-1505 Dolomite, light gray to light tan, finely to microcrystalline, slightly silty. Shale, green gray to black, soft; 20%. Siltstone, light tan, fine grained, dolomitic; heavy trace. TYMOCHTEE FORMATION AT 1494 FEET (GRN).

1505-1540 Dolomite, variably light tan gray, light gray, and yellow gray, finely to microcrystalline, oolitic, fair intercrystalline porosity, slightly silty and argillaceous.

1540-1565 Dolomite, medium tan to tan gray, lighter than above, finely crystalline, slightly silty, fair intercrystalline porosity; few microcrystalline to lithographic, dense. GREENFIELD FORMATION AT 1540 FEET (GRN).

1565-1575 Dolomite, light brown to gray brown, finely to medium crystalline, some sucrosic, fair intercrystalline porosity; a few light gray, dense.

1575-1580 Dolomite, yellow gray to light tan gray, finely to medium crystalline, fair porosity, oolitic.

1580-1600	Dolomite, yellow gray, light gray, and light tan gray, finely to medium crystalline, dense to fair porosity, pure, homogeneous. PEEBLES FORMATION AT 1580 FEET (GRN).
1600-1605	Dolomite as above, more gray brown, very slightly silty.
1605-1630	Dolomite, medium gray, finely crystalline, argillaceous and silty in part, fair porosity; few coarsely sucrosic. Dolomite, yellow gray, as above, pure, with good vug porosity.
1630-1660	Dolomite, yellow gray to light gray tan, finely to microcrystalline, some medium crystalline and sucrosic. Dolomite, gray to gray brown, argillaceous, dense; 20%.
1660-1700	Dolomite, yellow gray, as above. Dolomite, light gray, finely crystalline, slightly argillaceous, fossiliferous, silty, pyritic. Trace gray shale. LILLEY FORMATION AT 1660 FEET (GRN).
1700-1715	Dolomite as above. Dolomite, light tan gray, finely crystalline, silty to very silty. BISHER FORMATION AT 1700 FEET (GRN).
1715-1725	Siltstone, light gray, very fine to fine grained, argillaceous, dolomitic, compact. Dolomite, gray tan, finely to medium crystalline, silty, pyritic. Trace gray shale.
1725-1805	Shale, medium light gray. Dolomite, gray, finely crystalline, argillaceous; trace to 10%. Siltstone as above, trace. ESTILL SHALE AT 1722 FEET (GRN).
1805-1870	Shale, reddish gray, soft to moderately soft, trace silty. Dolomite, light gray to tan, finely crystalline, argillaceous, slightly silty; heavy trace.
1870-1880	Shale, light gray, dolomitic, slightly pyritic. Dolomite, light medium gray, finely crystalline, argillaceous; 15%. Siltstone, white, calcareous, fine grained; trace.
1880-1890	Dolomite, tan to light gray, medium crystalline, dense, some argillaceous. Shale as above, 50%. Siltstone, light tan to gray, very fine grained; trace. DAYTON LIMESTONE AT 1885 FEET (GRN).

1890-1900	Shale and dolomite as above. LULBEGRUD SHALE AT 1891 FEET (GRN).
1900-1915	Shale, medium gray, dolomitic; 85%. Dolomite, white to cream, medium crystalline, fair to poor porosity; 10%. Dolomite, gray, argillaceous; trace. Siltstone, light gray, very fine grained; trace.
1915-1930	Dolomite, mottled light gray, tan, and white, medium to finely crystalline, pyritic, dense, some slightly silty. Shale as above, trace. OLDHAM LIMESTONE AT 1917 FEET (GRN).
1930-1935	Limestone, ferruginous, brown, red gray, moderately friable, fossiliferous. Shale as above, 20%. UPPER CABOT HEAD SHALE AT 1927 FEET (GRN).
1935-1945	Siltstone, light gray to tan, fine to very fine grained, slightly calcareous, compact. Ferruginous limestone and shale as above, 40%. CLINTON SANDSTONE AT 1930 FEET (?).
1945-1960	Shale, medium light gray; 60%. Limestone and dolomite, gray, finely to medium crystalline, argillaceous and silty. LOWER CABOT HEAD SHALE AT 1936 FEET (GRN).
1960-1980	Shale, medium gray, moderately soft. Siltstone, white to tan, very fine grained, compact, with a few shale laminae. Dolomite, light gray, a few mottled tan and white, medium crystalline, slightly pyritic.
1980-1985	Limestone, white and tan, medium grained; 60%. Shale and siltstone as above. BRASSFIELD FORMATION AT 1978 FEET (GRN).
1985-1990	Dolomite, calcareous, gray, finely to medium crystalline, slightly silty, hard. Shale as above, 50%.
1990-1995	Limestone, dolomitic, tan gray and gray brown, medium to fine grained, fossiliferous, slightly ferruginous and silty. Shale as above, 40%.
1995-2000	Shale, medium gray. Limestone, mottled tan, white, and gray, medium to fine grained, hard, dense, silty.
2000-2015	Limestone, mottled tan, white, and light gray, medium to fine grained, very silty, fossiliferous, slightly argillaceous. Shale,

gray; 10-30%.

2015-2035	Limestone, mottled tan, gray, and white, medium grained, fossiliferous, silty. Shale, medium light gray; 30%. Siltstone, light gray, very fine grained; trace.
2035-2045	Limestone, gray, argillaceous, fine grained. Limestone and shale as above, 40%. Trace siltstone and ferruginous limestone. ORDOVICIAN AT 2038 FEET (GRN).
2045-2055	Shale, gray red to medium dark gray, moderately soft. Limestone and dolomite, light gray, fine grained, argillaceous.

Vinton County, Ohio
Wilkesville Township
Section 23
Sample No. 962

K. Wehmeyer & Co.
M. Hall #1
Permit No. 278
Elevation 639 GL

Core range 3133 to 3185 feet in CLINTON SANDSTONE AND UPPER CABOT HEAD SHALE.

3133.0-3136.5	Shale, olive gray (5 Y 3/2), moderately soft, laminated; with several thin, fine grained limestone interbeds which are pinkish gray (3 YR 8/1) faintly laminated and sparsely fossiliferous (brachiopods).
3136.5-3138.4	Limestone, ferruginous, grayish red (10 R 4/2), oolitic, fossiliferous, heavy, dense, slightly glauconitic, faintly cross bedded, and in sharp contact with overlying shale. At 3137.5 feet limestone becomes sandy, contains shale clasts, and is irregularly laminated.
3138.4-3144.1	Siltstone, yellow gray (5 Y 8/1), dolomitic, average grain size 125 μ, moderately well sorted, thoroughly bioturbated, with rare pyritized fossil debris; interbedded with medium gray, laminated shale below 3142 feet as partings and breaks up to 0.2 inches thick.
3144.1-3145.4	Siltstone, yellowish gray (5 Y 8/1), average grain size 150 μ, irregularly interbedded and laminated with medium gray and reddish gray shale. Siltstone appears faintly laminated with obscure ripple marks, and fills vertical burrows penetrating into

shale interbeds. Shale laminae are contorted. Oblate shale pebbles are present at the upper contact of interval.

3145.4-3148.7	Siltstone and shale as above with shale becoming less abundant toward base of interval. Horizontal and vertical burrows common along siltstone-shale contacts, shale intraclasts common.
3148.7-3149.5	Siltstone, pure, gradational in color from light gray (N 7) at top to pale red (10 R 6/2) at base, average grain size 125 μ, moderate to well sorted; with a few faint, irregular, dark (organic?) laminae.
3149.5-3149.8	Shale, olive gray, with a few whispy, silty, slightly hematitic lenses.
3149.8-3152.8	Siltstone, gradational with above shale, gradational in color from light gray at top to pale red at base, average grain size 150 μ, well sorted, subround to subangular, homogeneous.
3152.8-3153.0	Shale, dark gray (N 3).
3153.0-3156.0	Siltstone, light gray to yellowish gray, otherwise as above, with a few contorted shale clasts, and irregular laminations of dark gray shale.
3156.0-3160.8	Siltstone, light gray to pale yellow, average grain size 150 μ, well sorted, with dark gray shale occurring as irregular laminae and less commonly as discrete clasts.
3160.8-3168.0	Shale, dark greenish gray (5 G 4/1), with thin, irregular, bioturbated, yellowish gray siltstone interbeds. A few siltstone interbeds have rippled upper surfaces. Shale comprises 90% of the interval.
3168.0-3169.6	Shale as above, interbedded and interlaminated with siltstone; which is dense, dolomitic, sparsely fossiliferous. Siltstone comprises 50% of the interval.
3169.6-3178.5	Dolomite, silty, gradational to dolomitic siltstone, yellowish gray, fine grained, trough cross bedded to faintly laminated, some bioturbated, fossiliferous; interbedded and bioturbated with dark gray shale beds up to 0.45 feet thick.

3178.5-3185.0	Shale, dark gray, with a few very thin interbeds of laminated silty dolomite as above.

Cabell County, West Virginia
Athalia Quadrangle
Sample No. 537

Cyclops Corp.
E. Kingery #1
Permit No. 537
Elevation 667 KB

3850-3870	Dolomite, medium gray, slightly mottled pale brown, finely crystalline, slightly argillaceous and silty. Trace medium gray shale. C UNIT AT 3866 FEET (GRN).
3870-3880	Dolomite, very silty, gradational to dolomitic siltstone, medium- to light gray, slightly argillaceous, oolitic in part. NEWBURG SANDSTONE AT 3872 TO 3878 FEET (GRN).
3880-3890	Dolomite, light gray to green gray, finely crystalline, argillaceous in part, homogeneous. TYMOCHTEE EQUIVALENT AT 3892 FEET (GRN).
3890-3900	Anhydrite, white, very finely to finely crystalline; interbedded with medium gray, argillaceous dolomite.
3900-3920	Dolomite, medium- to dark gray, finely to very finely crystalline, argillaceous. Shale, medium gray; 20%. Trace anhydrite as above.
3920-3940	Dolomite, light gray to light brown gray, very finely to finely crystalline, less argillaceous than above, slightly silty, dense.
3940--3960	Dolomite, brown gray to gray, finely to medium crystalline, much more crystalline than above, poor to fair porosity, some silty and sandy, trace anhydrite. LOCKPORT DOLOMITE AT 3936 FEET (GRN).
3960-4000	Dolomite, light brown to yellow gray, finely to medium crystalline, pure. Dolomite, brown gray, as above; 30%.
4000-4020	Dolomite, gray to yellow gray, finely crystalline, relatively pure, slightly silty.
4020-4030	Dolomite as above. Dolomite, mottled pale

brown and yellow gray, finely crystalline, less pure than above, fossiliferous; 20%.

4030-4040	Dolomite, medium gray, medium to finely crystalline, some argillaceous and silty. LOCKPORT-KEEFER TRANSITION AT 4034 FEET (GRN).
4040-4060	Dolomite, very silty, gradational to dolomitic siltstone, pale brown to gray, finely to medium crystalline. KEEFER SANDSTONE AT 4050 FEET (GRN).
4060-4080	Siltstone, variably medium gray, light gray, and tan, dolomitic, medium to coarse grained, poorly to moderately sorted, compact.
4080-4270	Shale, reddish gray, dull, moderately soft, slightly silty and micaceous. ROSE HILL SHALE AT 4078 FEET, DAYTON LIMESTONE(?) AT 4243 TO 4250 FEET (GRN).
4270-4280	Shale, medium- and light gray, silty. Siltstone, tan to gray, very fine grained, compact, argillaceous; 10%. Dolomite, gray, very argillaceous, silty; heavy trace. CACAPON SANDSTONE AT 4278 to 4281 FEET (GRN).
4280-4340	Shale, grayish red, slightly silty.
4340-4345	Shale as above, 60%. Dolomite, silty, gray; 30%. Siltstone, brown, very fine grained. OLDHAM LIMESTONE AT 4337 FEET (GRN).
4345-4350	Siltstone, light gray to yellowish gray, fine grained, variably argillaceous to pure, dolomitic. Shale, gray.
4350-4400	Shale, gray and reddish gray, with a few interbeds of light gray, argillaceous, silty dolomite. UPPER CABOT HEAD SHALE AT 4377 FEET (GRN).
4400-4410	Shale, gray; interbedded with white, fine grained siltstone. Trace ferruginous siltstone. TUSCARORA SANDSTONE AT 4396 FEET (GRN).
4410-4430	Siltstone, white, average grain size 150 μ, very well sorted, subangular to subround, mostly pure, moderately compact to friable. Trace gray shale.
4430-4485	Shale, medium gray, slightly to very silty. LOWER CABOT HEAD SHALE AT 4429 FEET (GRN).

4485-4500	Shale as above. Limestone, light tan to white, fine grained; 20%. Siltstone, very light gray, very fine to fine grained; 10%. BRASSFIELD FORMATION AT 4472 FEET (GRN).
4500-4520	Shale, red, silty, micaceous. Shale turns red sharply at 4500 feet. ORDOVICIAN (QUEENSTON) AT 4500 FEET (GRN).

APPENDIX C. Locality Register

MAP NO.	GEOGRAPHIC LOCATION	UNITS EXPOSED	REFERENCE
1.	Exposure in Melvin Stone Quarry, 5 miles south of Washington Court House, along State Route 70 where it crosses Sugar Creek: New Martinsburg Quadrangle, Fayette County, Ohio.	Tymochtee Fm. Greenfield Fm.	Miller, 1955, Loc. 10
2.	Exposure in north-south ravine leading to Paint Creek, 1.4 miles northeast of Rocky Springs school: Greenfield Quadrangle, Highland County, Ohio.	Greenfield Fm. Peebles Fm. Lilley Fm. Bisher Fm.	Bowman, 1956, Loc. 17
3.	Exposure in spillway below dam at eastern terminus of Paint Creek Lake: Bainbridge Quadrangle, Highland County, Ohio.	Peebles Fm. Lilley Fm.- Bisher Fm.- CORE Estill Sh.-	Army Corp of Engineers, 1968
4.	Exposure in quarries southwest and northeast of intersection between Quarry Road and Sharpsville Road, 1.5 miles east of Lynchburg: New Vienna Quadrangle, Highland County, Ohio.	Dayton Ls. Plum Creek Sh. (?) Brassfield Fm. Ordovician	O'Donnell, 1967, Loc. 8 Rexroad, 1967, Loc. 10

5.	Exposure in active quarry of Highland Stone Division, at eastern terminus of Roush Road, 0.8 miles southeast of intersection between Danville Road and U.S. Route 50: New Market Quadrangle, Highland County, Ohio.	Dayton Ls. Plum Creek Sh. (?) Brassfield Fm.	
6.	Exposure in an abandoned quarry near the northeast edge of Hillsboro, between State Route 138 and U.S. Route 50: Hillsboro Quadrangle, Highland County, Ohio.	Peebles Fm. Lilley Fm. Bisher Fm.	Bowman, 1956, Loc. 10
7.	Roadcut exposures on both sides of State Route 124 at Lilley Hill, 1.2 miles east of Hillsboro: Hillsboro Quadrangle, Highland County, Ohio.	Peebles Fm. Lilley Fm. Bisher Fm.	Foerste, 1917, 1929
8.	Stream exposure on the east bluff of Rocky Fork at the sharp bend in stream, east of State Route 73, 1.7 miles southeast of Hillsboro: Hillsboro Quadrangle, Highland County, Ohio.	Bisher Fm. Estill Sh. Dayton Ls. Brassfield Fm.	Bowman, 1956, Loc. 12
9.	Exposure in abandoned quarry and in stream bed on south side of State Route 124, 2.8 miles south of Marshall: Rainsboro Quadrangle, Highland County, Ohio.	Peebles Fm Lilley Fm. Bisher Fm.	Bowman, 1956, Loc. 41
10.	Stream exposure on east branch of west tributary to Middle Fork of Ohio Brush Creek at crossing of State Route 124, near Pisgah Church: Sinking Springs Quadrangle, Highland County, Ohio.	Peebles Fm. Lilley Fm. Bisher Fm.	Bowman, 1956, Loc. 40

11.	Roadcut exposure on both sides of State Route 124 just east of Baker Fork, 0.75 miles west of intersection of State Routes 124 and 41, near Sinking Springs: Sinking Springs Quadrangle, Highland County, Ohio.	Peebles Fm. Lilley Fm.	Bowman, 1956, Loc. 25
12.	Exposure in Ralph Rodger's Quarry, south of State Route 124, 1.25 miles east of Byington: Byington Quadrangle, Pike County, Ohio.	Tymochtee Fm. Greenfield Fm. Peebles Fm.	Miller, 1955, Loc. 2
13.	Roadcut exposure on south side of State Route 73 at junction with unnamed secondary road, just north overpass of Flat Run, 1.6 miles west of Louden: Sinking Springs Quadrangle, Adams County, Ohio.	Brassfield Fm.	O'Donnell, 1967, Loc. 43 Kallio, 1976, Loc. 18 O.G.S. Field No. 228
14.	Roadcut exposure on both sides of State Route 32, 1.6 to 2.1 miles west of intersection with State Route 41, near Peebles: Peebles Quadrangle, Adams County, Ohio.	Peebles Fm. Lilley Fm. Bisher Fm. Estill Sh.	Herring, 1987, Lawshe Loc.
15.	Exposures in active quarry of Plum Run Division of Davon Inc., 2.8 miles east of Peebles on the south side of the Norfolk and Western railroad: Jaybird Quadrangle, Adams County, Ohio.	Tymochtee Fm. Greenfield Fm. Peebles Fm.	Schmidt, et al., 1961, p. 261-293 Kallio, 1976, Loc. 16 Miller, 1955, Loc. 1 Herring, 1987, Plum Run Loc.

16.	Roadcut exposure on west side of State Route 41, on south bluff of Ohio Brush Creek, 1.4 miles south of Jacksonville: Peebles Quadrangle, Adams County, Ohio.	Dayton Ls. Plum Creek Sh. (?) Brassfield Fm.	O'Donnell, 1967, Loc. 42 Kallio, 1976, Loc. 11 Rexroad, et al., 1965, Loc. 9 Schmidt, et al., 1961, p. 282 O.G.S. Field No. 229
17.	Roadcut exposure on County Route 6, 0.7 miles north of intersection with State Route 348 at Cedar Mills: Lynx Quadrangle, Adams County, Ohio.	Peebles Fm. Lilley Fm. Bisher Fm. Estill Sh.	Lovrak, 1978, Loc. 4 Kallio, 1976, Loc. 14 Herring, 1987, Cedar Mills Loc.
18.	Roadcut exposure on State Route 125, 0.7 to 1.0 miles west of Lynx: Lynx Quadrangle, Adams County, Ohio.	Lilley Fm. Bisher Fm. Estill Sh.	Kallio, 1976, Loc. 13 Herring, 1987, Lynx Loc.
19.	Stream exposure in small tributary to Moores Run, Parallel to State Route 247, 2.5 miles north of Wrightsville: Manchester Islands Quadrangle, Adams County, Ohio.	Estill Sh. Dayton Ls. Plum Creek Sh. (?) Brassfield Fm.	Rexroad, et al., 1965, Loc. 8
20.	Roadcut exposure on north side of U.S. Route 52 where Ohio Brush Creek enters the Ohio River, 4 miles east of intersection State Route 247 and U.S. Route 52: Concord Quadrangle, Adams County, Ohio.	Dayton Ls. Plum Creek Sh. (?) Brassfield Fm. Ordovician	O'Donnell, 1967, Loc. 41 O.G.S. Field No. 234
21.	Roadcut exposure on north side of U.S. Route 52, 1 mile southeast of Rome: Buena Vista Quadrangle, Adams County, Ohio.	Peebles Fm. Lilley Fm. Bisher Fm.	O.G.S. Field No. 1-2 Kallio, 1976, Loc. 17

22.	Roadcut exposure along north side of State Route 8, 0.6 miles southeast of Concord near McClurg's Cemetary: Concord Quadrangle, Lewis County, Kentucky.	Estill Sh. Dayton Ls. Lulbegrud Sh. (?) Oldham Ls. (?) Plum Creek Sh. (?) Brassfield Fm. Ordovician	McDowell, 1983, Concord Loc.
23.	Roadcut exposures at Herron Hill on south side of State Route 10 at junction with old State Route 10, and 0.2 miles west on north side of road, 2.2 miles east of Ribolt: Charters Quadrangle, Lewis County, Kentucky.	Ohio Shale Bisher Fm. Estill Sh.	Noger and Branson, 1968, Stop 2 Holbrook, 1964, Loc. 44 Scott, 1971, Loc. VII
24.	Roadcut exposure on north side of State Route 10, 0.5 miles east of junction with State Route 989, 2 miles northeast of Charters: Charters Quadrangle, Lewis County, Kentucky.	Bisher Fm. Estill Sh.	
25.	Roadcut exposure along north side of State Route 10 below Webster Cemetary, 0.5 miles west of Clarksburg: Charters Quadrangle, Lewis County, Kentucky.	Peebles Fm. Lilley Fm.	
26.	Roadcut exposure on both sides of State Route 10 and on both bluffs of Cabin Creek, 2.3 miles east of junction with State Route 57 in Tollesboro: Tollesboro Quadrangle, Lewis County, Kentucky.	Estill Sh. Dayton Ls. Lulbegrud Sh. (?) Oldham Ls. (?) Plum Creek Sh. (?) Brassfield Fm. Ordovician	McDowell, 1983, Tollesboro Loc. Rexroad, et al., 1965, Loc. 5 Holbrook, 1964, Loc. 43

27.	Roadcut exposures on both sides of State Route 32 and in stream bed of Bluebank Brook, 1.8 miles northeast of Goddard, 1.3 miles southeast of Bluebank: Flemingsburg Quadrangle, Fleming County, Kentucky.	Estill Sh. Dayton Ls. Lulbegrud Sh. Oldham Ls. Plum Creek Sh. Brassfield Fm. Ordovician	McDowell, 1983, Bluebank Loc. O'Donnell, 1967, Loc. 39
28.	Roadcut exposures on east side of secondary road, 0.15 to 1.6 miles north of Ramey Chapel: Plummers Landing Quadrangle, Fleming County, Kentucky.	Ohio Shale Bisher Fm. Estill Sh.	
29.	Roadcut exposures on both sides of State Route 211 and on south bluff of tributary to Storey Creek, 0.7 miles north of Colfax: Colfax Quadrangle, Fleming County, Kentucky.	Estill Sh. (Dayton absent) Oldham Ls. Plum Creek Sh. Brassfield Fm. Ordovician	McDowell, 1983, Colfax Loc. Rexroad, et al., 1965, Loc. 4 Holbrook, 1964, Loc. 41 Scott, 1971, Loc. III
30.	Roadcut exposure on east side of State Route 1722, 2.3 miles north of overpass Interstate 64, 0.2 miles east of Three Lick Branch of Licking River: Farmers Quadrangle, Rowan County, Kentucky.	Ohio Shale Bisher Fm. Estill Sh.	Holbrook, 1964, Loc. 40
31.	Roadcut exposure on south side of eastbound lane of Interstate 64 at underpass of State Route 1722, 4.5 miles north of Farmers, approximately 9 miles west of Moorehead: Farmers Quadrangle, Rowan County, Kentucky.	Ohio Shale Estill Shale	McDowell, 1983, Fig. 13

32.	Roadcut exposure on north side of U.S. Route 60, 1.2 miles east of Owingsville: Owingsville Quadrangle, Bath County, Kentucky.	Brassfield Fm. Ordovician	Holbrook, 1964, Lo.c. 15
33.	Roadcut exposure on south side of east-bound lane of Interstate 64 in large cut and bench, 200 yards west of exit to State Route 36 at Owingsville: Owingsville Quadrangle, Bath County, Kentucky.	Boyle Dolomite Estill Sh. (Dayton absent) Oldham Ls. Plum Creek Sh. Brassfield Fm.	Holbrook, 1964, Loc. 14 Scott, 1971, Loc. V
34.	Roadcut exposure on both sides of Stepstone Road, south of overpass of Interstate 64, 0.2 miles north of Sugar Grove Church, 1.5 miles north of Stepstone: Preston Quadrangle, Bath County, Kentucky.	Boyle Dolomite Estill Sh. Dayton Ls. (?) Lulbegrud Sh. Oldham Ls. Plum Creek Sh. Brassfield Fm. Ordovician	McDowell, 1983, Sugar Grove Church Loc. O'Donnell, 1967, Loc. 37

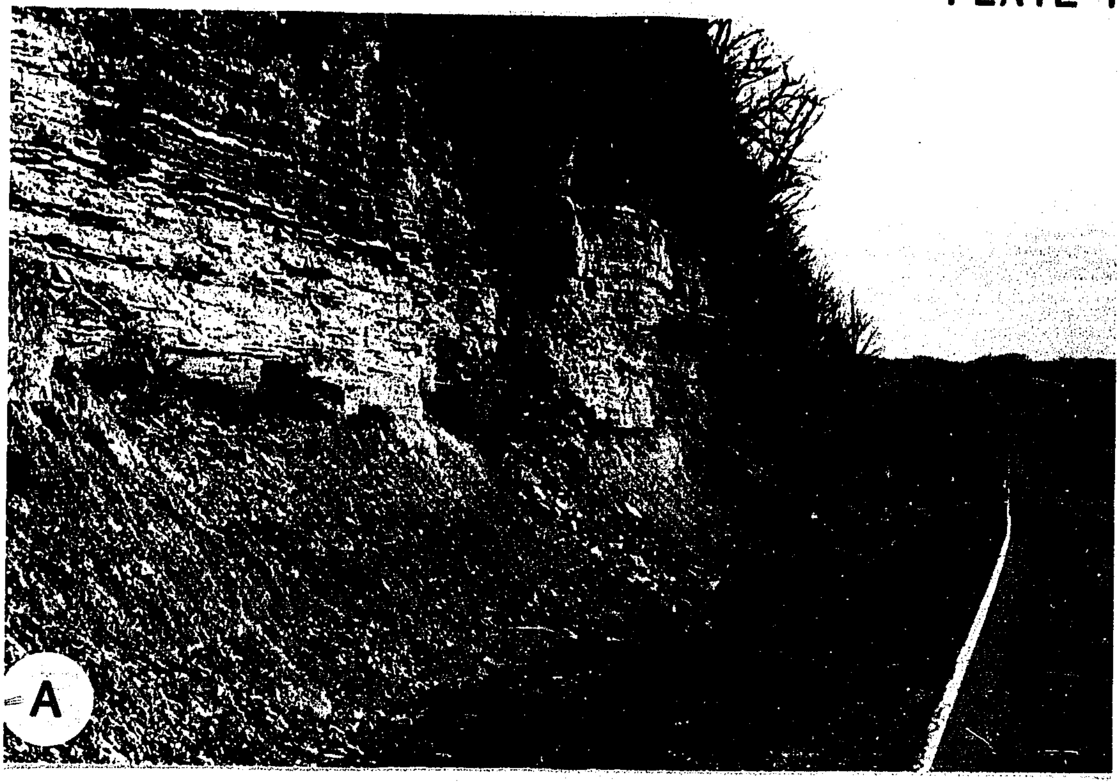
APPENDIX D - Photographic plates.

PLATE 1.

A. Ordovician/Silurian systemic boundary on the north side of U.S. Route 52 just west of Ohio Brush Creek, Adams County, Ohio (Loc. 20). Boundary occurs at distinct shale-carbonate break, with Drakes Formation below and Brassfield Formation above. Note thin shale beds intercalated in lowermost Brassfield, and thin lentils and beds of light colored, resistant chert interbedded with more massive middle Brassfield carbonates. Total section exposed approximately 25 feet; no scale. (Photograph by Dr. P.E. Potter)

B. Exposure of Drakes Formation (Ordovician), Brassfield Formation, undifferentiated Plum Creek Shale-Oldham Limestone-Lulbegrud Shale, and Dayton Limestone on north side of State Route 41 at Ohio Brush Creek, Adams County, Ohio (Loc. 16). Note the gradational appearance of the systemic boundary, and expanded thickness of lower Brassfield carbonates and intercalated shales from that shown in Plate 1A. Massive, cherty middle Brassfield which crosses the photograph centrally is relatively resistant to weathering and is overlain by interbedded carbonates and shales of the upper Brassfield. The overlying shales and thin carbonates of the undifferentiated Plum Creek Shale-Oldham Limestone-Lulbegrud Shale, are bracketed below by the Brassfield's "bead-bed", and above by the prominent ledge of Dayton Limestone which caps the outcrop.

PLATE 1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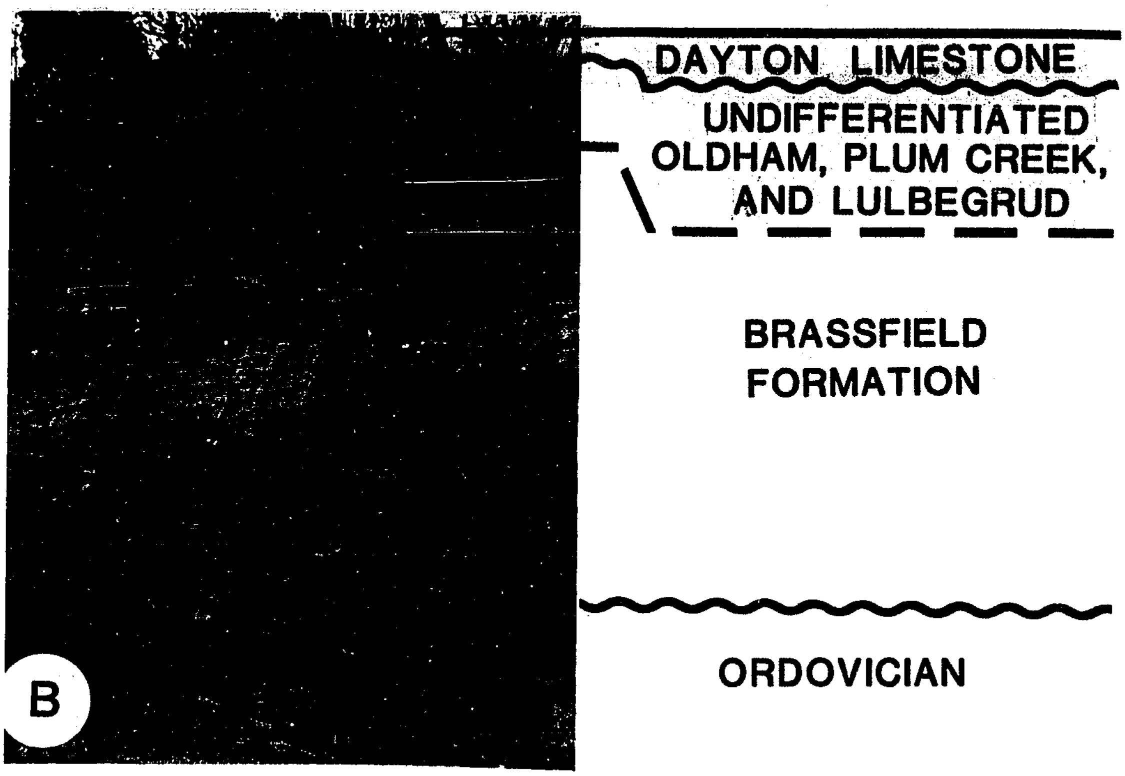

B
DAYTON LIMESTONE
UNDIFFERENTIATED OLDHAM, PLUM CREEK, AND LULBEGRUD
BRASSFIELD FORMATION
ORDOVICIAN

PLATE 2.

A. Brassfield Formation, Plum Creek Shale, and Oldham Limestone exposed on the east side of Stepstone Road, Bath County, Kentucky (Loc. 34). Top of the meter stick approximates the Brassfield-Plum Creek contact, whereas the Plum Creek-Oldham contact is taken at the base of the continuous carbonate section capping the outcrop; both contacts are moderately sharp. Note the two thin, discontinuous carbonate beds contained within the Plum Creek Shale.

B. Unconformable contact between the Dayton Limestone and Plum Creek Shale exposed in active quarry of the Highland Stone Division of Davon Inc., Highland County, Ohio (Loc. 5). The prominent ledge of Dayton lies directly atop approximately 3 feet of Plum Creek shales, which in turn overlie shaly upper Brassfield carbonates seen in the lower left of the outcrop face. The Lulbegrud Shale and Oldham Limestone are absent here because of sub-Dayton erosional truncation.

PLATE 2

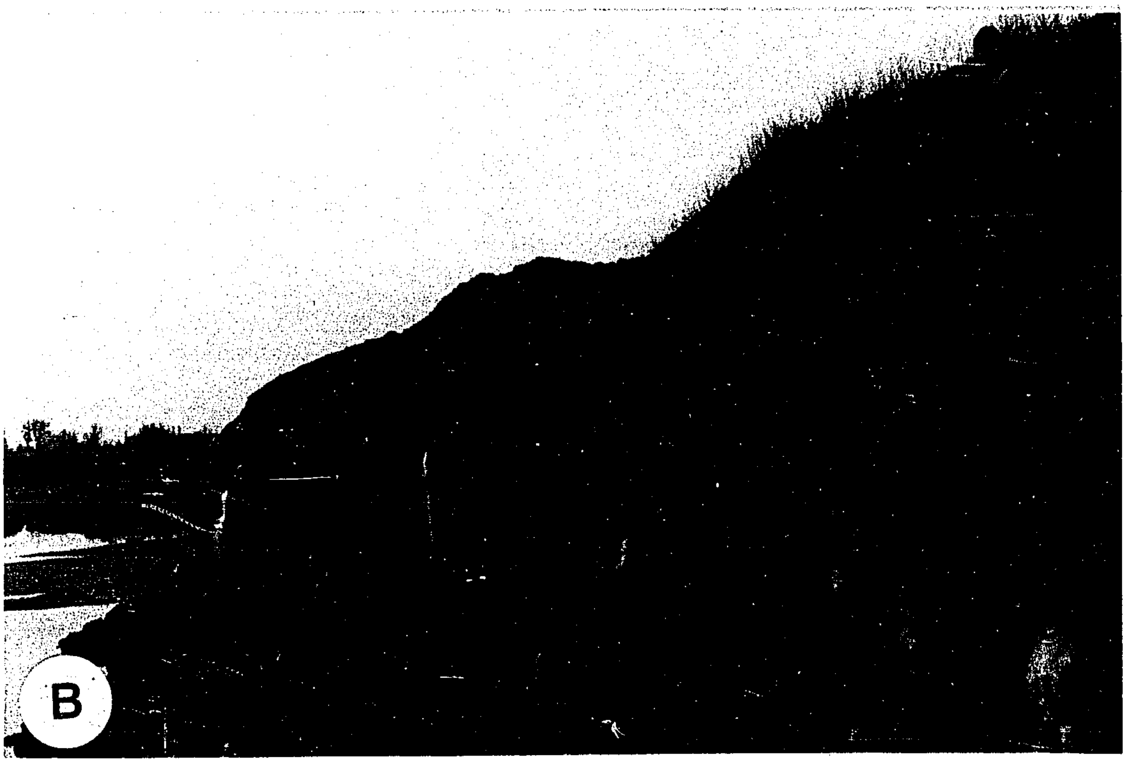


PLATE 3.

A. Estill Shale exposed on the north side of State Route 10 near Charters, Lewis County, Kentucky (Loc. 24). Note darker coloration of Estill downsection, and faint color banding. A few feet of uncharacteristically shaly Bisher Formation are exposed at the top of the upper bench.

B. Devonian Ohio Shale unconformably overlying erosional remnant of Bisher Formation near Ramey Chapel, Fleming County, Kentucky (Loc. 28). Systemic boundary lies at base of tree line; Ohio Shale exposed on shallow slope in upper background. The preserved 6 to 10 feet of Bisher is highly fractured and extensively leached; larger vugs have been infilled with Devonian shales. Estill Shale is exposed beneath the Bisher at ditch level. Meter stick for scale.

PLATE 3

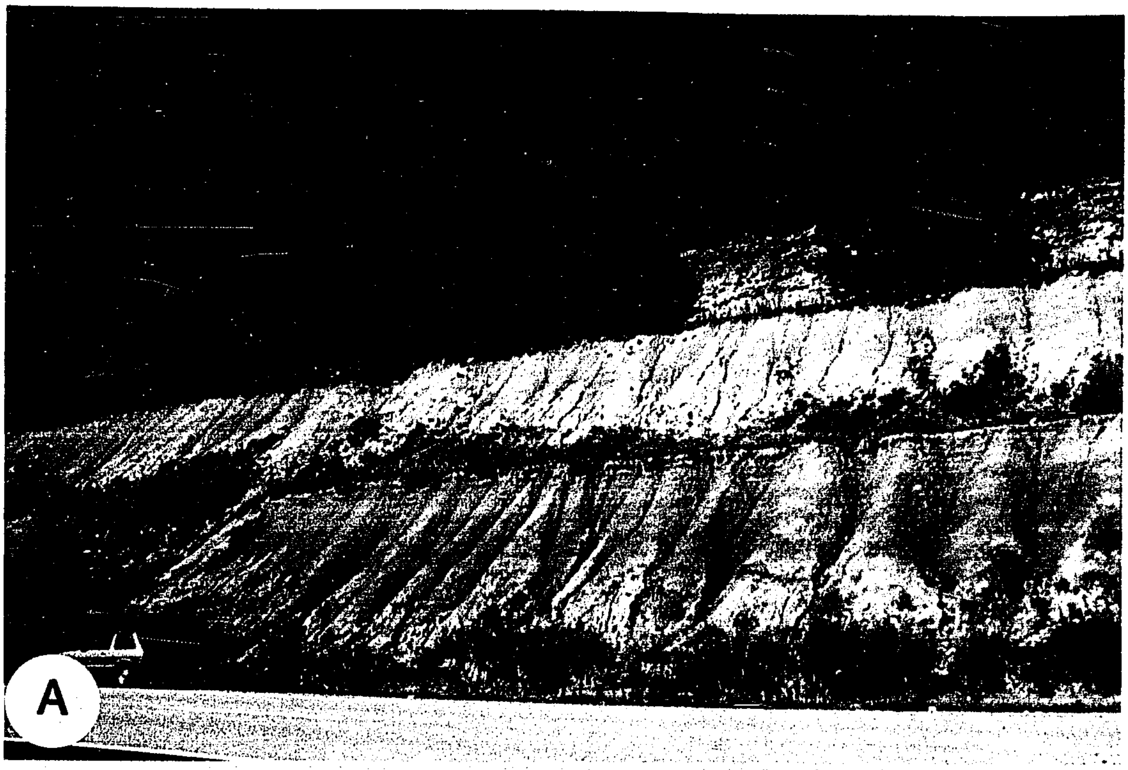


PLATE 4.

A. Plum Creek Shale, Oldham Limestone, Lulbegrud Shale, and Dayton Limestone exposed on west side of Stepstone Road, Bath County, Kentucky (Loc. 34). Base of meter stick approximates Plum Creek-Oldham contact; contact of Oldham with Lulbegrud Shale is obscured by overgrowth. Isolated ledge of Dayton Limestone occurs at tree level.

B. Hummocky bedding typical of the Bisher Formation exposed on south side of State Route 41, 0.5 miles south of Jacksonville, Peebles Quadrangle, Adams County, Ohio (near Loc. 16). Meter stick for scale.

C. Low angle cross-bedding in coarse grained, silty Bisher dolomite exposed at Herron Hill, Lewis County, Kentucky (Loc. 23). Scale in inches/centimeters.

PLATE 4

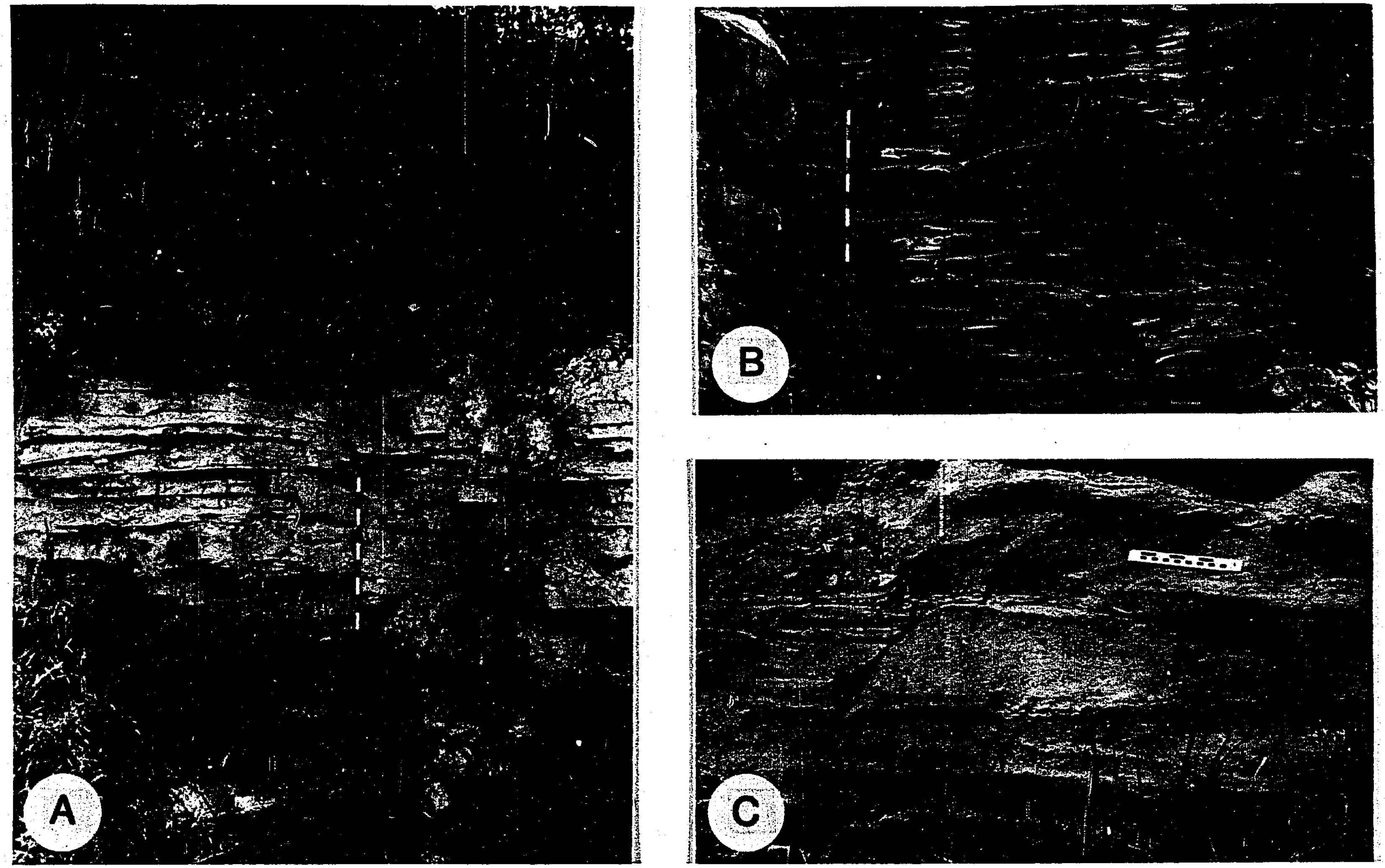


PLATE 5.

A. Keefer Sandstone, Core 1549 (3514 feet), Wayne County, West Virginia. Note faint cross-lamination in coarse grained layer above centerline of photograph, and thin shale laminae and scattered shale clasts near base.

B. Keefer Sandstone, Core 1549 (3527.5 feet), Wayne County, West Virginia. Note poorly developed sand flasers in shaly upper one-third of photograph, central homogeneous coarse grained layer containing abundant sand-size crinoidal debris, and burrow (lower left) in finely laminated sandstone at base of photograph.

C. Peebles Formation, Core 162, Plum Run Stone Division, Davon Inc., Adams County, Ohio. Core slabs show representative light gray, fossiliferous, extensively dolomitized, slightly brecciated, porous Peebles dolomite with asphalt stain.

D. Greenfield Formation, Core 162, Plum Run Stone Division, Davon Inc., Adams County, Ohio. Core slabs show typical gray to greenish gray Greenfield dolomite containing stylolites, and discontinuous and distorted algal lamination which grades to brecciated and homogeneous textures.

PLATE 5

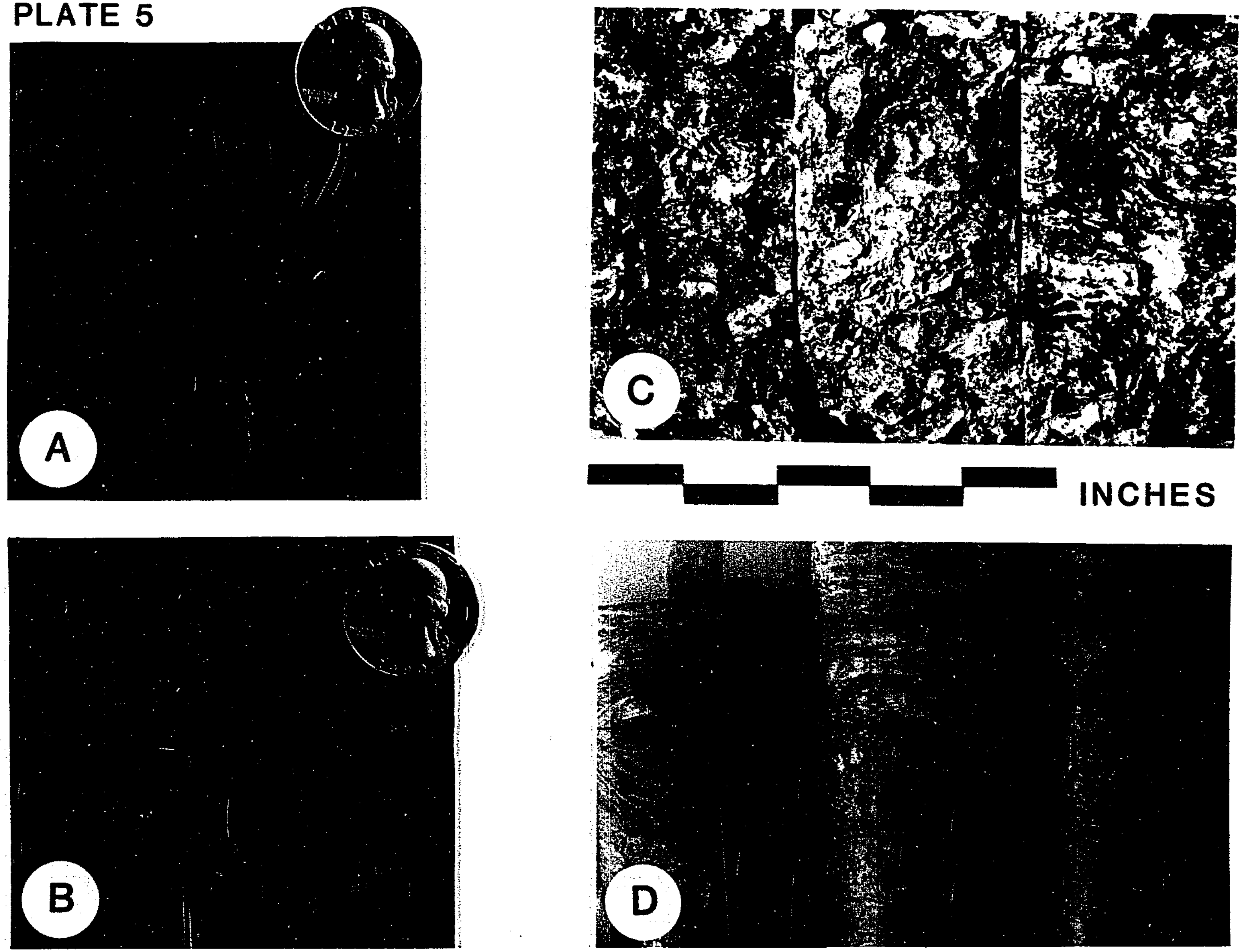


PLATE 6.

A. Unconformable contact between the Peebles Formation (Lockport Group) and Greenfield Formation (Salina Group) exposed along access road to active quarry of Plum Run Stone Division of Davon Inc., Adams County, Ohio (Loc. 15). Note the massive bedding, light color, and homogeneous character of the Peebles Formation which clearly distinguishes this unit from the medium to thin bedded, darker colored rocks of the overlying Greenfield. (Photograph by Dr. P.E. Potter).

B. Suggested contact between the Greenfield and Tymochtee Formations (lower and upper Tymochtee) as determined at exposure in active quarry of the Plum Run Stone Division of Davon Inc., Adams County, Ohio (Loc. 15). The contact occurs at the sharp break in coloration, which lies slightly above the medial line of the outcrop face. The contact shown corresponds to the Greenfield-Tymochtee boundary recognized in subsurface areas. (Photograph by Dr. P.E. Potter).

PLATE 6

PLATE 7. SEM Photomicrographs.

Bar scale equals 10 microns in all photographs.

A. Sample of representative light gray, slightly argillaceous and silty Bisher dolomite from Core 2799 (132 feet), Highland County, Ohio. Note the abundant grain-coating and pore-filling illite which largely obscures the subhedral and anhedral, slightly corroded dolomite crystals. Magnification x 480.

B. Enlarged magnification of lower center portion of Plate 7A, showing clearly illite flakes and booklets, and euhedral, authigenic quartz crystal with partial clay coating. Magnification x 2000.

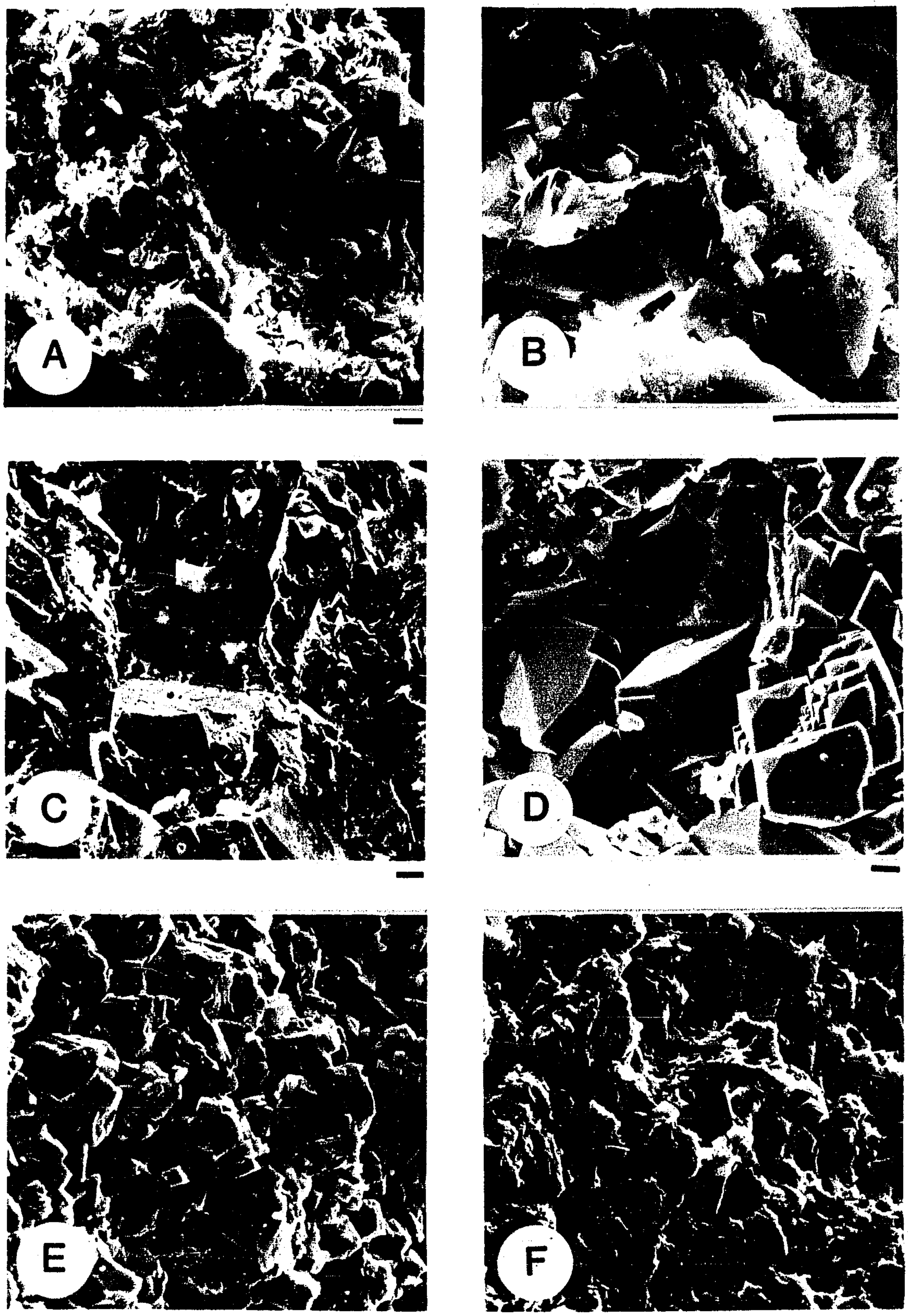
C. Sample of representative light gray, medium to coarsely crystalline, vuggy Peebles dolomite; Core 1340 (188 feet), Pike County, Ohio. The dolomite appears to have been diagenetically leached, resulting in fine pin-point intracrystalline porosity. Magnification x 480.

D. Intercrystalline megapore in Peebles dolomite bounded by coarse decimicron to fine centimicron grade euhedral to subhedral dolomite crystals; Core 1340 (188 feet), Pike County, Ohio. Magnification x 480.

E. Sample of representative grayish brown, dense, finely crystalline Greenfield dolomite; Core 1339 (567 feet), Pike County, Ohio. Note equigranular fine decimicron grade subhedral to euhedral dolomite crystals and absence of clays. Magnification x 480.

F. Sample of representative tan, dense, finely to very finely crystalline Tymochtee dolomite; Core 1339 (457 feet), Pike County, Ohio. Dolomite texture comparable to Greenfield sample in 7E, however Tymochtee specimen illustrated contains more subhedral and anhedral grains, in addition to scattered illite clay flakes which obscure many crystals. Magnification x 480.

PLATE 7



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Oversize maps and charts are filmed in sections in the following manner:

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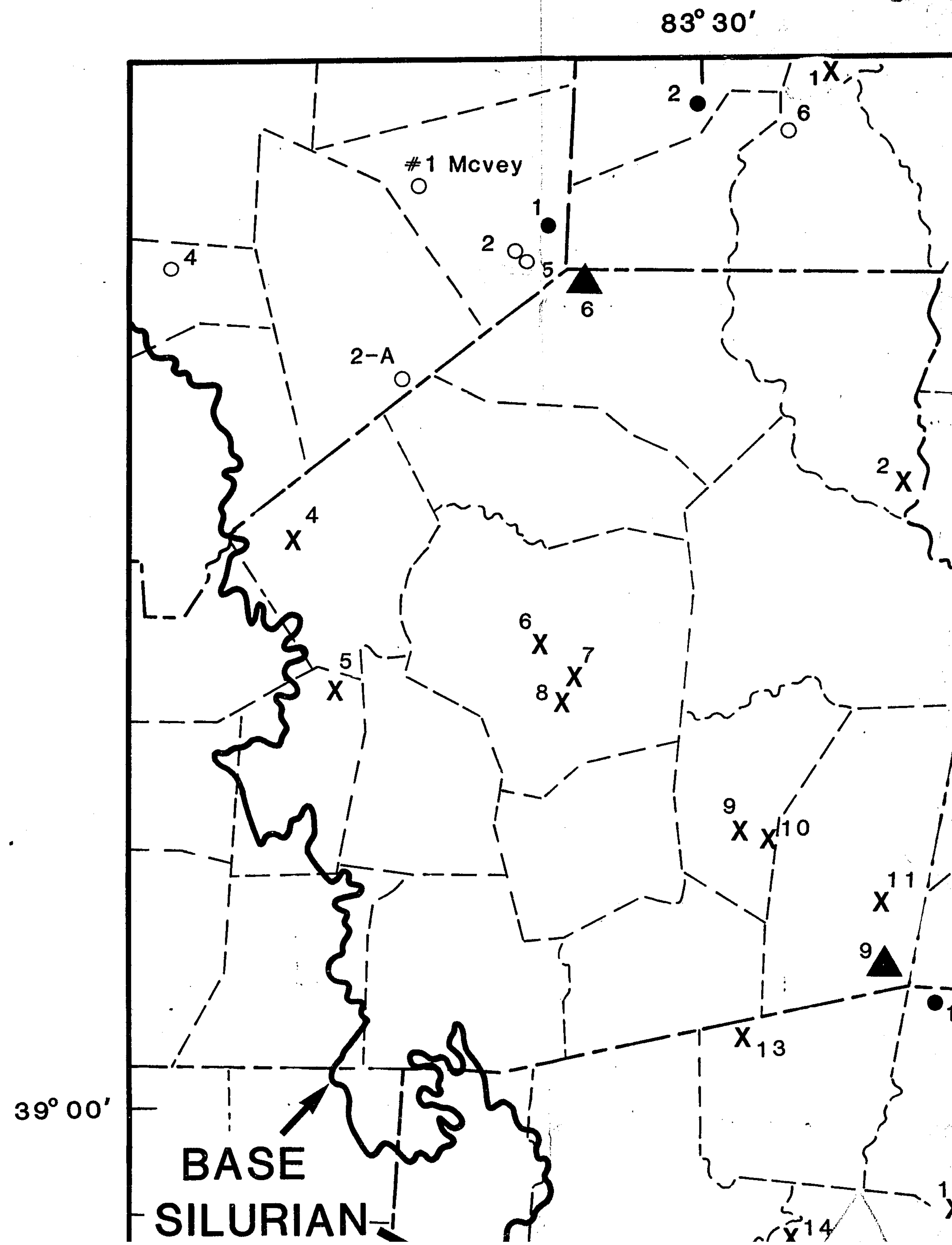
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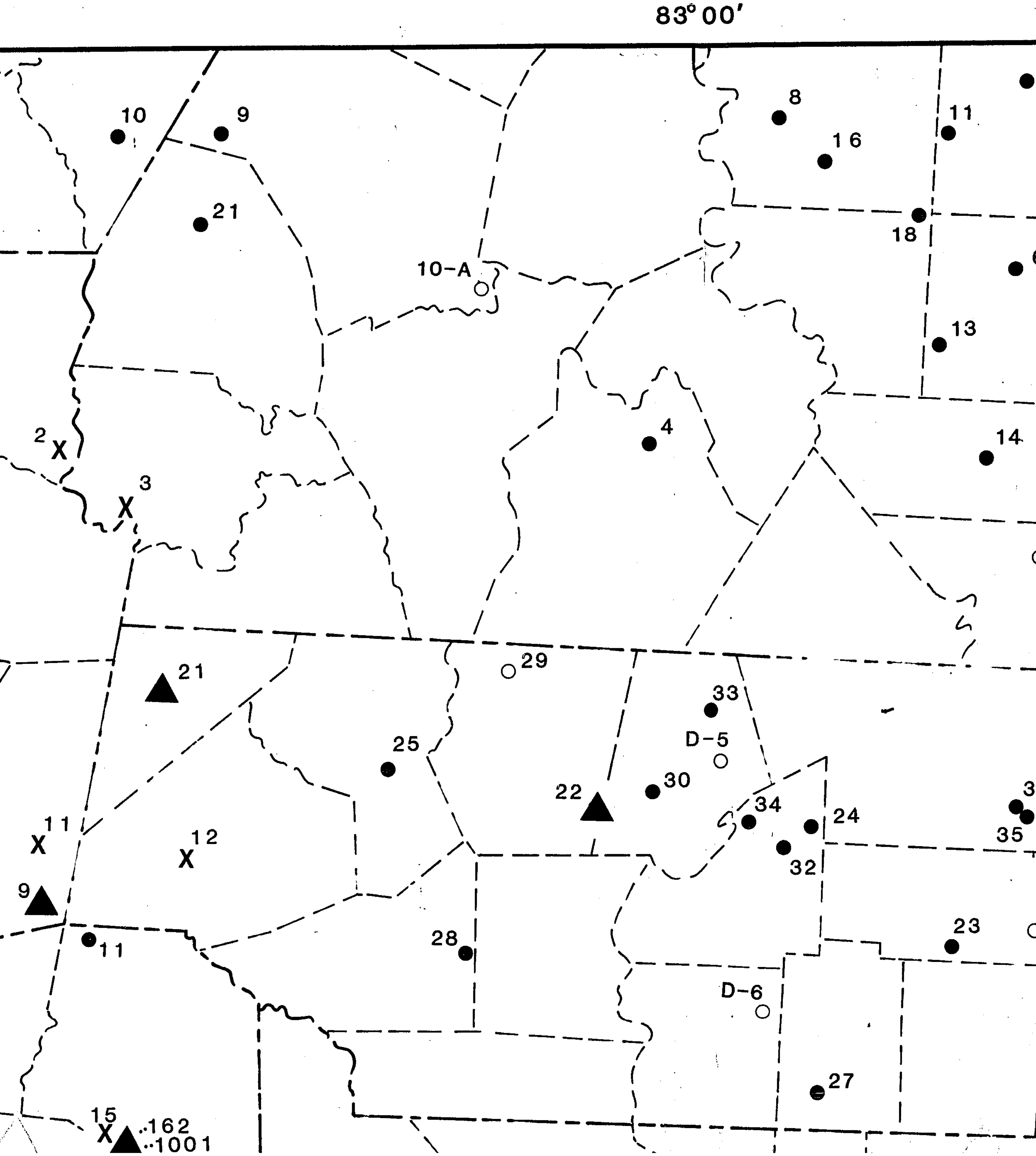
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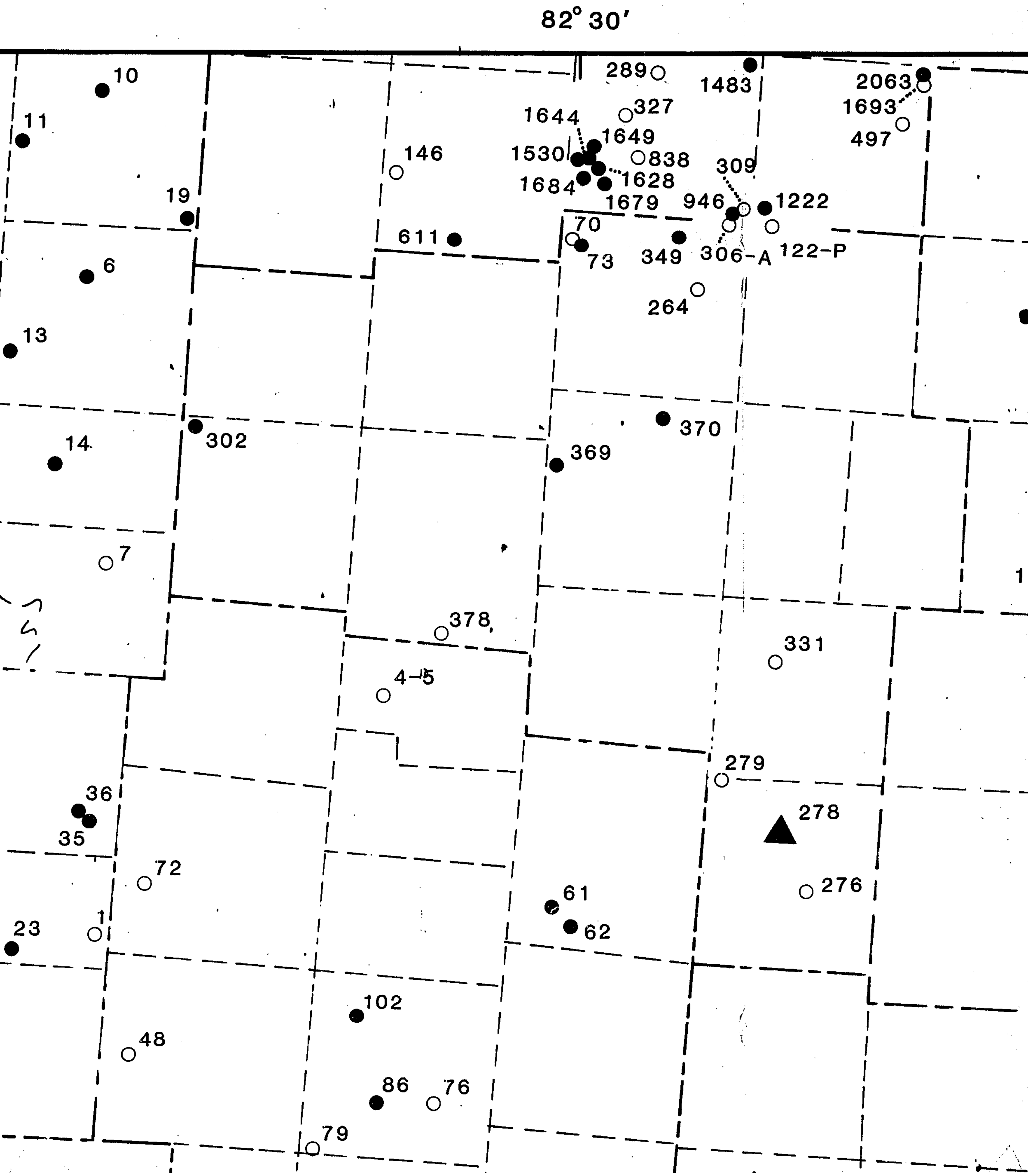
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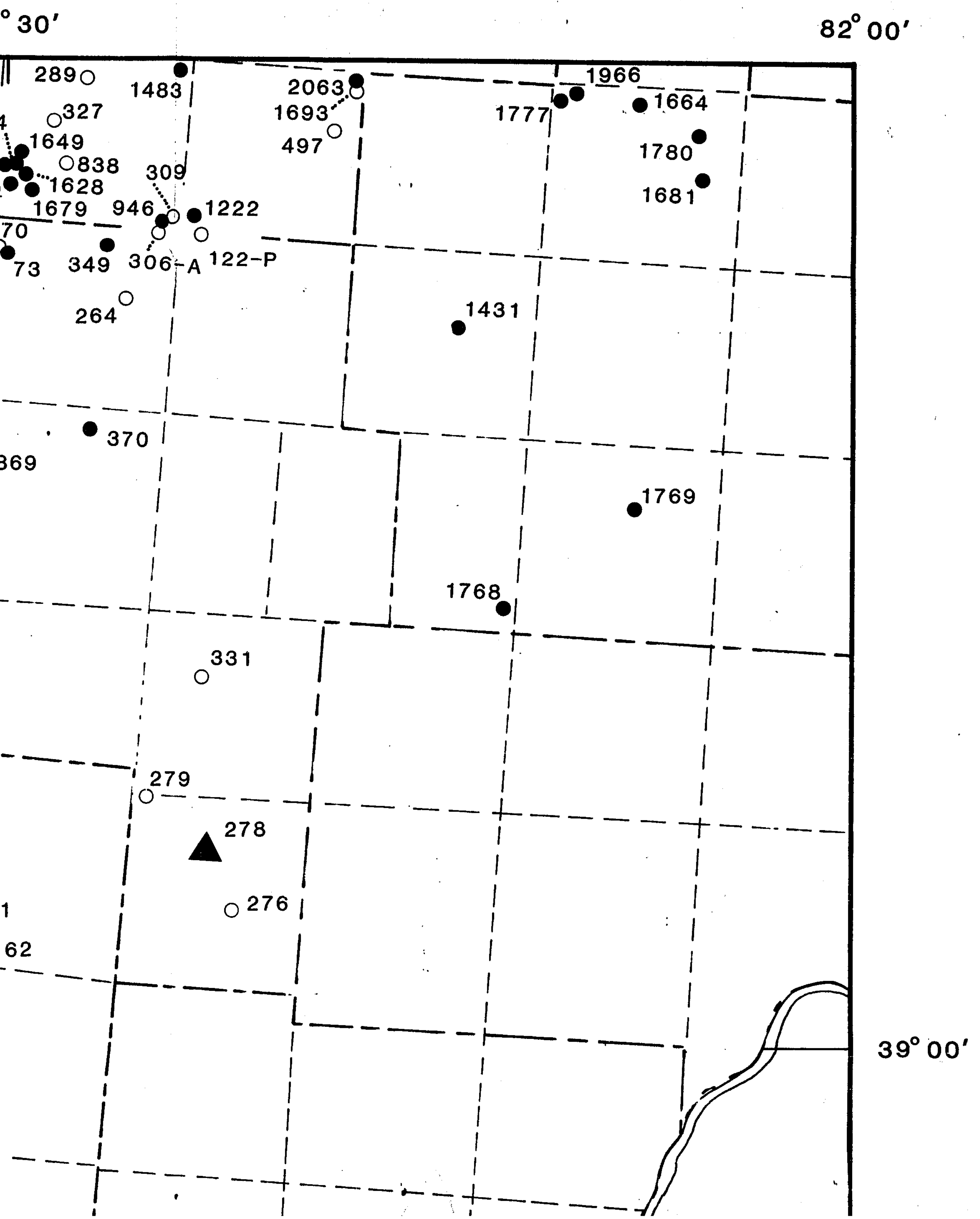
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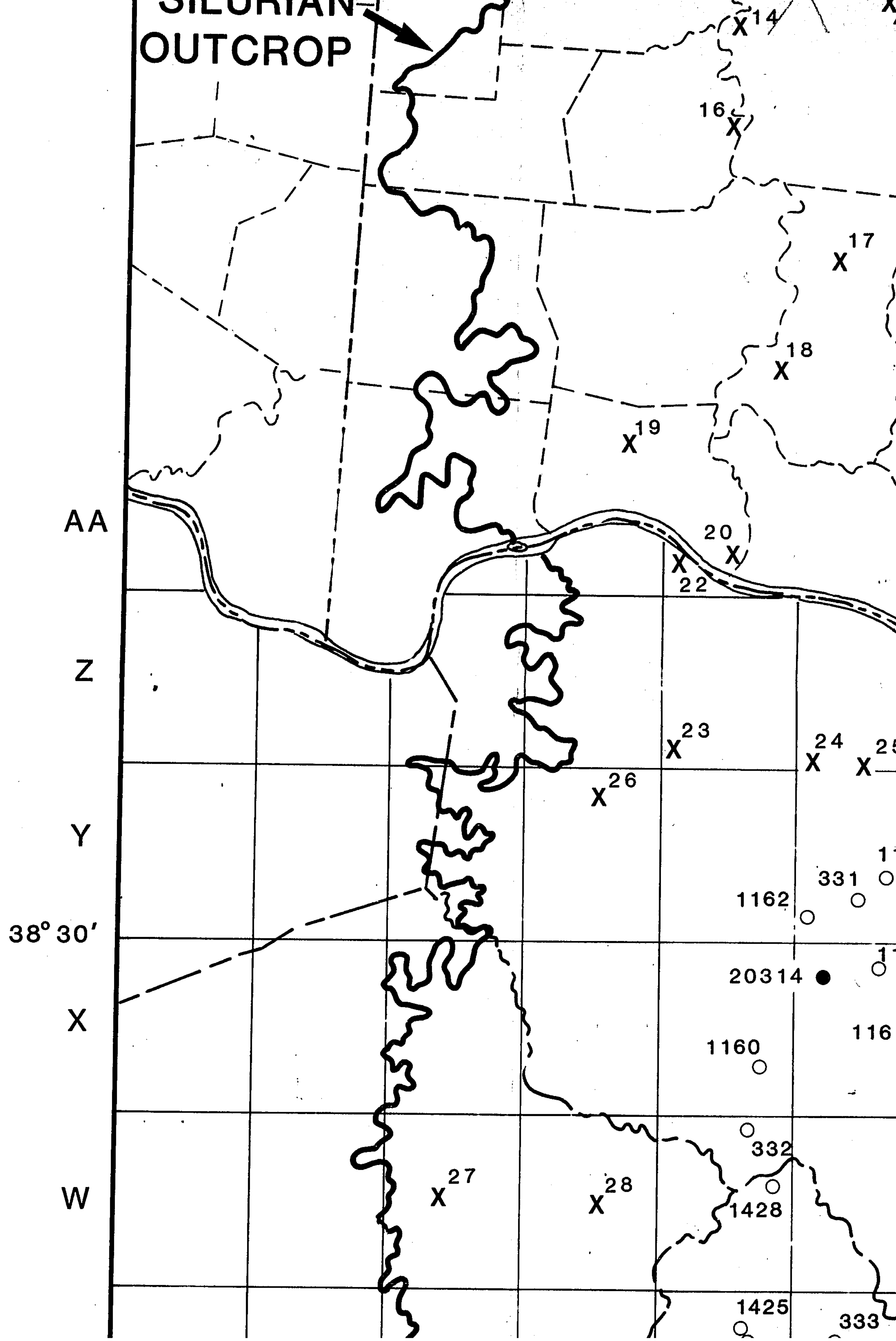
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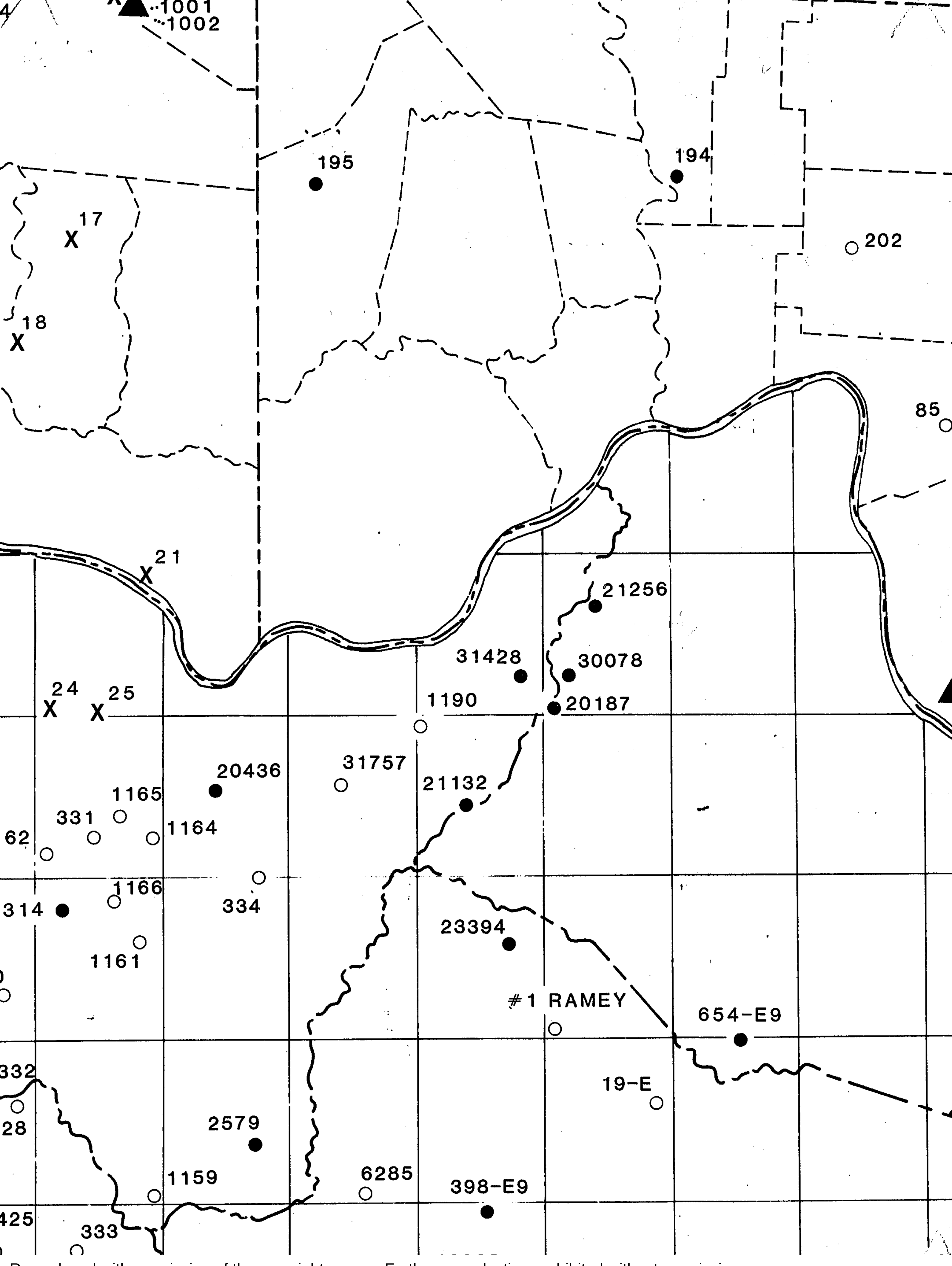
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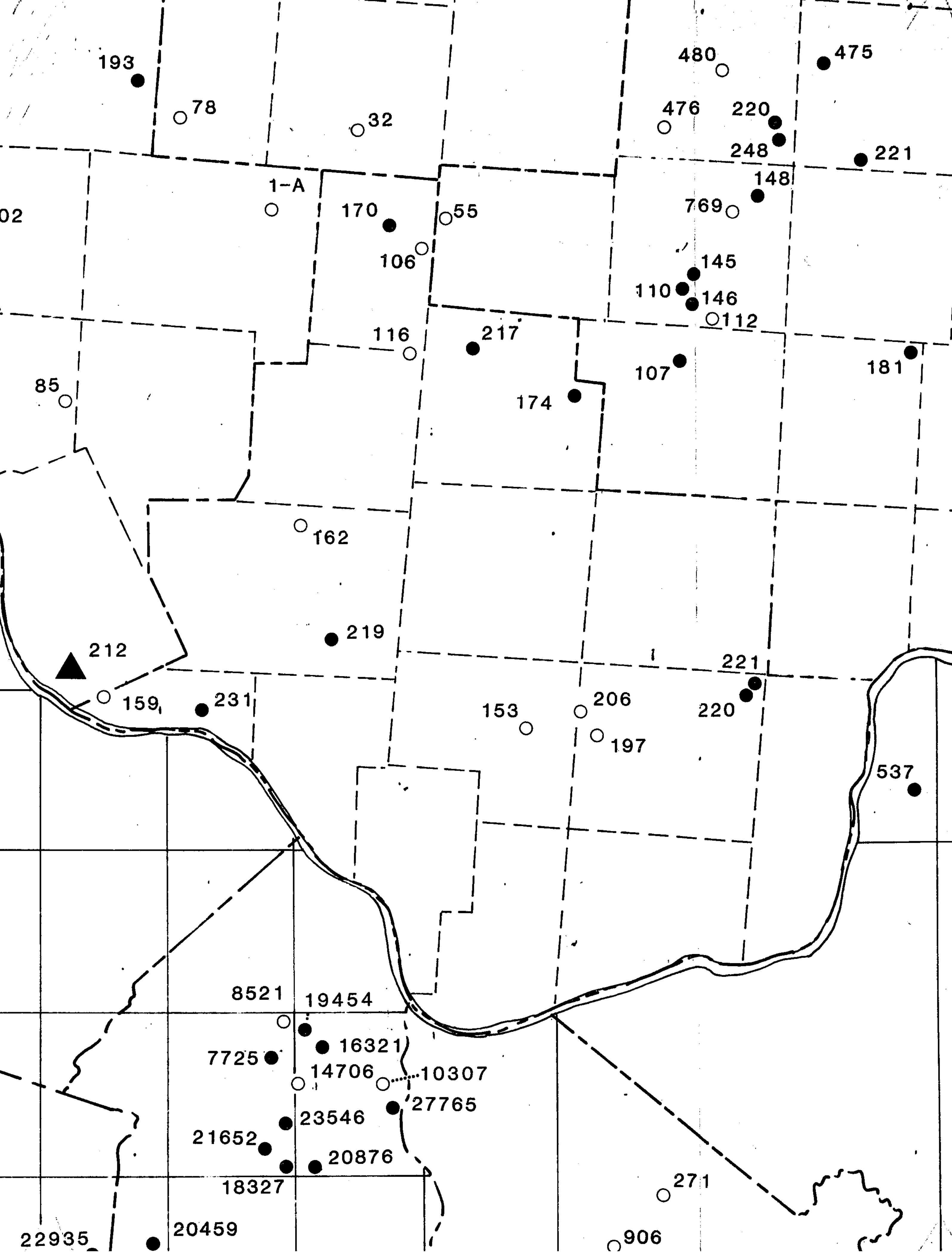
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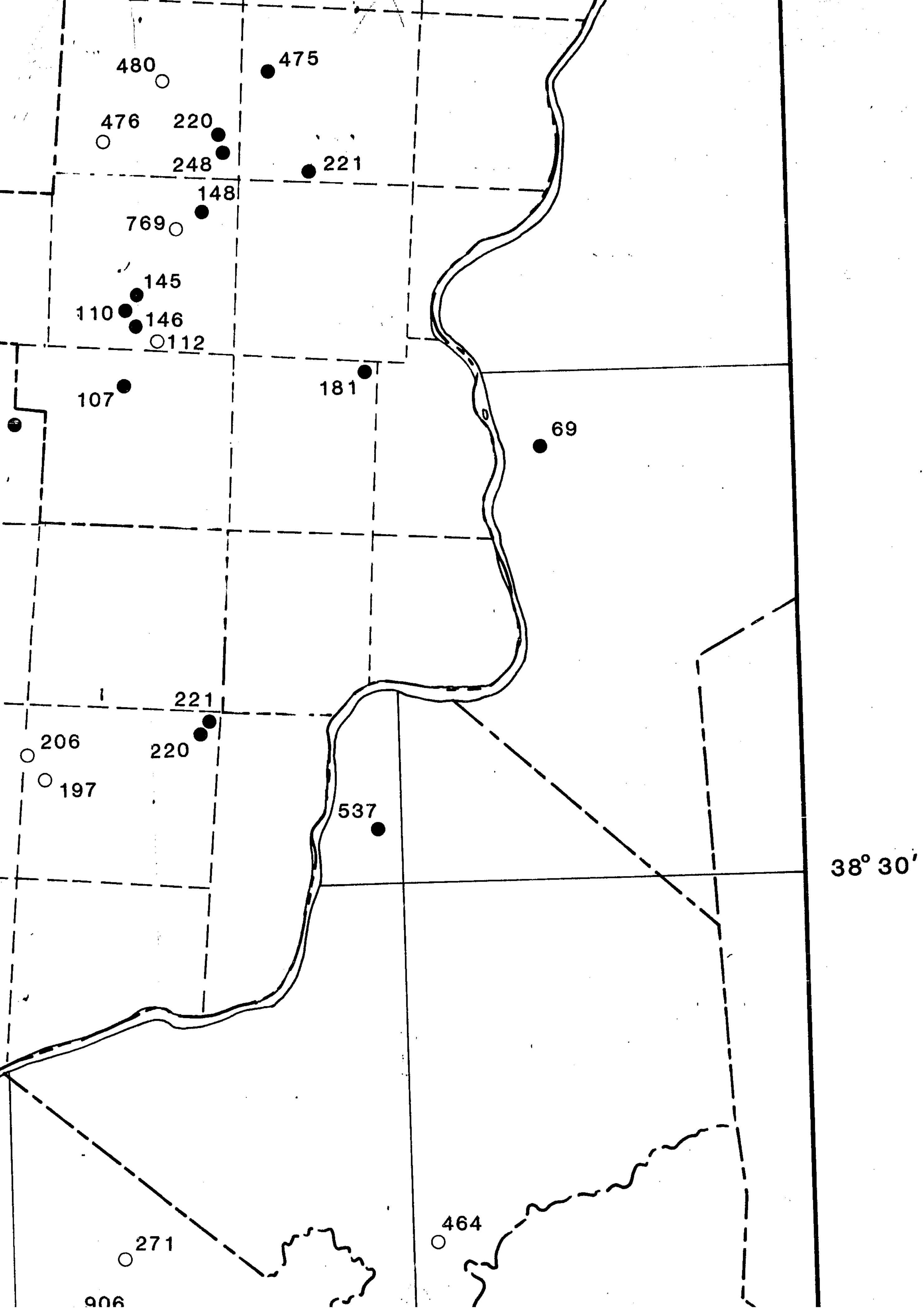
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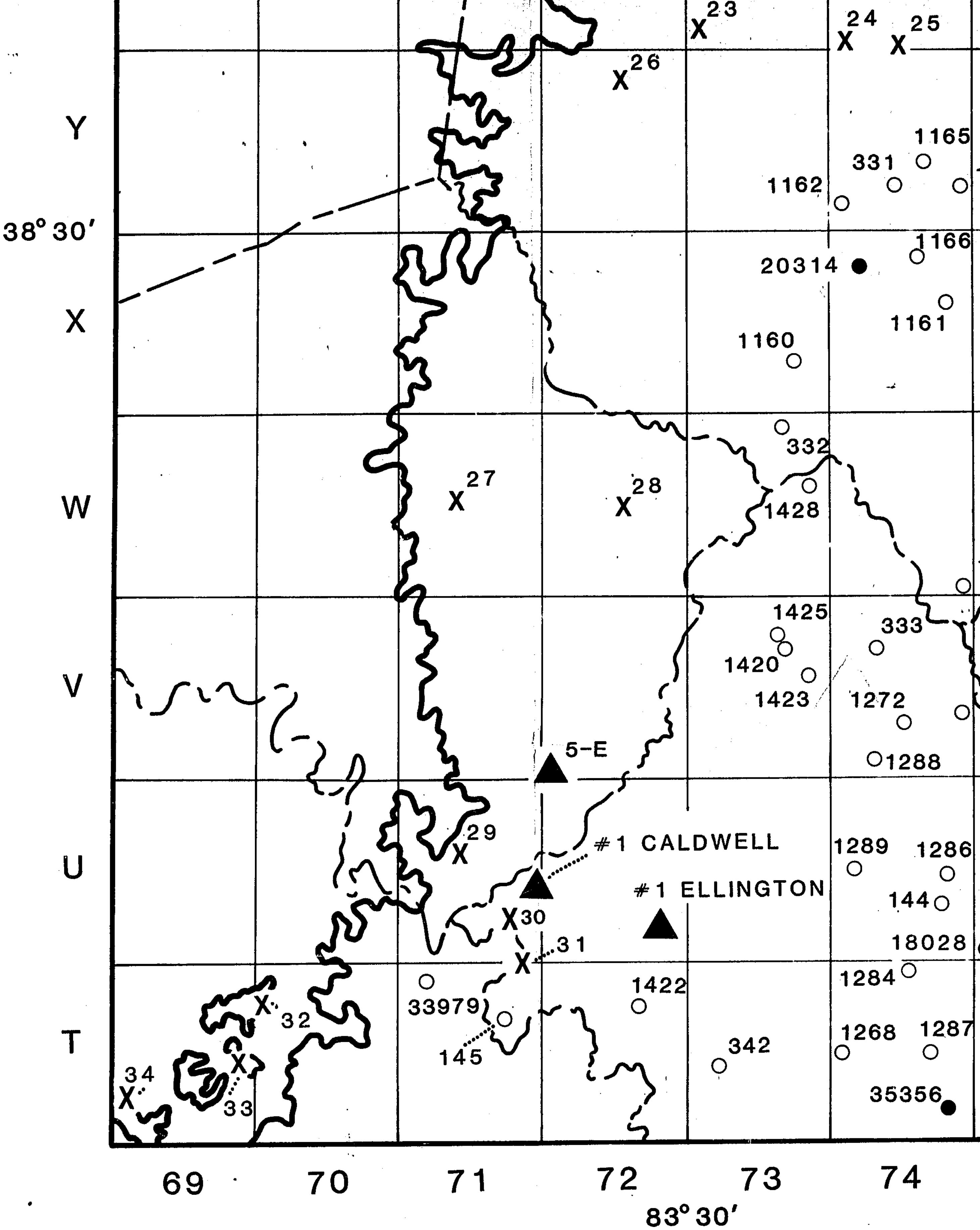

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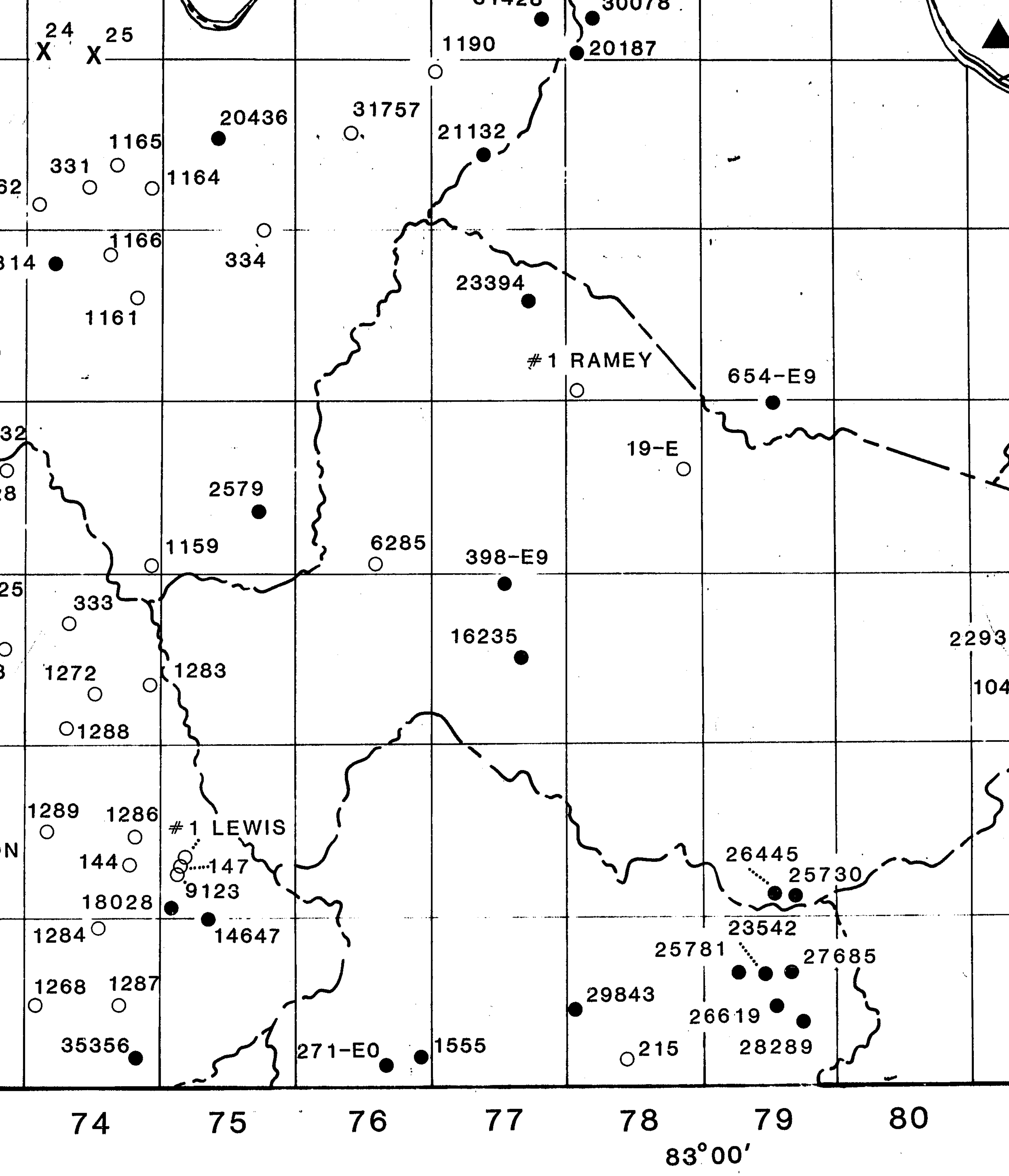

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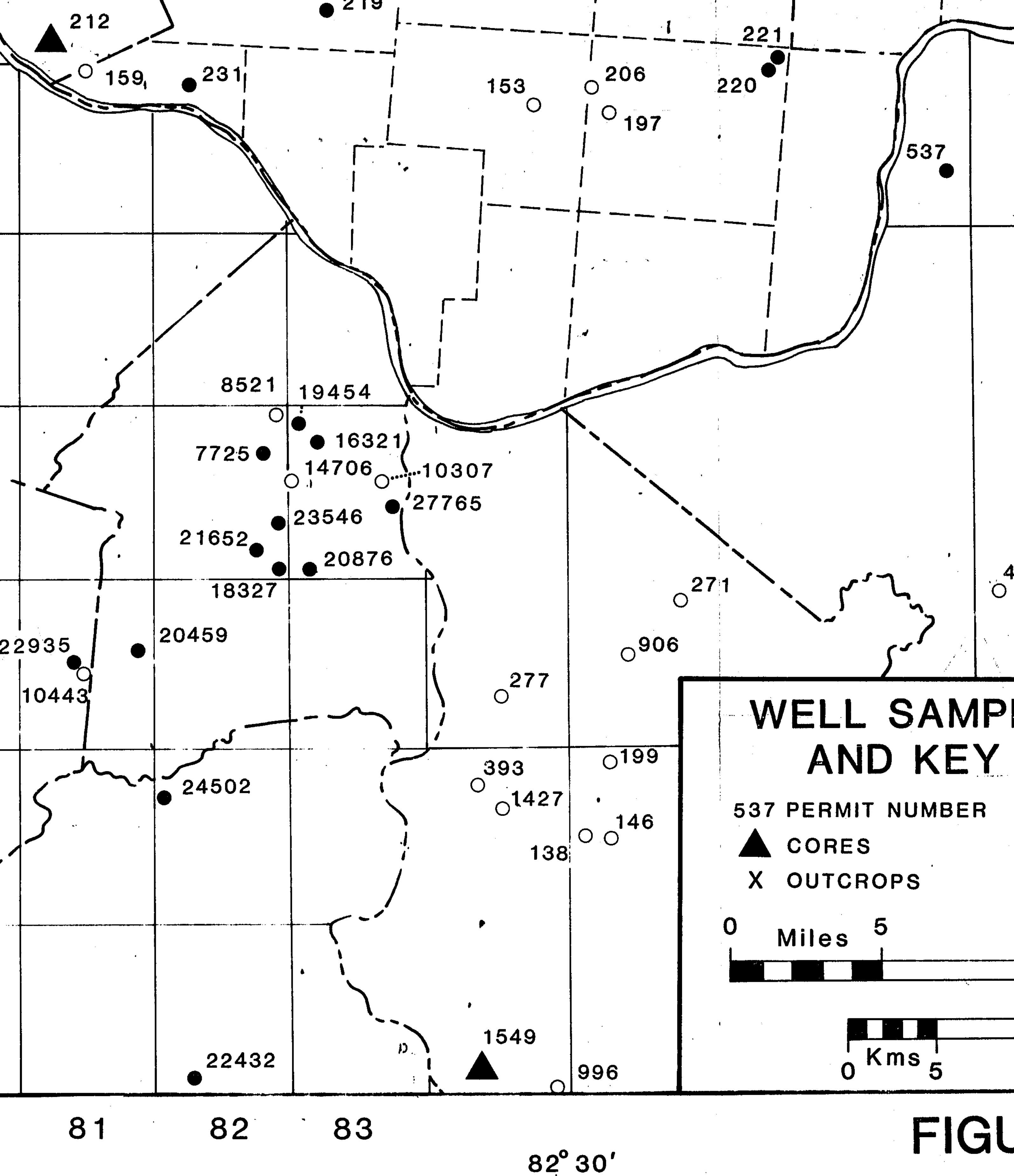
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FIGU

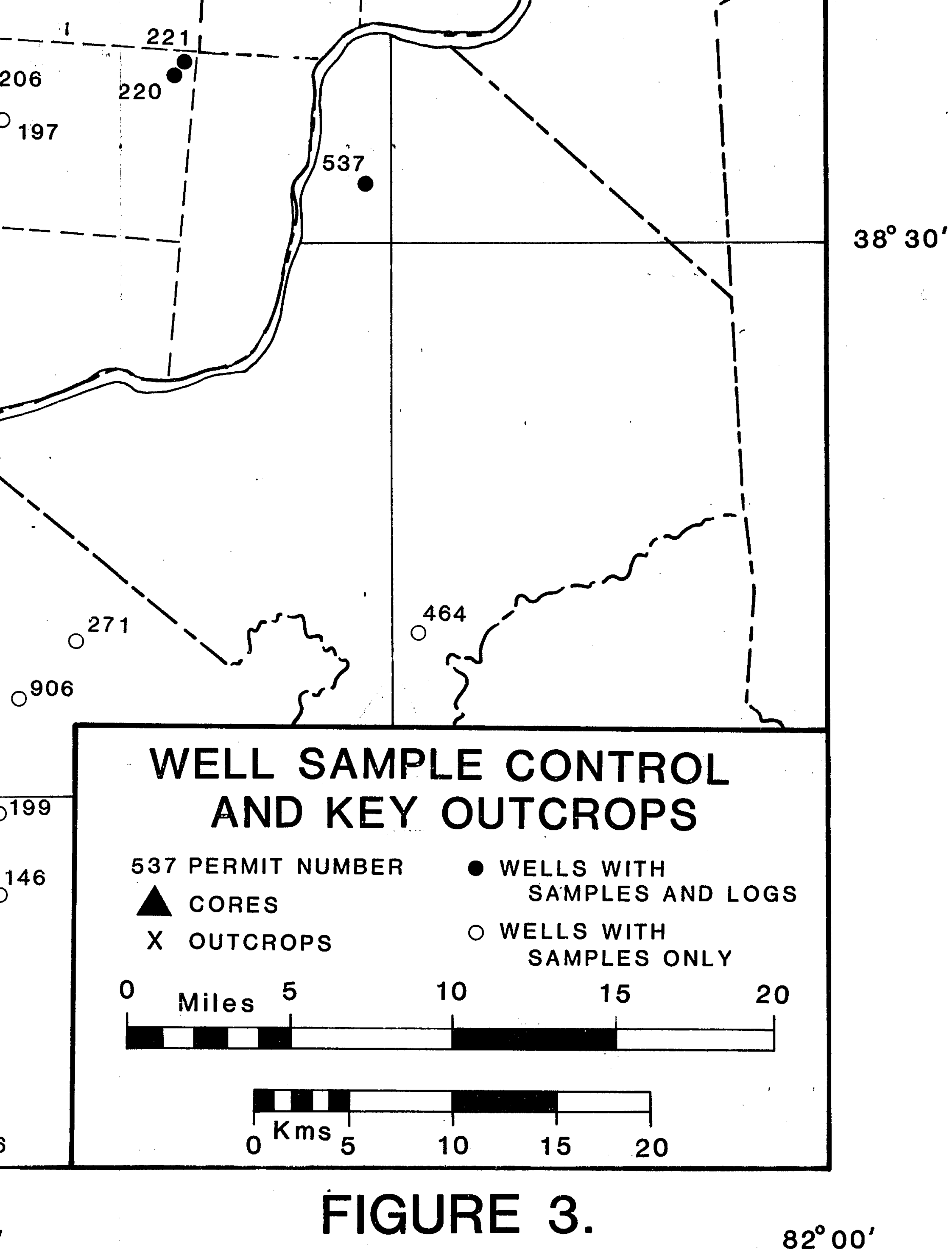
221
206
220
197
537
38° 30′
464
271
906
199
146
WELL SAMPLE CONTROL AND KEY OUTCROPS
537 PERMIT NUMBER
CORES
X OUTCROPS
WELLS WITH SAMPLES AND LOGS
WELLS WITH SAMPLES ONLY
0 Miles 5 10 15 20
0 Kms 5 10 15 20
82° 00′

FIGURE 3.

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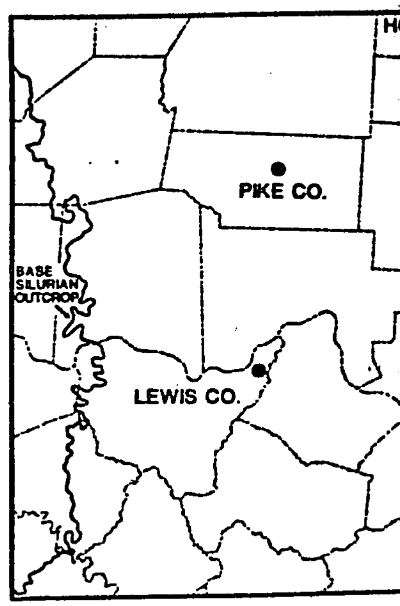
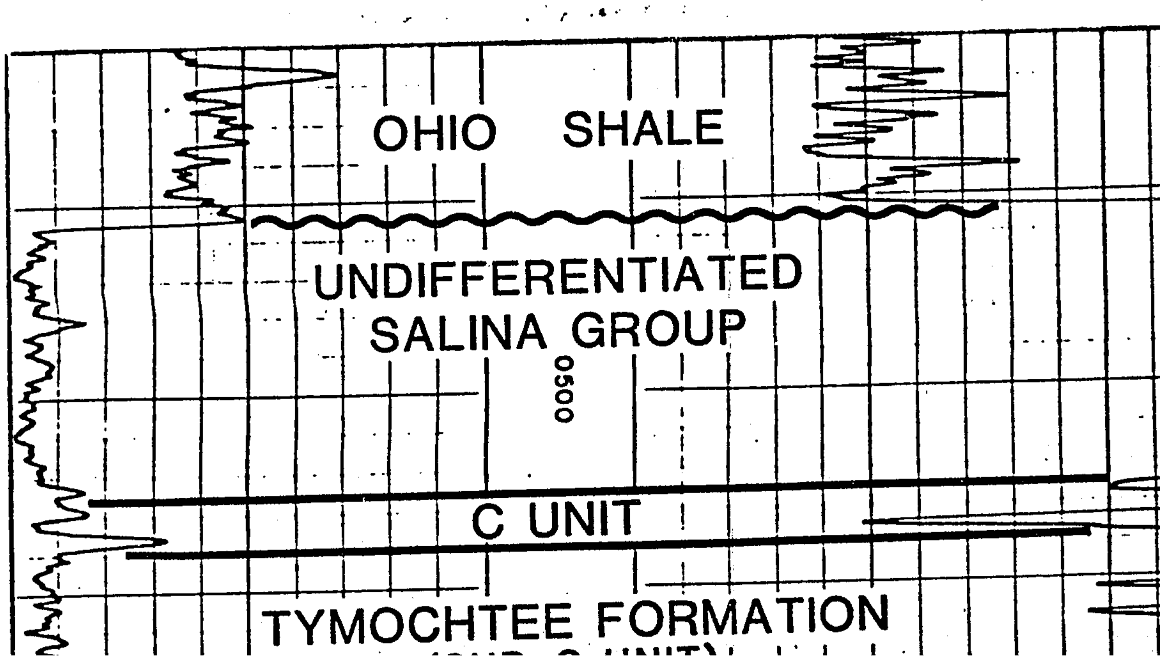
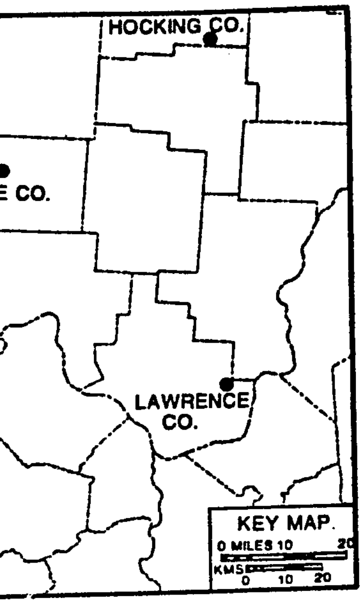
FIGURE 6. REFERENCE NU
BRASSFIELD F

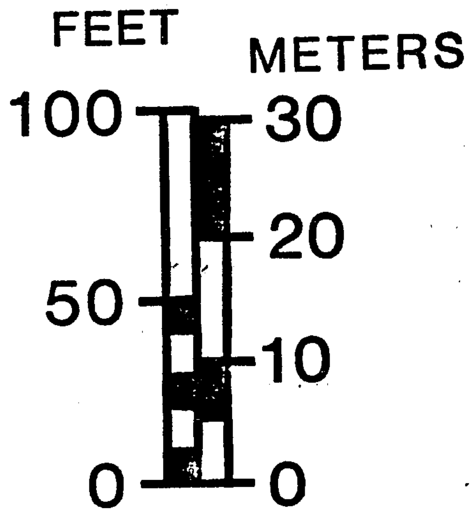


PIKE COUNTY, OHIO
PEBBLE TWP. PERMIT 2

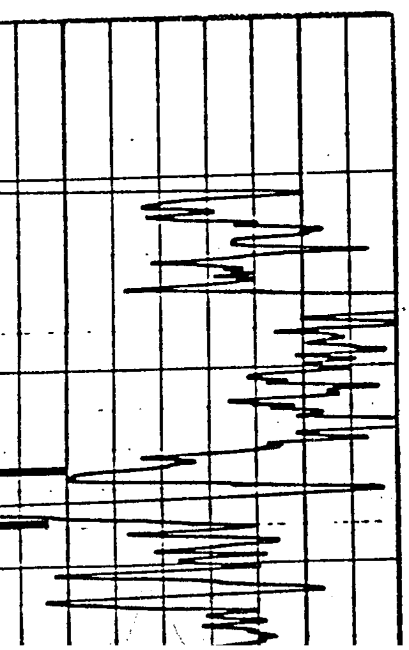


E NUCLEAR LOGS SHOWING GEOPHYSIC
D FORMATION THROUGH C UNIT STRAT

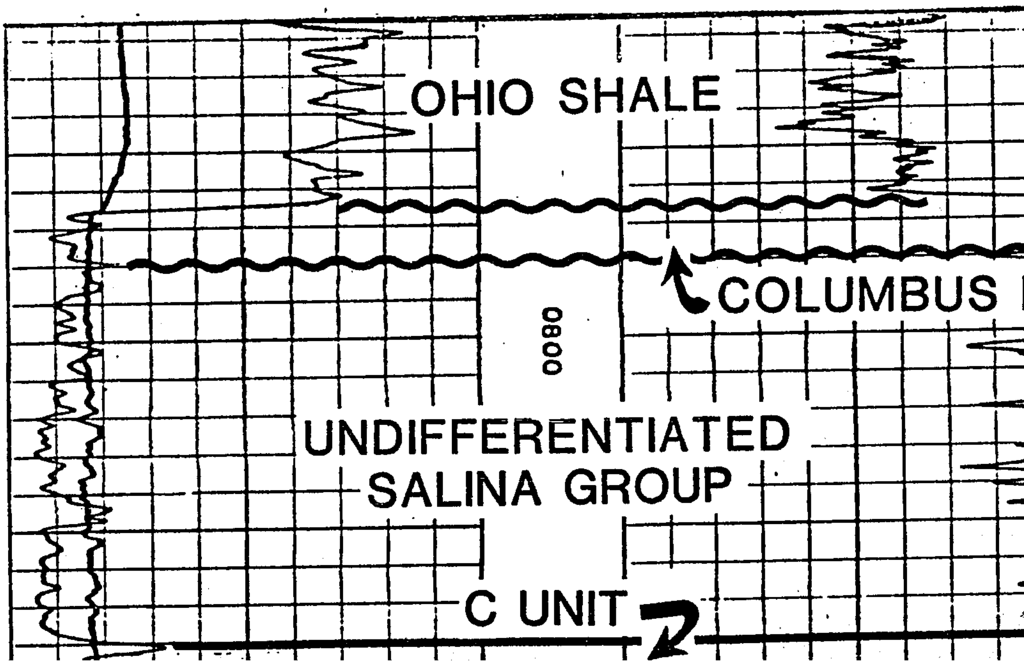




IO
IT 22



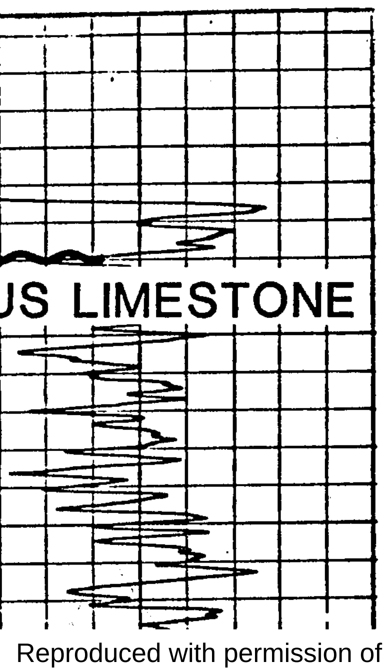
LEWIS COUNTY , KENTUC
20 Z 77 PERMIT 3142

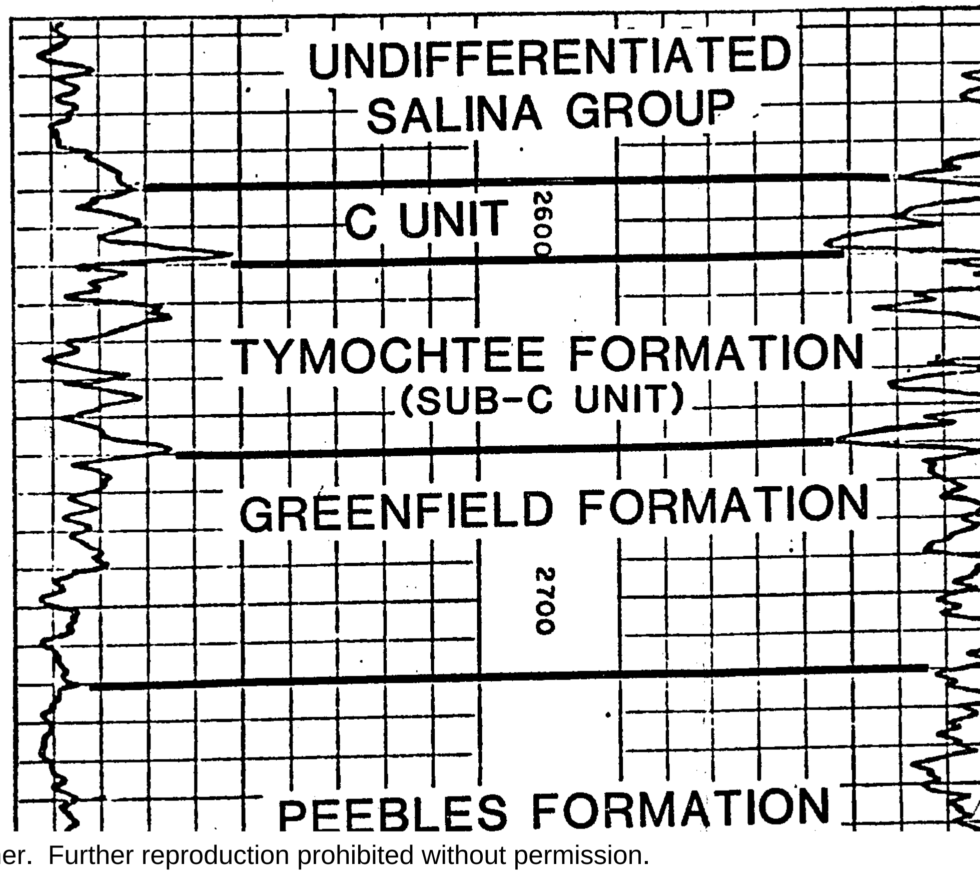


SICAL IDENTIFICATION OF
RATA

HOCKING COUNTY, OH
STAR TWP. PERMIT 12

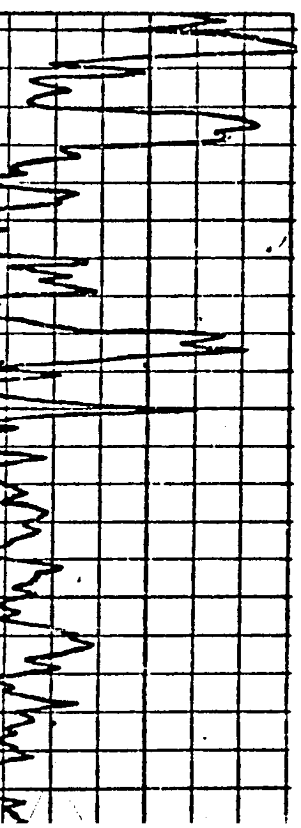
TUCKY
428





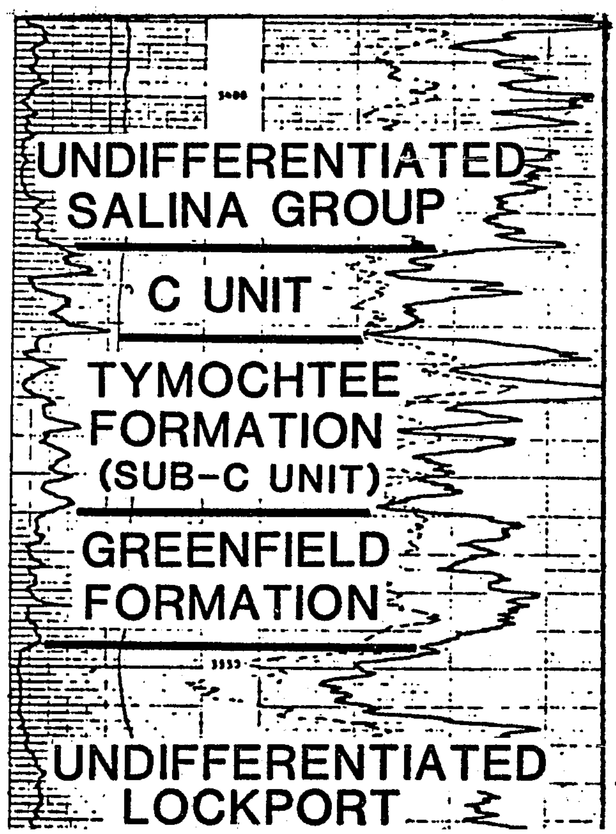
HIO

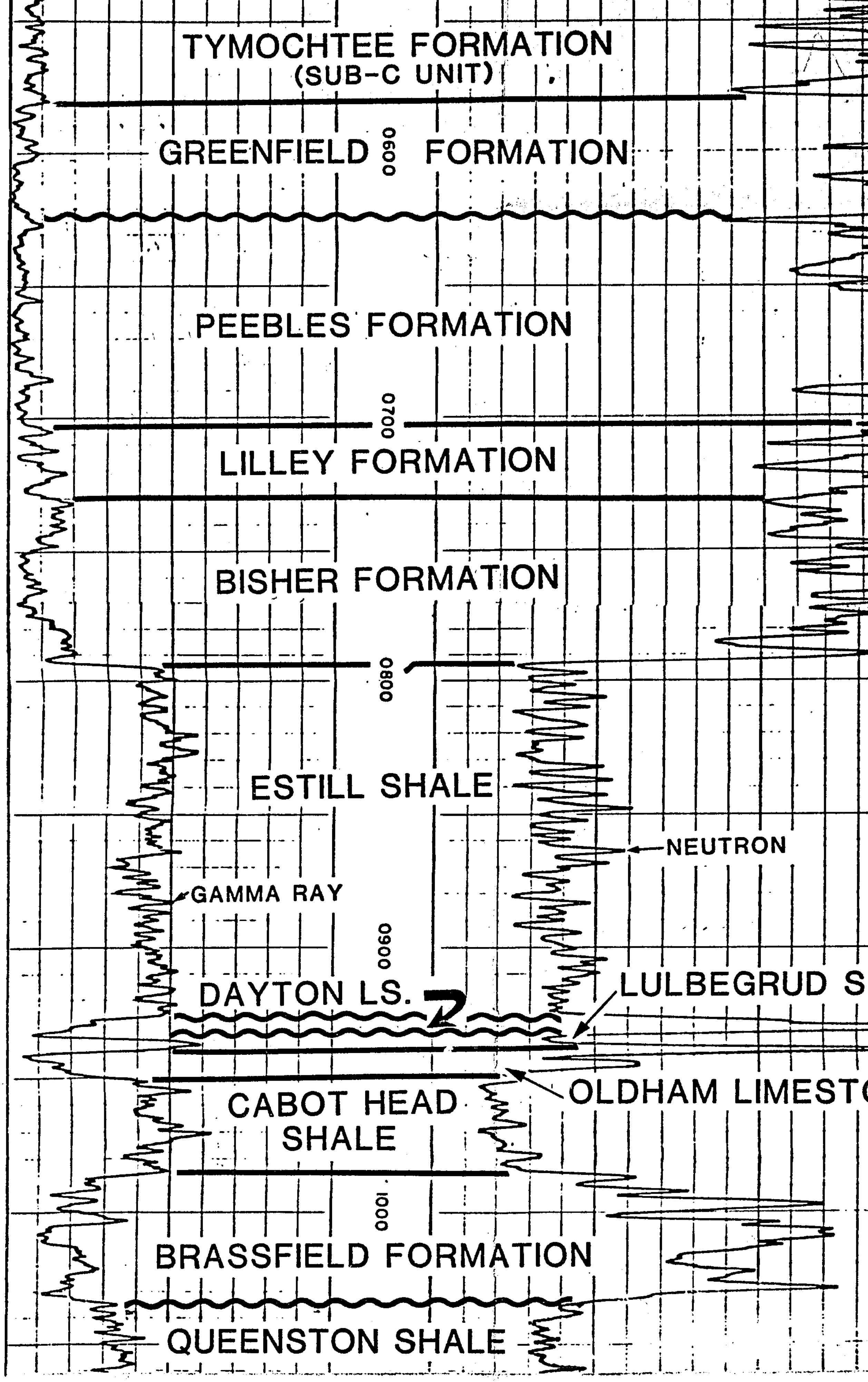
222



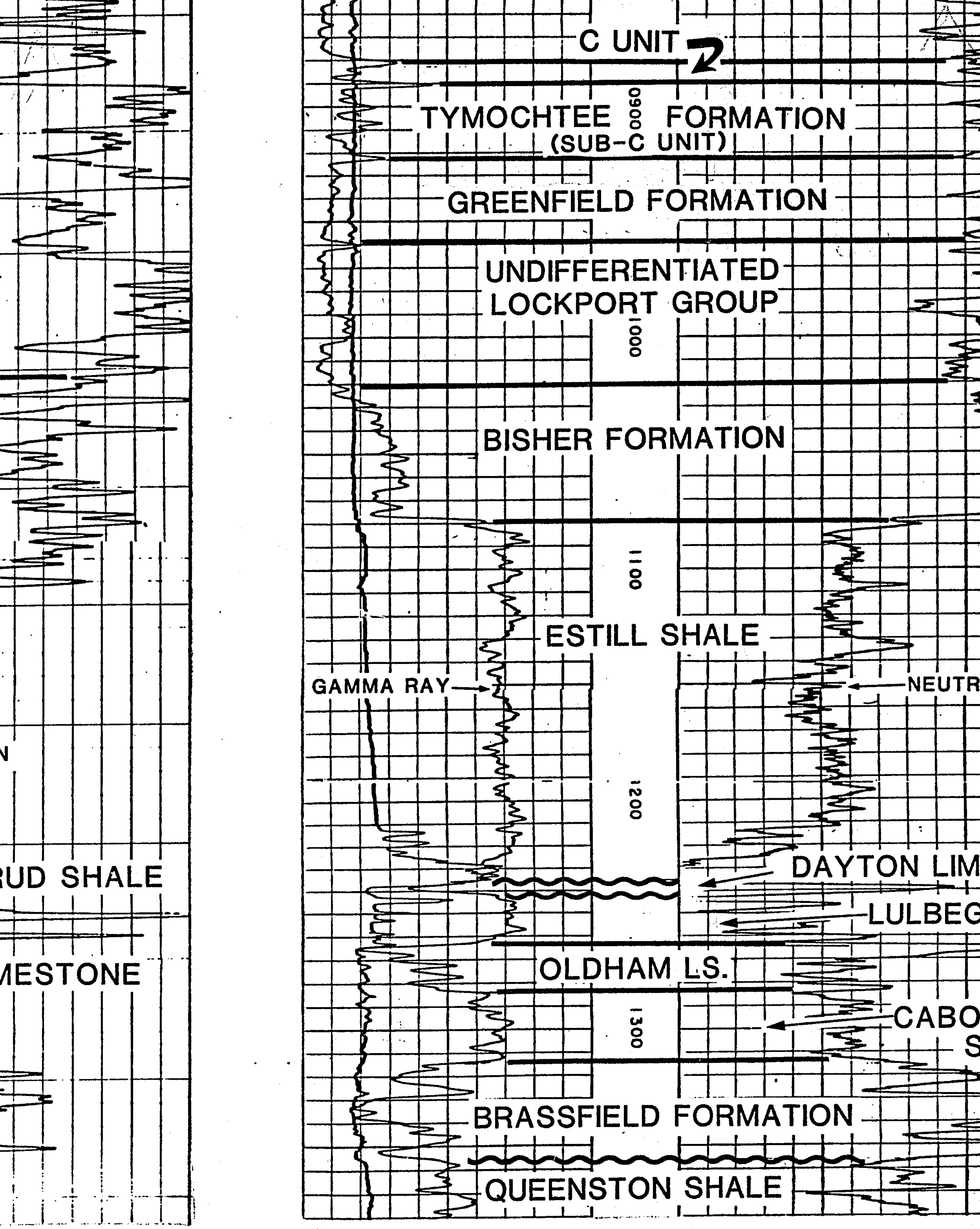
LAWRENCE COUNTY, OHIO

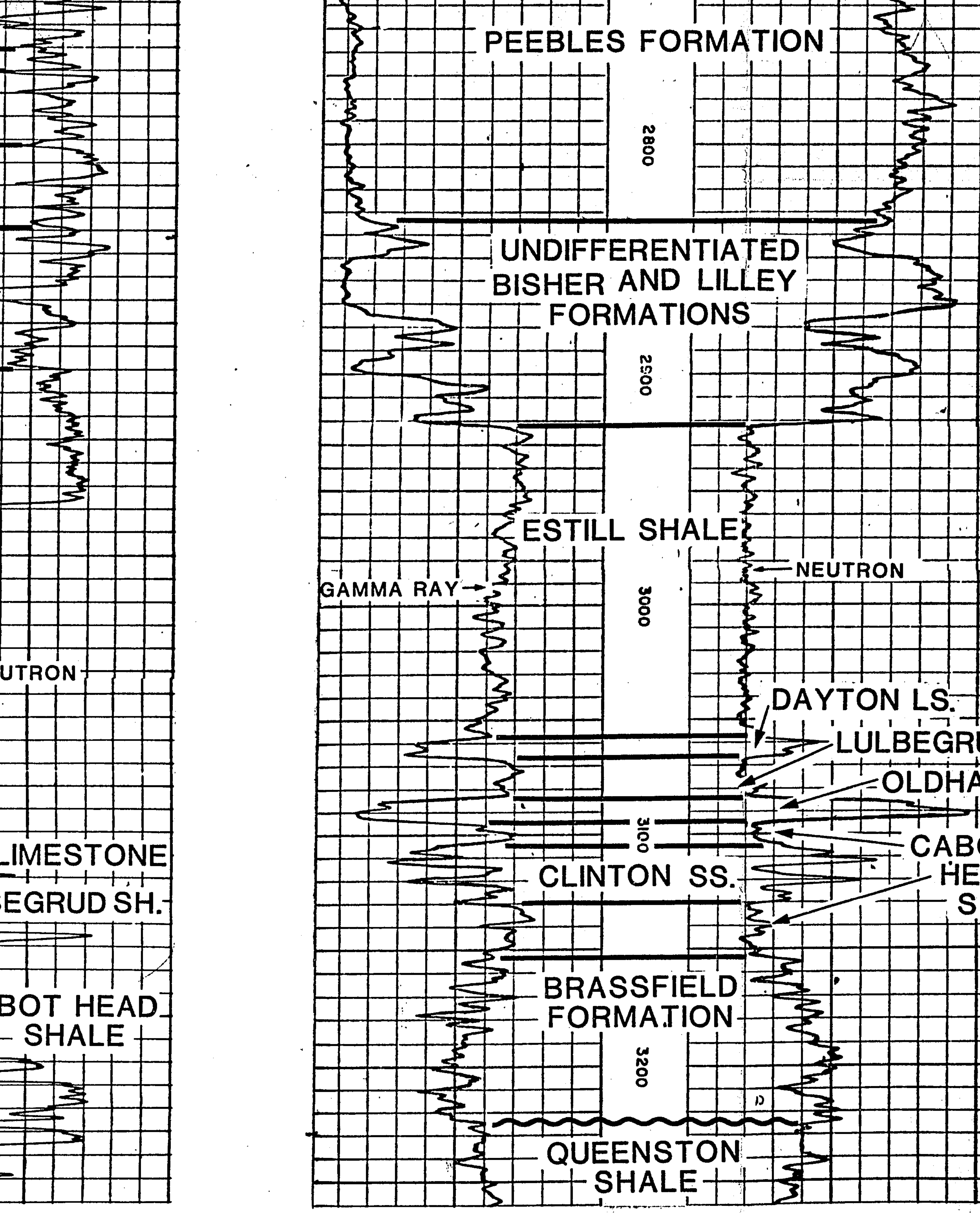
WINDSOR TWP. PERMIT 221





TYMOCHTEE FORMATION
(SUB-C UNIT)
GREENFIELD
0090
FORMATION
PEEBLES FORMATION
0700
LILLEY FORMATION
BISHER FORMATION
0800
ESTILL SHALE
NEUTRON
GAMMA RAY
0900
DAYTON LS.
LULBEGRUD S
OLDHAM LIMESTO
CABOT HEAD
SHALE
1000
BRASSFIELD FORMATION
QUEENSTON SHALE


C UNIT
TYMOCHTEE FORMATION
(SUB-C UNIT)
GREENFIELD FORMATION
UNDIFFERENTIATED
LOCKPORT GROUP
1000
BISHER FORMATION
1100
ESTILL SHALE
GAMMA RAY
NEUTR
1200
DAYTON LIM
LULBEG
OLDHAM LS.
1300
CABO
S
BRASSFIELD FORMATION
QUEENSTON SHALE
RUD SHALE
MESTONE
N



UTRON
LIMESTONE
EGRUD SH.
BOT HEAD
SHALE
PEEBLES FORMATION
2800
UNDIFFERENTIATED
BISHER AND LILLEY
FORMATIONS
2900
ESTILL SHALE
NEUTRON
GAMMA RAY
3000
DAYTON LS.
LULBEGRU
OLDHA
3100
CABO
HE
S
CLINTON SS.
BRASSFIELD
FORMATION
3200
QUEENSTON
SHALE

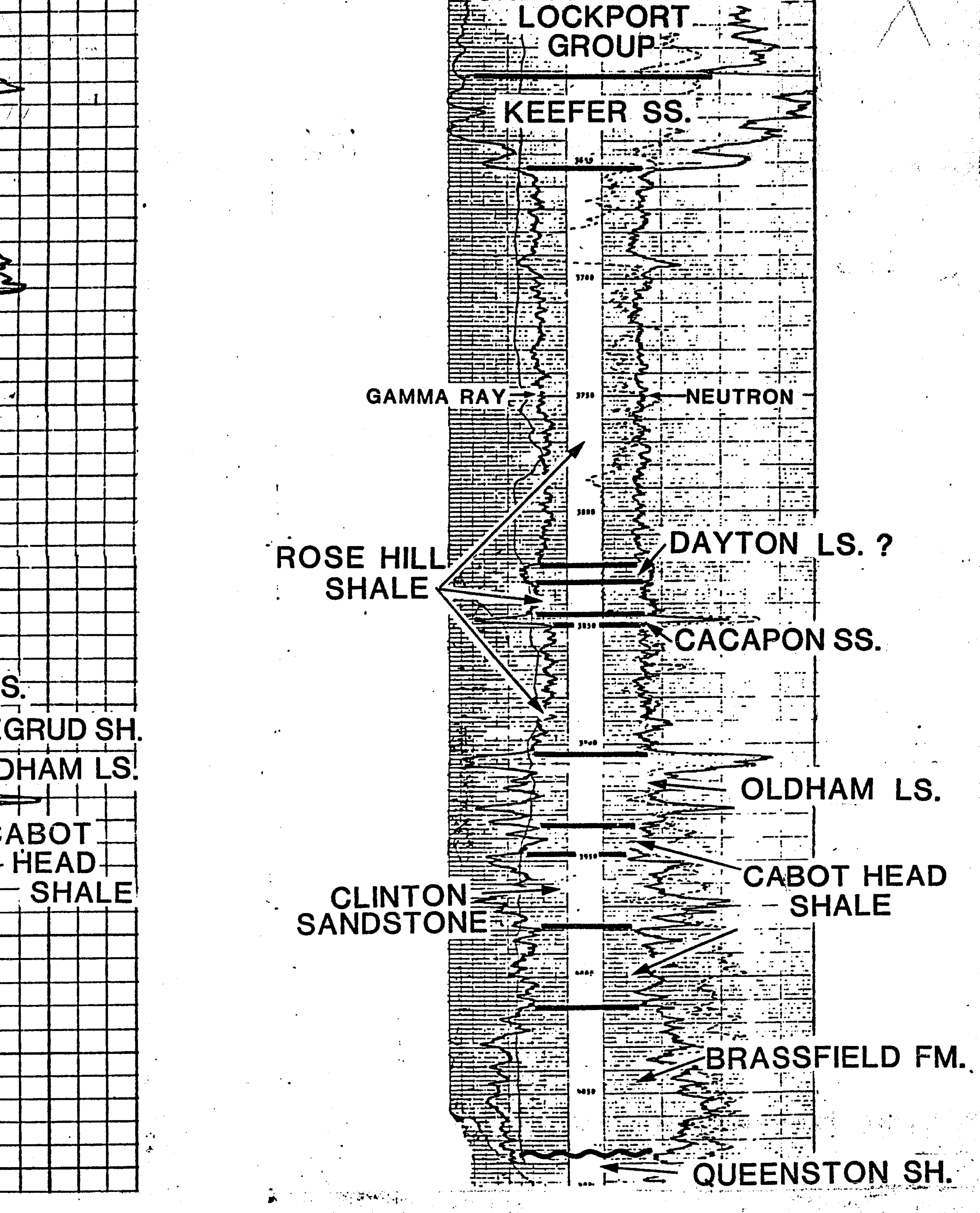

LOCKPORT GROUP
KEEFER SS.
GAMMA RAY
NEUTRON
ROSE HILL SHALE
DAYTON LS. ?
CACAPON SS.
OLDHAM LS.
CABOT HEAD SHALE
CLINTON SANDSTONE
BRASSFIELD FM.
QUEENSTON SH.

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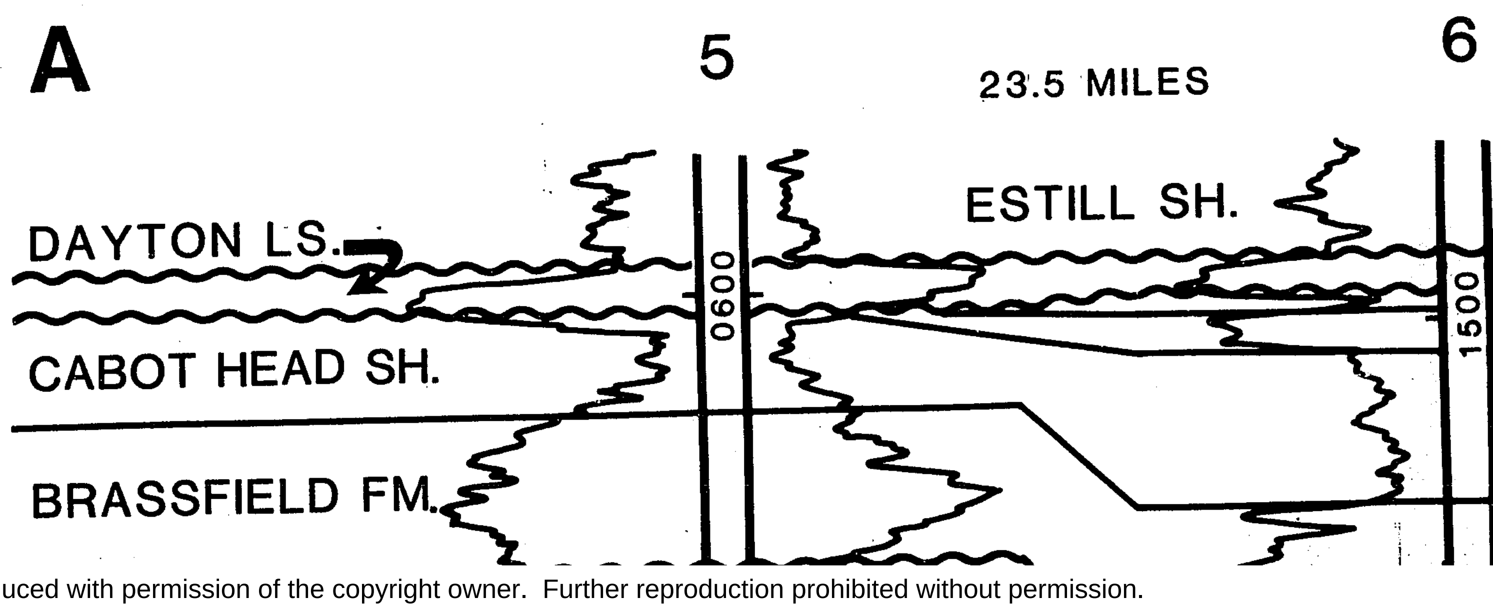
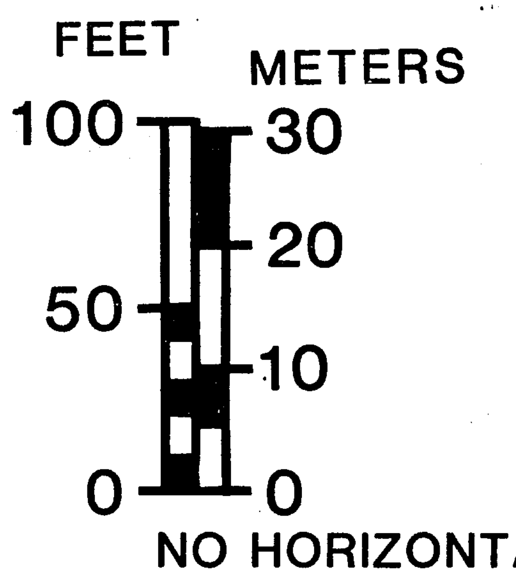
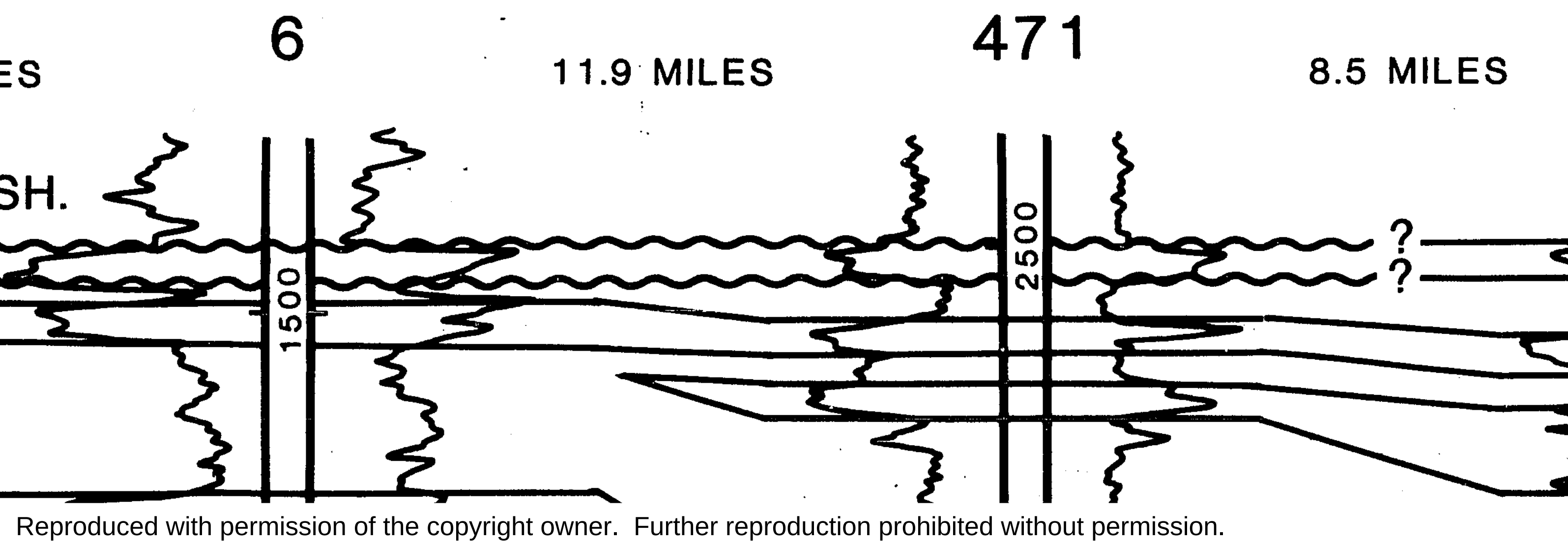
FIGURE 9. NUCLEAR LOG CROSS S
IDENTIFICATION AND CO
LOWER CLINTON GROU



CROSS SECTIONS SHOWING GEOPHYS
N AND CORRELATION OF THE MEDINA A
ON GROUPS

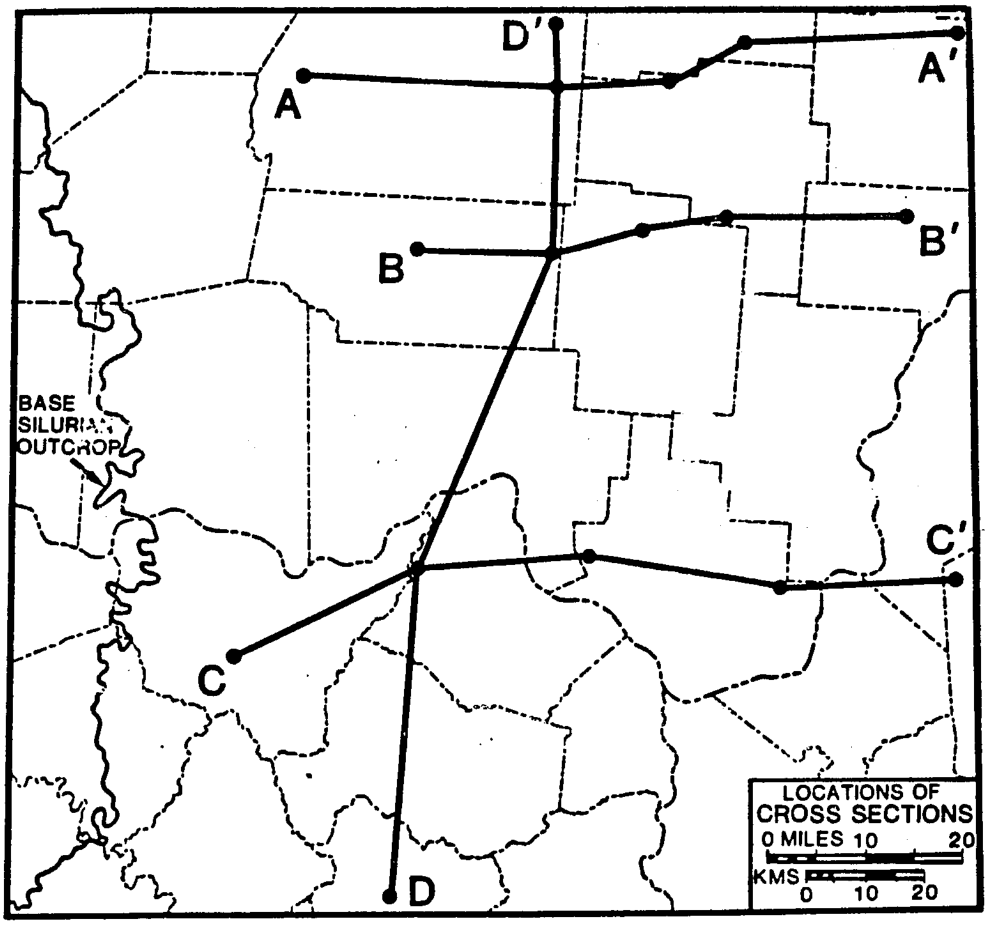




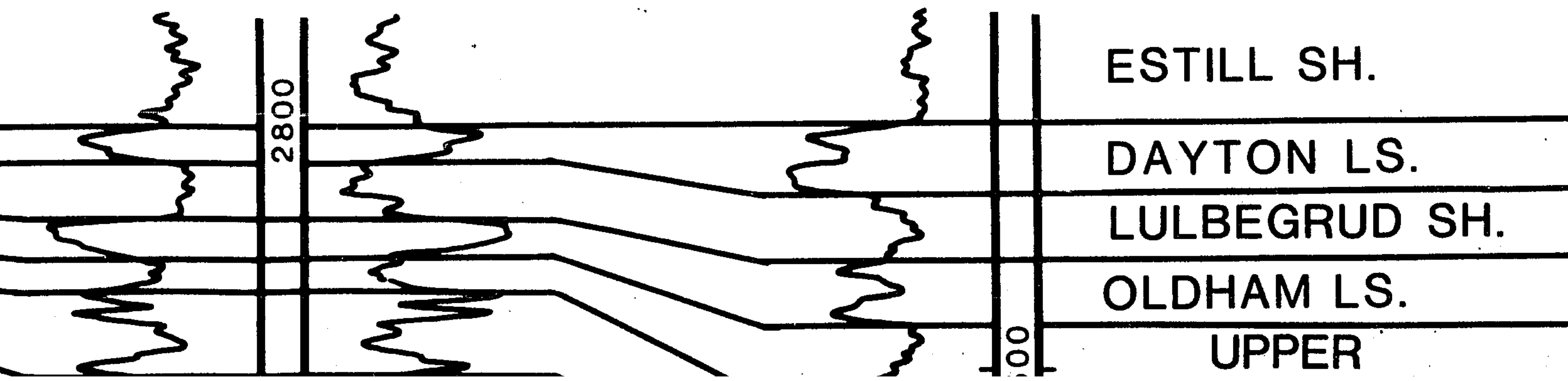
YSICAL
A AND

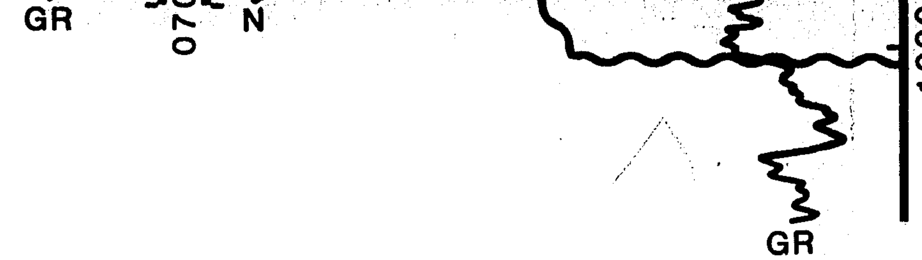
RS

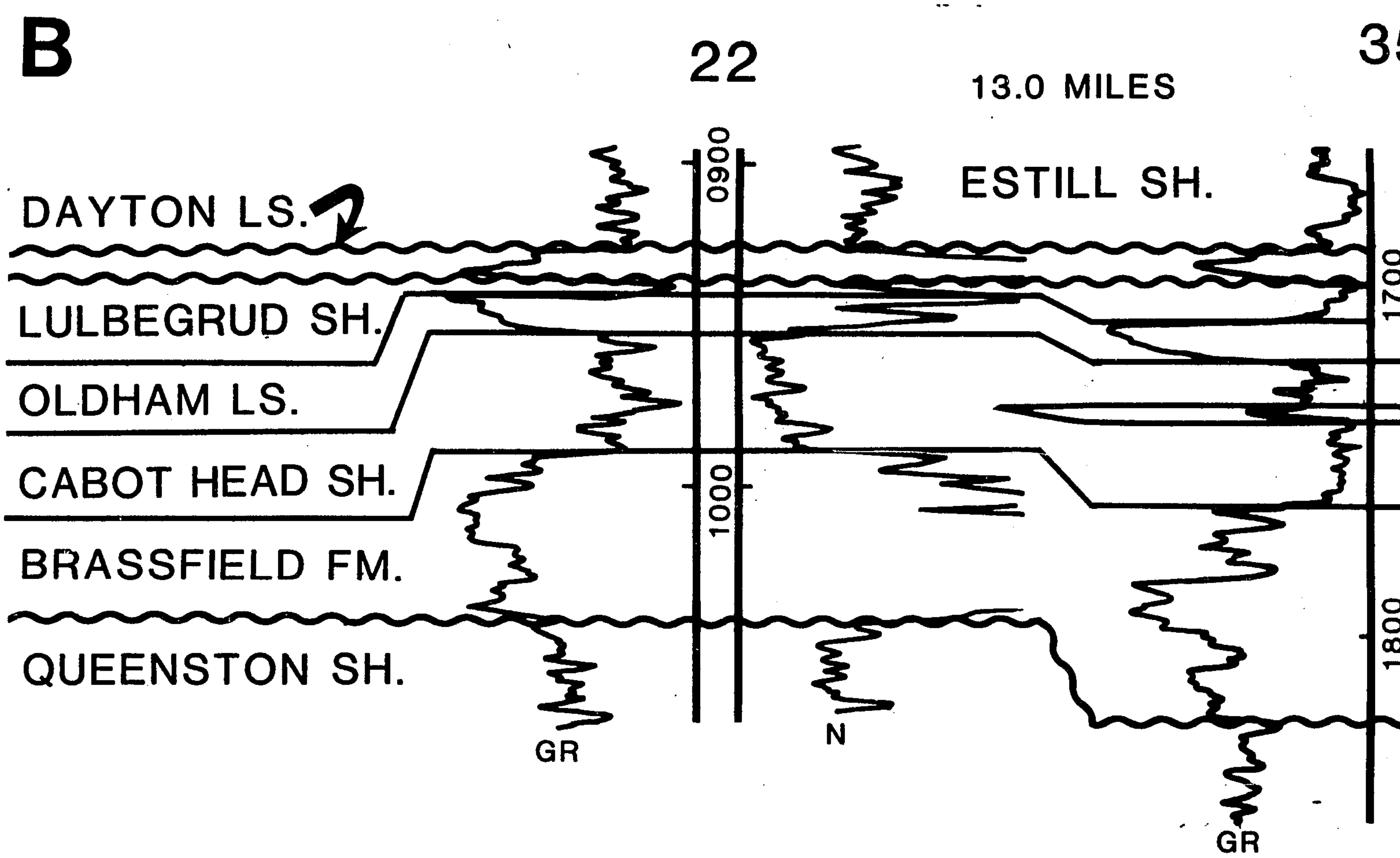
ONTAL SCALE

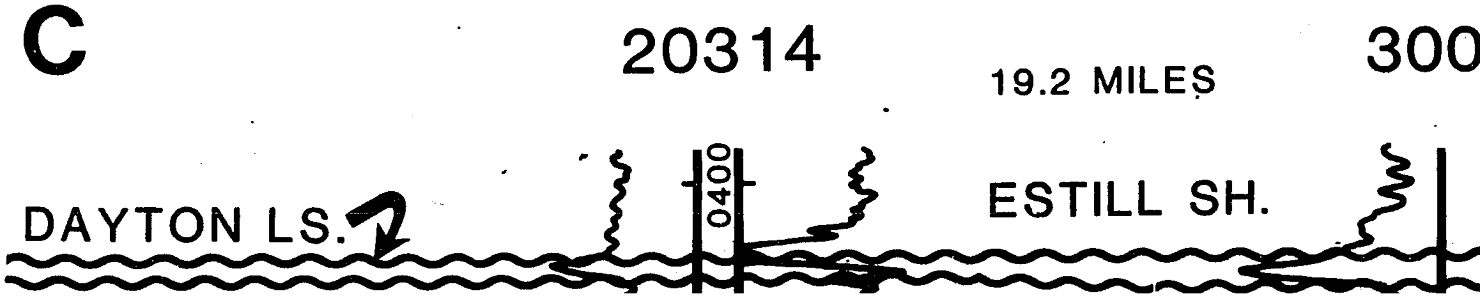


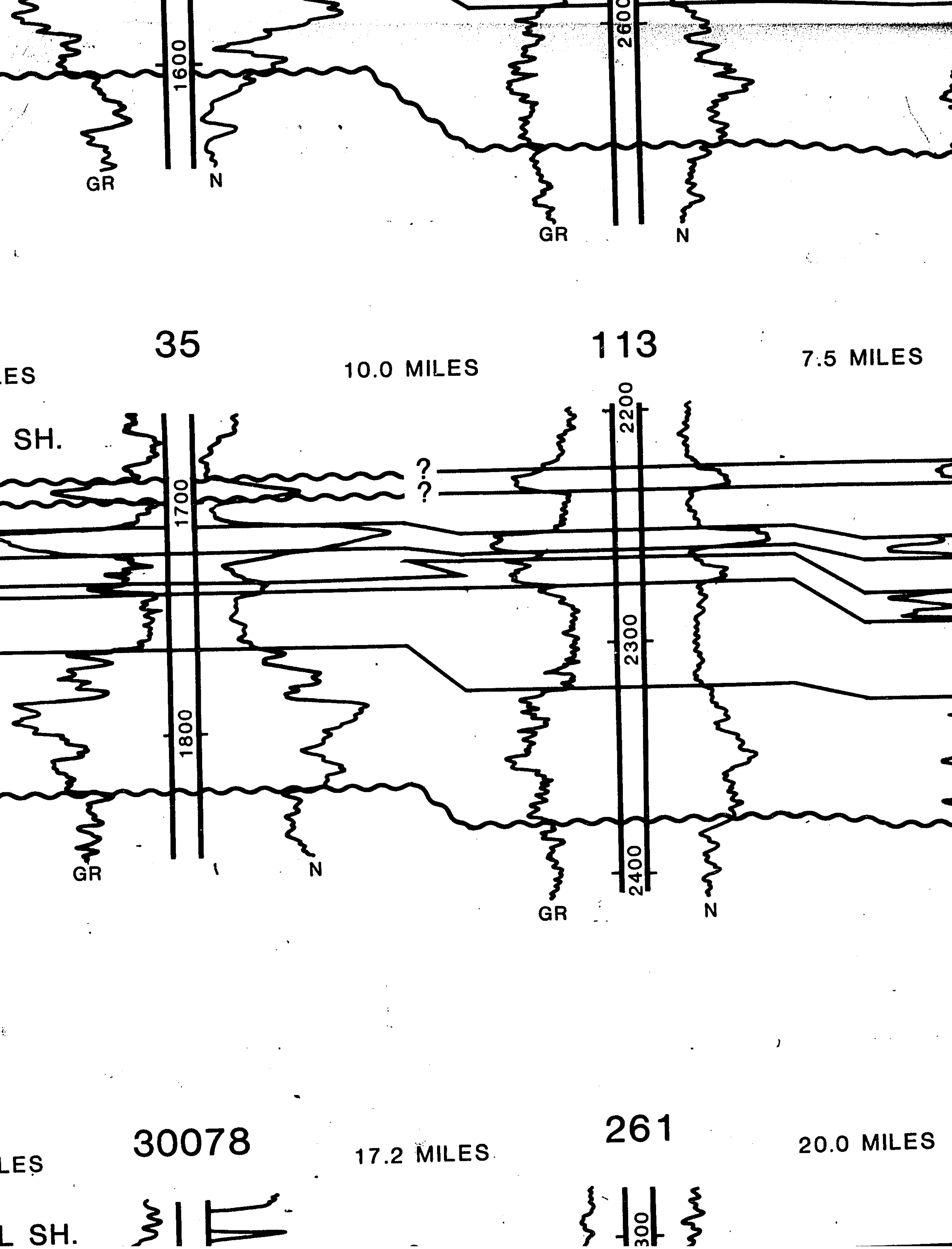
ES 2389 24.7 MILES 3008 A’

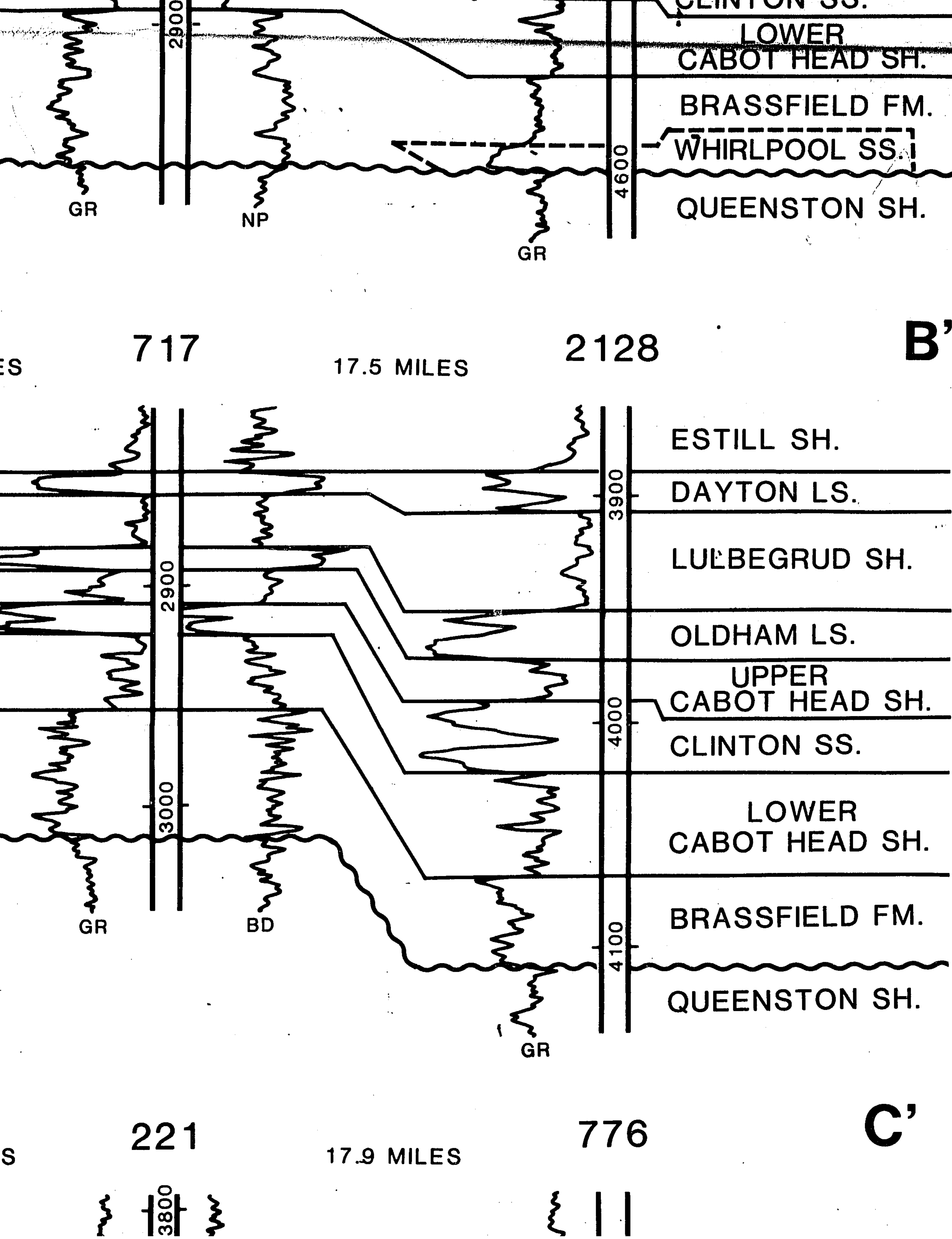


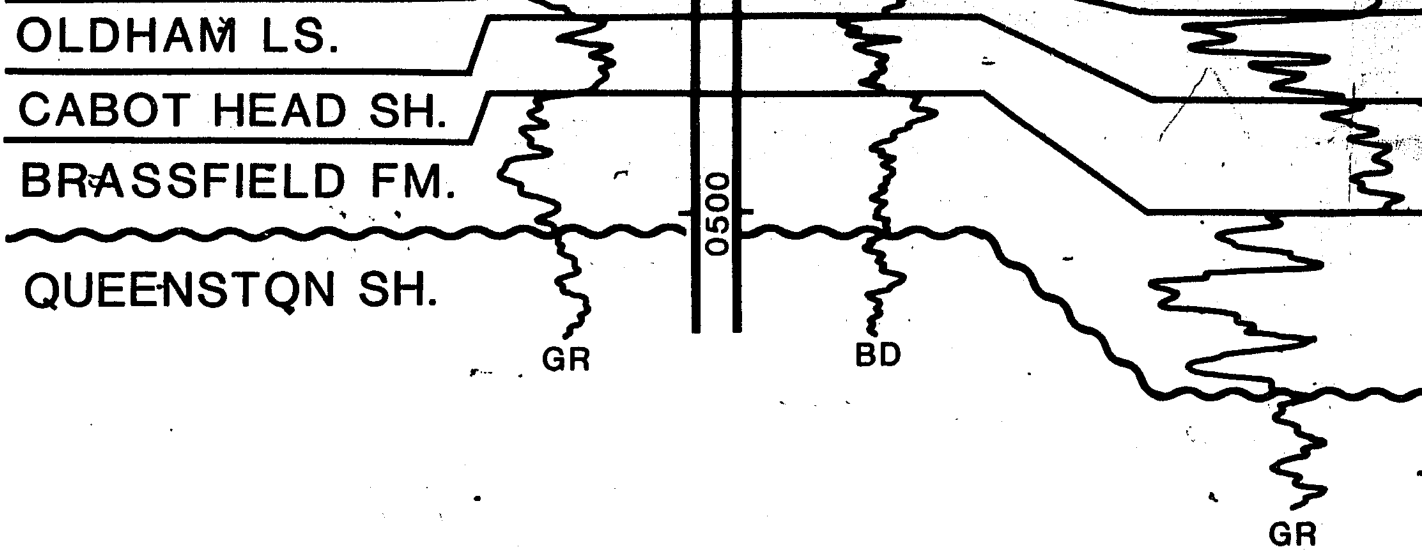

GR
N
GR

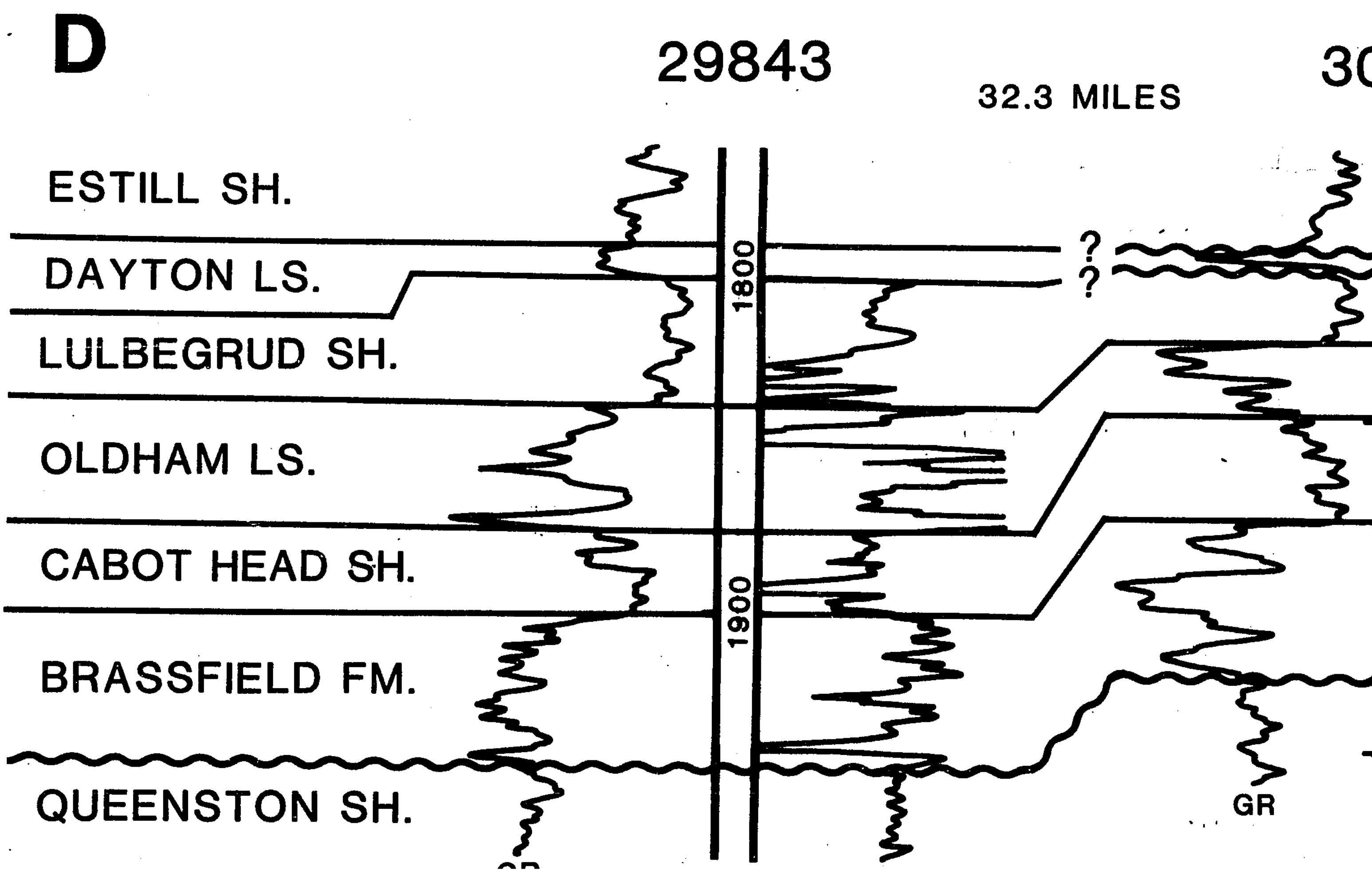

B
22
13.0 MILES
0900
ESTILL SH.
DAYTON LS.
1700
LULBEGRUD SH.
OLDHAM LS.
CABOT HEAD SH.
1000
BRASSFIELD FM.
1800
QUEENSTON SH.
GR
N
GR

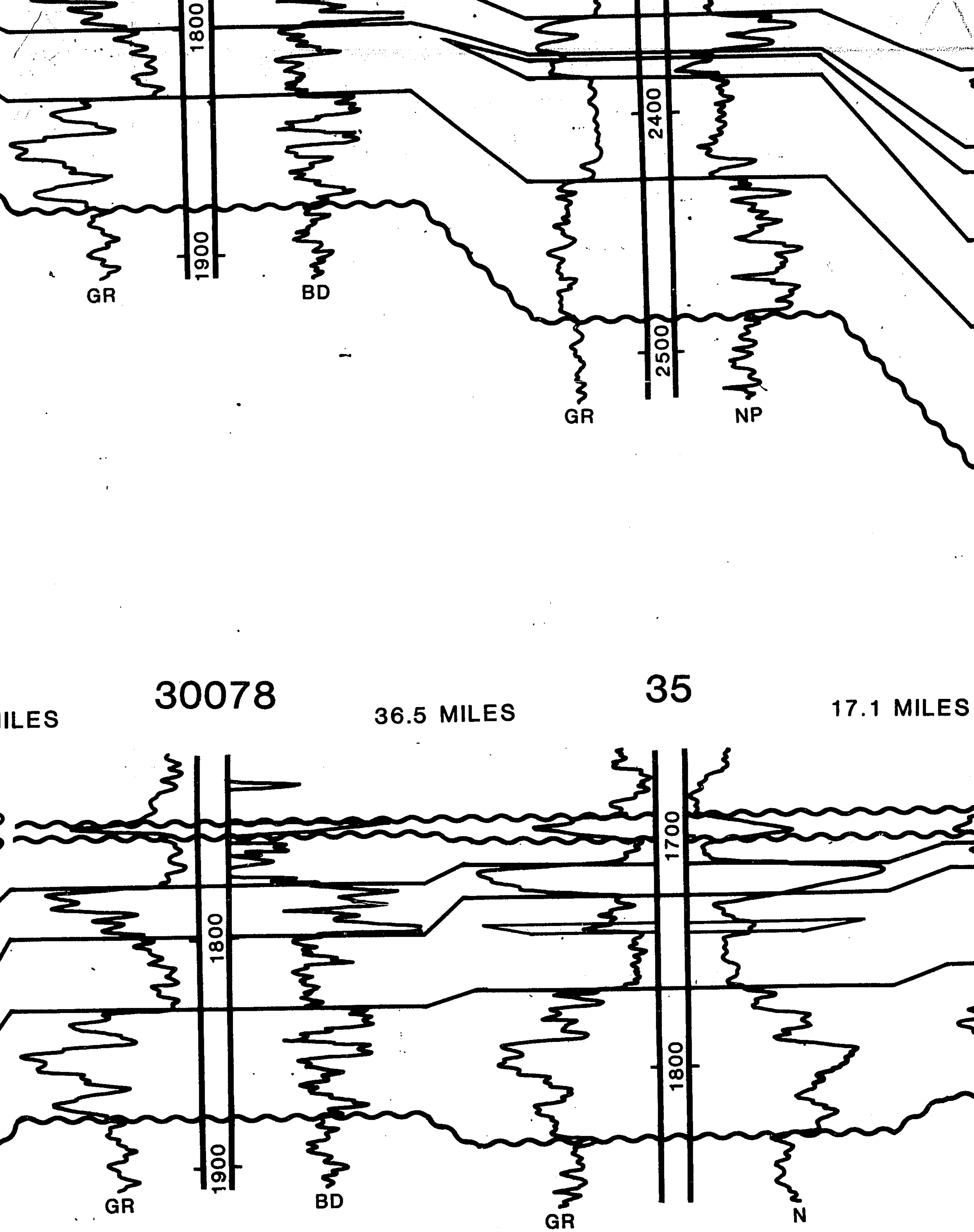

C
20314
19.2 MILES
0400
ESTILL SH.
DAYTON LS.


1600
GR
N
2600
GR
N
35
10.0 MILES
113
7.5 MILES
SH.
1700
?
?
2200
2300
1800
2400
GR
N
GR
N
30078
17.2 MILES
261
20.0 MILES
L SH.
300


CLINTON SS.
LOWER CABOT HEAD SH.
BRASSFIELD FM.
WHIRLPOOL SS.
QUEENSTON SH.
2900
4600
GR
NP
GR
B'
717
17.5 MILES
2128
ESTILL SH.
DAYTON LS.
LULBEGRUD SH.
OLDHAM LS.
UPPER CABOT HEAD SH.
CLINTON SS.
LOWER CABOT HEAD SH.
BRASSFIELD FM.
QUEENSTON SH.
2900
3000
3900
4000
4100
GR
BD
GR
C'
221
17.9 MILES
776
3800


OLDHAM LS.
CABOT HEAD SH.
BRASSFIELD FM.
QUEENSTON SH.
0500
GR
BD
GR


D
29843
32.3 MILES
ESTILL SH.
DAYTON LS.
LULBEGRUD SH.
OLDHAM LS.
CABOT HEAD SH.
BRASSFIELD FM.
QUEENSTON SH.
1800
1900
?
?
GR


1800
1900
GR
BD
2400
2500
GR
NP
ILES
30078
36.5 MILES
35
17.1 MILES
1800
1900
GR
BD
1700
1800
GR
N

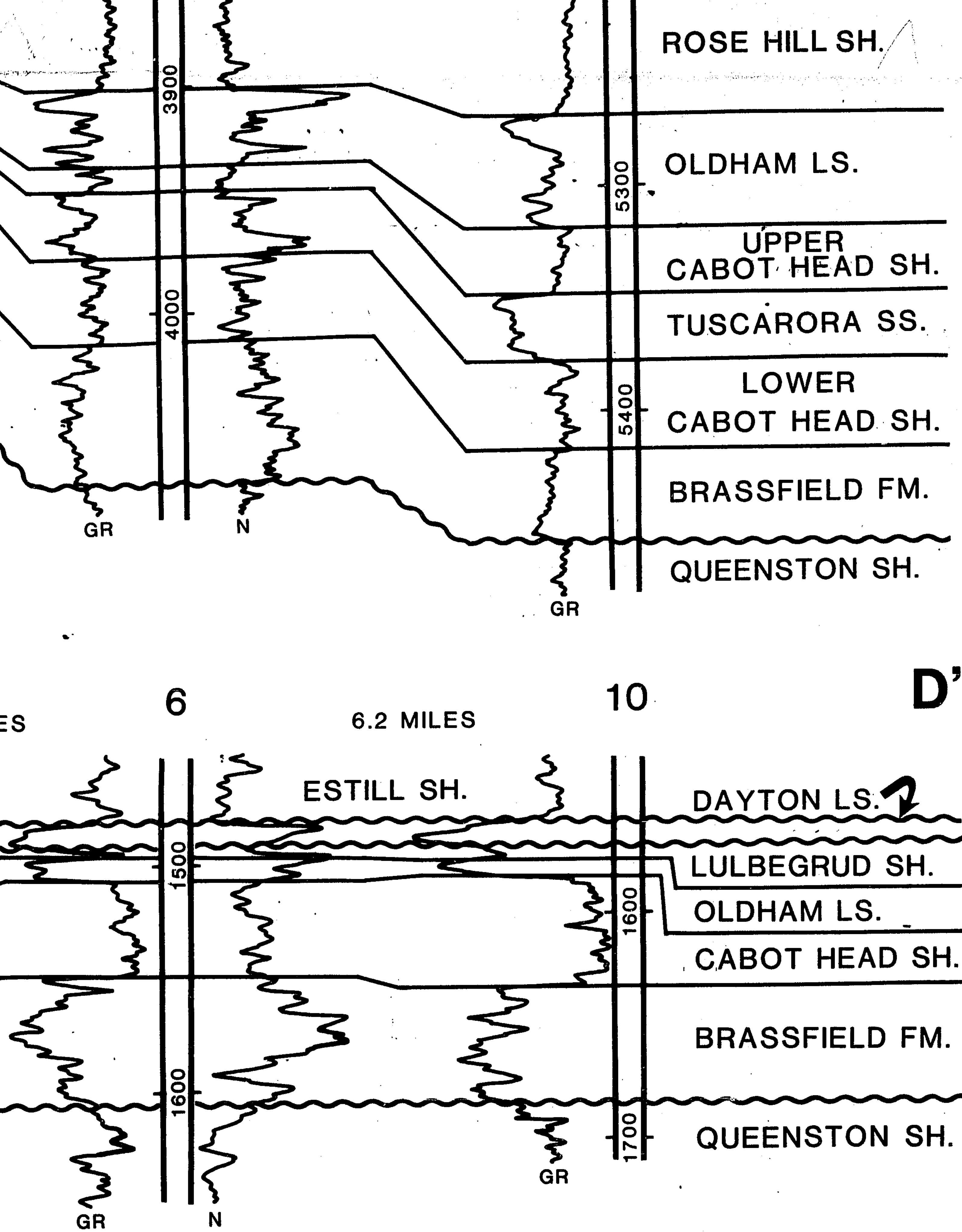

ROSE HILL SH.
3900
OLDHAM LS.
5300
UPPER CABOT HEAD SH.
4000
TUSCARORA SS.
LOWER CABOT HEAD SH.
5400
BRASSFIELD FM.
QUEENSTON SH.
GR
N
GR
6
10
D'
ES
6.2 MILES
ESTILL SH.
DAYTON LS.
LULBEGRUD SH.
1500
1600
OLDHAM LS.
CABOT HEAD SH.
BRASSFIELD FM.
1600
1700
QUEENSTON SH.
GR
N
GR

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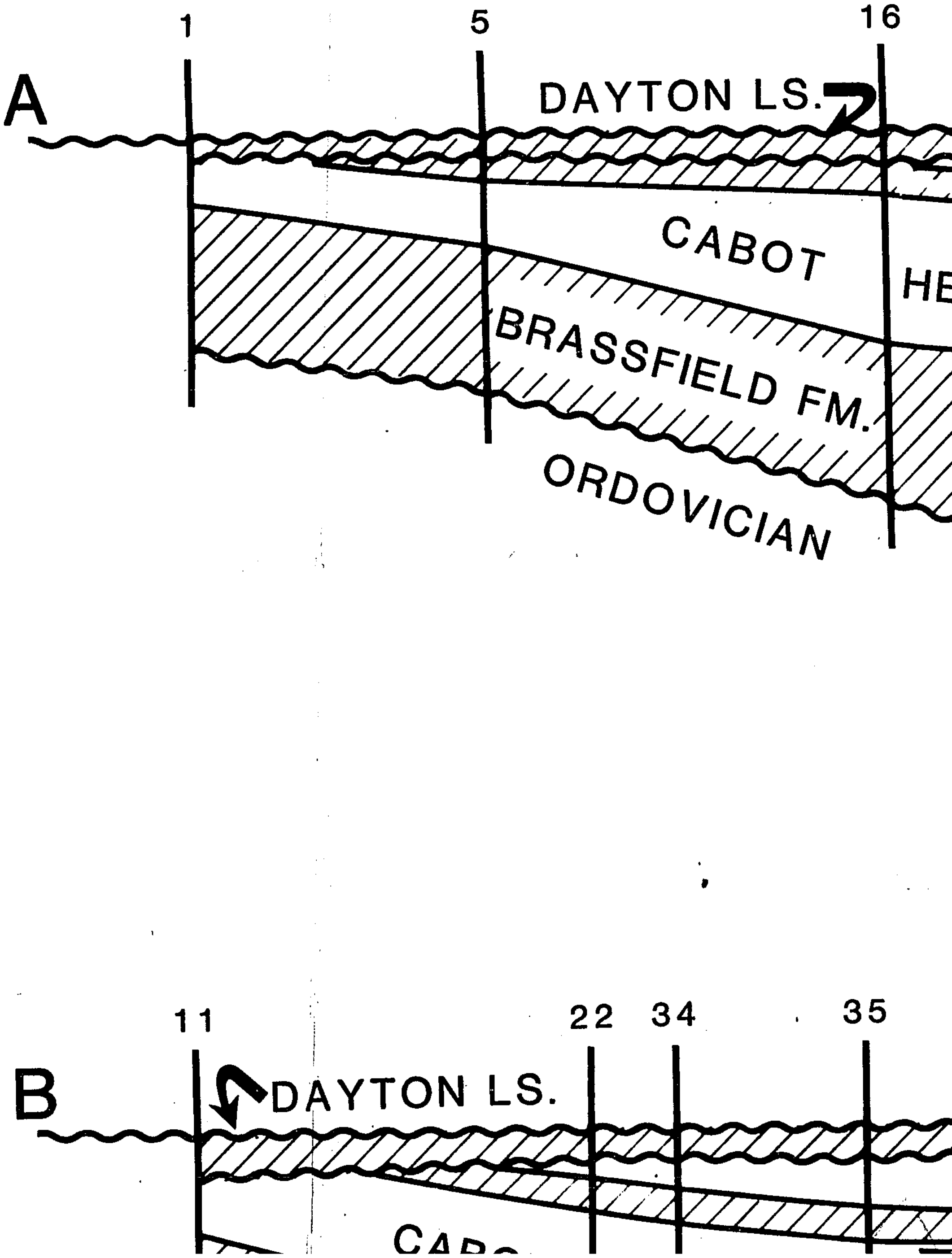
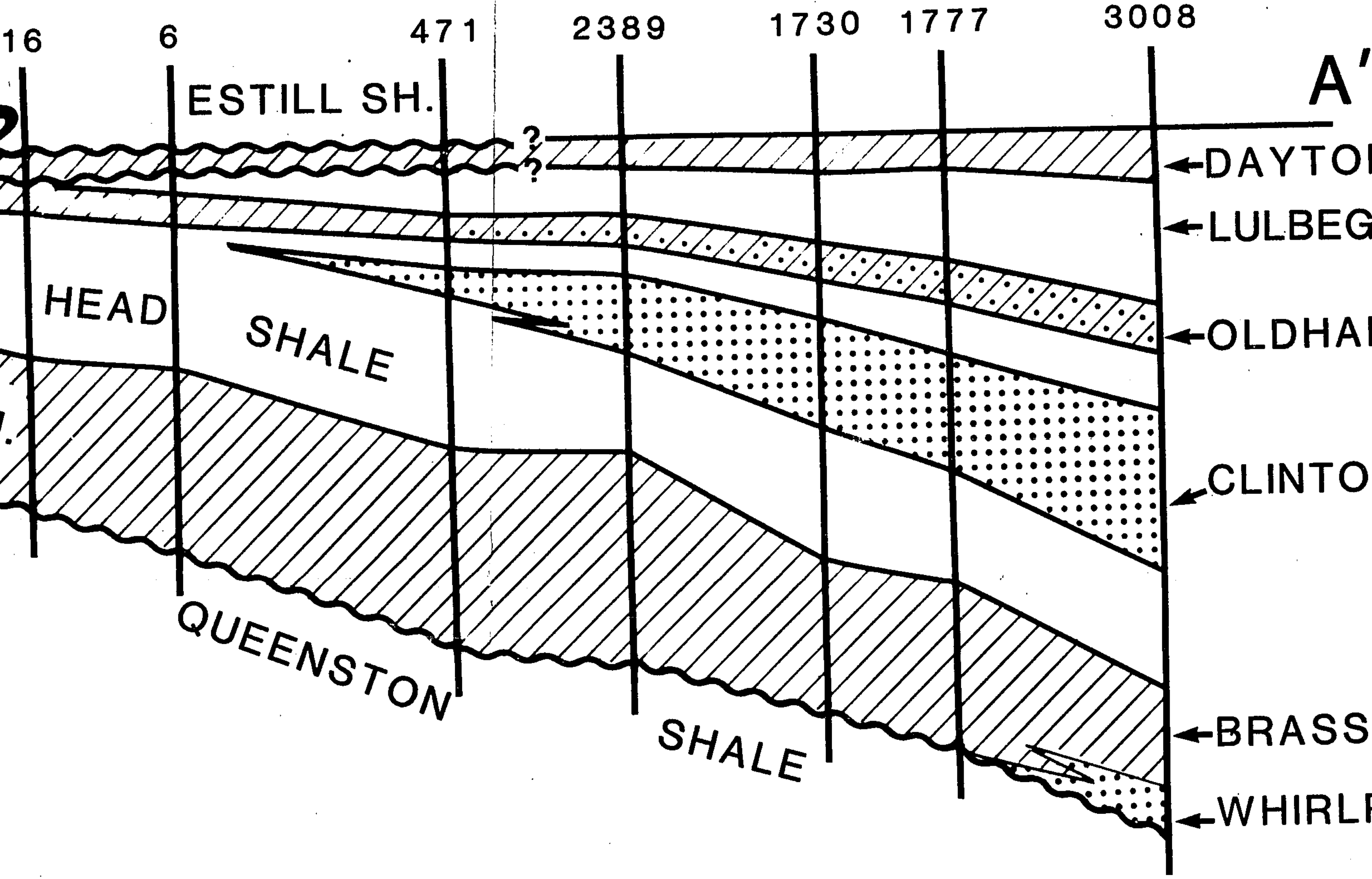
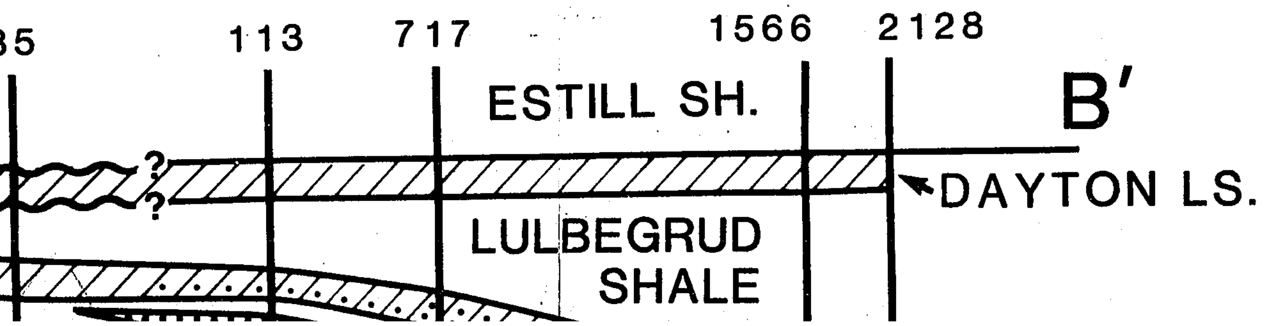
FIGURE 10. CROSS SECT

THE MEDINA

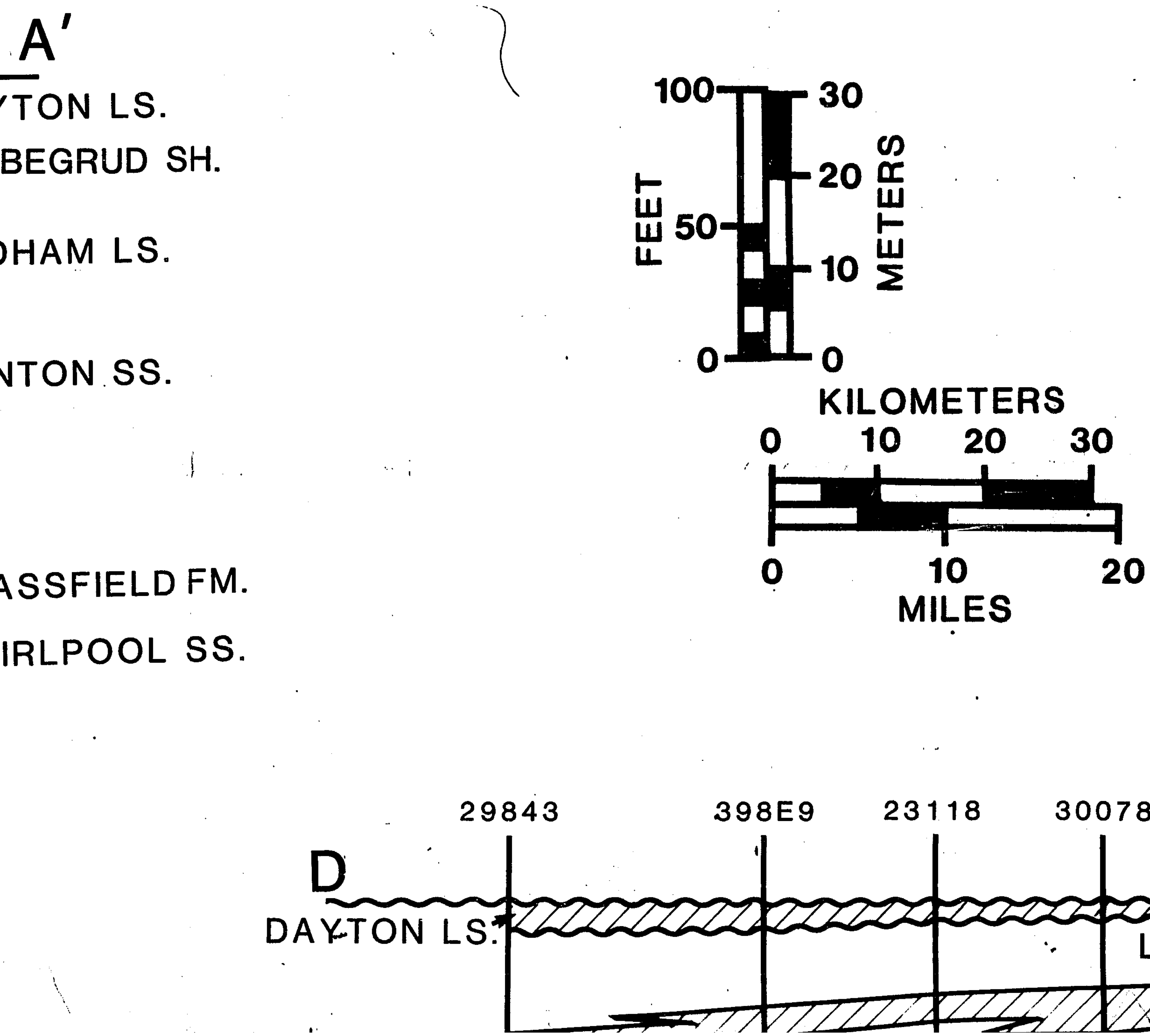


ECTIONS SHOWING STRATIGRAPHIC RE
NA AND LOWER CLINTON GROUPS

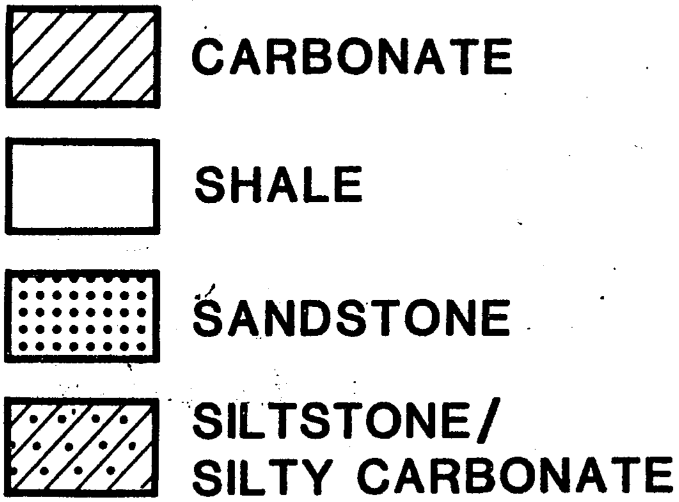


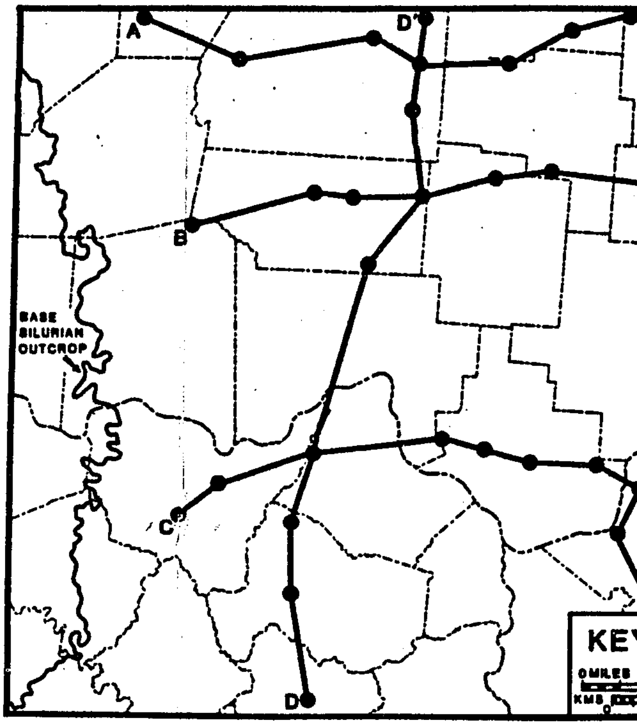


RELATIONS, GENERAL LITHOLOGY, AI

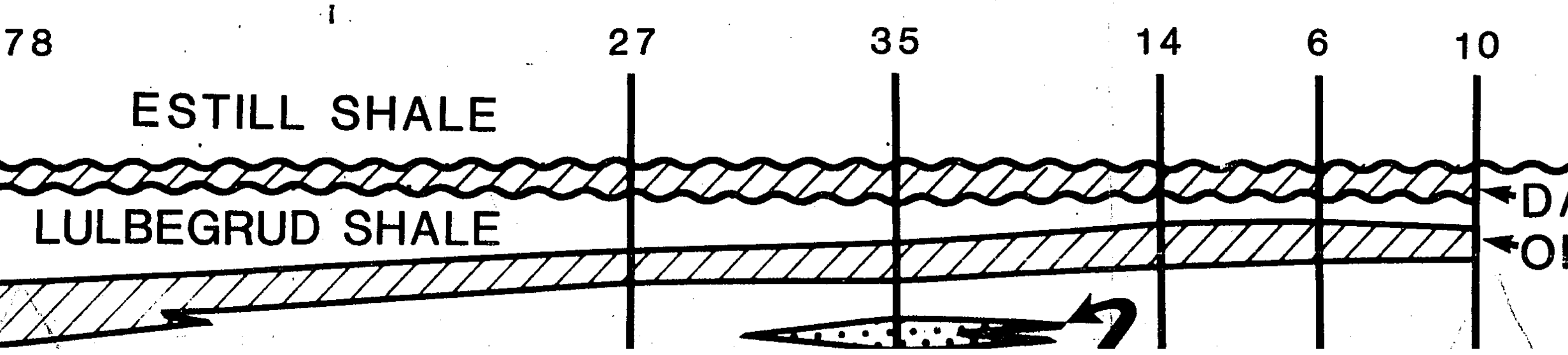


AND THICKNESS OF





H
20



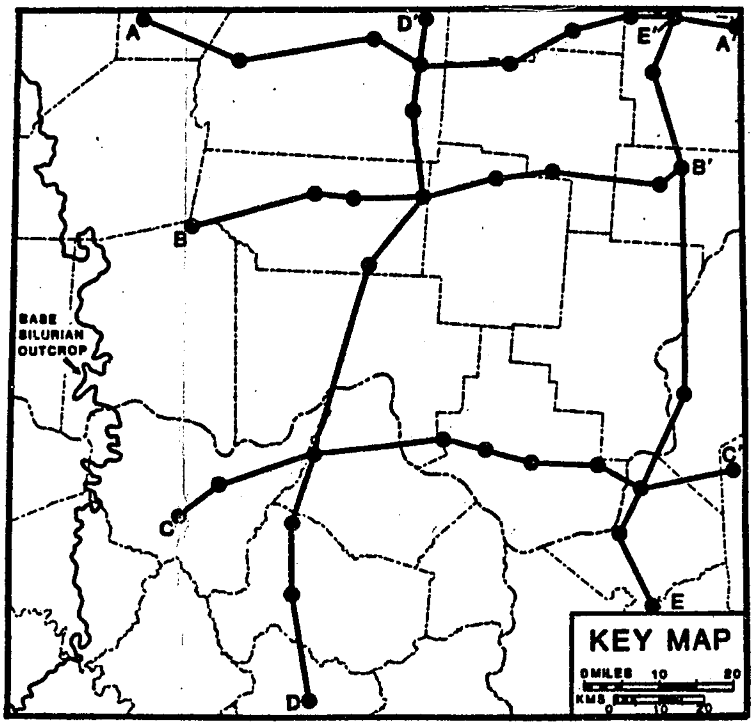
ICKNESS OF

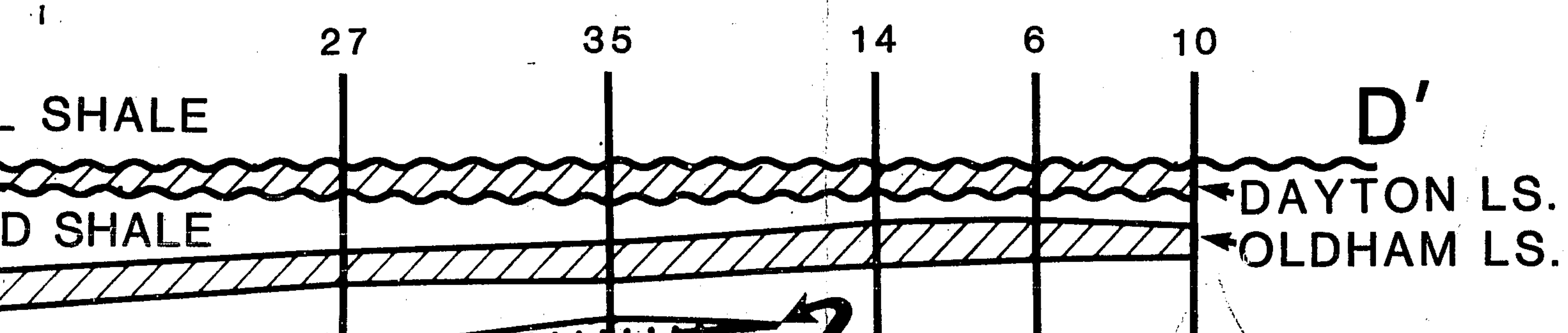
CARBONATE

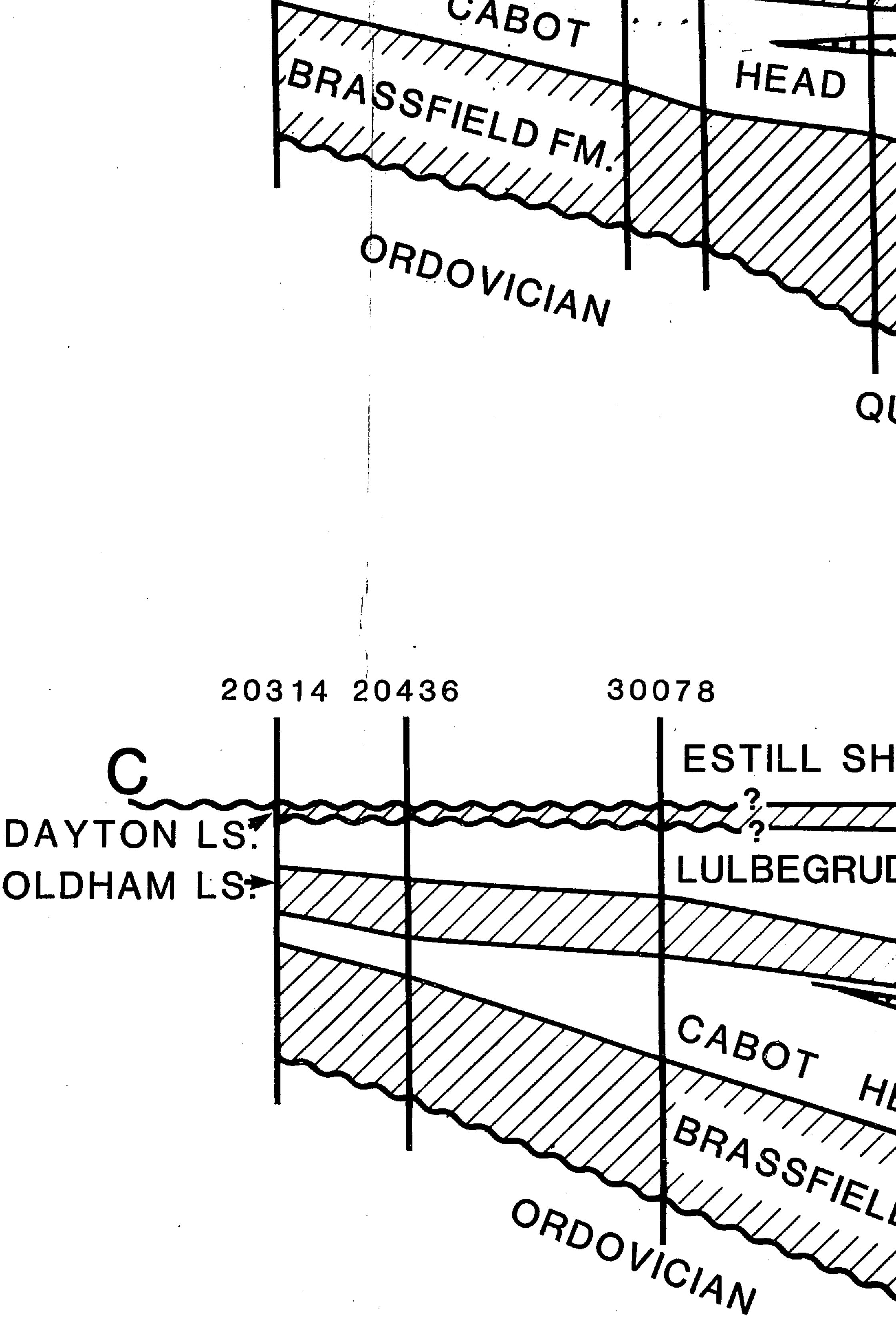
SHALE

SANDSTONE

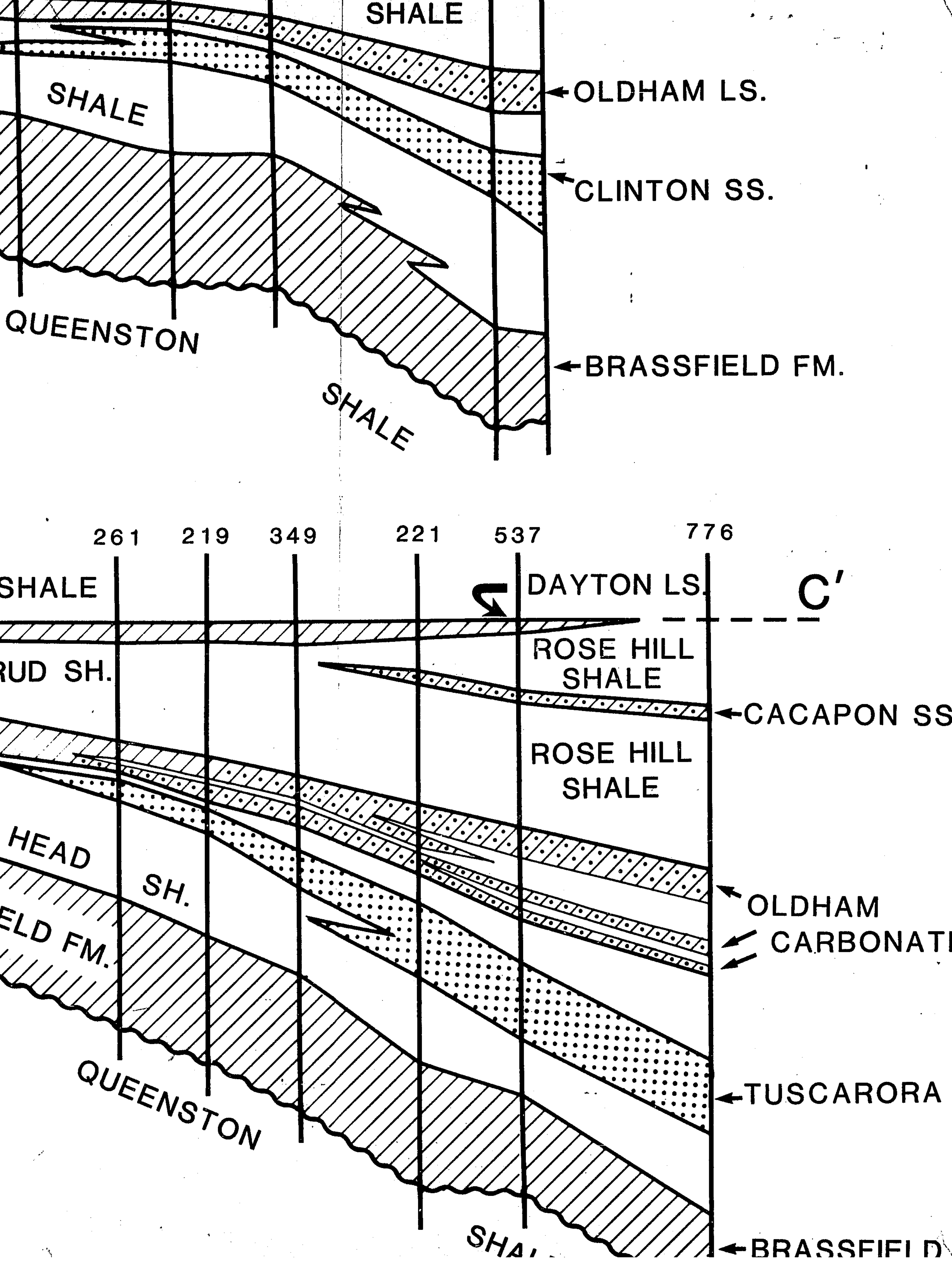
SILTSTONE/
SILTY CARBONATE



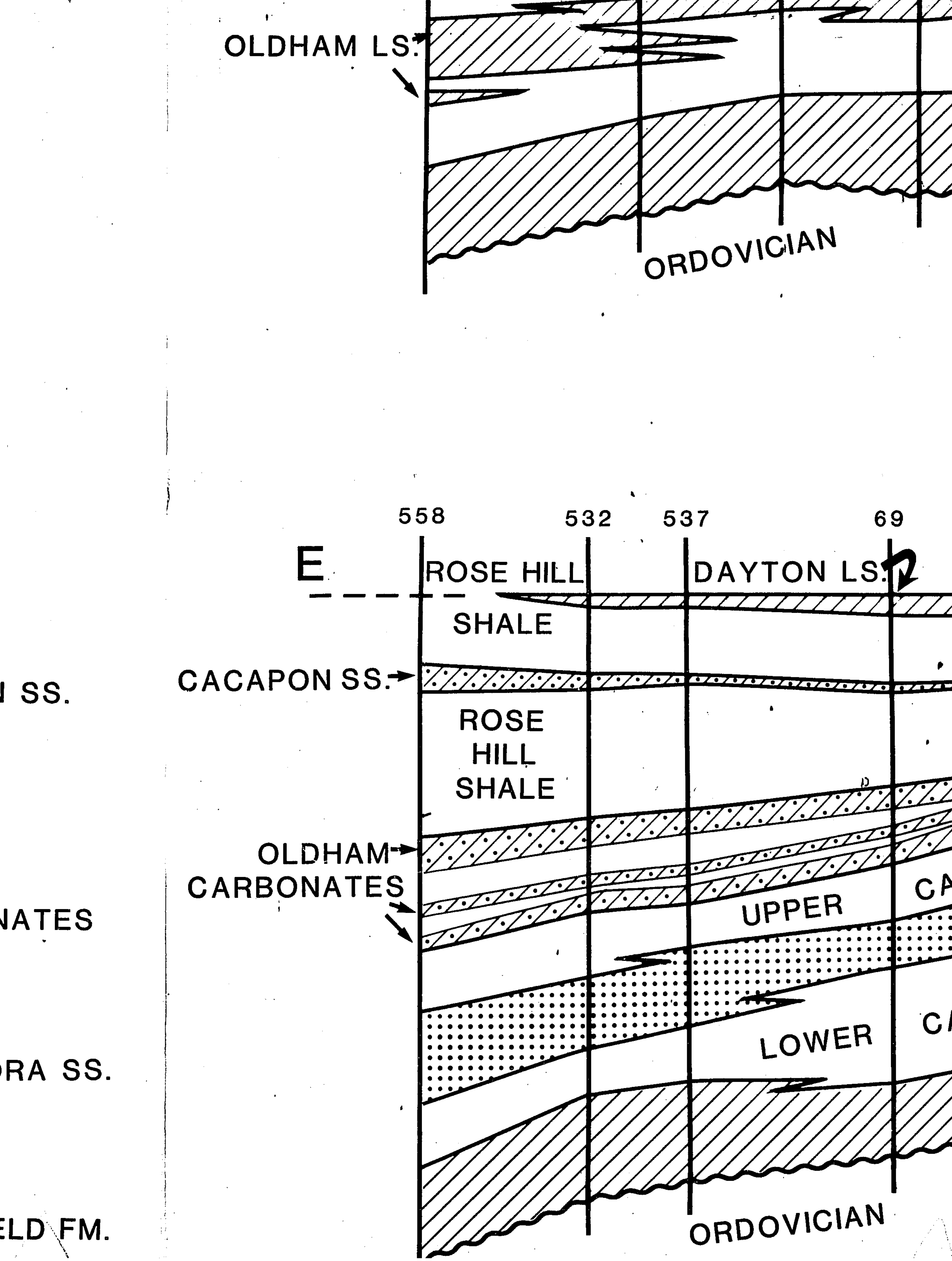


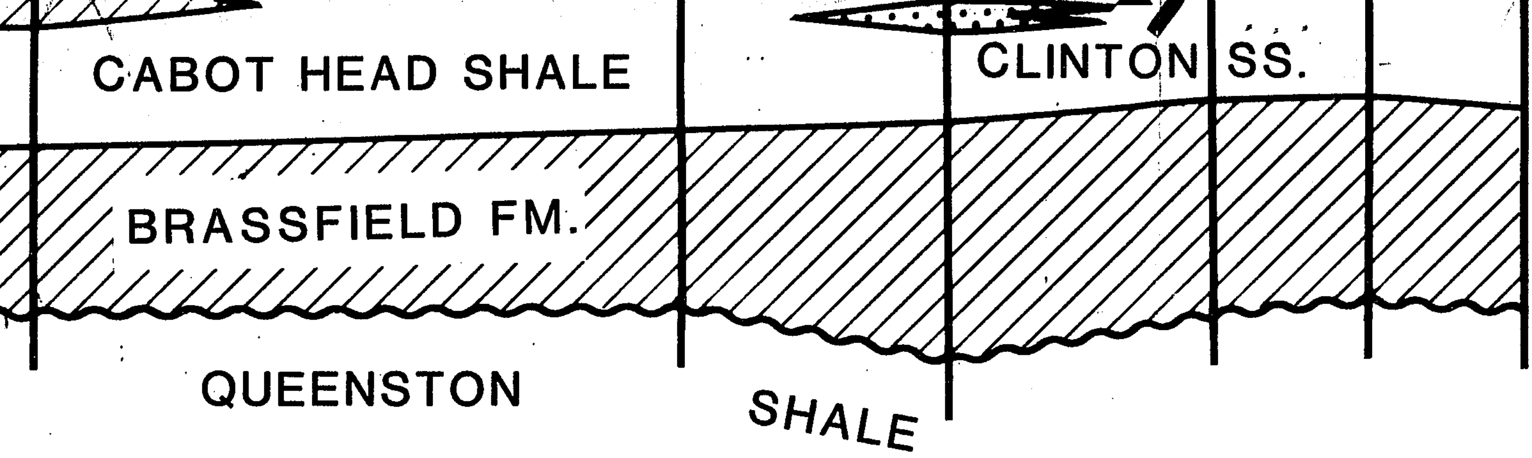


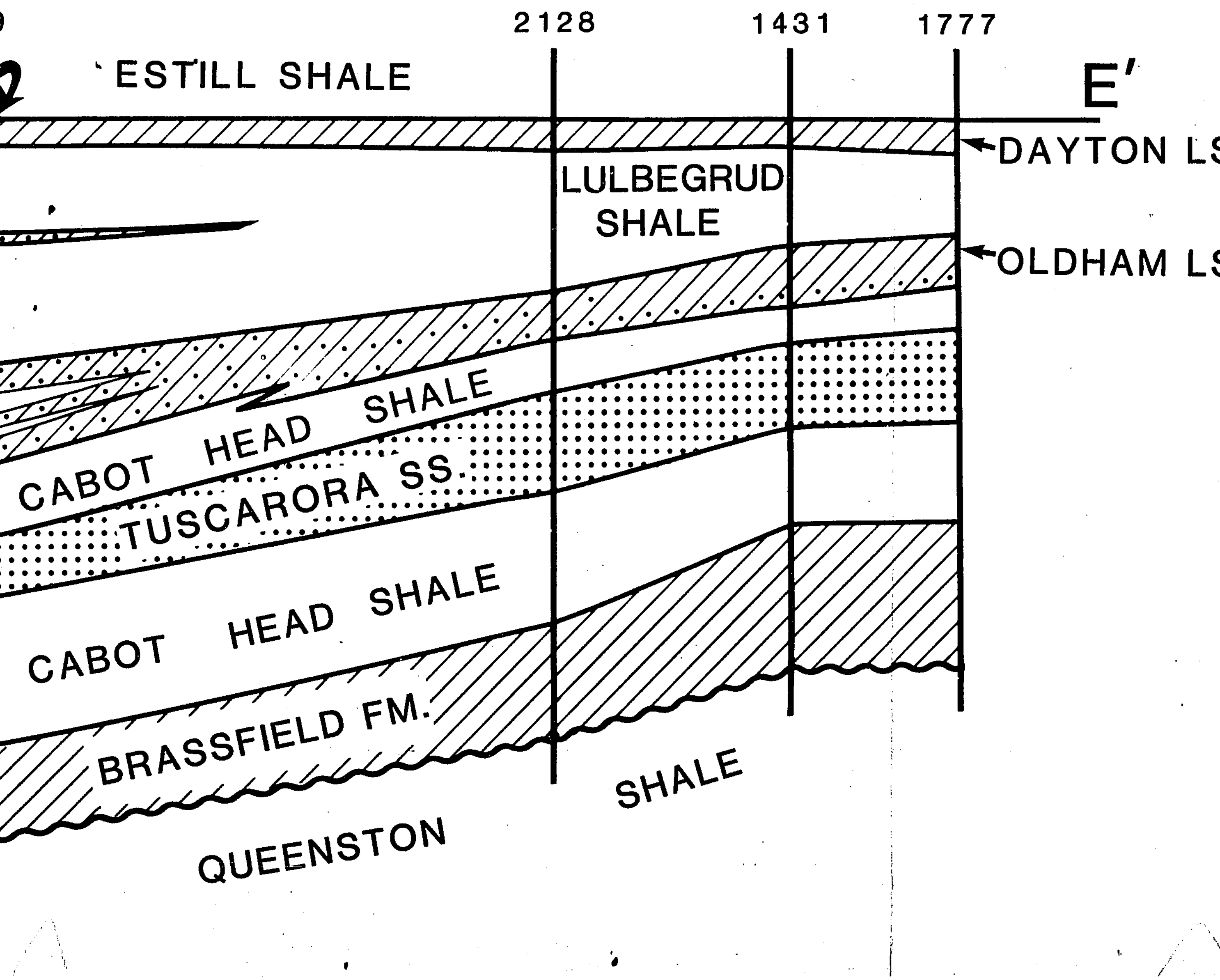
CABOT
HEAD
BRASSFIELD FM.
ORDOVICIAN
QU
20314
20436
30078
C
ESTILL SH
DAYTON LS.
OLDHAM LS.
LULBEGRUD
CABOT
HE
BRASSFIELD
ORDOVICIAN

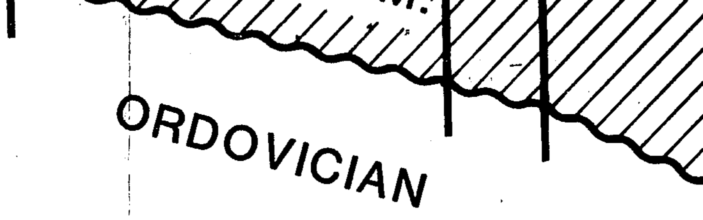


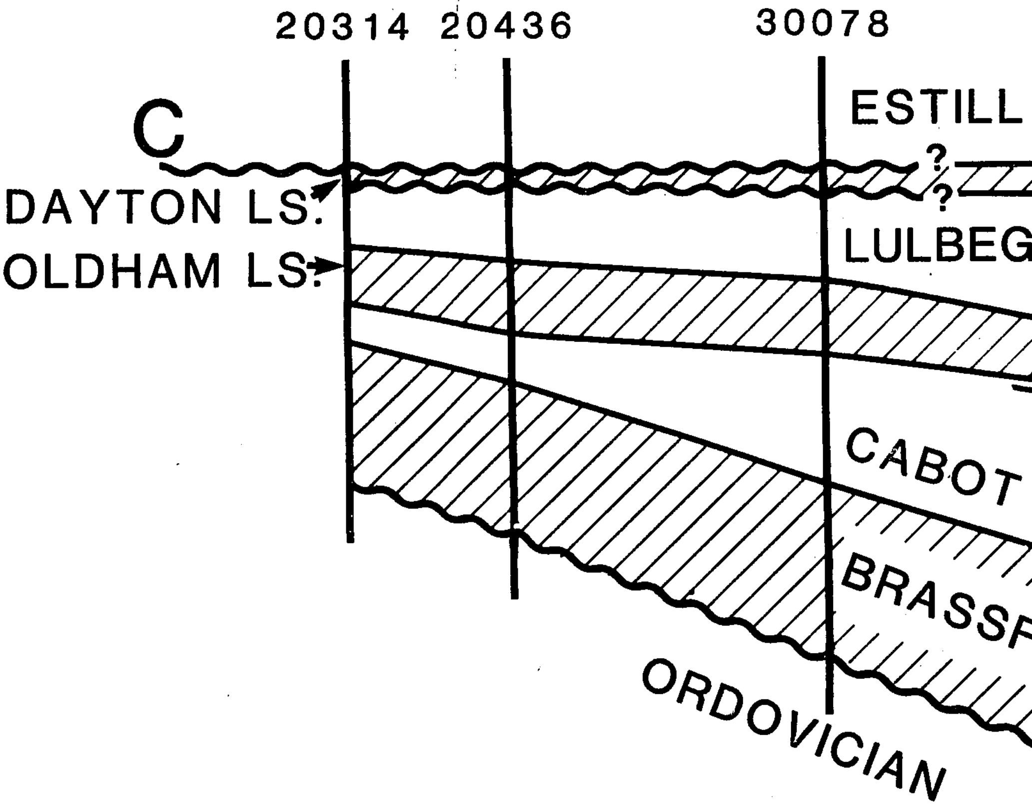
SHALE
OLDHAM LS.
SHALE
CLINTON SS.
QUEENSTON
BRASSFIELD FM.
SHALE
261
219
349
221
537
776
SHALE
DAYTON LS.
C′
RUD SH.
ROSE HILL SHALE
CACAPON SS
ROSE HILL SHALE
HEAD
SH.
ELD FM.
OLDHAM
CARBONATE
QUEENSTON
TUSCARORA
BRASSFIELD

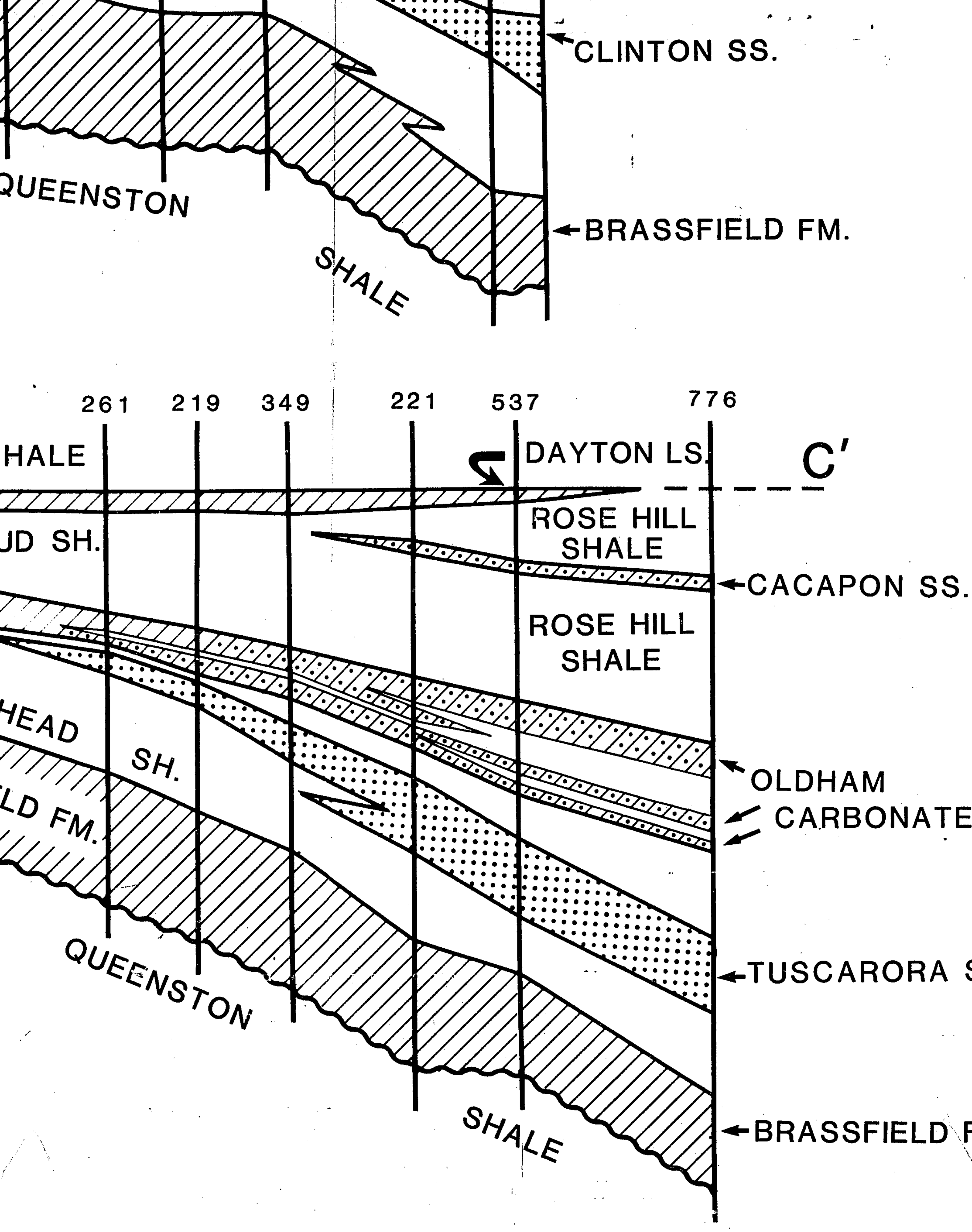

OLDHAM LS.
ORDOVICIAN
558
532
537
69
E
ROSE HILL
DAYTON LS.
SHALE
CACAPON SS.
ROSE
HILL
SHALE
OLDHAM
CARBONATES
UPPER
LOWER
ORDOVICIAN
SS.
NATES
RA SS.
ELD FM.


CABOT HEAD SHALE
CLINTON SS.
BRASSFIELD FM.
QUEENSTON
SHALE


2128
1431
1777
ESTILL SHALE
E′
DAYTON LS
LULBEGRUD SHALE
OLDHAM LS
CABOT HEAD SHALE
TUSCARORA SS.
CABOT HEAD SHALE
BRASSFIELD FM.
SHALE
QUEENSTON


ORDOVICIAN


20314
20436
30078
C
ESTILL
DAYTON LS.
LULBEG
OLDHAM LS.
CABOT
BRASSF
ORDOVICIAN

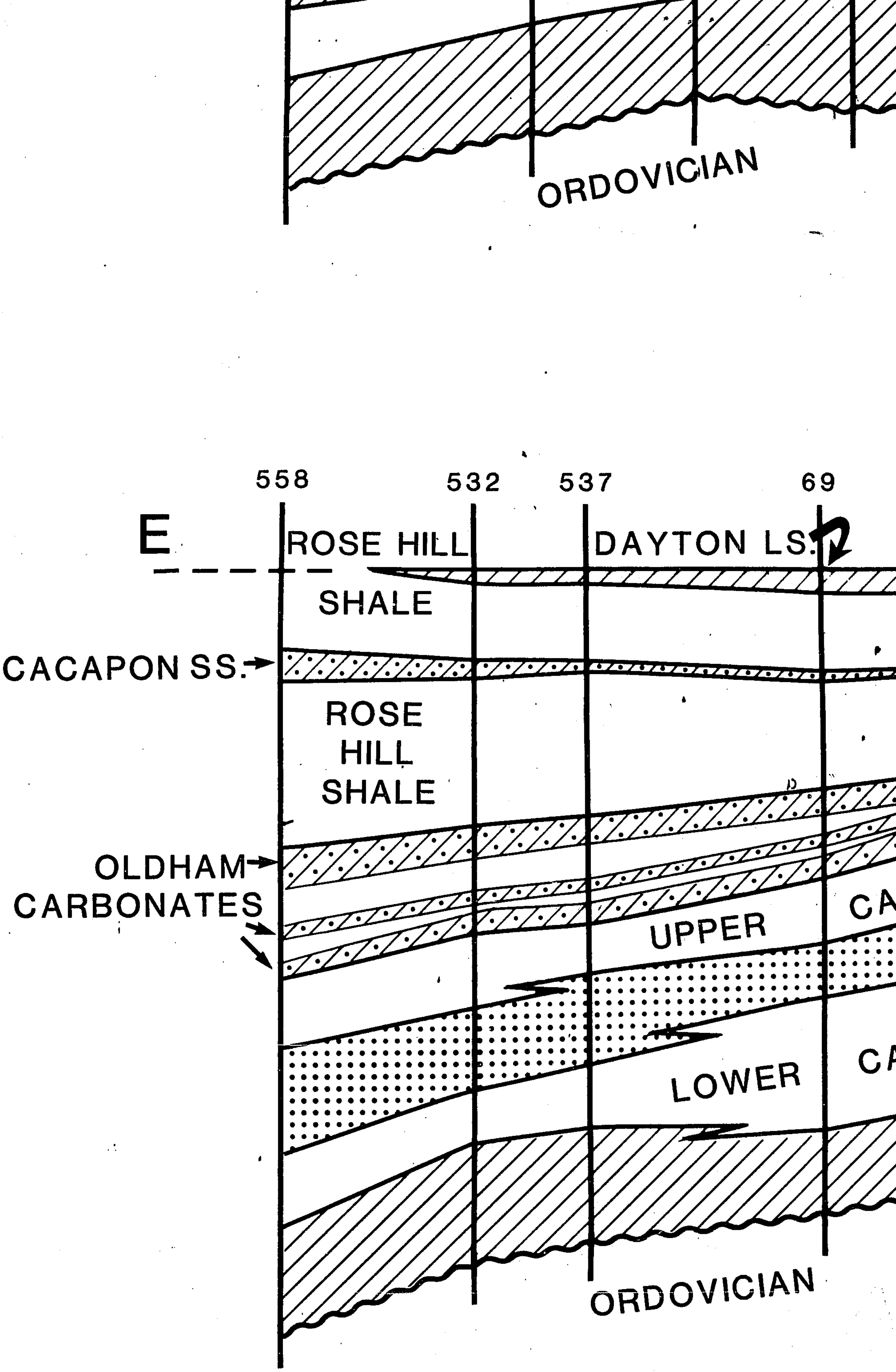

CLINTON SS.
QUEENSTON
BRASSFIELD FM.
SHALE
261
219
349
221
537
776
HALE
DAYTON LS.
C′
ROSE HILL SHALE
JD SH.
CACAPON SS.
ROSE HILL SHALE
HEAD
SH.
LD FM.
OLDHAM CARBONATE
TUSCARORA S
QUEENSTON
SHALE
BRASSFIELD F

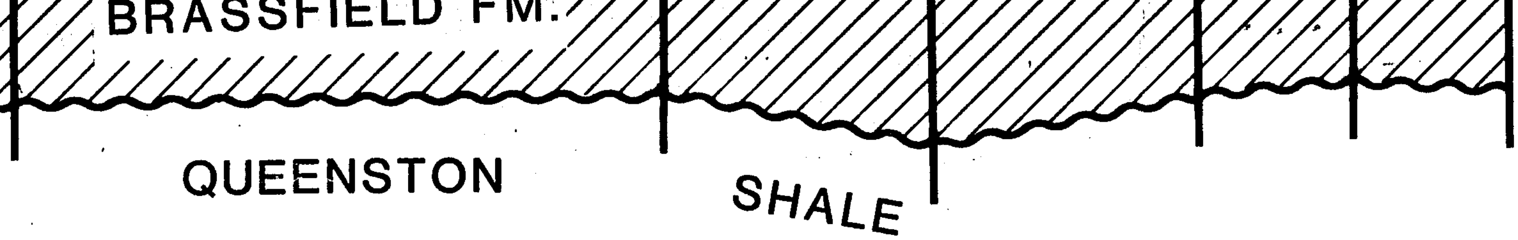
SS.

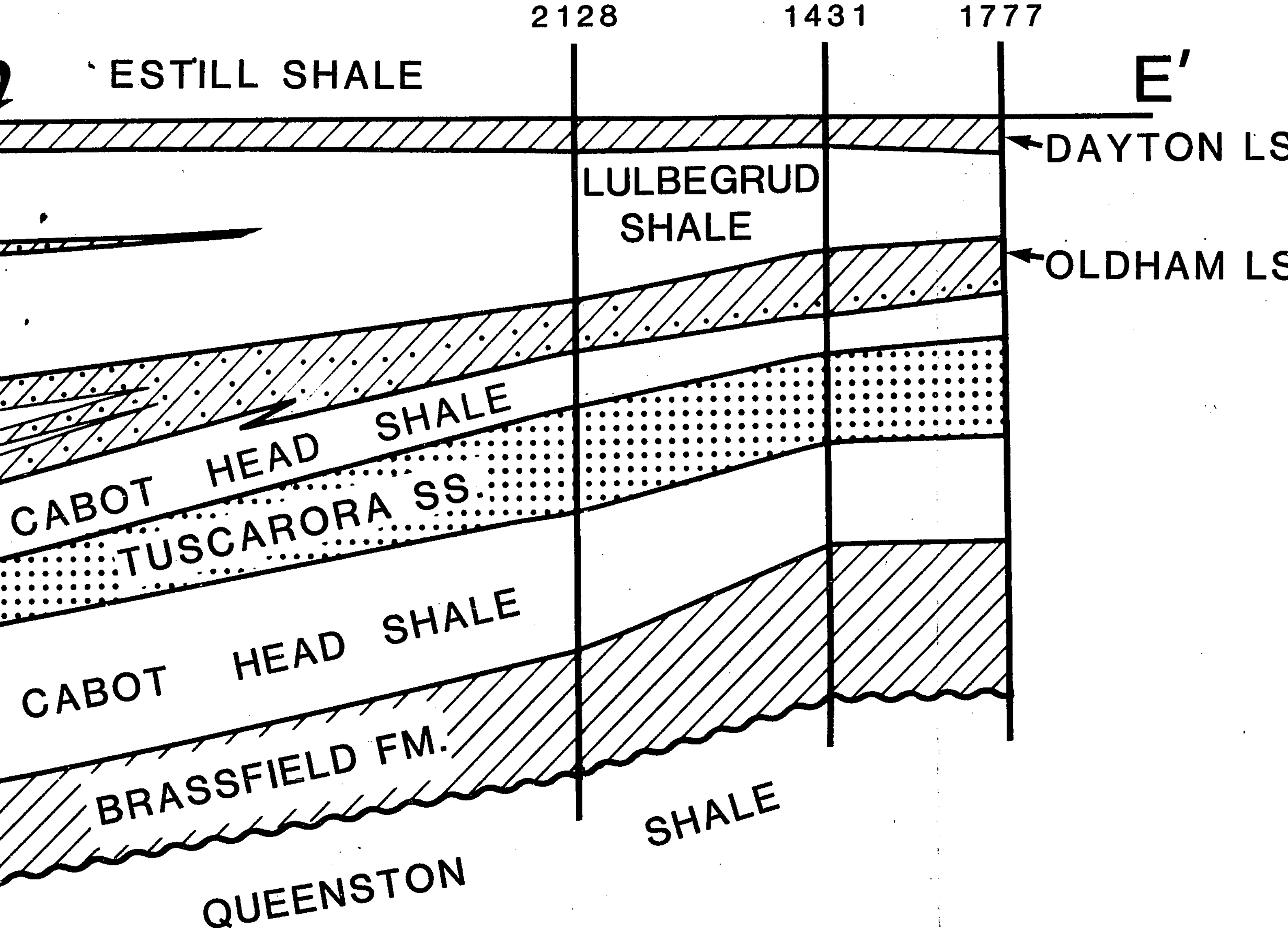
NATES

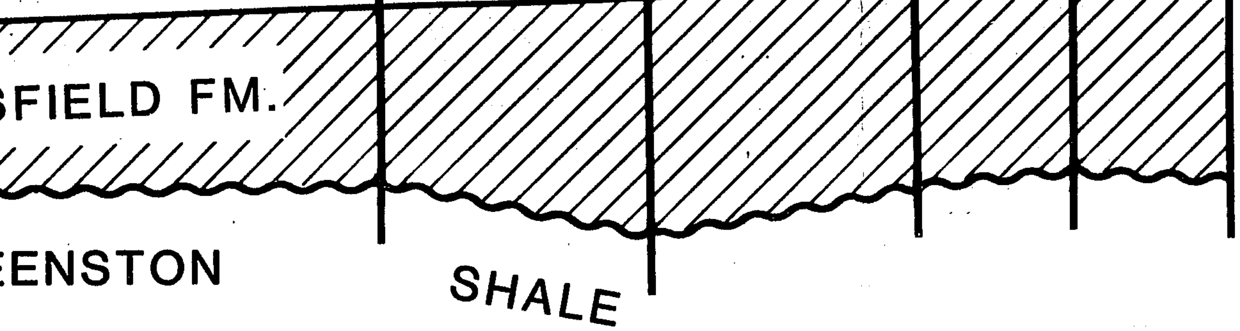
RA SS.

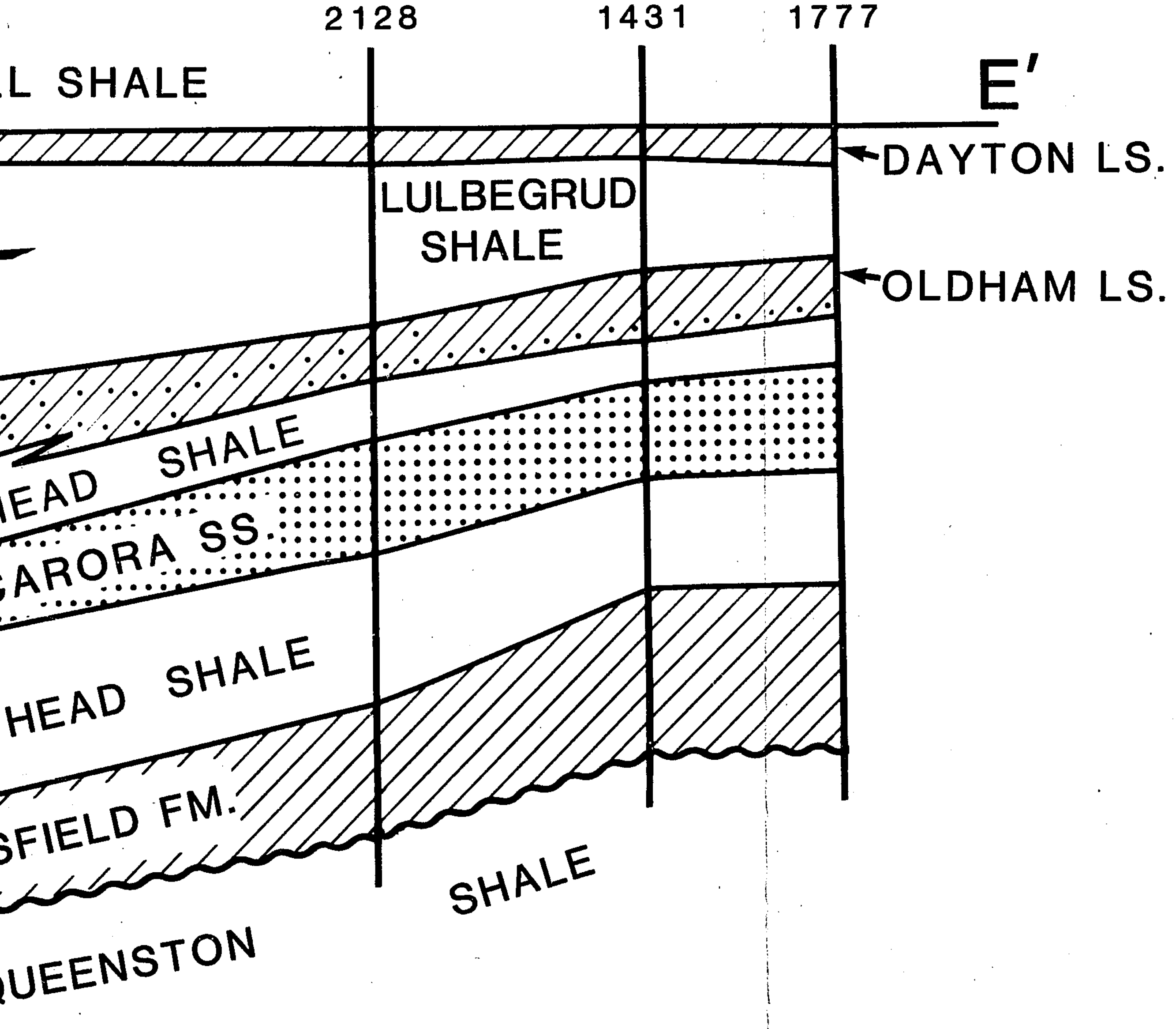
ELD FM.




BRASSFIELD FM.
QUEENSTON
SHALE


2128
1431
1777
ESTILL SHALE
E′
DAYTON LS
LULBEGRUD
SHALE
OLDHAM LS
CABOT HEAD SHALE
TUSCARORA SS.
CABOT HEAD SHALE
BRASSFIELD FM.
SHALE
QUEENSTON


SFIELD FM.
EENSTON
SHALE


2128
1431
1777
L SHALE
E′
DAYTON LS.
LULBEGRUD
SHALE
OLDHAM LS.
HEAD SHALE
CARORA SS
HEAD SHALE
SFIELD FM.
SHALE
QUEENSTON

PLEASE NOTE:

Oversize maps and charts are filmed in sections in the following manner:

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Standard 35mm slides or 17" x 23" black and white photographic prints are available for an additional charge.

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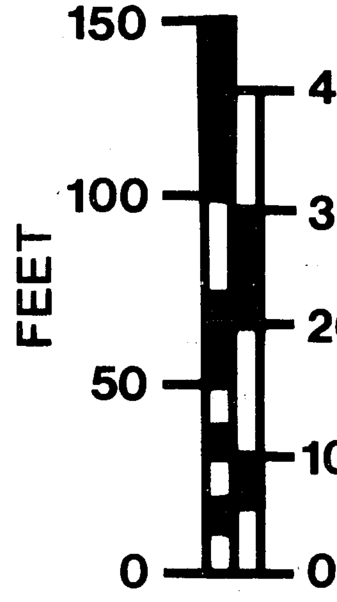
FIGURE 24. NUCLEAR LOG CROS
THE UPPER CLINTON

SCALE

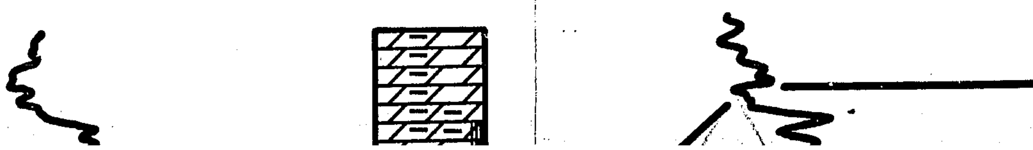


HORIZONTAL DIS
AS MARKE

DATUM TOP OF E

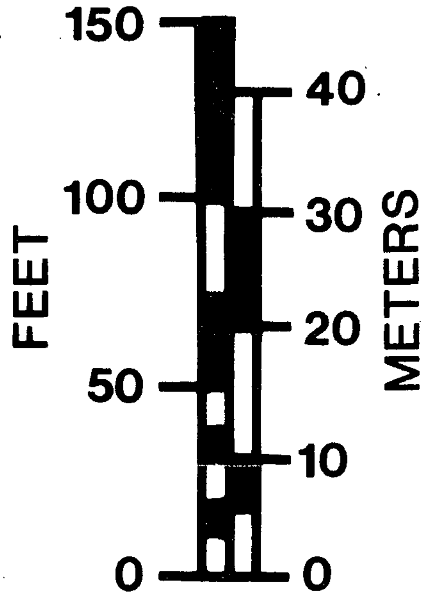
A
WEST

R-16



OG CROSS SECTIONS SHOWING GEOP
CLINTON, LOCKPORT, AND LOWER SA

SCALE

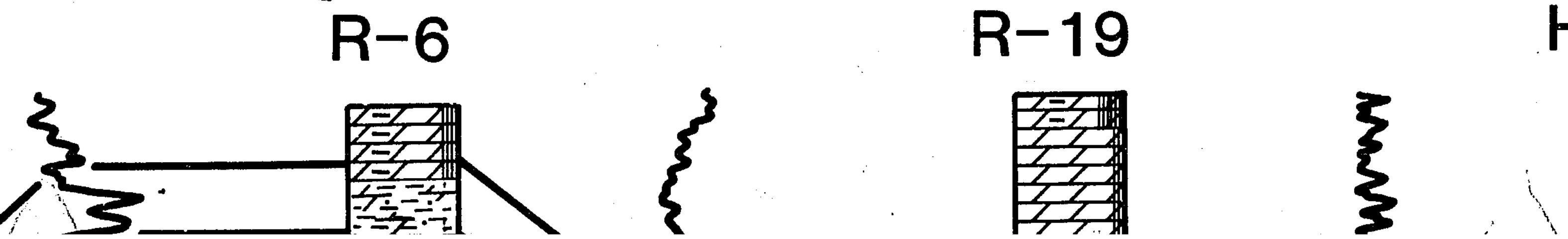


RIZONTAL DISTANCES
AS MARKED

LITHOLOGIC SYMBOLS

- DOLOMITE
- LIMESTONE
- SANDSTONE
- SHALE
- ARGILLACEOUS
- CALCAREOUS
- DOLOMITIC
- SILTY
- ANHYD
- OOLITI
- FOSSI
- CHERT
- NO SA
- CORED

TUM TOP OF ESTILL-ROSE HILL SHALE



OPHYSICAL IDENTIFICATION, CORRELA
SALINA GROUPS.

LS

LTY

NHYDRITIC

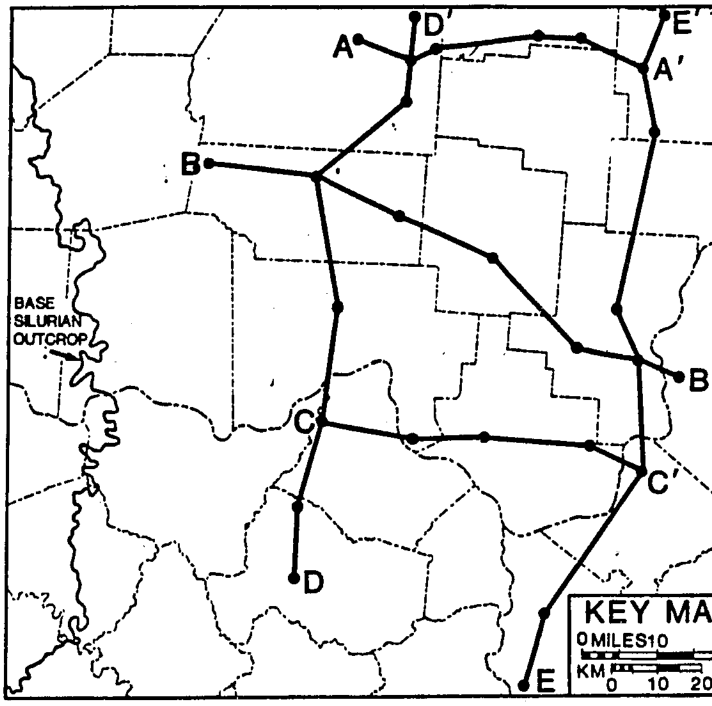
OLITIC

OSSILIFEROUS

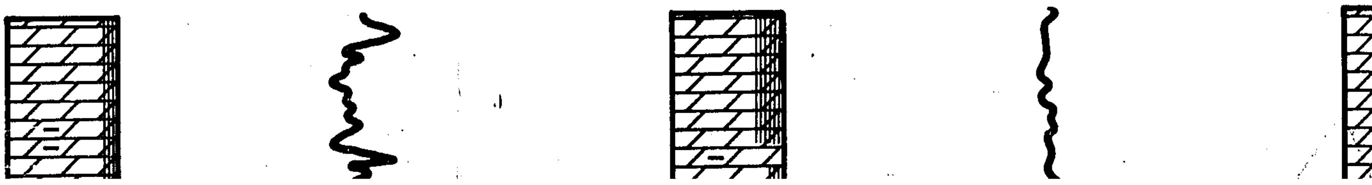
HERTY

) SAMPLES

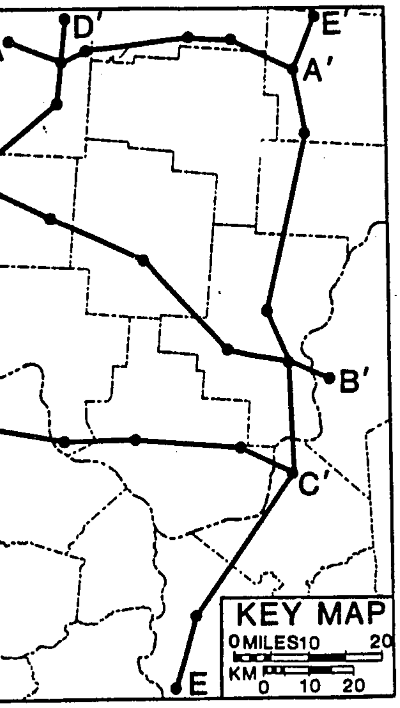
ORED INTERVAL



H-1679 H-122 A-14

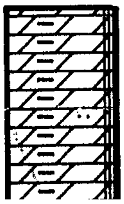


CORRELATION, AND LITHOLOGY OF

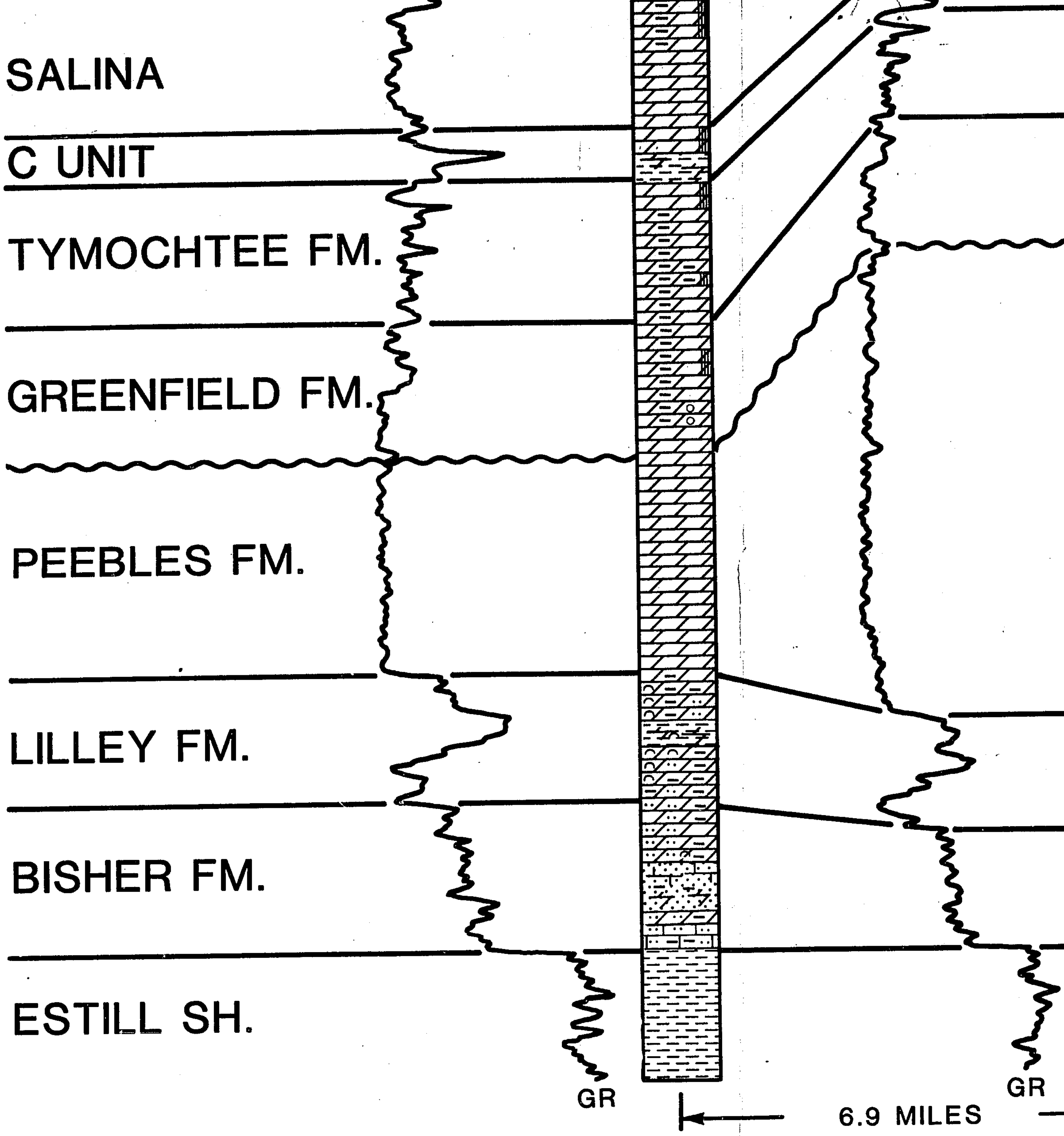


A′
EAST

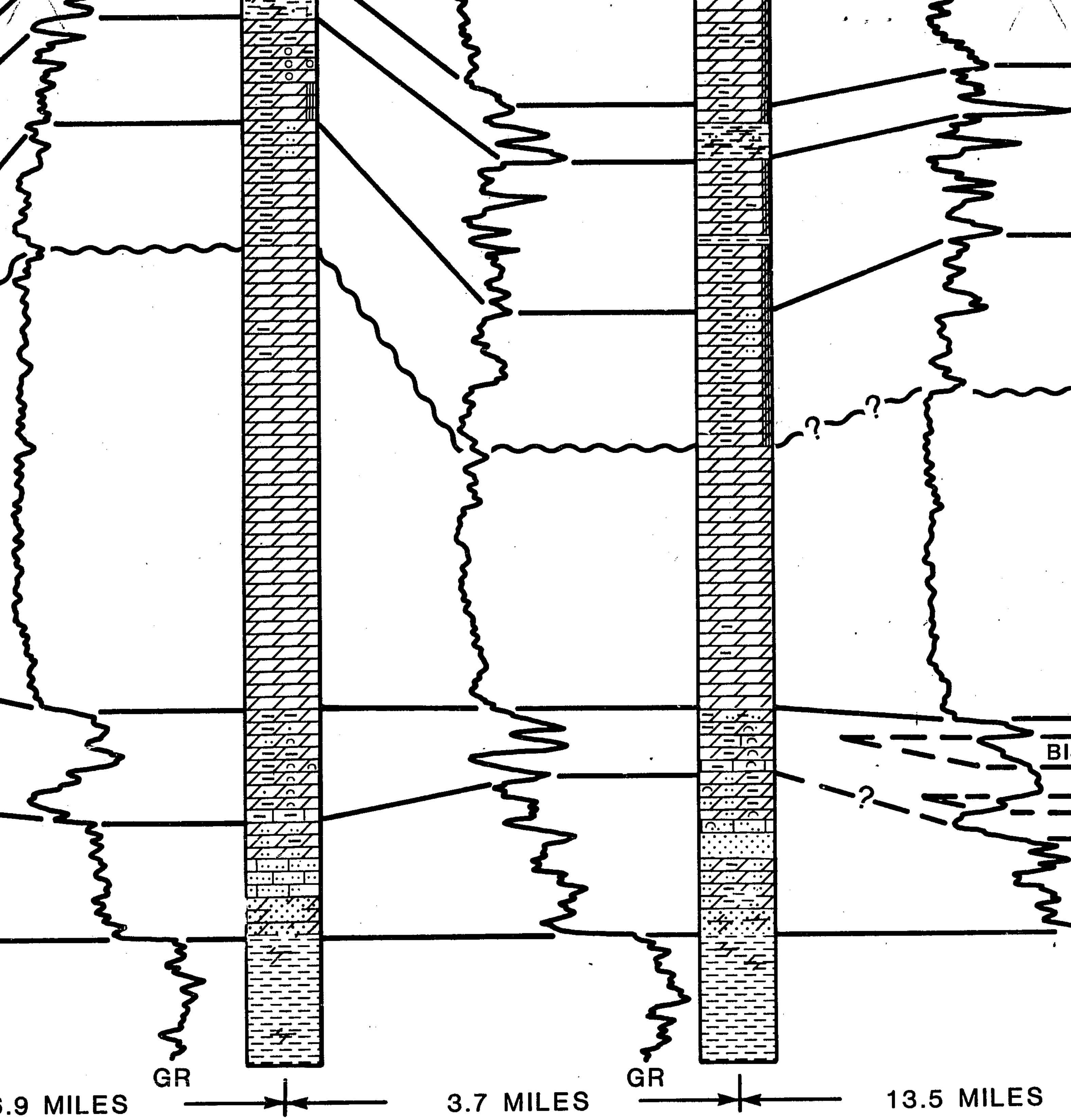
A–1431



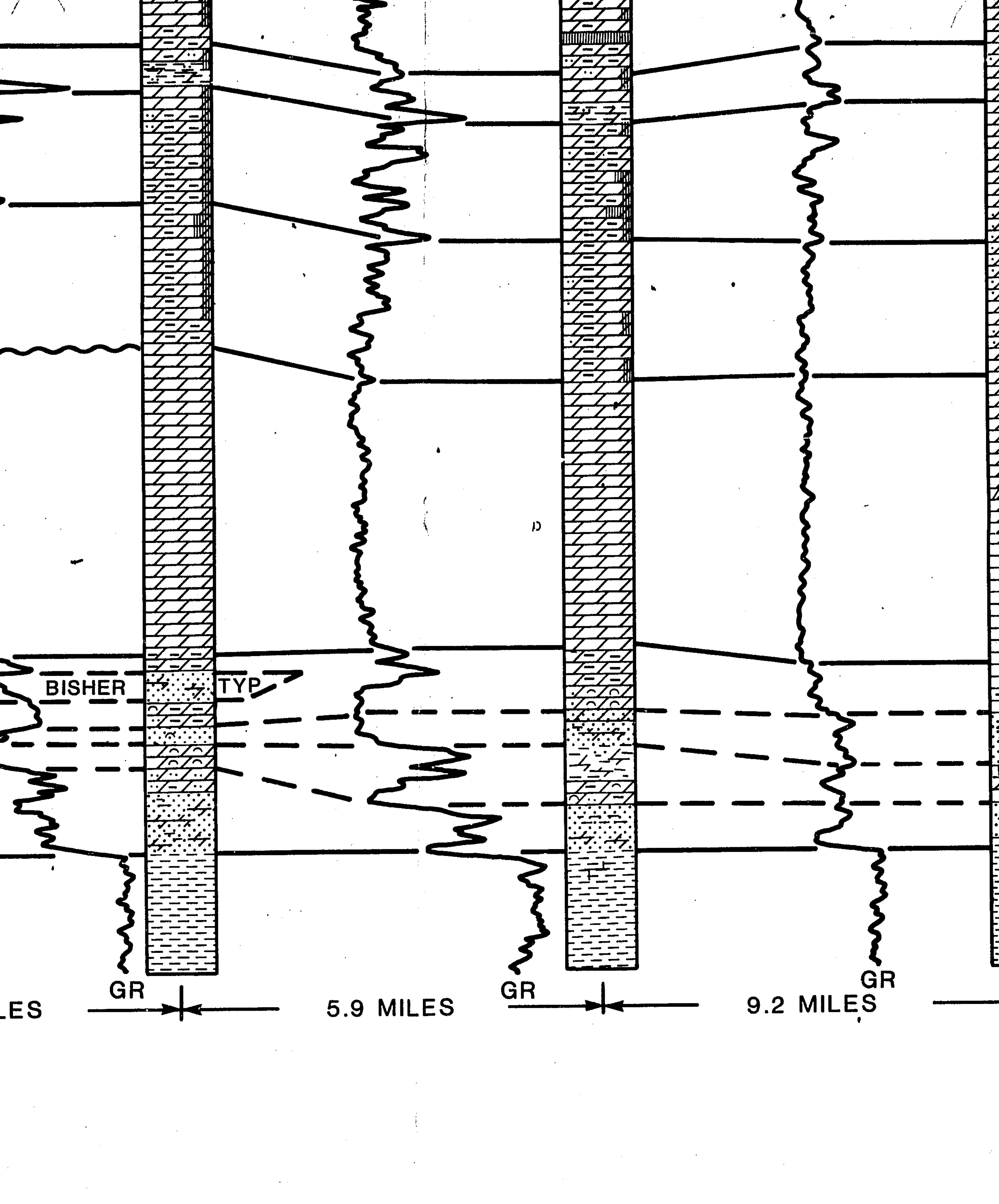
SALINA

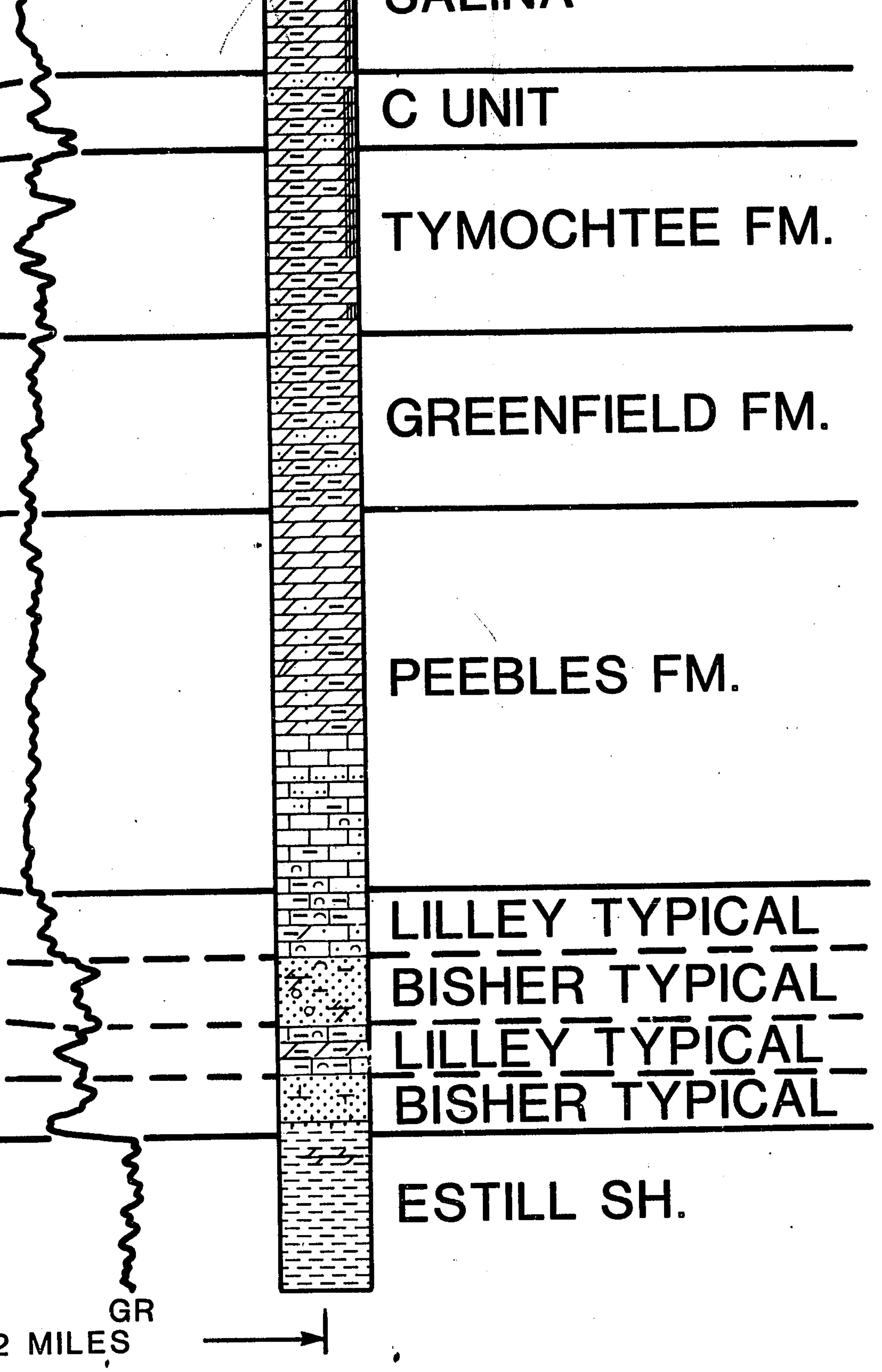

SALINA
C UNIT
TYMOCHTEE FM.
GREENFIELD FM.
PEEBLES FM.
LILLEY FM.
BISHER FM.
ESTILL SH.
GR
GR
6.9 MILES

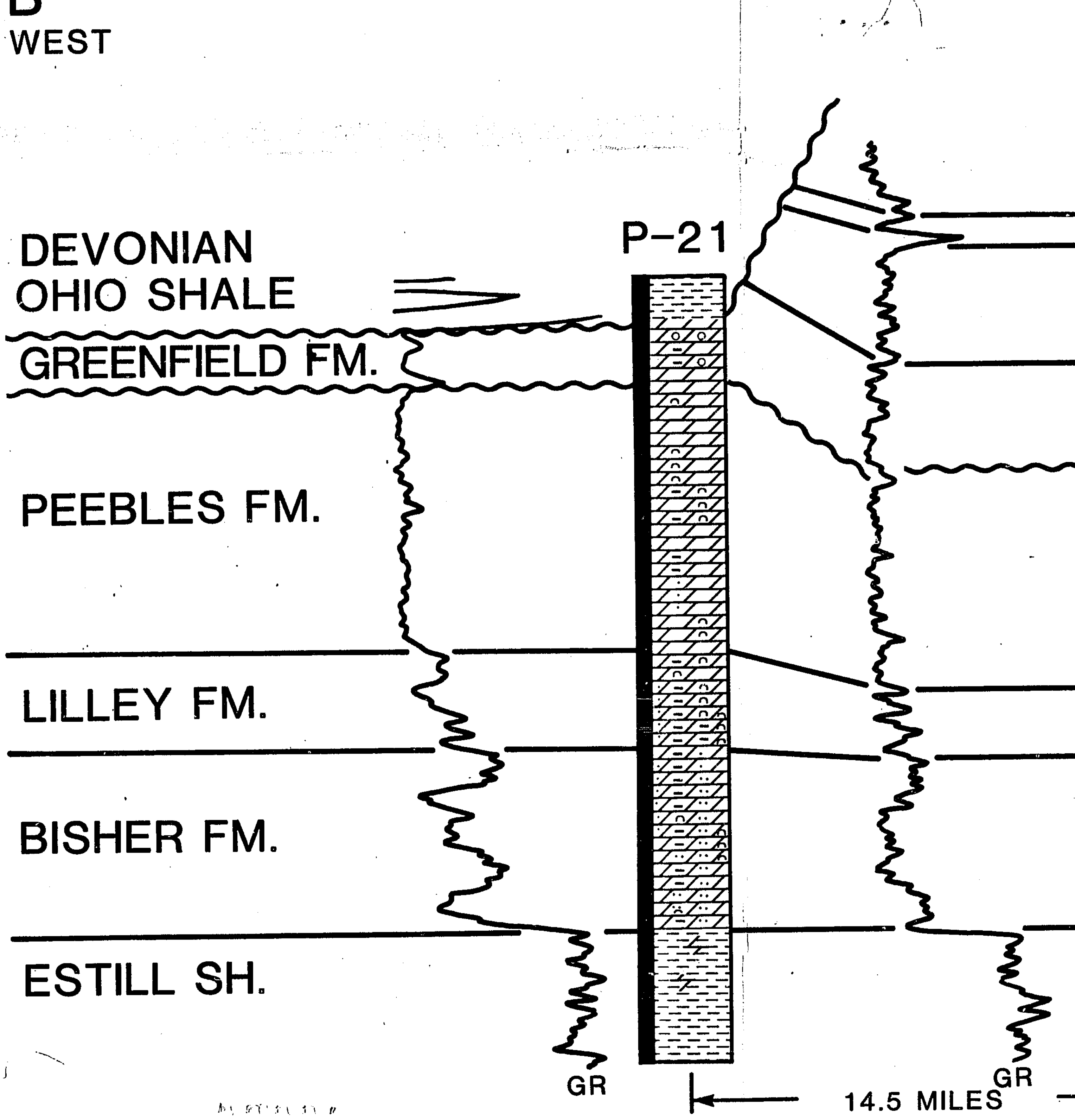
B



GR
GR
.9 MILES
3.7 MILES
13.5 MILES
BI

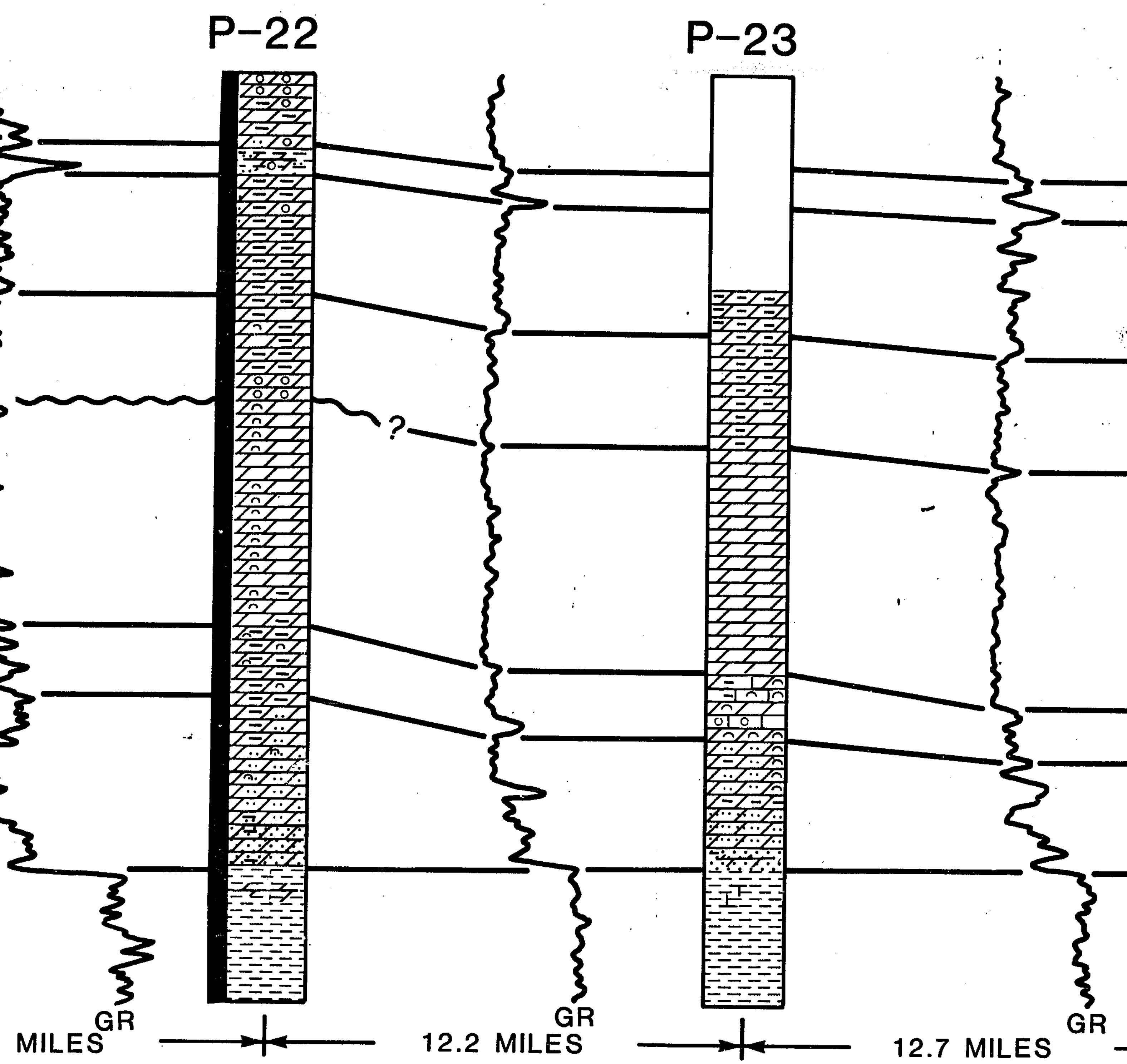

BISHER
TYP
GR
LES
5.9 MILES
GR
9.2 MILES
GR


SALINA
C UNIT
TYMOCHTEE FM.
GREENFIELD FM.
PEEBLES FM.
LILLEY TYPICAL
BISHER TYPICAL
LILLEY TYPICAL
BISHER TYPICAL
ESTILL SH.
GR
MILES

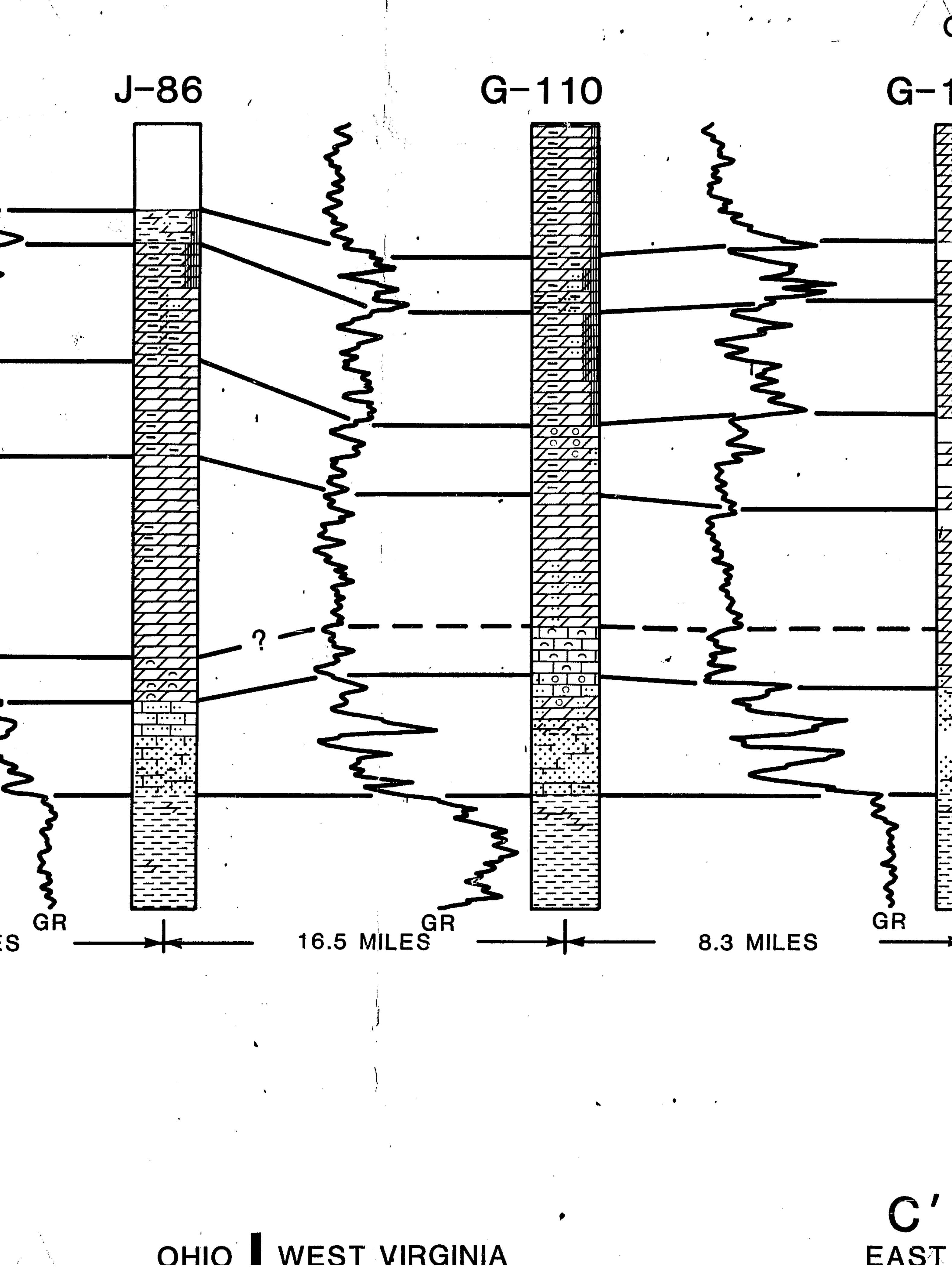


C
WEST

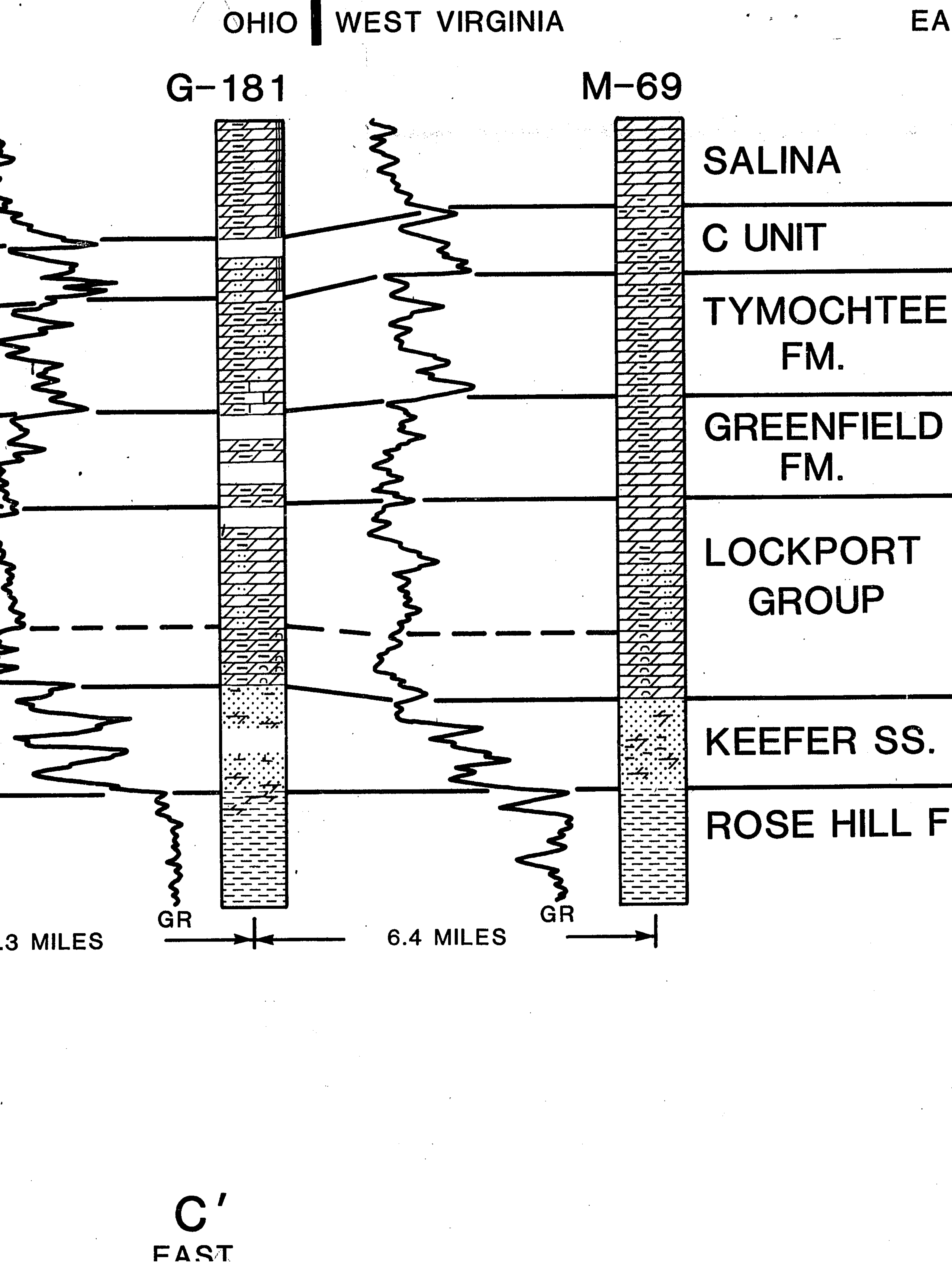
KENTUCKY | OHIO

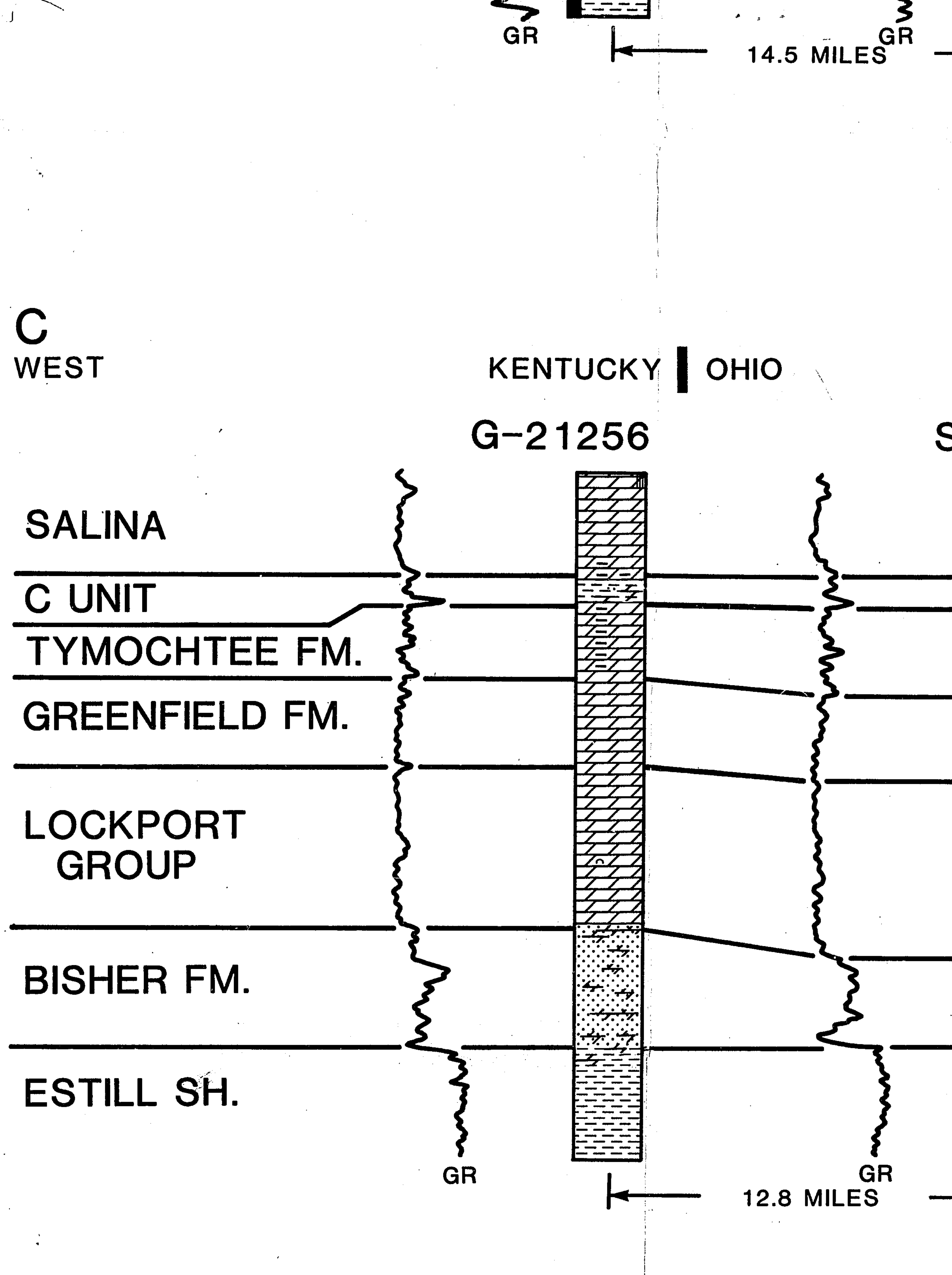


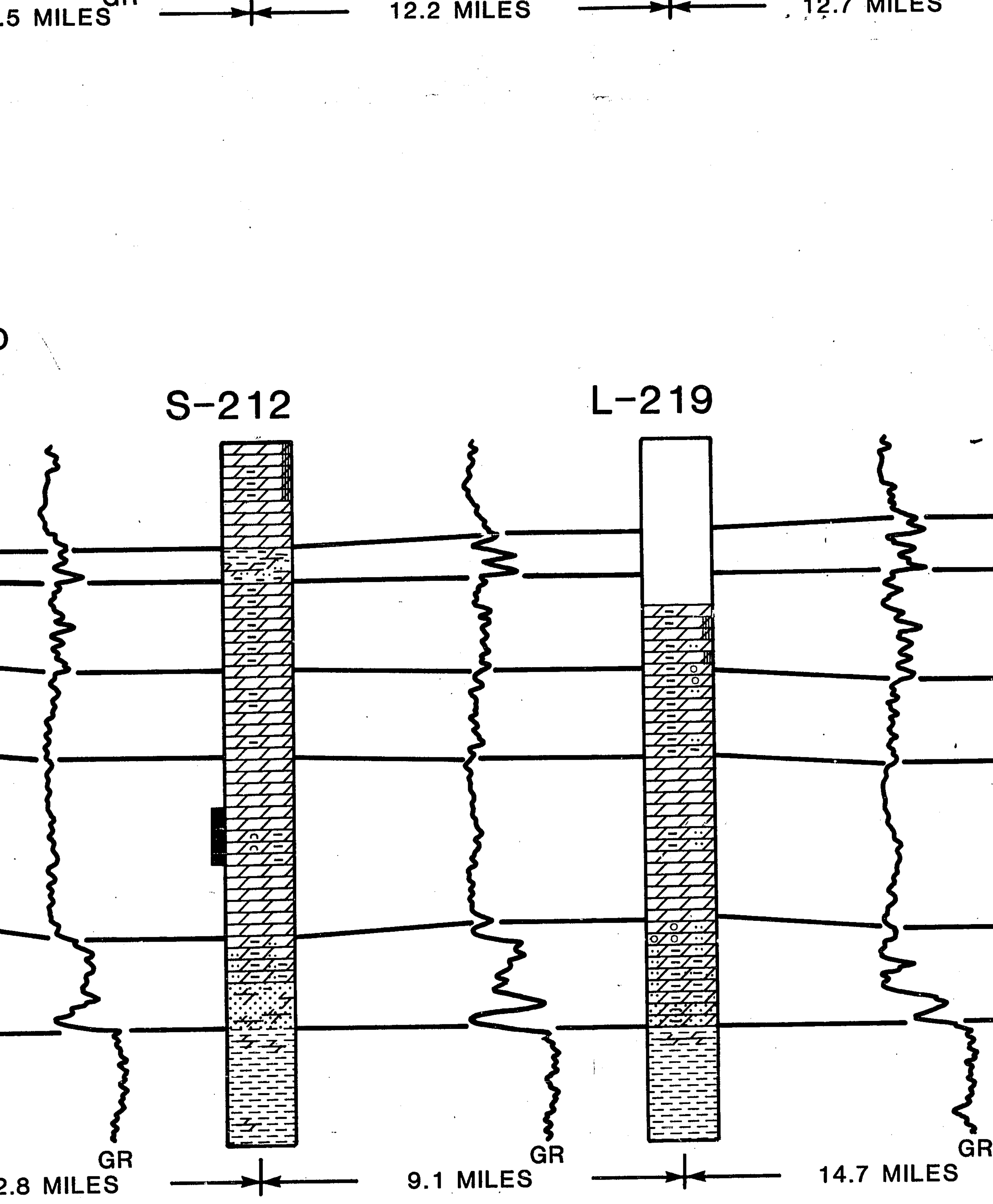
P-22
P-23
?
GR
GR
GR
MILES
12.2 MILES
12.7 MILES

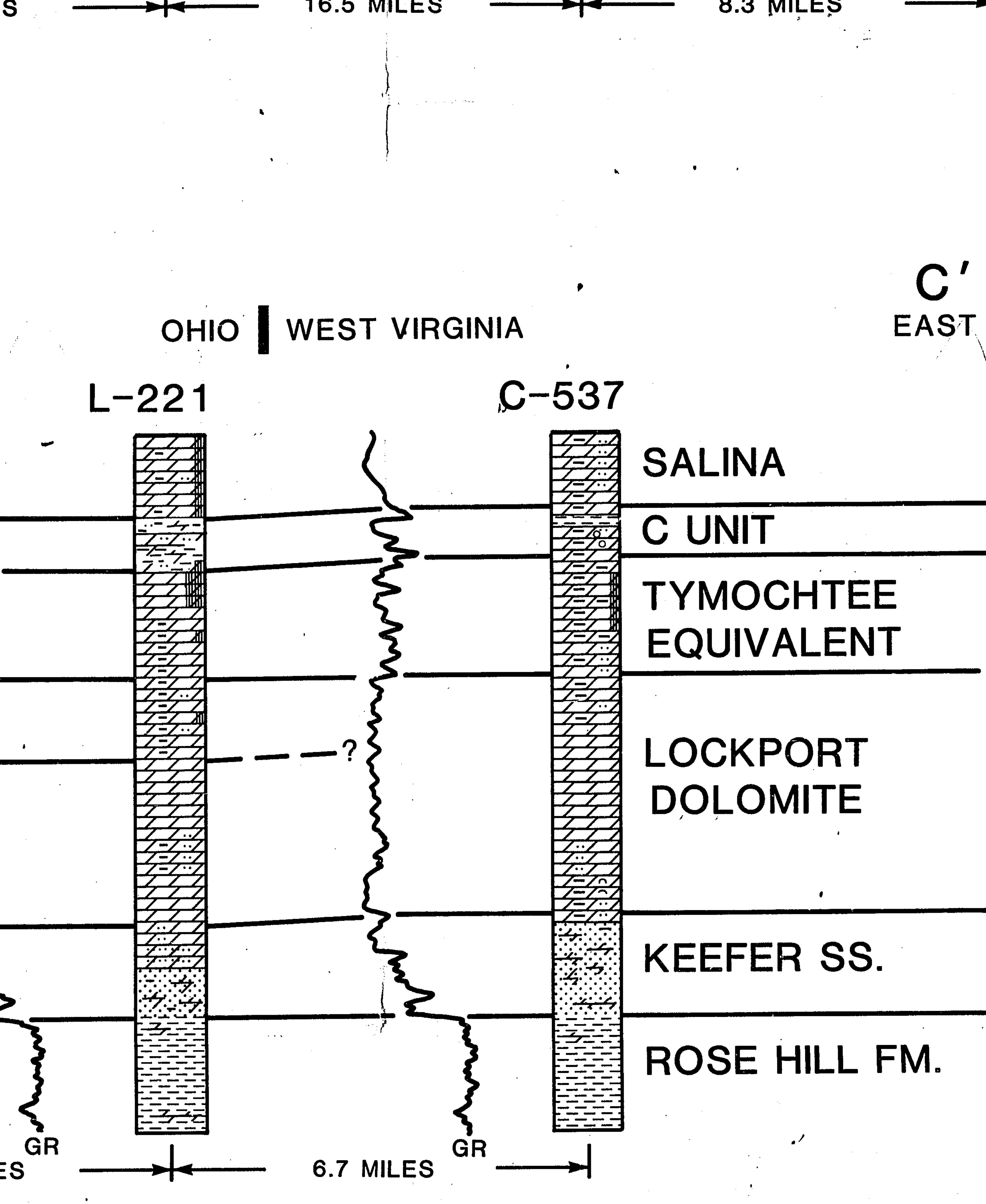


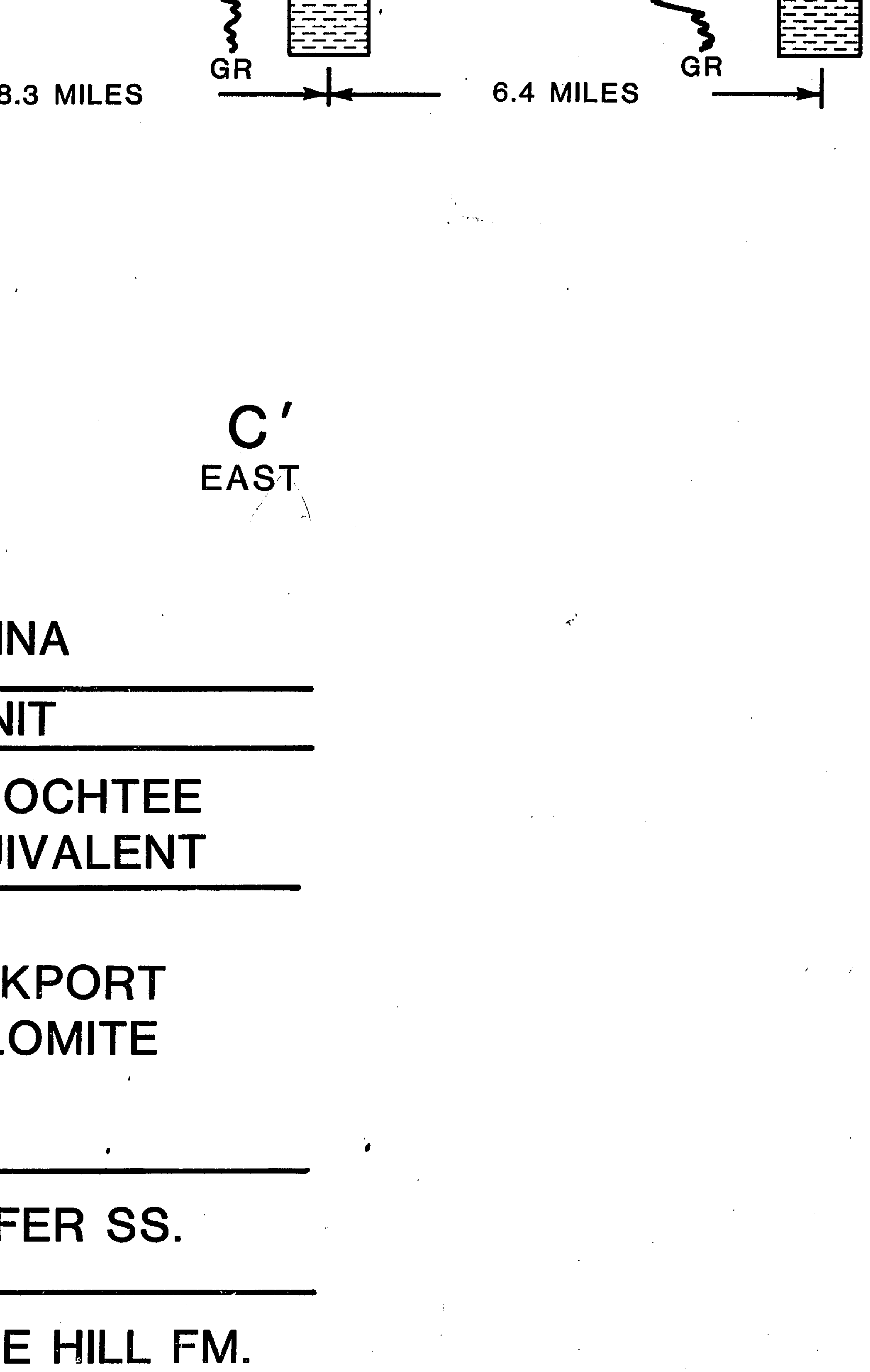
J-86
G-110
G-1
?
GR
GR
GR
ES
16.5 MILES
8.3 MILES
C'
OHIO
WEST VIRGINIA
EAST


OHIO
WEST VIRGINIA
EA
G-181
M-69
SALINA
C UNIT
TYMOCHTEE FM.
GREENFIELD FM.
LOCKPORT GROUP
KEEFER SS.
ROSE HILL F
GR
GR
.3 MILES
6.4 MILES
C′
EAST


GR
GR
14.5 MILES
C
WEST
KENTUCKY
OHIO
G-21256
SALINA
C UNIT
TYMOCHTEE FM.
GREENFIELD FM.
LOCKPORT GROUP
BISHER FM.
ESTILL SH.
GR
GR
12.8 MILES


.5 MILES
GR
12.2 MILES
12.7 MILES
S-212
L-219
GR
GR
GR
2.8 MILES
9.1 MILES
14.7 MILES


S
16.5 MILES
8.3 MILES
C′
EAST
OHIO
WEST VIRGINIA
L-221
C-537
SALINA
C UNIT
TYMOCHTEE
EQUIVALENT
LOCKPORT
DOLOMITE
KEEFER SS.
ROSE HILL FM.
?
GR
GR
ES
6.7 MILES



GR
8.3 MILES
6.4 MILES
GR
C′
EAST
INA
NIT
OCHTEE
IVALENT
KPORT
LOMITE
FER SS.
E HILL FM.

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FIGURE 24 CONT'D.

S

150

100

FEET

50

0

HORIZON

AS

DATUM T

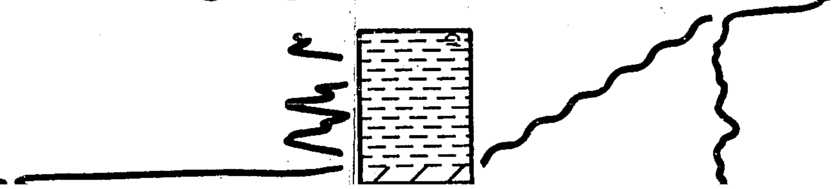
D

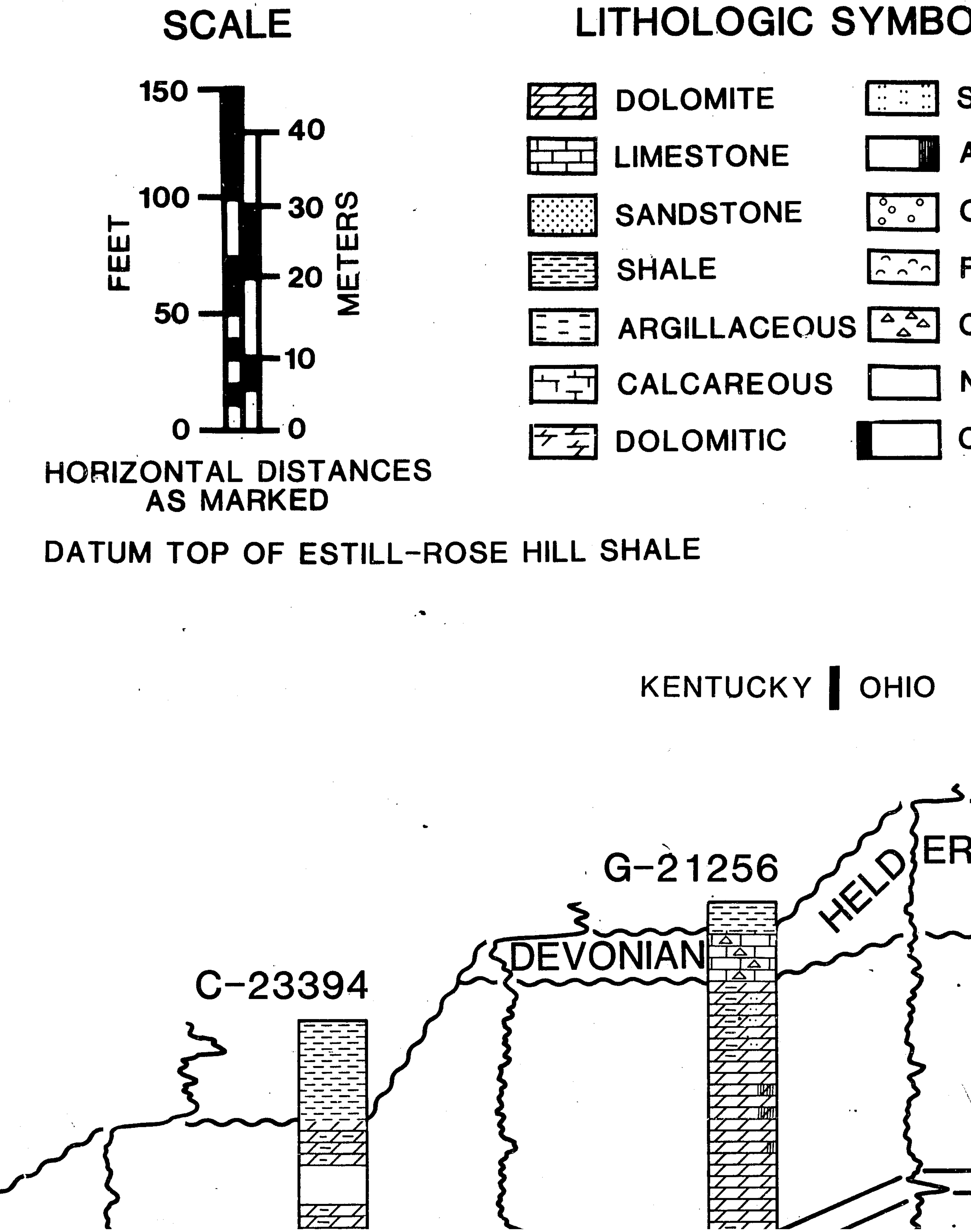
SOUTH

C-398E9

DEVONIAN

OHIO SHALE




SCALE
150
100
50
0
FEET
40
30
20
10
0
METERS
HORIZONTAL DISTANCES AS MARKED
DATUM TOP OF ESTILL–ROSE HILL SHALE
LITHOLOGIC SYMBO
DOLOMITE
LIMESTONE
SANDSTONE
SHALE
ARGILLACEOUS
CALCAREOUS
DOLOMITIC
KENTUCKY
OHIO
G–21256
C–23394
DEVONIAN
HELD
ER

MBOLS

SILTY

ANHYDRITIC

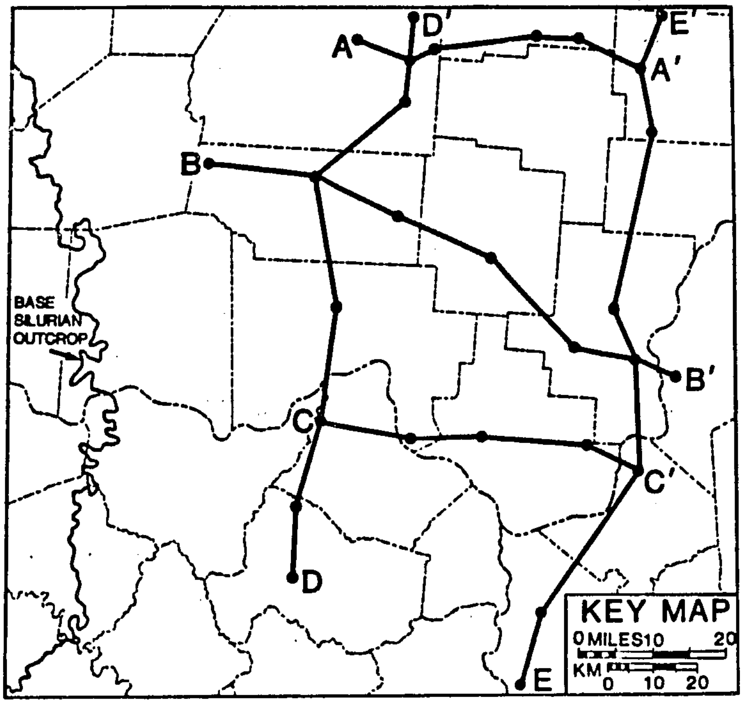
OOLITIC

FOSSILIFEROUS

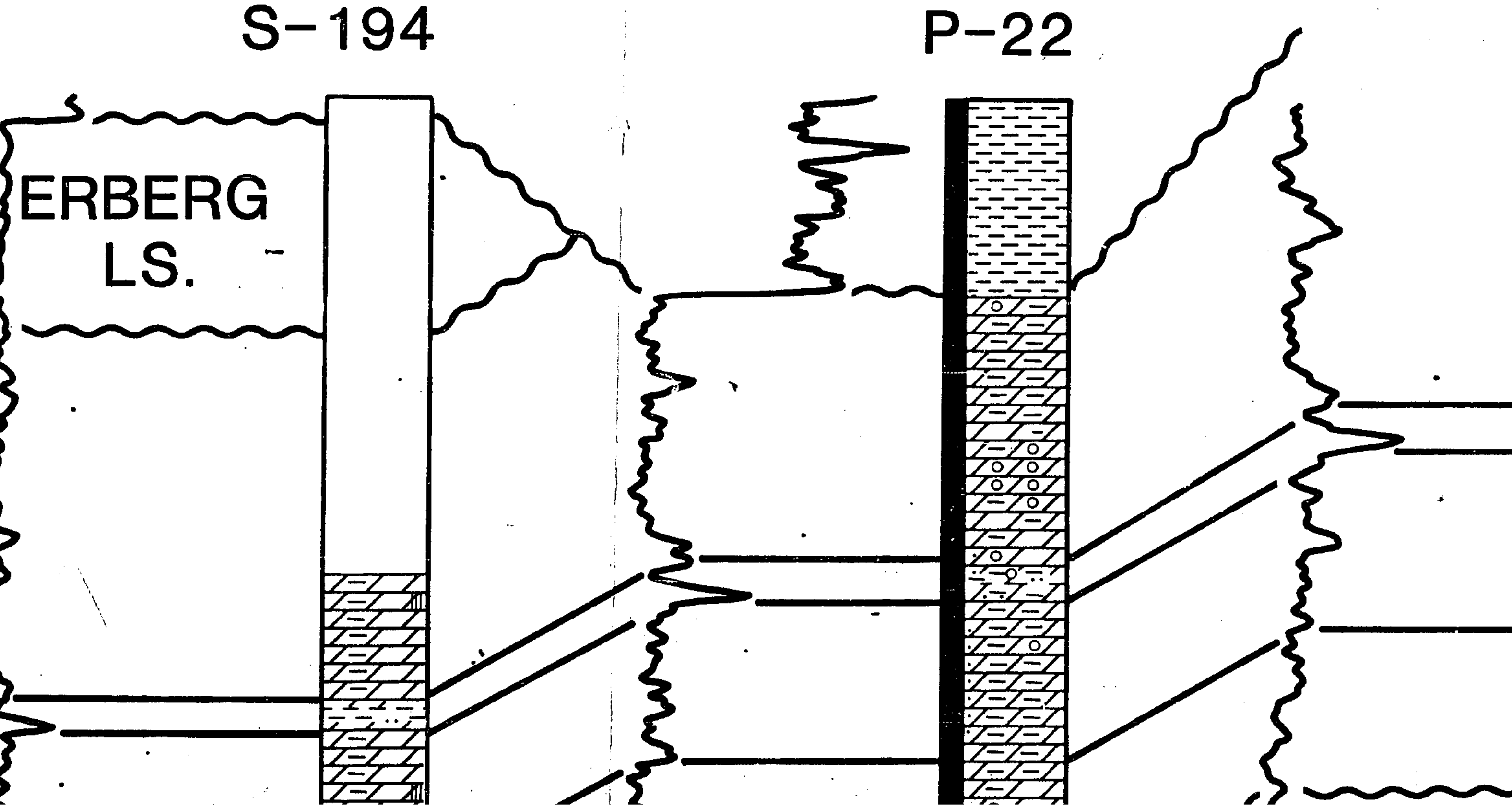
CHERTY

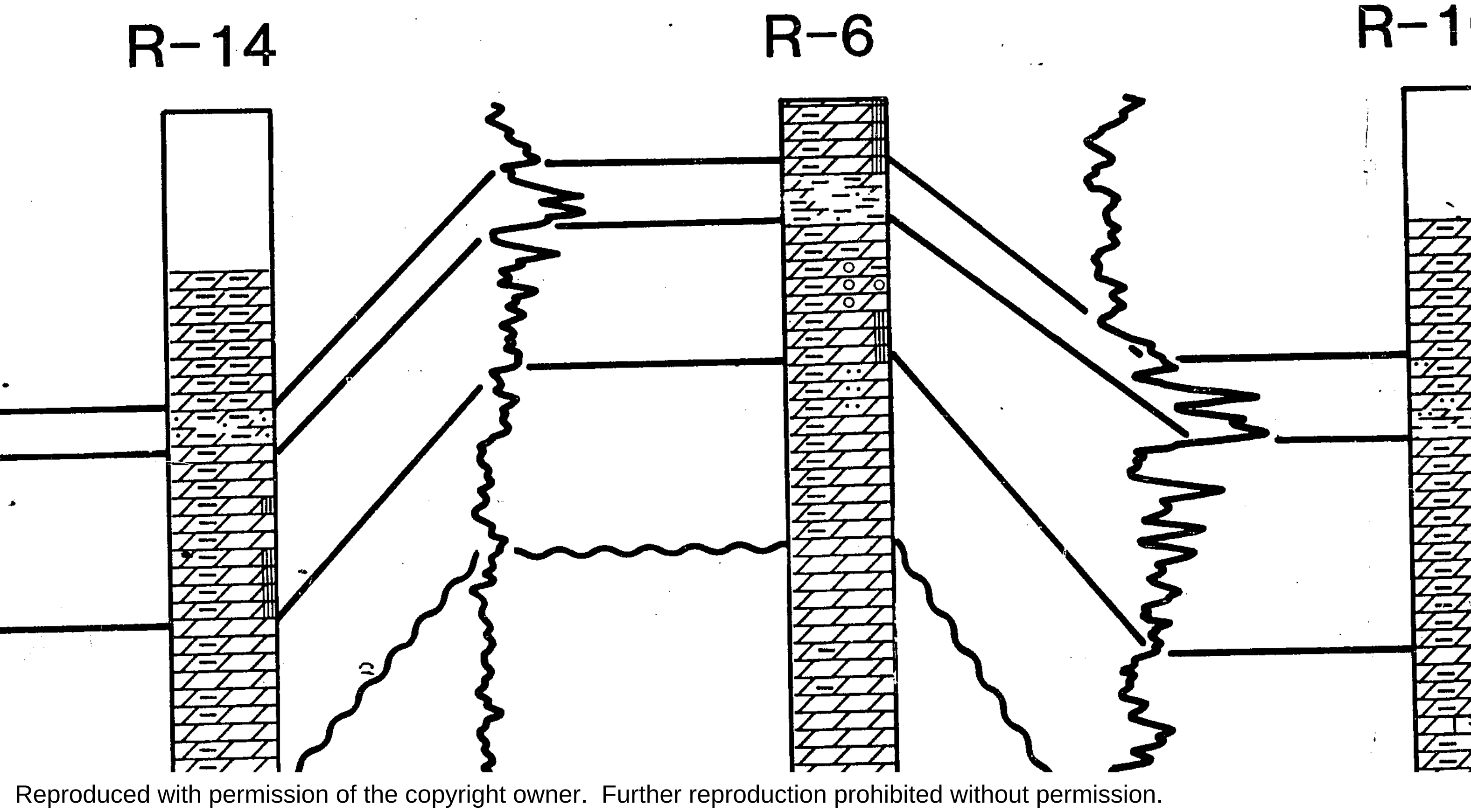
NO SAMPLES

CORED INTERVAL

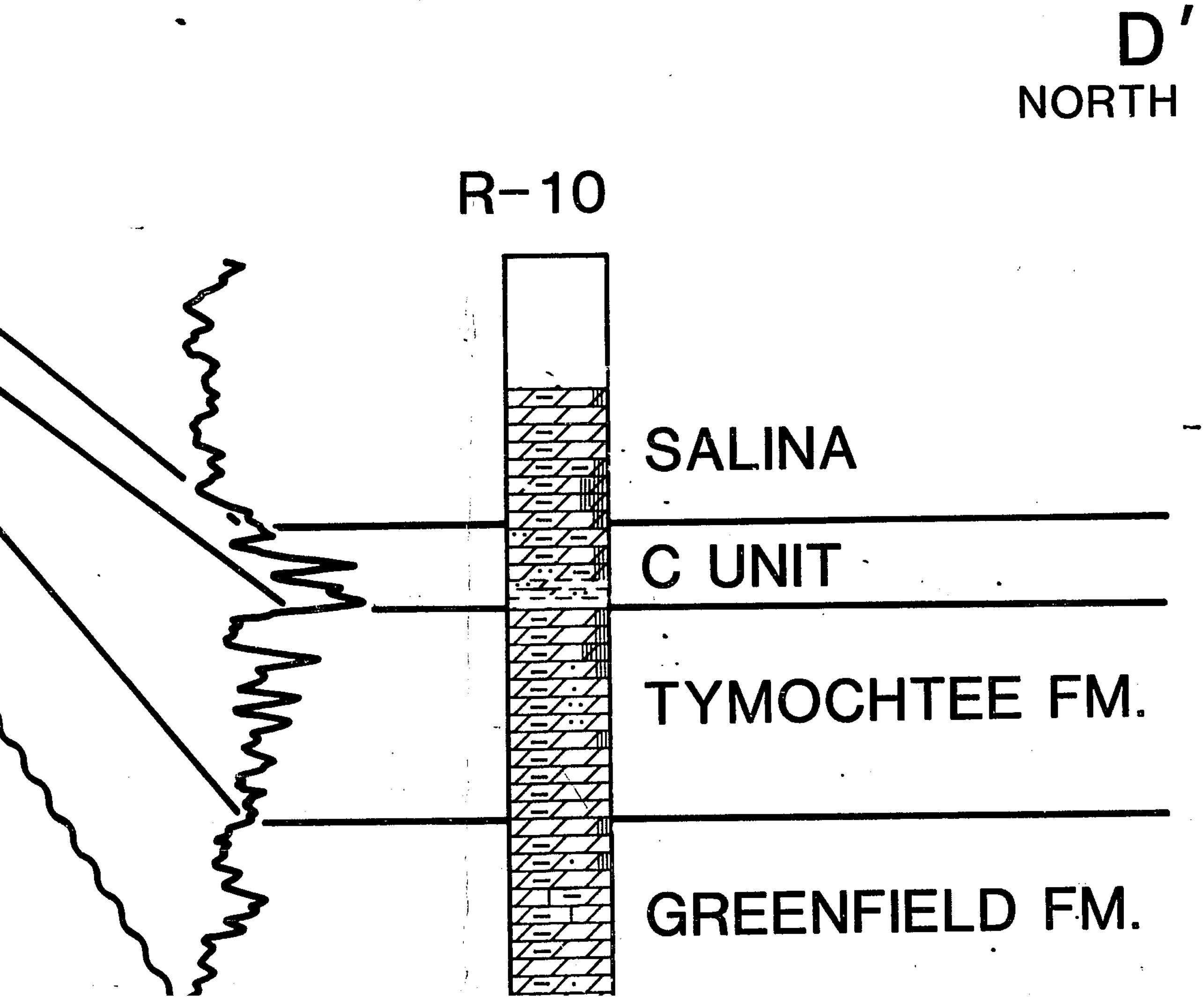


IO

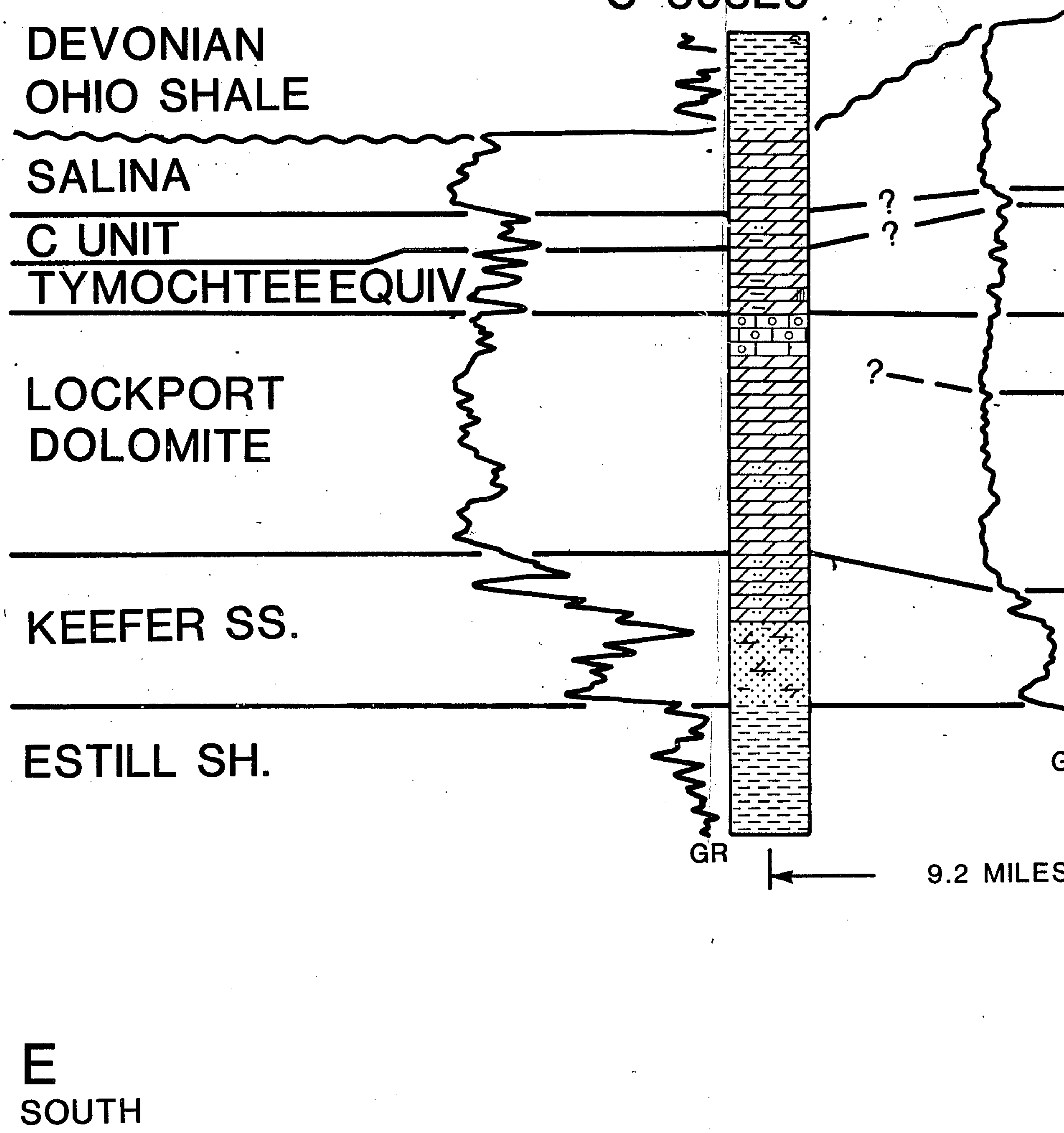




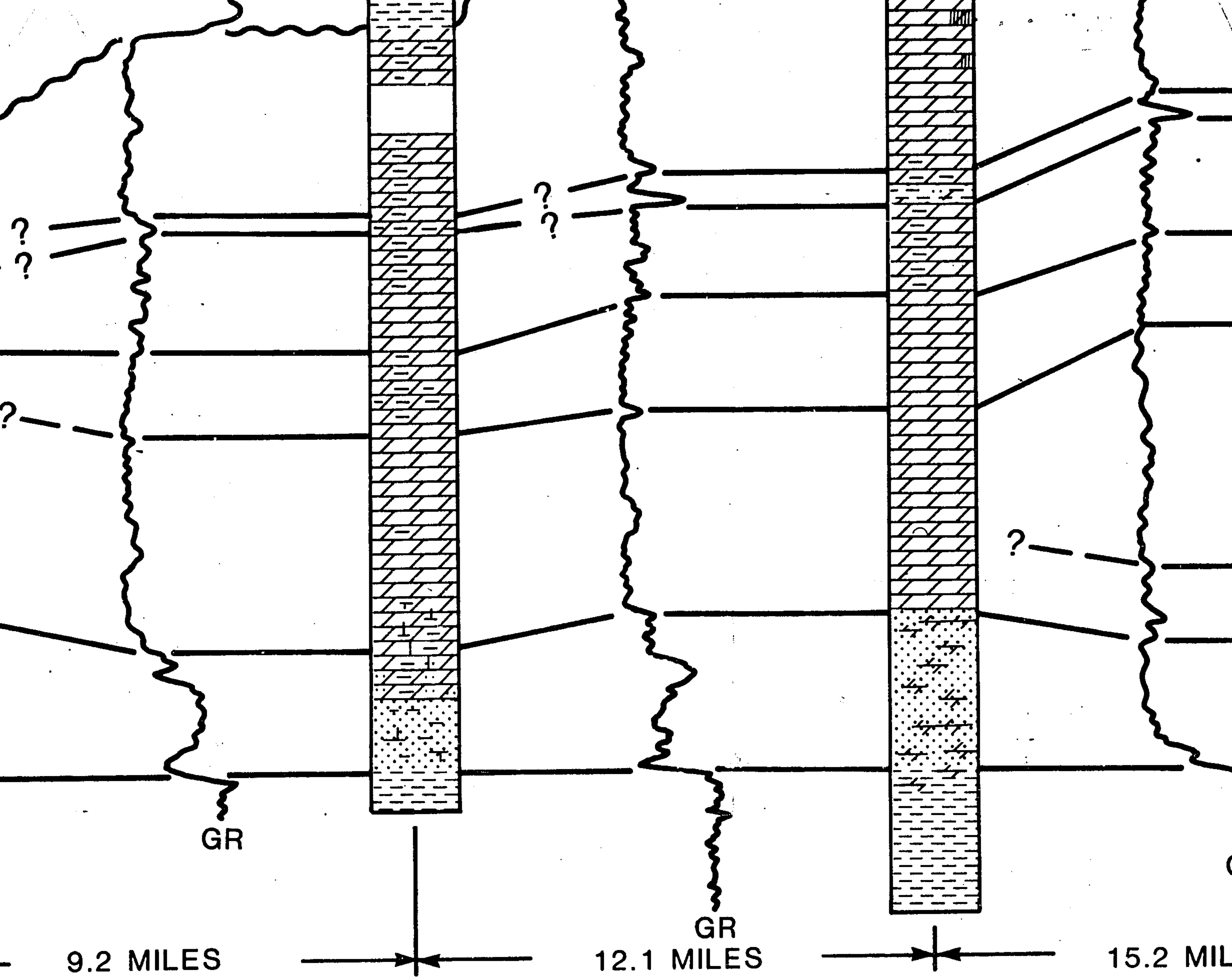
R-14
R-6



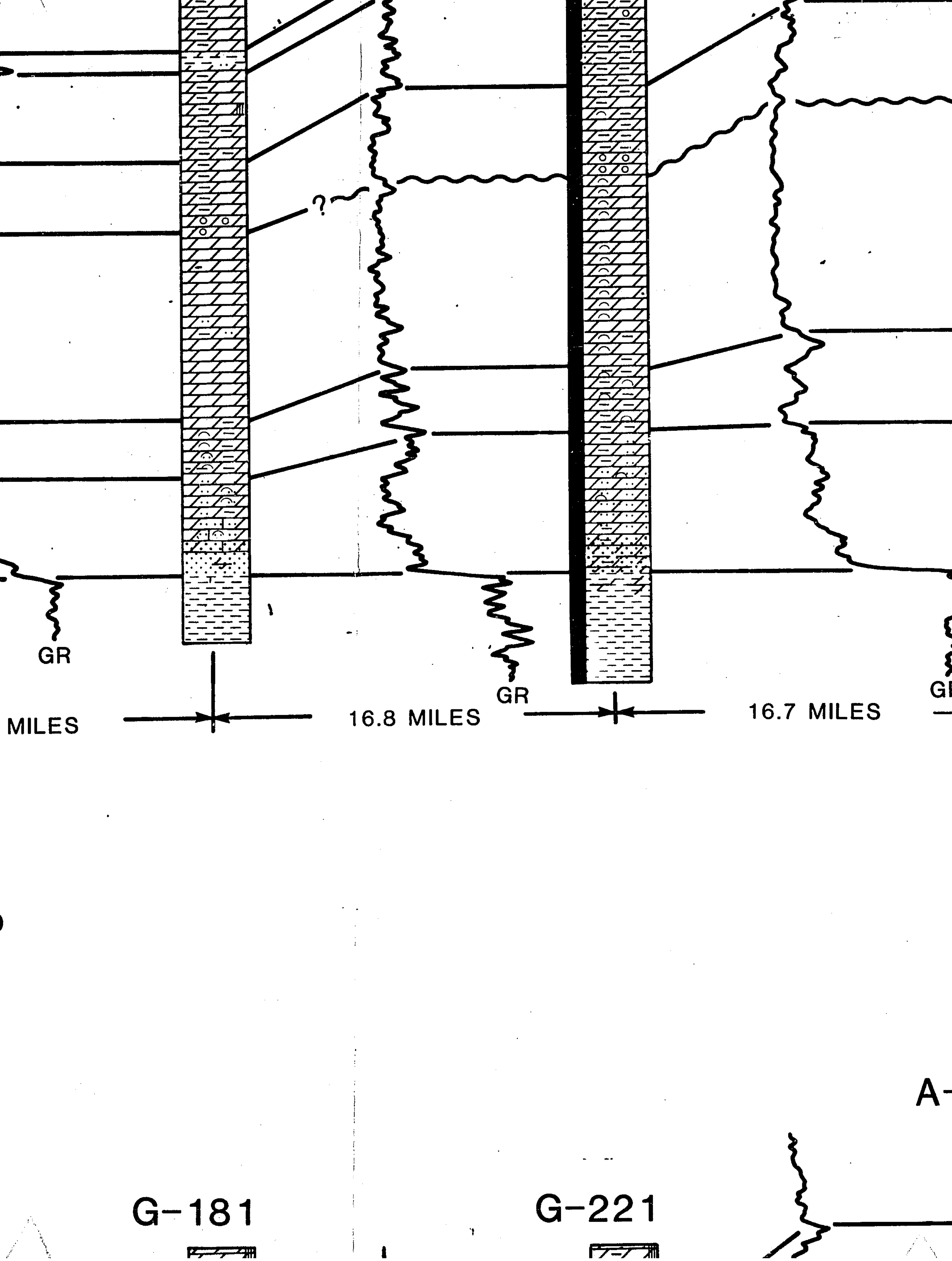
D′
NORTH
R-10
SALINA
C UNIT
TYMOCHTEE FM.
GREENFIELD FM.

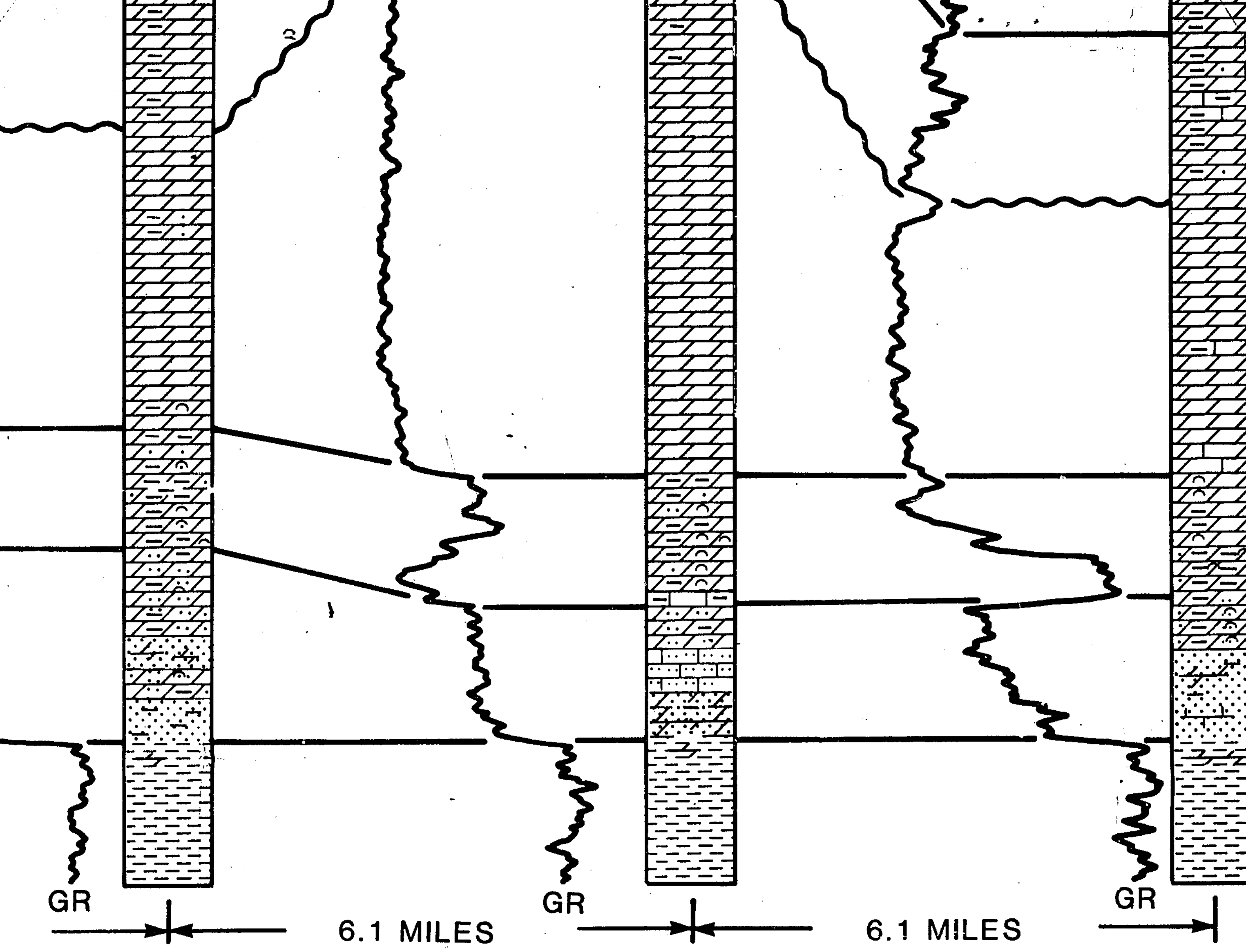


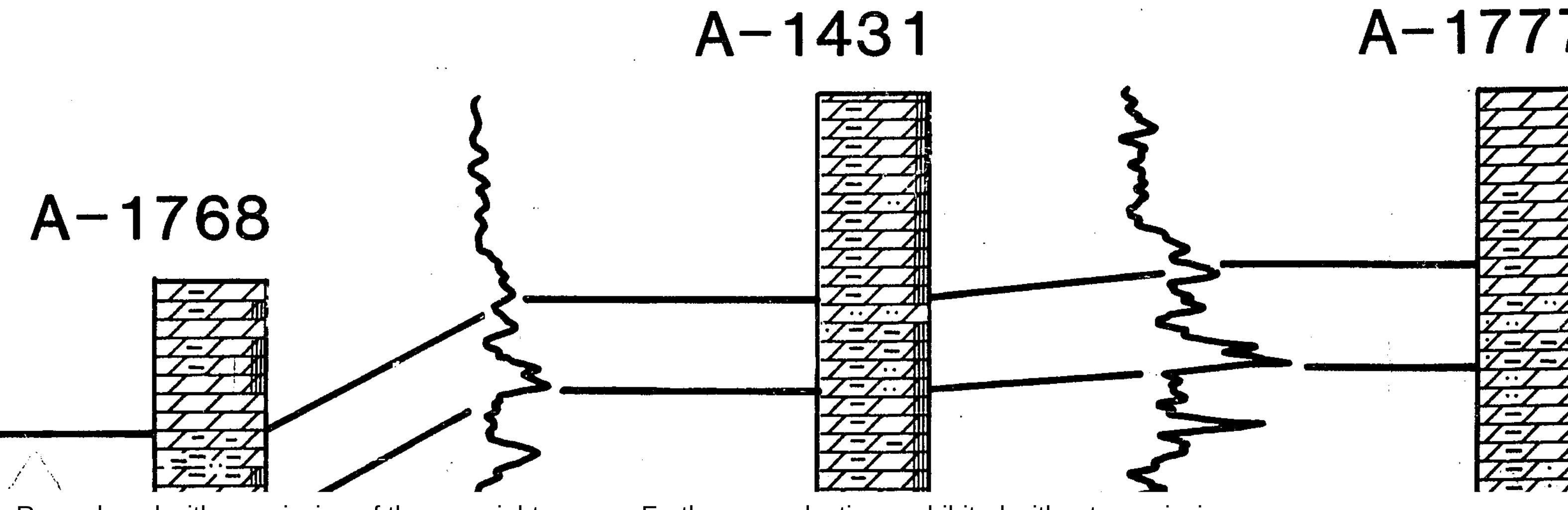
DEVONIAN
OHIO SHALE
SALINA
C UNIT
TYMOCHTEE EQUIV
LOCKPORT
DOLOMITE
KEEFER SS.
ESTILL SH.
?
?
?
GR
9.2 MILES
E
SOUTH

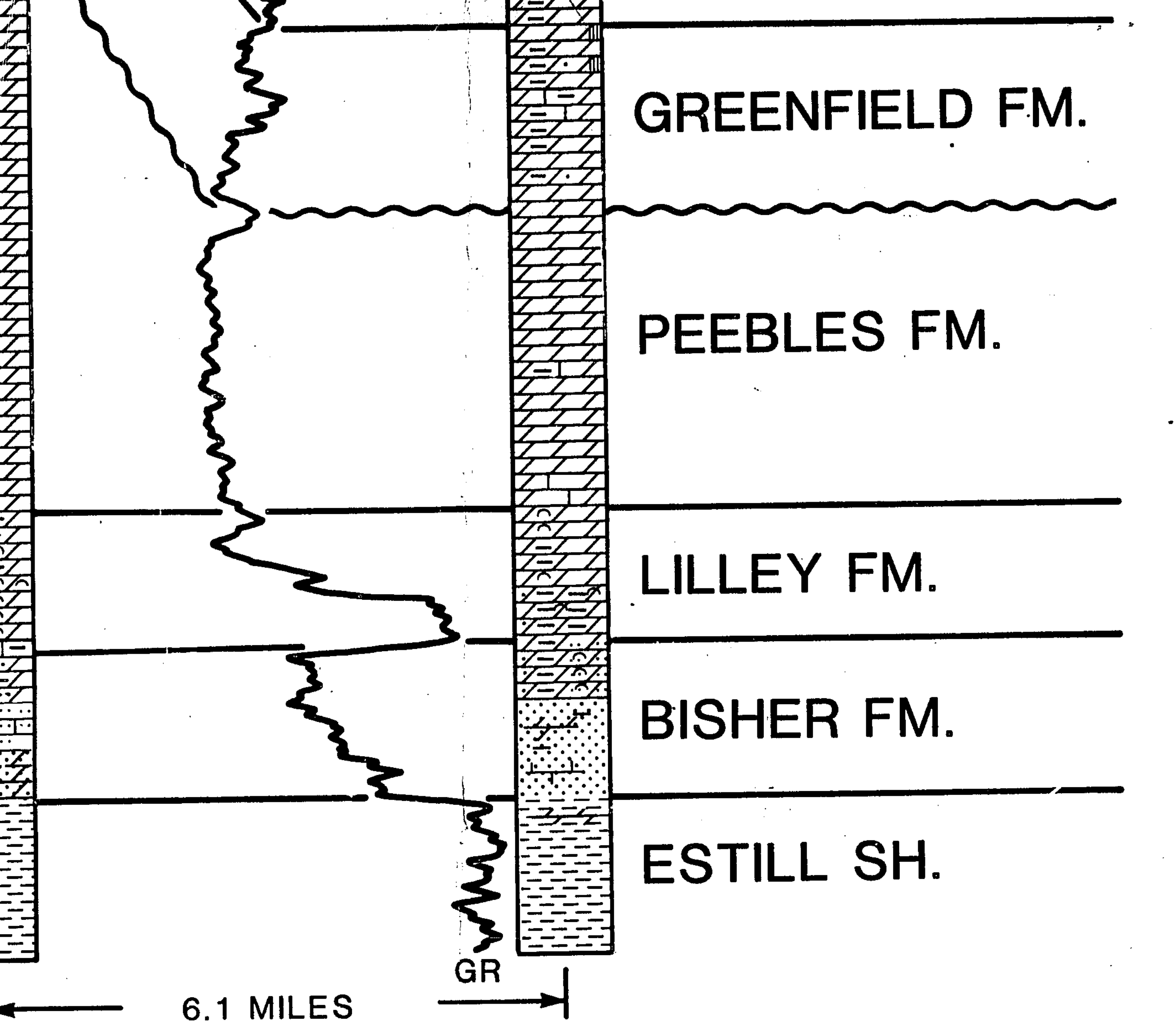


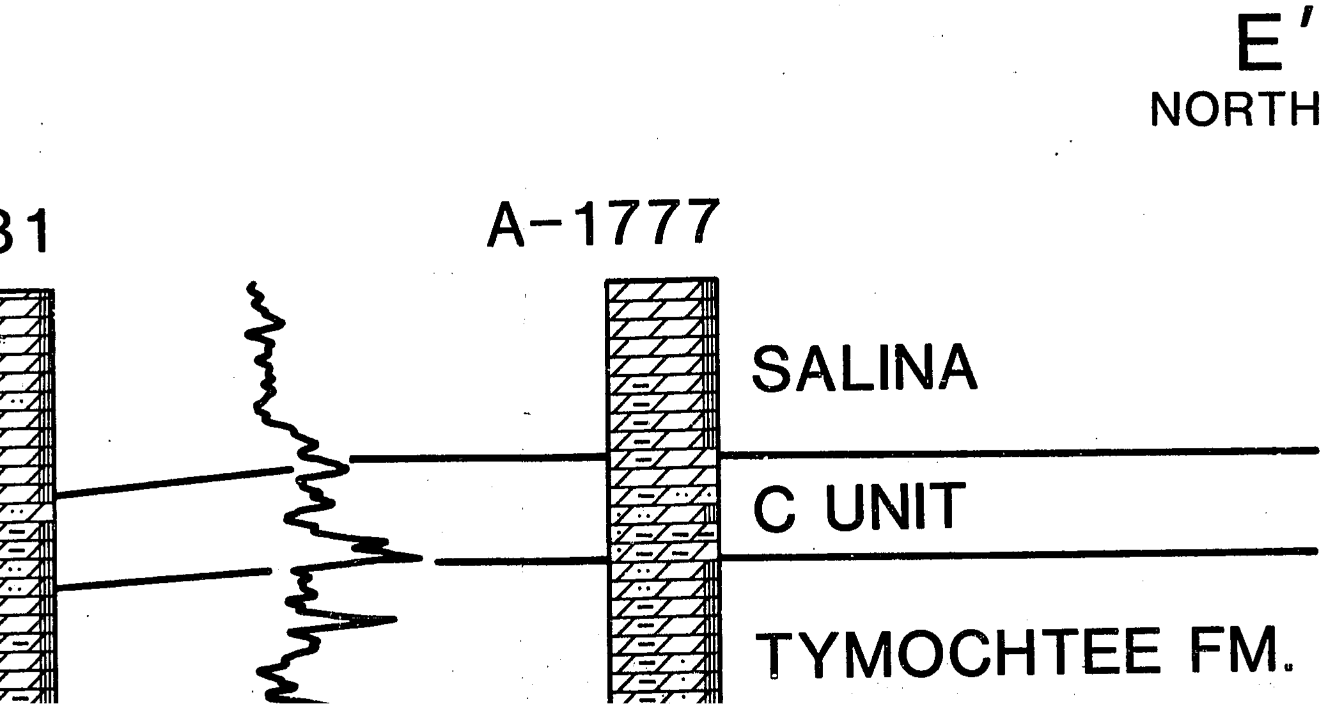
WEST VIRGINIA | OHIO

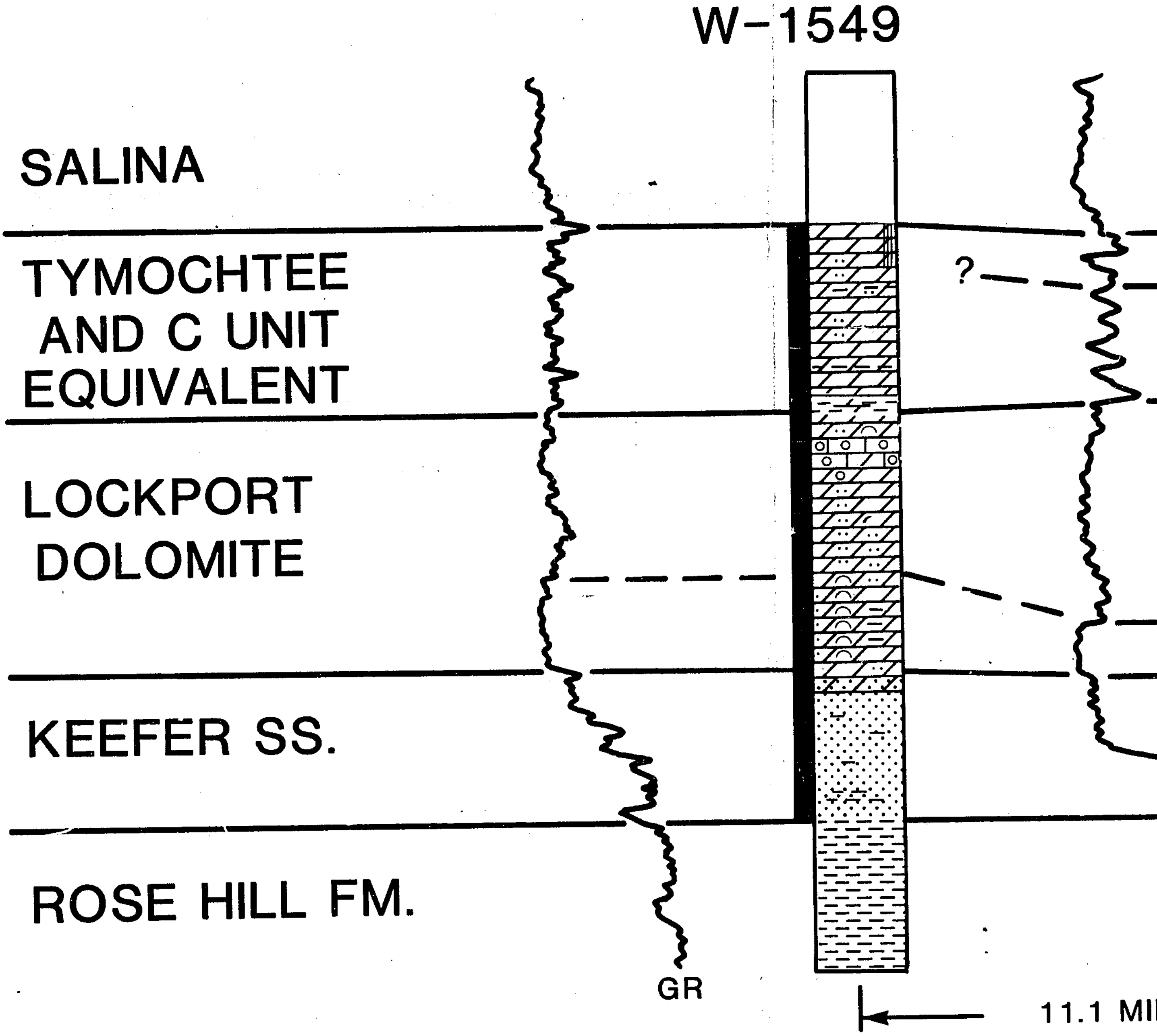

GR
MILES
16.8 MILES
GR
16.7 MILES
G-181
G-221


GR
GR
GR
6.1 MILES
6.1 MILES

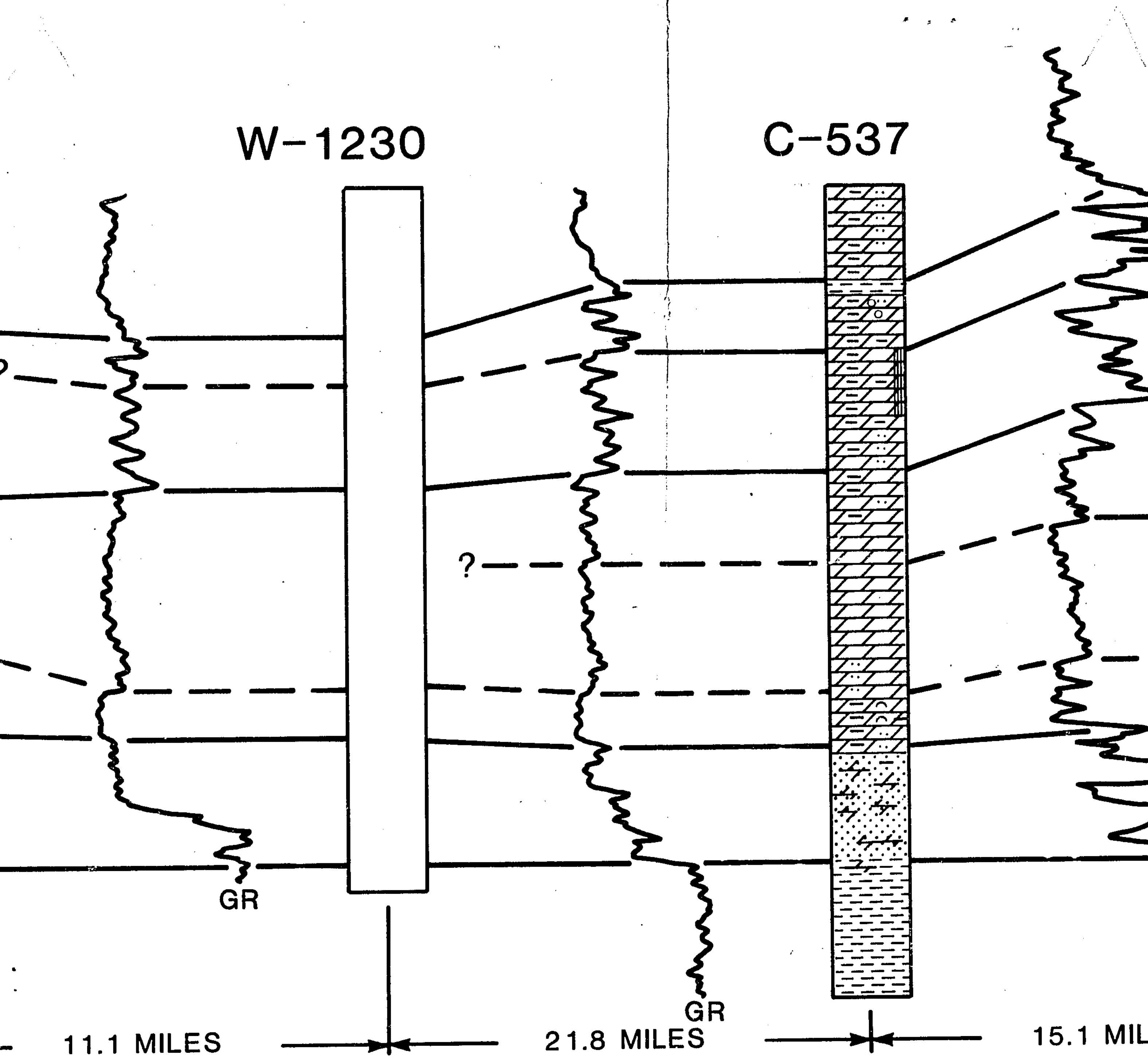

A-1768
A-1431
A-177

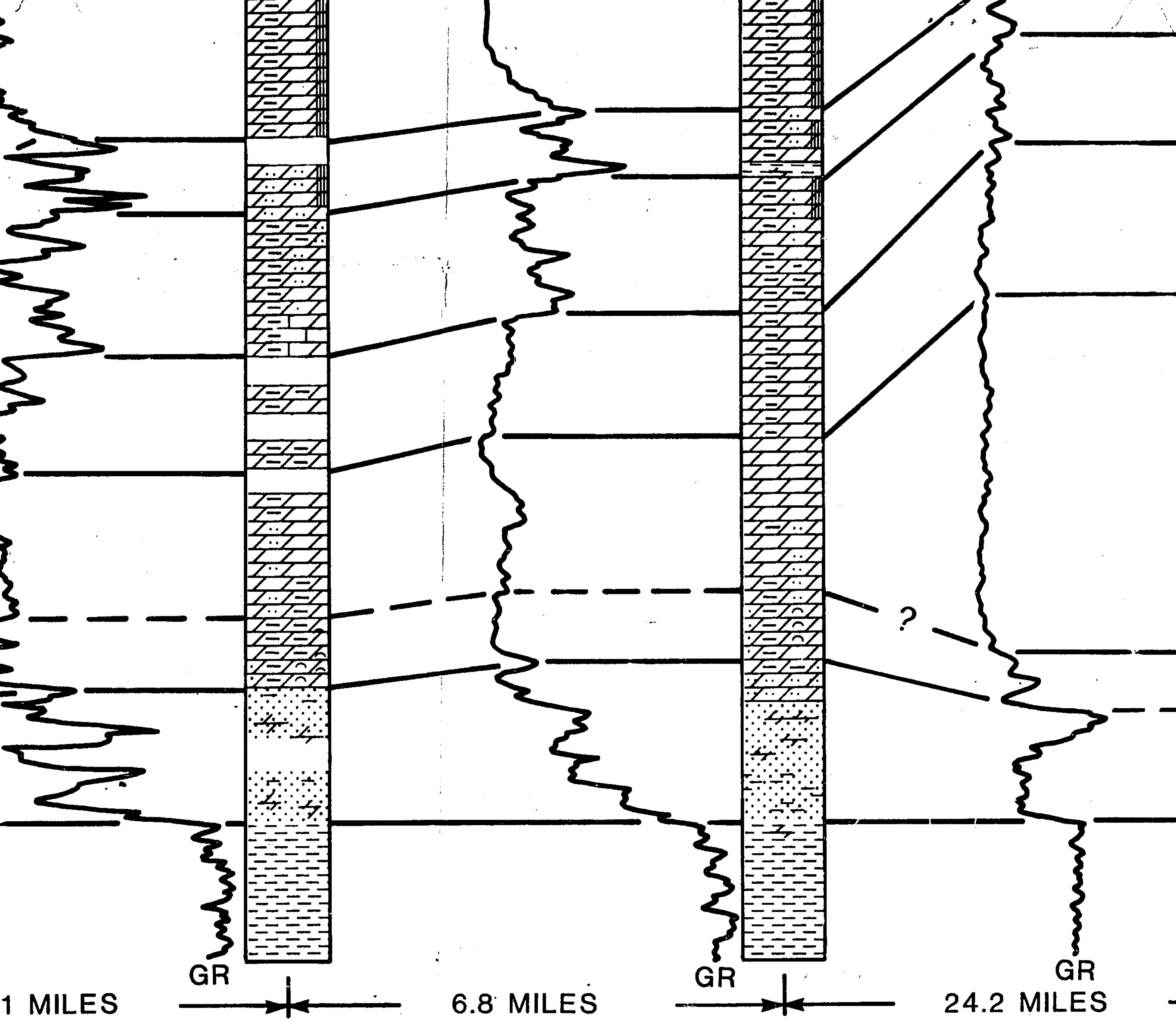

GREENFIELD FM.
PEEBLES FM.
LILLEY FM.
BISHER FM.
ESTILL SH.
GR
6.1 MILES

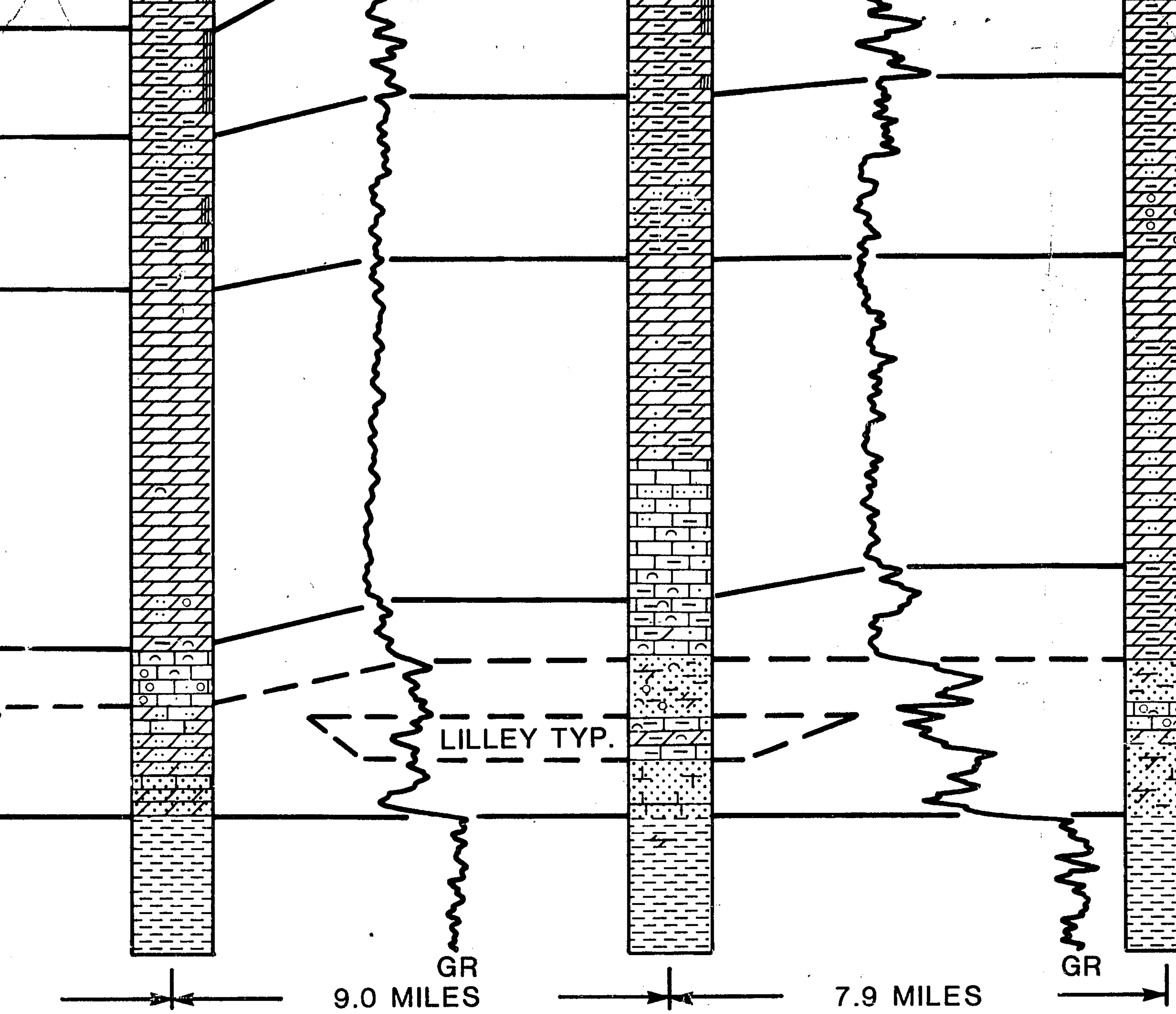

E′
NORTH
A–1777
SALINA
C UNIT
TYMOCHTEE FM.

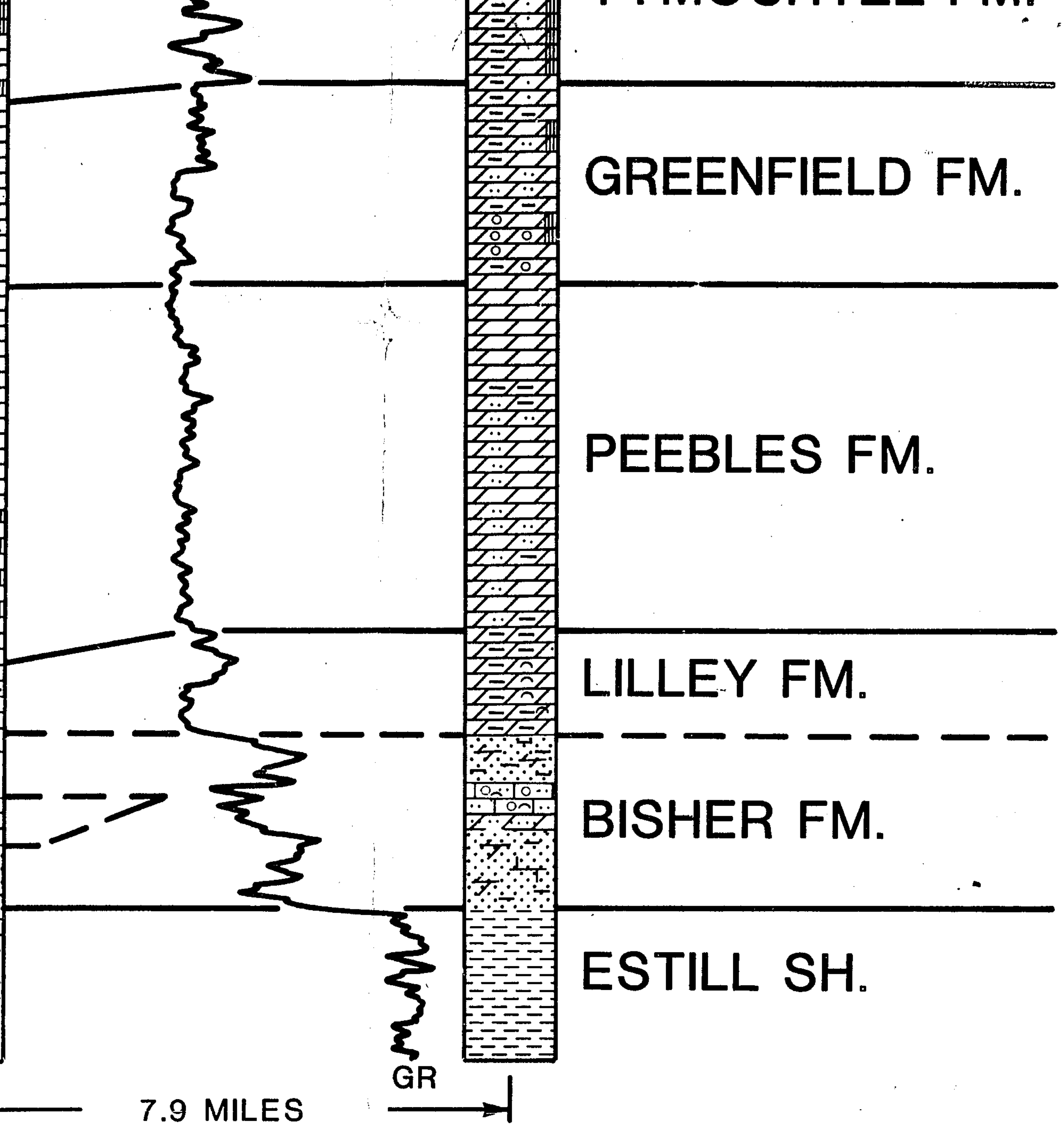


W-1549
SALINA
TYMOCHTEE AND C UNIT EQUIVALENT
LOCKPORT DOLOMITE
KEEFER SS.
ROSE HILL FM.
GR
?
11.1 MI


W-1230
C-537
GR
?
GR
11.1 MILES
21.8 MILES
15.1 MIL


GR
GR
GR
?
1 MILES
6.8 MILES
24.2 MILES


LILLEY TYP.
GR
9.0 MILES
GR
7.9 MILES


GREENFIELD FM.
PEEBLES FM.
LILLEY FM.
BISHER FM.
ESTILL SH.
GR
7.9 MILES