DEPARTMENT OF THE INTERIOR

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Geochemistry of selected oil and source rock samples from Cambrian and Ordovician strata, Ohio-West Virginia-Tennessee part of the Appalachian basin

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INTRODUCTION

Oil and gas fields producing from Cambrian and Ordovician reservoirs in Ohio range from a modest number of very small to small fields in the Appalachian basin part of Ohio to the giant Lima-Indiana field aligned in part with the Findlay arch of northwestern Ohio (fig. 1). The majority of the oil and gas fields in the Appalachian basin part of Ohio are trapped at or near the Middle Ordovician Knox unconformity whereas oil and gas in the Lima-Indiana field is trapped about 1000 ft above the Knox unconformity. The main objective of this investigation is to define the geochemical character of selected oils from Cambrian and Lower Ordovician reservoirs in the Appalachian basin part of Ohio. A second objective of this investigation is to identify the probable source of the Ohio oils by analyzing the total organic carbon (TOC) and Rock-Eval yields of selected shale and argillaceous limestone samples in the Ohio-West Virginia-Tennessee part of the Appalachian basin. The report presents gas chromatograms of the saturated hydrocarbon fraction for 15 Ohio oils, TOC and Rock-Eval data for 92 rock samples, and preliminary conclusions regarding the geochemical character and source of the 15 Ohio oils.

Fifteen oil samples from stratigraphic and subtle anticlinal traps along the Middle Ordovician Knox unconformity in Ohio were analyzed by gas chromatography to determine their geochemical character. The most productive group of Knox unconformity oil fields sampled (five samples) in this investigation are concentrated in Morrow County where oil is trapped directly beneath the unconformity in buried hills (fig. 1). The buried hills consist of finely to coarsely crystalline dolomite with local solution-enlarged fractures and caverns in the Upper Cambrian part of the Knox Dolomite (Copper Ridge Dolomite of driller's usage) (Calvert, 1964; Dolly and Busch, 1972; Petrie, 1982) (figs. 2, 3). Gas fields, with local oil and condensate, producing from the Upper Cambrian (?) Rose Run Sandstone Member of the Knox Dolomite and the overlying Lower Ordovician part of the Knox Dolomite (Beekmantown Dolomite of driller's usage) constitute another important group of fields sampled in this investigation (seven samples) (figs. 2, 3). Discovered mainly in the 1980's, these fields are scattered across a 200-mi-long, northeast-trending zone in eastern Ohio where the Rose Run Sandstone subcrops beneath the Knox unconformity (fig. 1). Traps for the Rose Run fields consist of buried hills, updip pinchouts, and small anticlines (Janssens, 1973; Coogan and Maki, 1986; Moyer, 1988). In Erie and Huron Counties, several small anticlinal oil fields (South Birmingham and Collins) were sampled (two samples) in this investigation (fig. 1). These fields produce oil from directly beneath the Knox unconformity. The Collins field (pool) produces oil from the Upper Cambrian part of the Knox Dolomite whereas the South Birmingham field produces oil from a local sandstone recognized by drillers as the Krysik sandstone of Late Cambrian age (Janssens, 1973) (figs. 2, 3). The Knox Dolomite and Krysik sandstone in the Collins and South Birmingham fields (Janssens, 1973) and the Knox Dolomite in the Tiffin field (Janssens, 1973) in adjoining Seneca County (fig. 1) are the oldest oil-producing strata in Ohio. The remaining sample collected for this investigation is from the Harlem field (Gannan, 1983; Wickstrom and Gray, 1985; Maslowski, 1986) in Delaware County (fig. 1) where gas and minor oil is produced from the Middle Ordovician Black River and Trenton Limestones (figs. 2 and 3). Here, the gas and oil appear to be stratigraphically trapped in a zone of localized dolomitization about 500 ft above the Knox unconformity (Gannan, 1983).

Of the 15 Ohio oils sampled for this investigation, only the Morrow County oils previously have been analyzed and characterized (McKirdy and others, 1981; Cole and others, 1987). Geochemical analyses of oils from the Lima-Indiana field on the Findlay arch--not sampled in this investigation--have been reported by Longman and Palmer (1987) and Cole and others (1987).

Ninety-two core and outcrop samples from Ohio, Tennessee, and West Virginia were analyzed by Rock-Eval for total organic carbon (TOC) and pyrolysis yields and by solvent extraction to evaluate the source of the Ohio oils. Four stratigraphic intervals were tested: (1) the Middle and Upper Cambrian strata in the Rome trough and thrust belt, (2) the Middle Ordovician Wells Creek Formation and the equivalent part of the Beekmantown Group, (3) the Middle Ordovician Black River Limestone, and (4) the Middle and Upper Ordovician Antes Shale (figs. 2, 3). These stratigraphic intervals are considered by us to be the most likely candidates for the source of the Ohio oils trapped in Cambrian and Ordovician strata. They are proximal to the oil reservoirs and they contain local to abundant, dark gray to black shale and argillaceous limestone that are indicative of above-average organic richness. TOC, Rock-Eval, and solvent extraction analysis of selected rock samples in this investigation may provide evidence to eliminate one or more of the candidates. Other Rock-Eval analyses in Ohio and adjoining states that are relevant to this investigation have been reported by Cole and others (1987) (numerous Cambrian and Ordovician units in Ohio), Wallace and Roen (1989) (Utica and Antes Shales in Ohio, New York, Pennsylvania, and West Virginia), and Laughrey (1991) (numerous Cambrian and Ordovician units in Pennsylvania).

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OIL GEOCHEMISTRY

Sample Collection and Analytical Procedure

Fifteen oil samples, listed in table 1 and located on figure 4, constitute the crude-oil data set used in this investigation. Four major groups of oil and gas fields, based on geographic and stratigraphic position, were sampled: (1) Morrow County fields; (2) Rose Run Sandstone fields; (3) South Birmingham and Collins fields; (4) Harlem field (figs. 1, 2). The oil samples were collected in 1987 and 1988 by oil industry and Ohio Division of Geological Survey personnel cited in the acknowledgments. Most of the oil samples were collected directly from the well head, but several of the samples were collected from a holding tank adjoining the producing well. Gas chromatography was performed on the C_5+ saturated hydrocarbon fraction of the oil samples using a Hewlett-Packard 5890A gas chromatograph.

Gas Chromatograms and Geochemical Character

Gas chromatograms (normal and expanded scale) of the 15 oil samples analyzed in this investigation are shown in figures 5 through 34. The expanded-scale chromatograms were plotted to more readily identify the isoprenoids, pristane (pr) and phytane (ph) and to measure their peak heights. The distribution of the C_9+ n-alkanes in each oil is compared against all oils (fig. 35) and selected groups of oils (figs. 36-39).

The oil samples show similar geochemical characteristics including: (1) predominance of odd-numbered n-alkanes between nC_{12} and nC_{19} (carbon preference indices from 1.04 to 1.15); (2) pr/ph between 1.0 and 1.4 (fig. 40); (3) a full profile of the C_{21}+ saturated hydrocarbon fraction except for samples J and K (figs. 23 and 25) which are very light oils or condensates; and (4) pr/nC_{17} and ph/nC_{18} between 0.2 and 0.5 (fig. 41).

ROCK-EVAL ANALYSES OF SELECTED ROCK SAMPLES

Sample Collection and Analytical Procedure

The 92 rock samples collected from cored drill holes and outcrops listed in table 2 and located on figure 4 constitute the rock data set used in this investigation. These core and outcrop samples consist of shale and argillaceous carbonate collected from 1984 through 1988 by R. T. Ryder. The samples were collected in stratigraphic intervals which we consider to be likely candidates for the source of the Ohio oils. All rock samples were ground to a powder size of 100 mesh and analyzed for standard pyrolysis yields and organic carbon content (TOC) using a Rock-Eval instrument.

Organic Carbon Content and Rock-Eval Pyrolysis Yields

The organic carbon content and pyrolysis "products" of the 92 rock samples are shown in figures 42 through 70. Because the pyrolysis "products" are not accurately known they are simply identified as yields of volatile hydrocarbons (S_1), kerogen breakdown products (S_2), and carbon dioxide (S_3) (Appendix A). Oxygen Index (OI) values greater than 200 mg $CO_{2/g}$ organic carbon noted in many of the analyses are most certainly the result of carbonate rock decomposition during pyrolysis rather than carbon dioxide from organic matter (for example, see figure 44). The sample analyses are organized by state: Ohio (figs. 42-53); West Virginia (figs. 54-66); Tennessee (figs. 67-70). Figure 71 shows the TOC content of strata considered here to be the most probable candidates as the source of the Ohio oils (Antes Shale; Wells Creek Formation and equivalent part of the Beekmantown Group; Middle and Upper Cambrian Strata in the Rome trough and thrust belt; and Black River Limestone). Also, TOC values for shale units in the Knox Dolomite, Beekmantown Group (lower part), and Rose Run Sandstone Member are shown in figure 71 but these strata are not seriously considered to be source beds for the Ohio oils. Of the four groups of potential source beds, the Antes Shale samples show the highest TOC values ($\bar{x}$ = 1.2, n = 12). The average TOC for each of the remaining three groups is less than 0.5. For example, the Wells Creek Formation and equivalent Beekmantown Group have an average TOC value of 0.3. In this study we use a 1% TOC lower limit for source rocks.

Figure 72 shows the distribution of Tmax temperatures calculated for S_2 > 0.40 mg/g and production indices (PI) calculated for TOC > 0.5. The values can be used as an indication of thermal maturity with respect to oil and gas generation (Espitalié and others, 1977; Tissot and Welte, 1984). Because of the high thermal maturity and (or) low TOC of many samples, few reliable Tmax temperatures and PI values were obtained in this study. Except for one data point on figure 72 (Tmax=420; PI=0.07), Tmax temperatures and production indices suggest that the Lower and Middle Ordovician strata in central and eastern Ohio are marginally mature to mature with respect to oil generation. Production indices between 0.3 and 0.5 ($\bar{x}$ = 0.4, n = 9) suggest that in adjoining West Virginia, on the hinge zone between the Rome trough and the relatively stable shelf (fig. 4), the Lower and Middle Ordovician strata are at or slightly above the upper limit of oil generation. In the Rome trough of West Virginia and the thrust belt of eastern Tennessee, production indices between 0.4 and 0.6 indicate that the Middle and Upper Cambrian strata are in the zone of gas generation.

Thermal maturity trends inferred from the Tmax and PI values presented in this study (fig. 72) correspond broadly with the eastward increasing level of thermal maturation in Ordovician strata recognized by Harris and others (1978), Cole and others (1987), and Wallace and Roen (1989). Wallace and Roen (1989) suggested that the oil generation zone for Ordovician strata continues westward along a 50- to 75-mi-wide, lobate-shaped belt through central Ohio and into part of western Ohio. Cole and others (1987) showed that Ordovician strata in northwestern Ohio are in the zone of oil generation but exclude all of central Ohio from the zone of oil generation. The curious extension of the oil generation zone through central Ohio as shown by Wallace and Roen (1989), and supported by our control points in Morrow County, requires additional study.

Solvent Extraction

The thermal maturity of most of the samples with TOC > 1.0 was too high to yield adequate solvent extracts for detailed characterization.

CONCLUSIONS

1. The 15 Ohio oils studied here are geochemically similar to one another and to oils in North American, European, and Australian localities that have been correlated with Ordovician source rocks (Reed and others, 1986; Longman and Palmer, 1987; Jacobson and others, 1988). The most notable characteristic of these oils is the predominance of odd-numbered n-alkanes between nC_{12} and nC_{19}.

2. Rose Run Sandstone oils are the most mature of the 15 Ohio oils examined based on their greater gas-to-oil ratios, greater condensate content, predominance of n-alkane fraction less than nC_{15}, and greater reservoir depths. Low pr/nC_{17} and ph/nC_{18} values (fig. 41) for the Rose Run oils with respect to the oil located in central and north-central Ohio support Connan (1981) who reported an inverse relation between these ratios and the maturation level of crude oil.

3. Judging from the rock samples studied here, the Middle and Upper Ordovician Antes Shale is the most probable source of the Ohio oils because of its moderate TOC values ($\bar{x}$ = 1.2), production indices between 0.3 and 0.5, and stratigraphic position about 1,000 ft above the Knox unconformity. Powell and others (1984), Cole and others (1987), and Wallace and Roen (1989) also concluded that the Antes Shale and equivalent units such as the Utica Shale are good petroleum source rocks and are the probable source for oils in Cambrian and (or) Ordovician reservoirs in Ohio and Ontario.

4. Maturation levels based on a limited number of Tmax temperatures and production indices suggest that the Ohio oils analyzed in this investigation were generated in easternmost Ohio and (or) adjoining Pennsylvania and West Virginia and migrated along the Knox unconformity into traps in eastern and

central Ohio. The Rose Run oil probably was trapped at about the same time as the oil in and adjoining Morrow County was trapped, but the Rose Run oil experienced greater in-reservoir maturation owing to its more basinward position.

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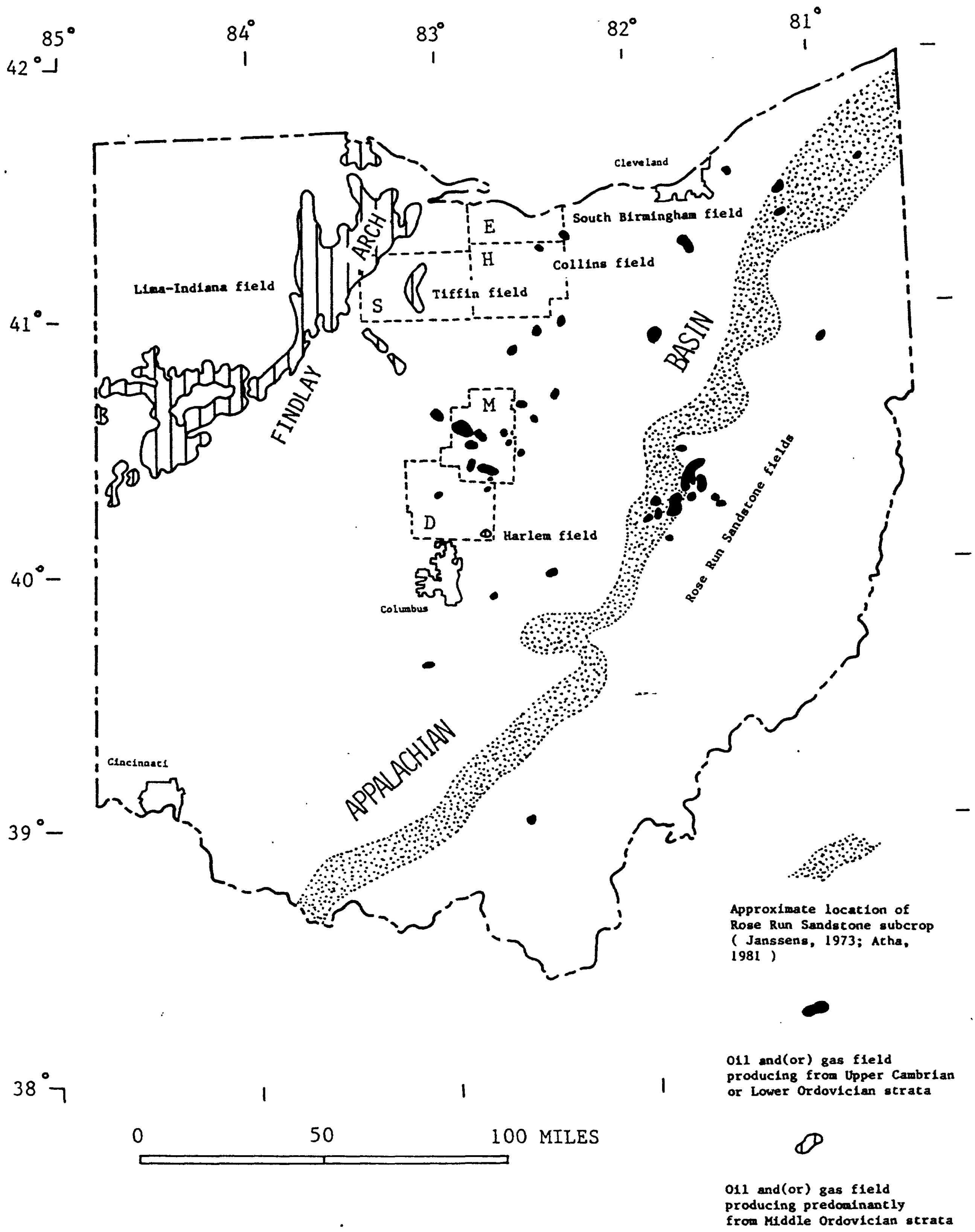


Figure 1. Map of Ohio showing oil and gas fields that produce from Cambrian and (or) Ordovician reservoirs. Selected counties are identified as follows: D, Delaware; E,Erie; H, Huron; M, Morrow; S, Seneca. Named fields apply to fields used in this study. Most Rose Run Sandstone fields are unnamed.

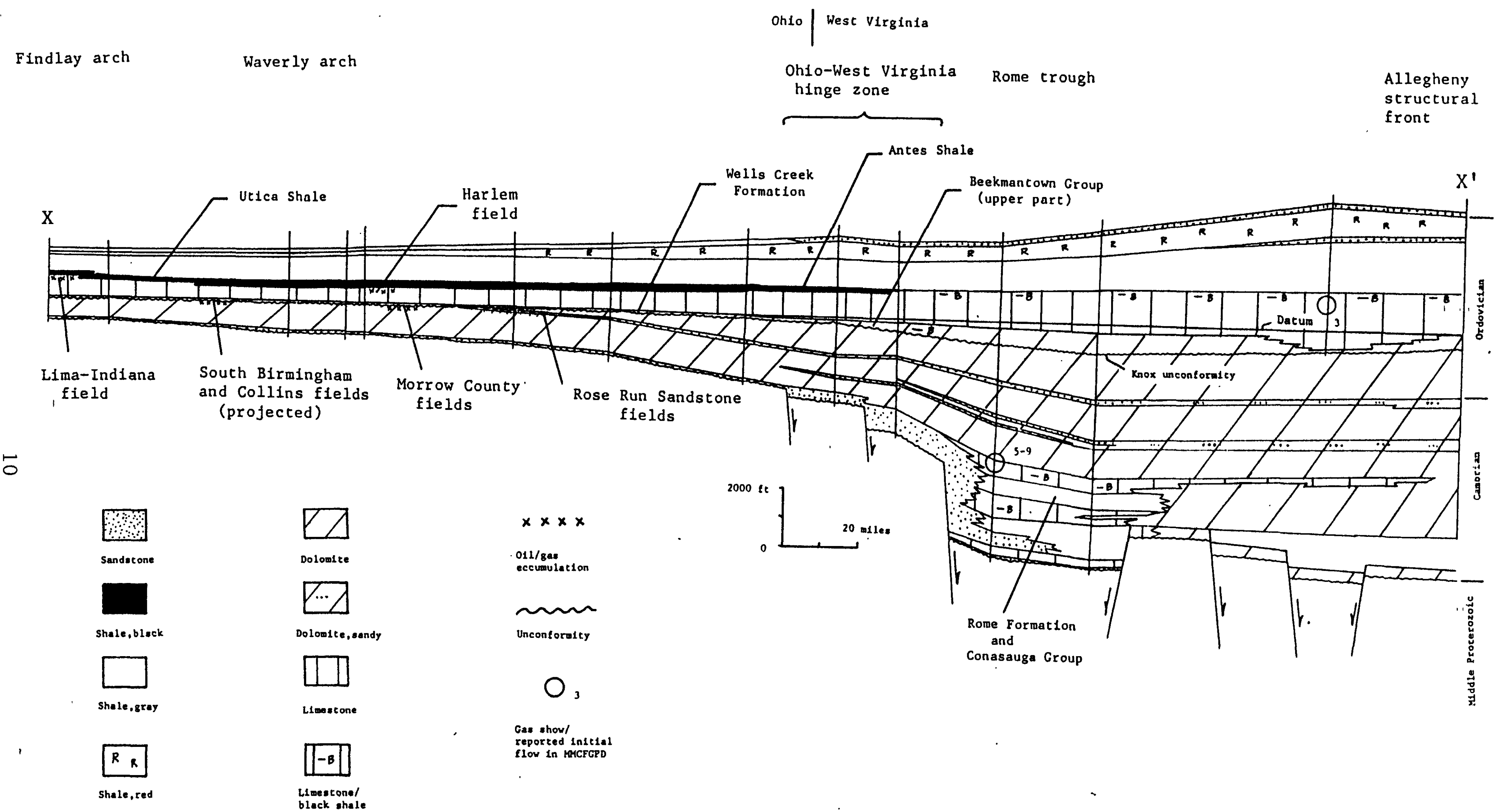


Figure 2. Stratigraphic section X-X' from Sandusky County, Ohio, to Pendleton County, West Virginia, showing Cambrian and Ordovician sequences (modified after Ryder, in press a). The section is restored to a datum 50 to 1000 ft above the Knox unconformity. Also shown are the stratigraphic positions of oil and gas fields and potential source rocks discussed in this report. The line of section X-X' is identified in figure 4.

Figure 3. Correlation chart of Proterozoic, Cambrian, and Ordovician rocks along section X-X′ and adjoining Virginia (Ryder, in press a). Also shown is the stratigraphic position of the oil and rock samples used in this investigation. The time scale from Palmer (1983) is nonlinear. North American chronostratigraphic units are modified after Barnes and others (1981), Ross and others (1982), and Palmer (1983).

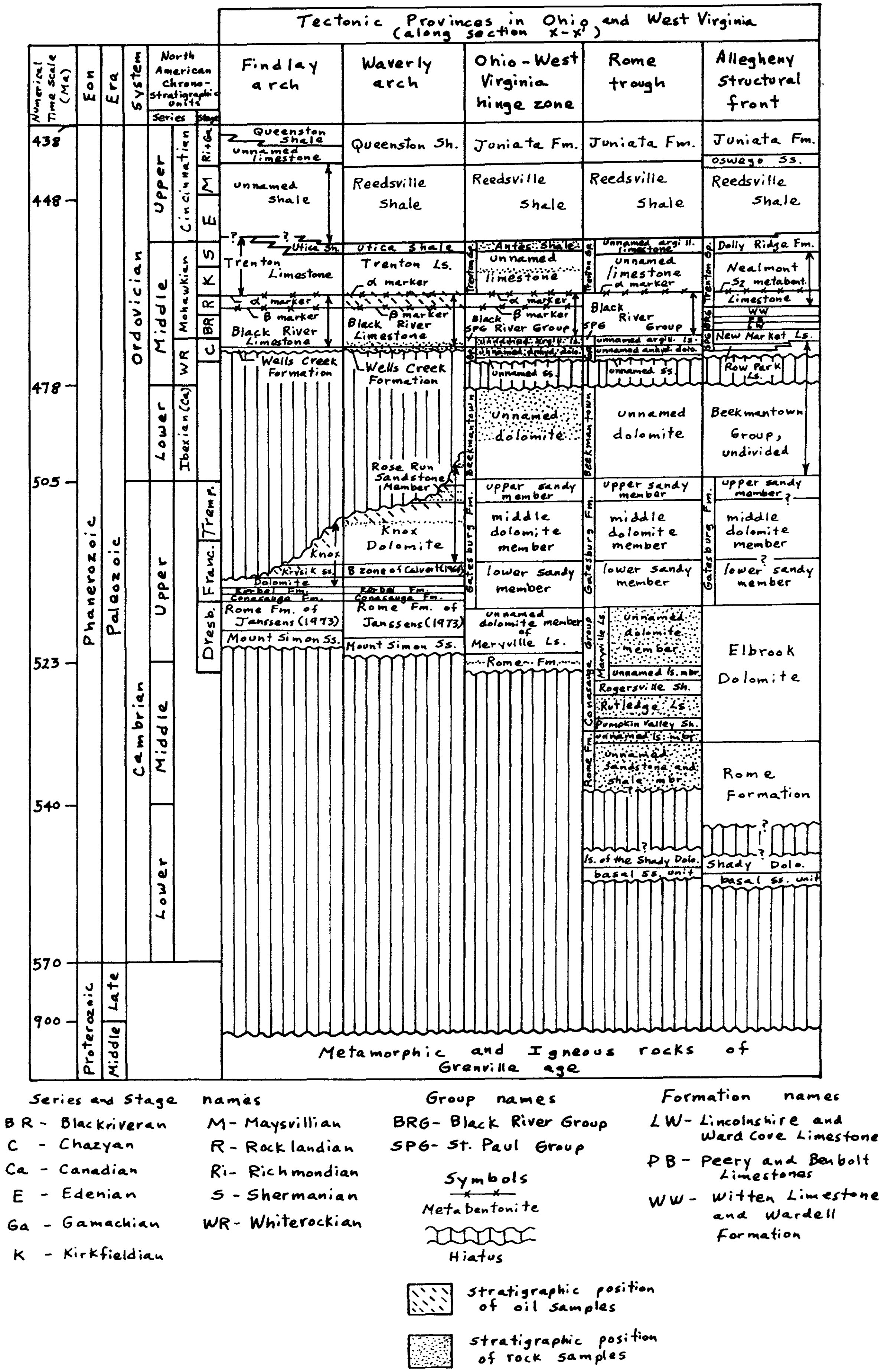
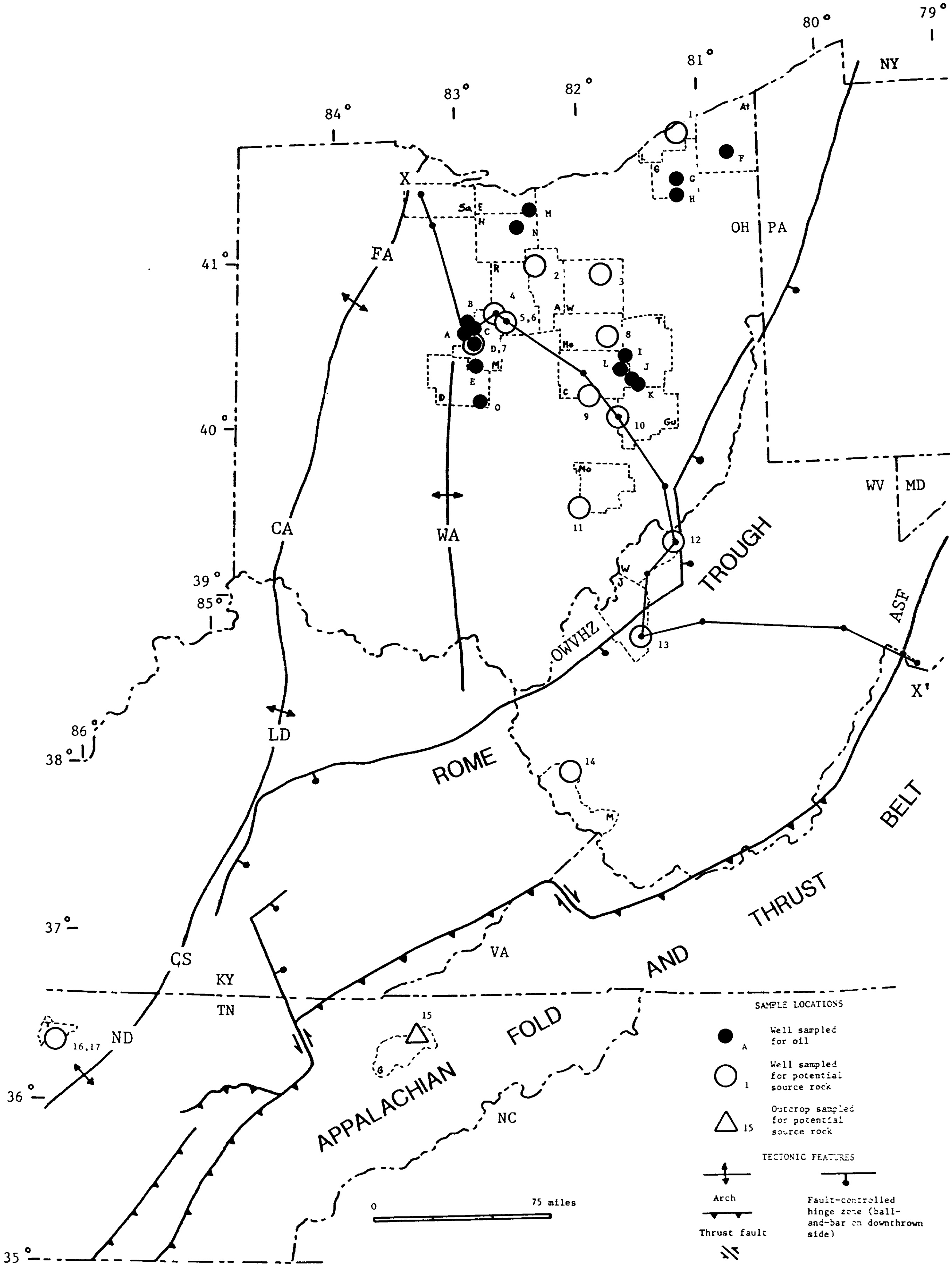

Tectonic Provinces in Ohio and West Virginia (along section X-X')
Numerical Time Scale (Ma)
Eon
Era
System
North American Chrono-stratigraphic Units
Series
Stage
Findlay arch
Waverly arch
Ohio-West Virginia hinge zone
Rome trough
Allegheny Structural front
438
448
478
505
523
540
570
900
Phanerozoic
Paleozoic
Proterozoic
Late
Middle
Ordovician
Cambrian
Upper
Middle
Lower
Cincinnatian
Mohawkian
Ibexian (Ca)
Tremp.
Franc.
Dresb.
Queenston Shale
unnamed limestone
unnamed shale
Utica Sh.
Trenton Limestone
α marker
β marker
Black River Limestone
Wells Creek Formation
Knox
Krysik ss.
Dolomite
Kerbel Fm.
Conasauga Fm.
Rome Fm. of Janssens (1973)
Mount Simon Ss.
Queenston Sh.
Reedsville Shale
Utica Shale
Trenton Ls.
Rose Run Sandstone Member
Knox Dolomite
B zone of Calvert (1962)
Juniata Fm.
Antes Shale
unnamed limestone
Black River Group
SPG
Beekmantown
unnamed dolomite
upper sandy member
middle dolomite member
lower sandy member
Gatesburg Fm.
unnamed dolomite member of Maryville Ls.
Rome Fm.
unnamed argil. limestone
unnamed ss.
Conasauga Group
Maryville Ls.
unnamed dolomite member
unnamed ls. mbr.
Rogersville Sh.
Rutledge Ls.
Pumpkin Valley Sh.
unnamed sandstone and shale mbr.
Ls. of the Shady Dolo.
basal ss. unit
Oswego Ss.
Dolly Ridge Fm.
Nealmont
Sz metabent.
Limestone
WW
PB
LW
New Market Ls.
Row Park Ls.
Beekmantown Group, undivided
Elbrook Dolomite
Rome Formation
Shady Dolo.
basal ss. unit
Metamorphic and Igneous rocks of Grenville age
Series and Stage names
BR - Blackriveran
C - Chazyan
Ca - Canadian
E - Edenian
Ga - Gamachian
K - Kirkfieldian
M - Maysvillian
R - Rocklandian
Ri - Richmondian
S - Shermanian
WR - Whiterockian
Group names
BRG - Black River Group
SPG - St. Paul Group
Symbols
Metabentonite
Hiatus
stratigraphic position of oil samples
stratigraphic position of rock samples
Formation names
LW - Lincolnshire and Ward Cove Limestones
PB - Peery and Benbolt Limestones
WW - Witten Limestone and Wardell Formation

Figure 4. Map of Ohio, Tennessee (part), West Virginia (part), and adjoining states showing major tectonic features, line of section X-X', and the location of oil and rock samples used in this investigation. Major tectonic features are identified as follows: ASF, Allegheny structural front; CA, Cincinnati arch; CS, Cumberland saddle; FA, Findlay arch; LD, Lexington dome; ND, Nashville dome; OWVHZ, Ohio-West Virginia hinge zone; WA, Waverly arch. Selected counties are identified as follows: (Ohio) A, Ashland; At, Ashtabula; C, Coshochton; D, Delaware; E, Erie; G, Geauga; Gu, Guernsey; Ho, Holmes; H, Huron; L, Lake; Mo, Morgan; M, Morrow; R, Richland; Sa, Sandusky; T, Tuscarawas; W, Wayne; (Tennessee) G, Grainger; T, Trousdale; (West Virginia) J, Jackson; M, Mingo; W, Wood. Additional data regarding wells sampled for oil and potential source rocks are listed in tables 1 and 2, respectively.



NY
OH
PA
WV
MD
VA
KY
TN
NC
FA
CA
WA
LD
CS
ND
ASF
OWVHZ
ROME TROUGH
APPALACHIAN FOLD AND THRUST BELT
X
X'
SAMPLE LOCATIONS
Well sampled for oil
Well sampled for potential source rock
Outcrop sampled for potential source rock
TECTONIC FEATURES
Arch
Fault-controlled hinge zone (ball-and-bar on downthrown side)
Thrust fault
Strike-slip fault
0
75 miles

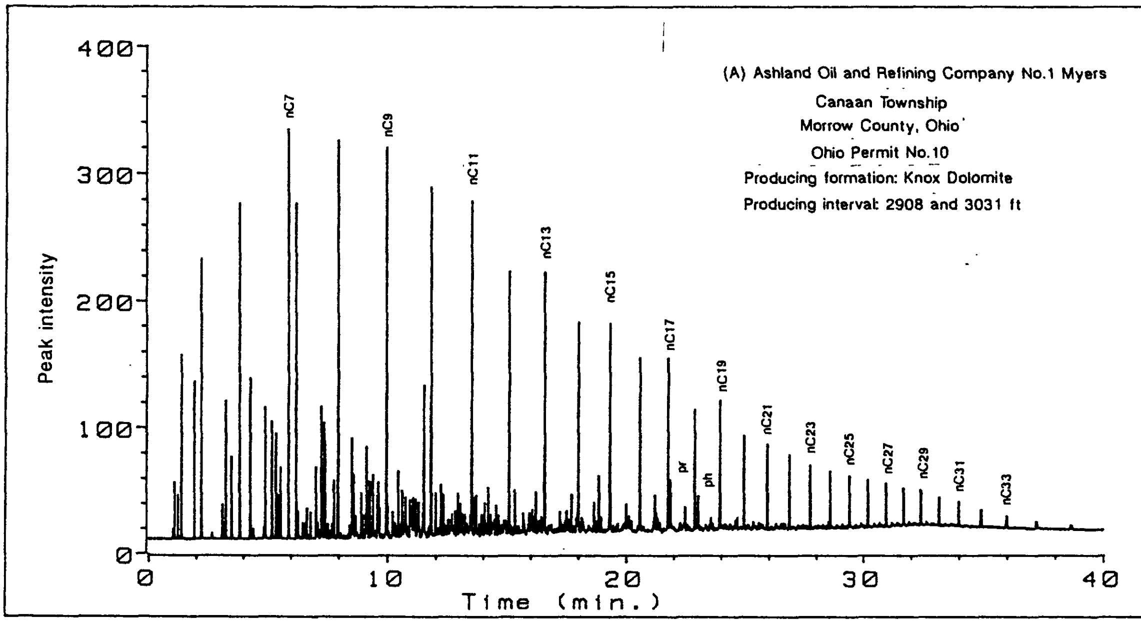


Figure 5. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample A, Ashland Oil and Refining Company No. 1 Myers well, Morrow County, Ohio. The C_7 through C_{33} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

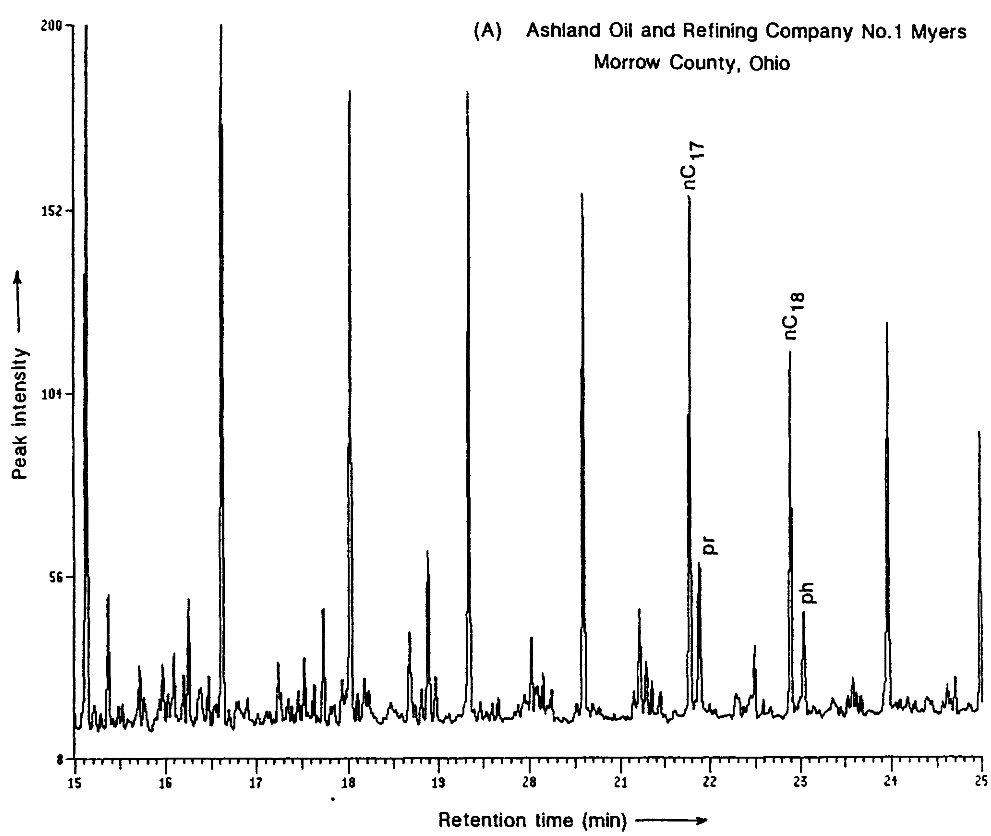


Figure 6. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample A, Ashland Oil and Refining Company No. 1 Myers well, Morrow County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

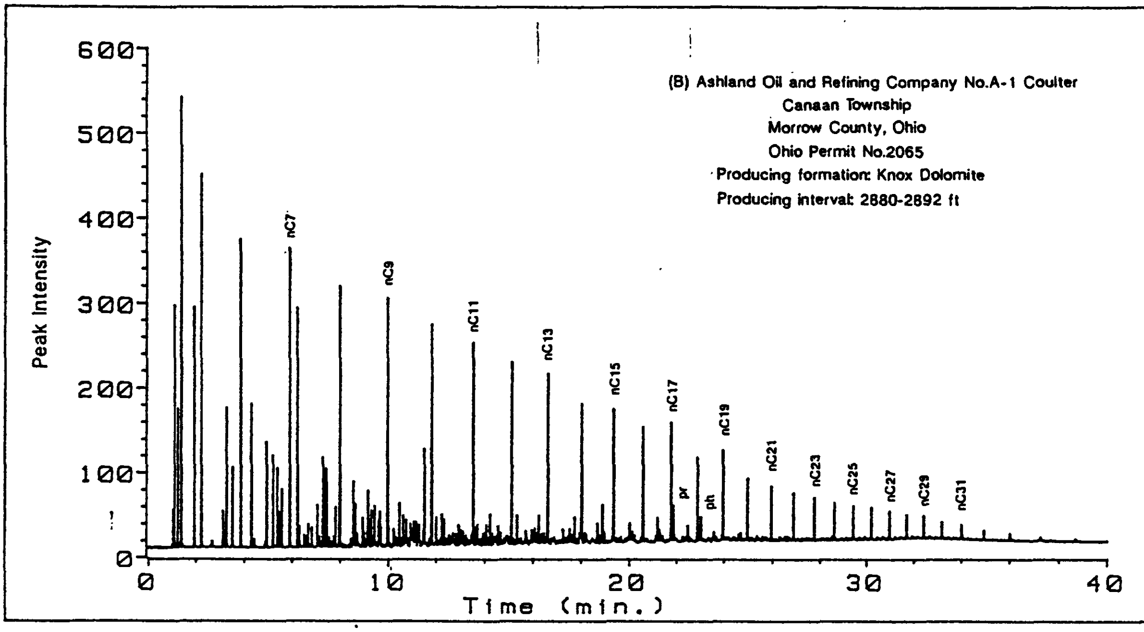


Figure 7. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample B, Ashland Oil and Refining Company No. A-1 Coultar well, Morrow County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

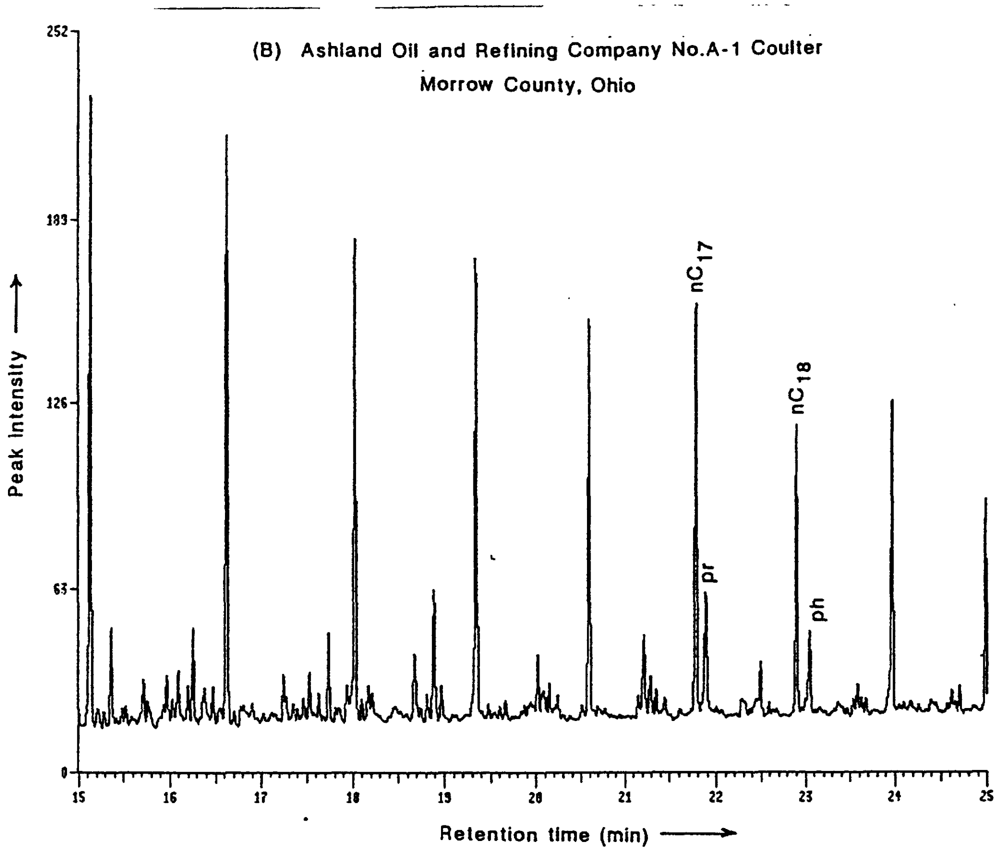


Figure 8. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample B, Ashland Oil and Refining Company No. A-1 Coulter well, Morrow County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

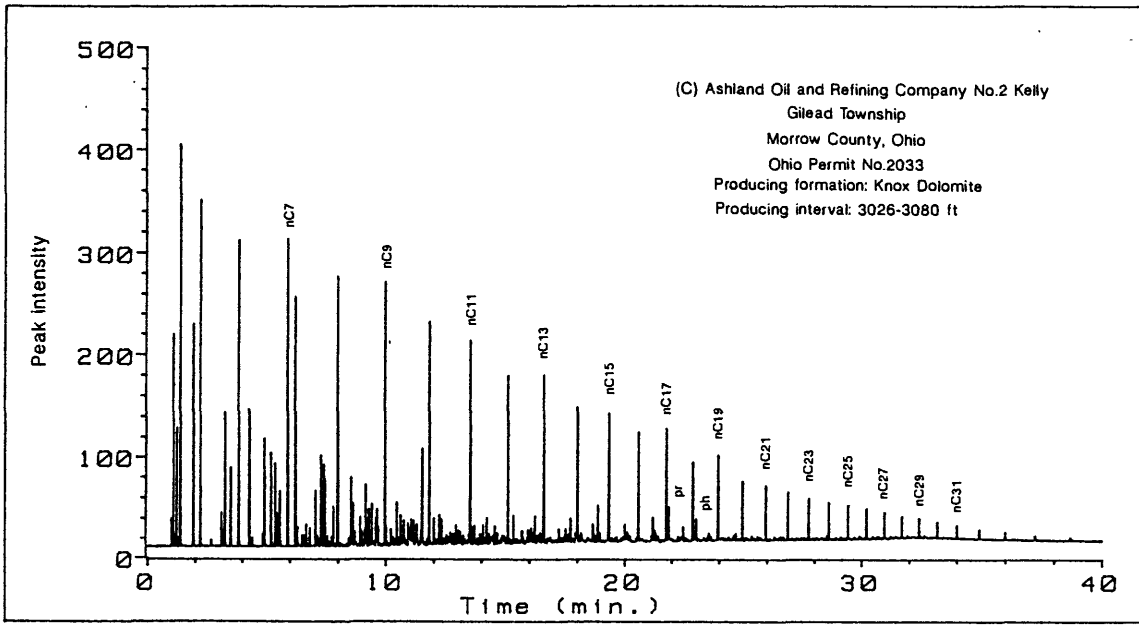


Figure 9. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample C, Ashland Oil and Refining Company No. 2 Kelly well, Morrow County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

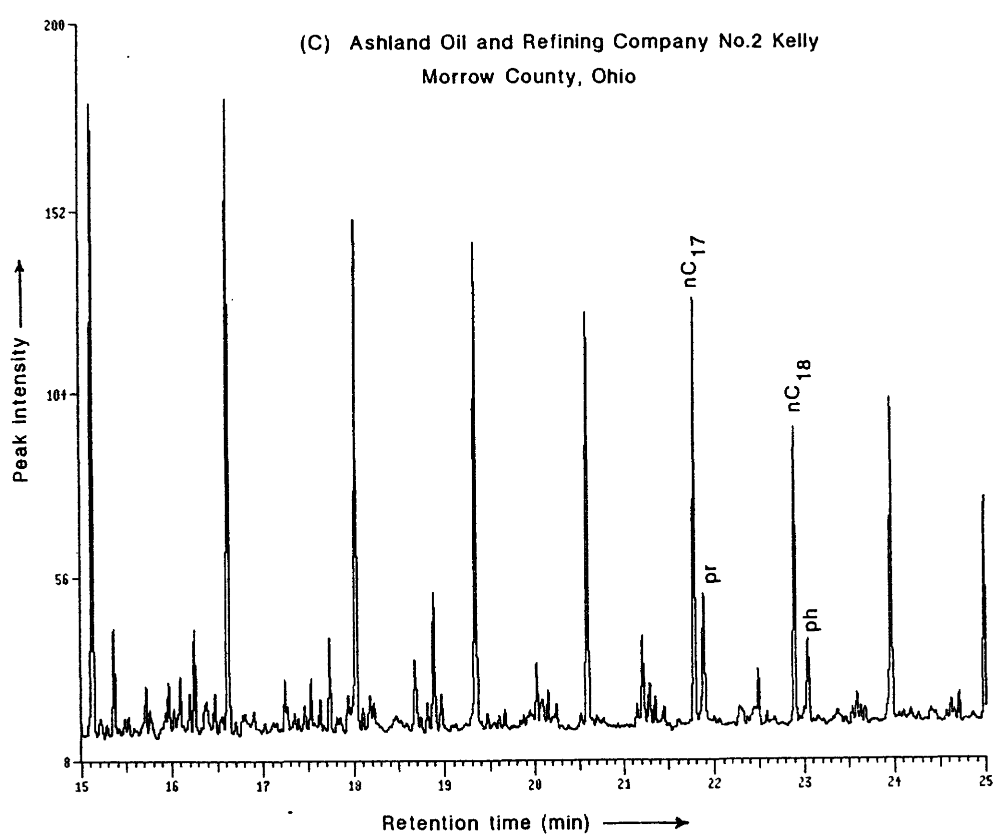


Figure 10. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample C, Ashland Oil and Refining Company No. 2 Kelly well, Morrow County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

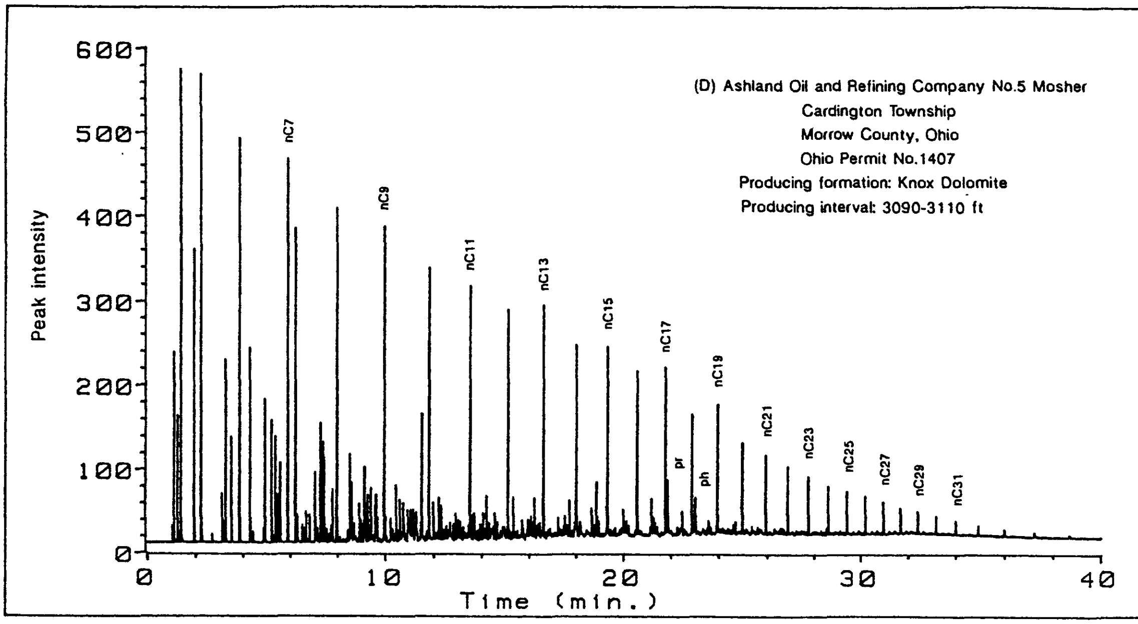


Figure 11. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample D, Ashland Oil and Refining Company No. 5 Mosher well, Morrow County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

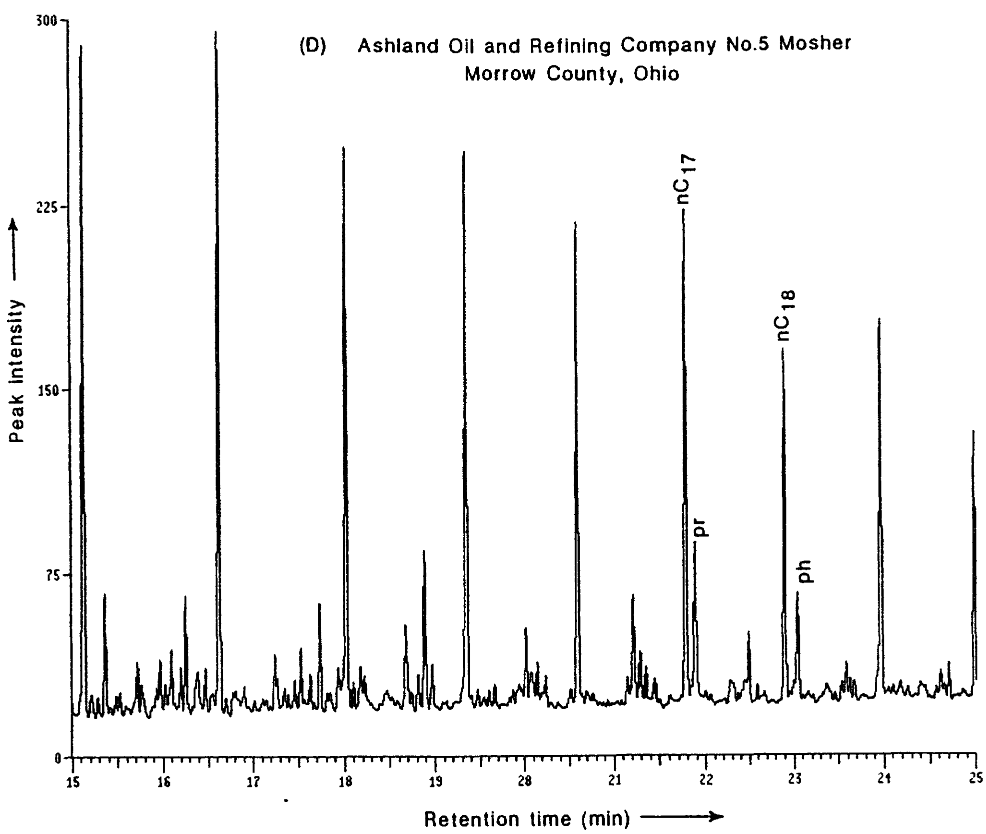


Figure 12. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample D, Ashland Oil and Refining Company No. 5 Mosher well, Morrow County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

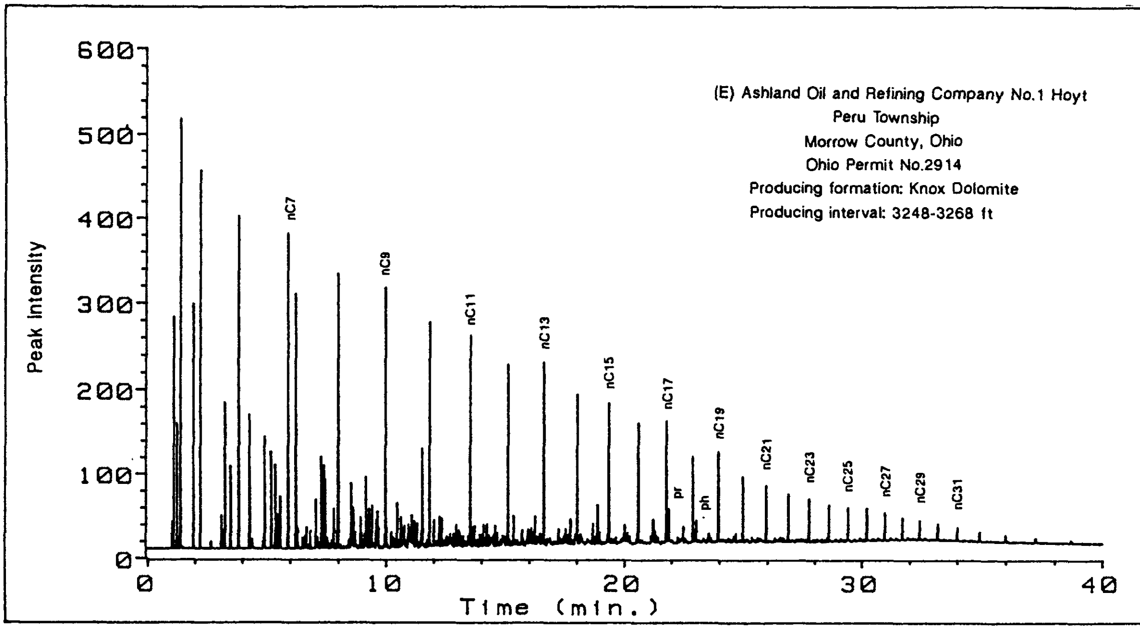


Figure 13. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample E, Ashland Oil and Refining Company No. 1 Hoyt well, Morrow County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

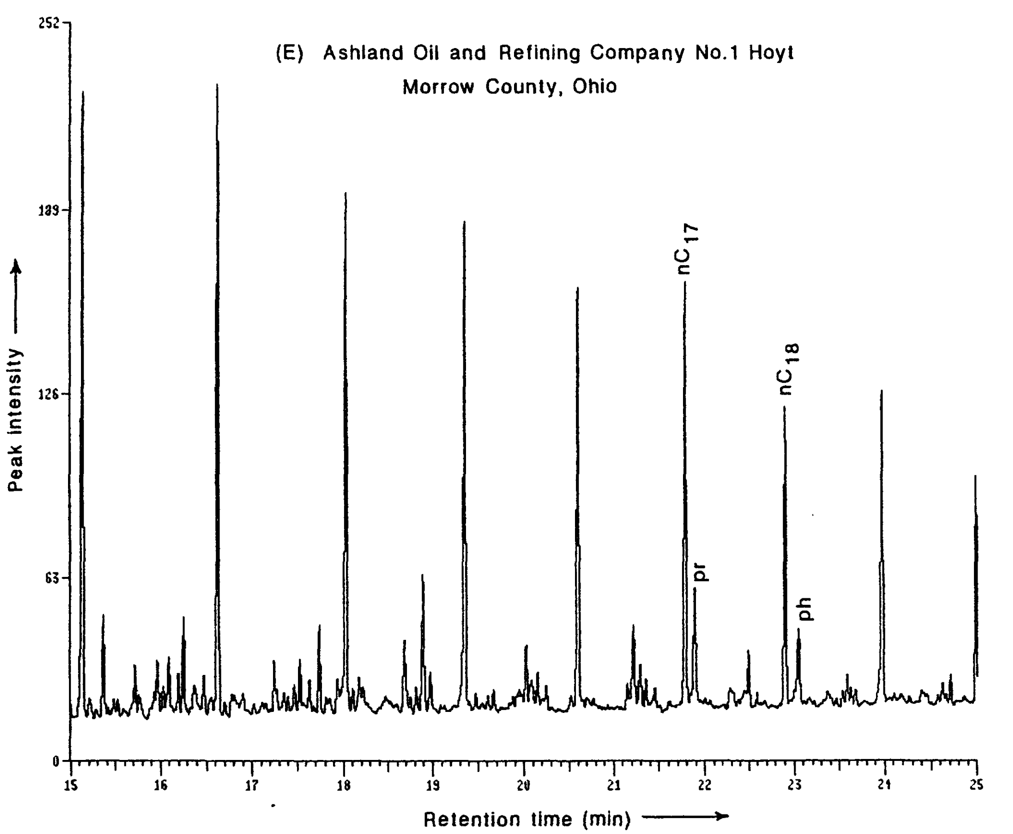


Figure 14. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample E, Ashland Oil and Refining Company No. 1 Hoyt well, Morrow County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

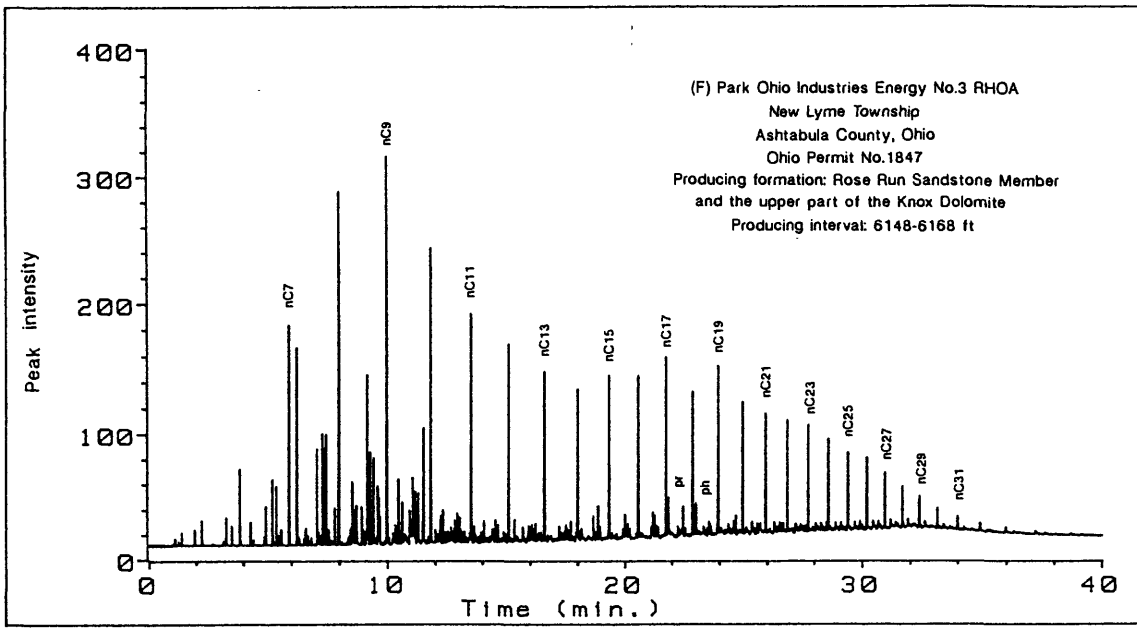


Figure 15. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample F, Park Ohio Industries Energy No. 3 RHOA well, Ashtabula County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

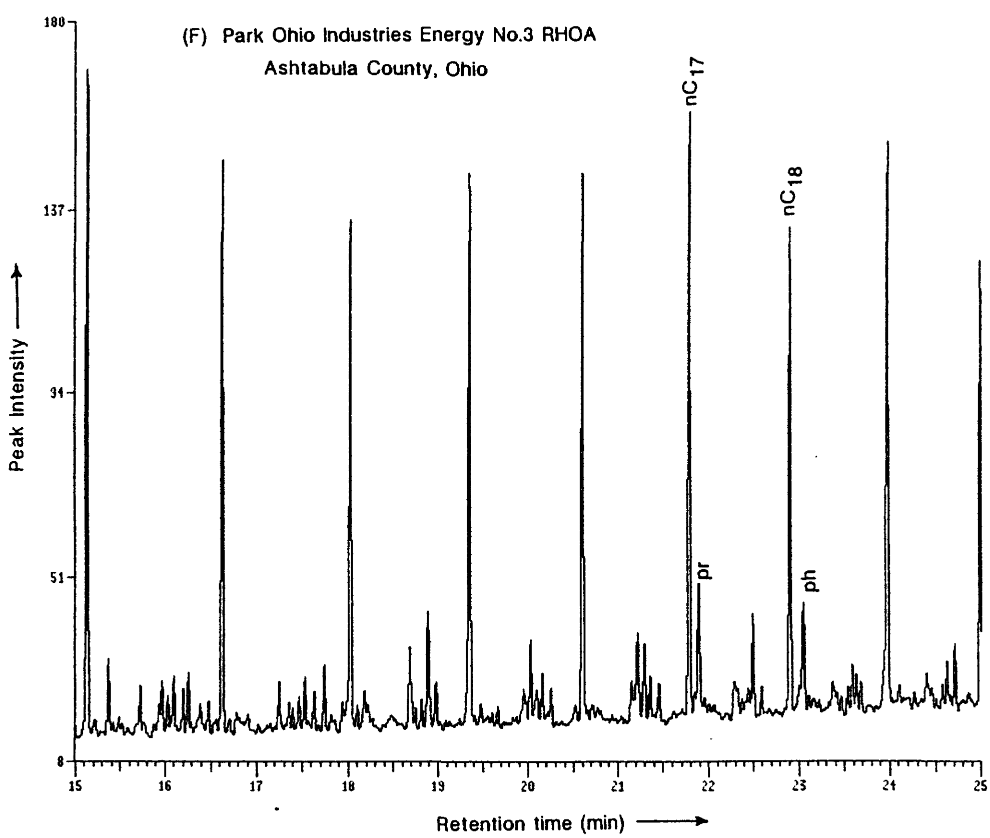


Figure 16. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample F, Park Ohio Industries Energy No. 3 RHOA well, Ashtabula County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

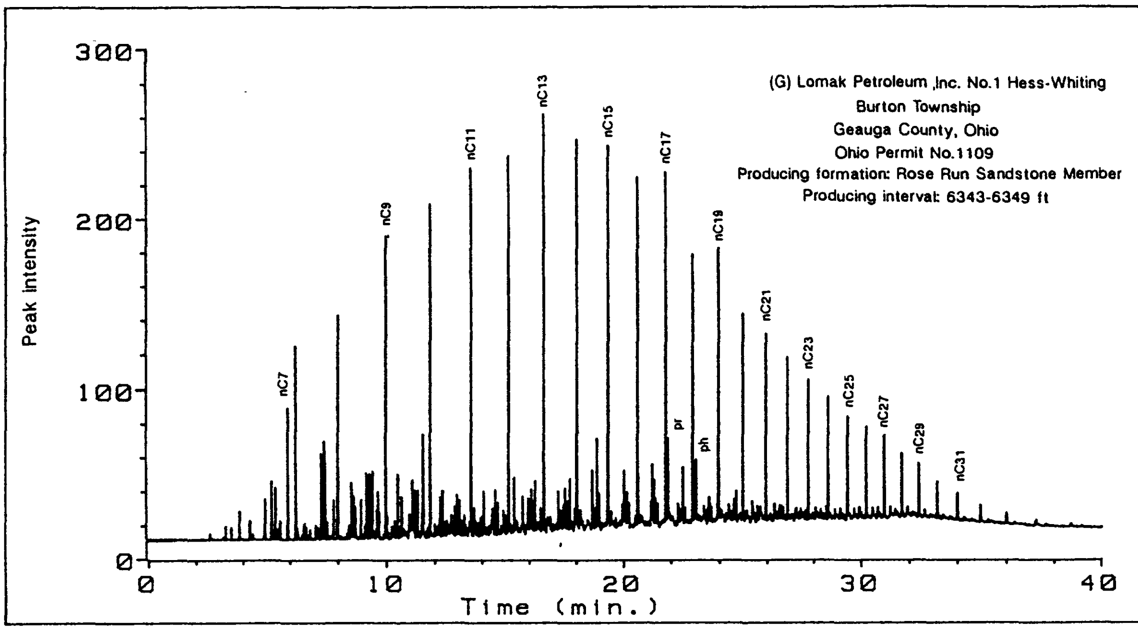


Figure 17. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample G, Lomak Petroleum No. 1 Hess-Whiting well, Geauga County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

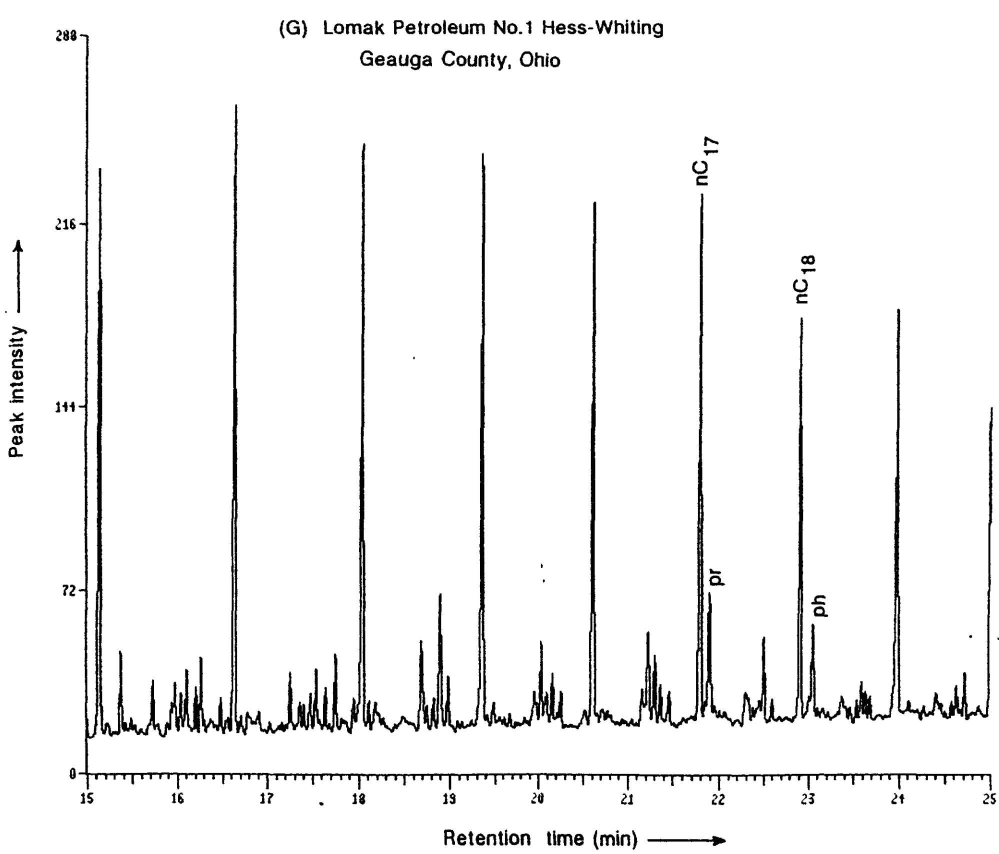


Figure 18. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample G, Lomak Petroleum No. 1 Hess-Whiting well, Geauga County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

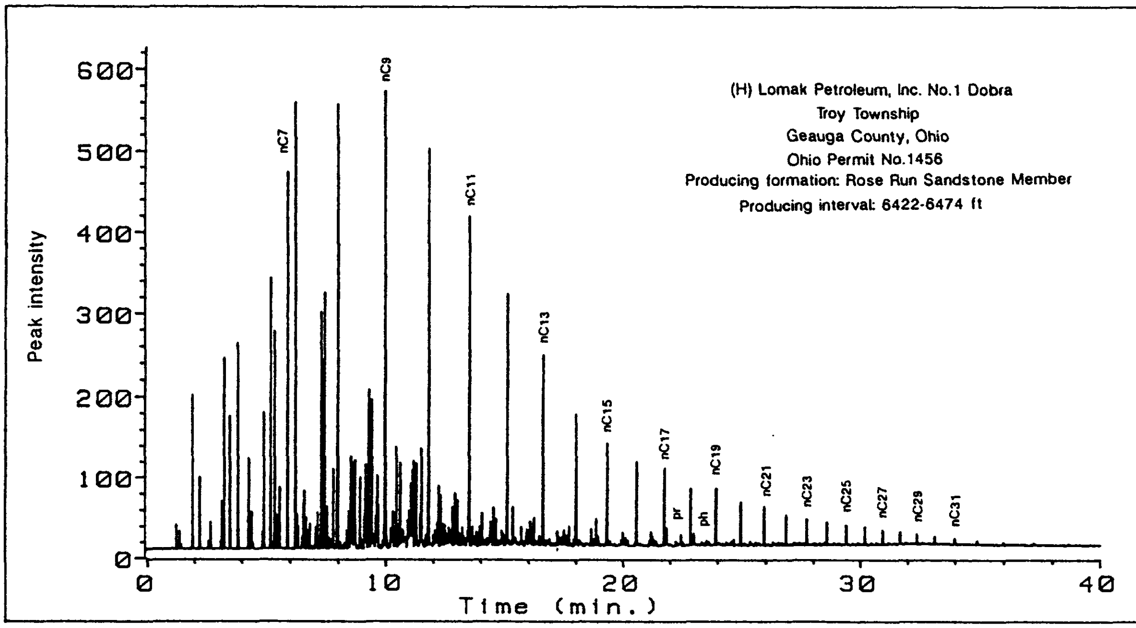


Figure 19. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample H, Lomak Petroleum No. 1 Dobra well, Geauga County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

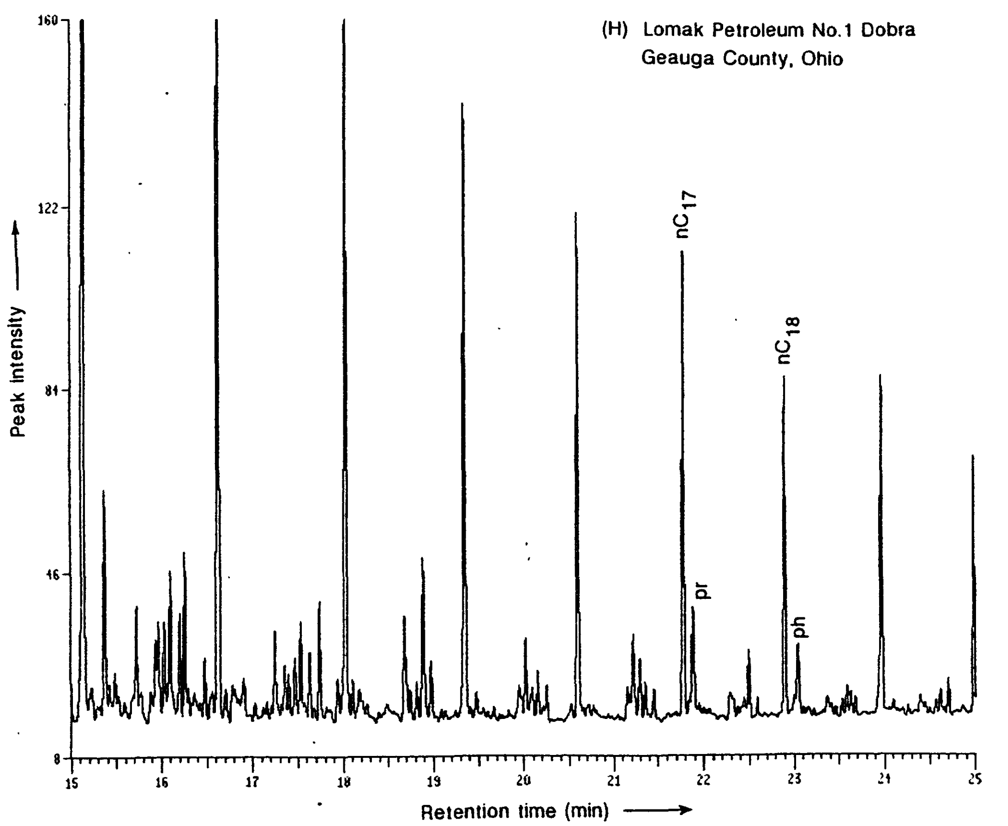


Figure 20. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample H, Lomak Petroleum No. 1 Dobra well, Geauga County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

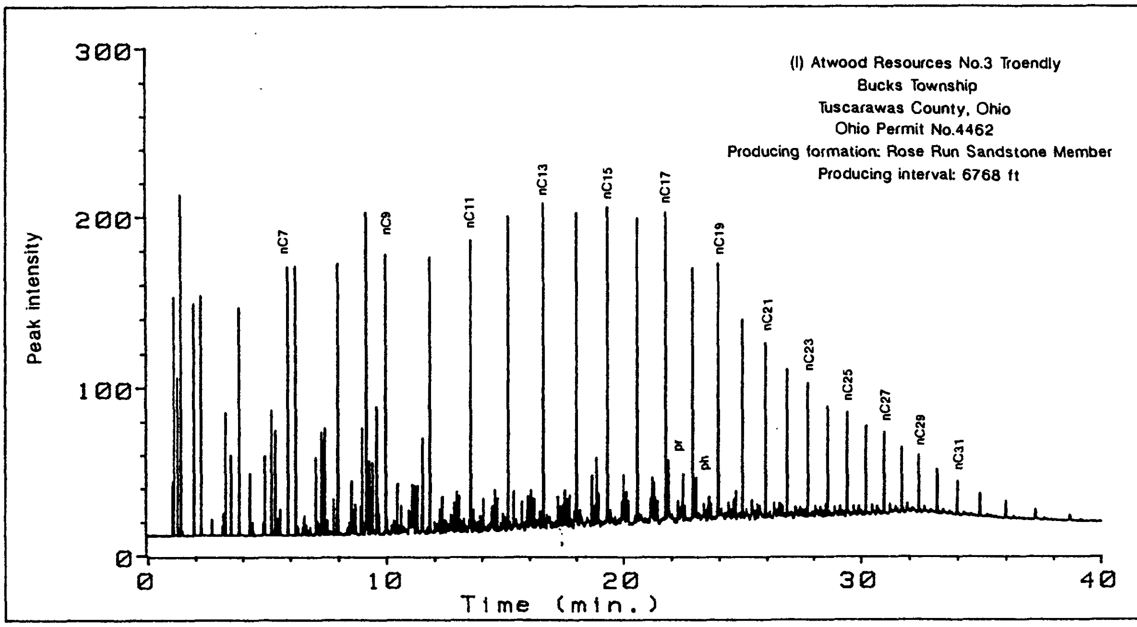


Figure 21. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample I, Atwood Resources No. 3 Troendly well, Tuscarawas County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

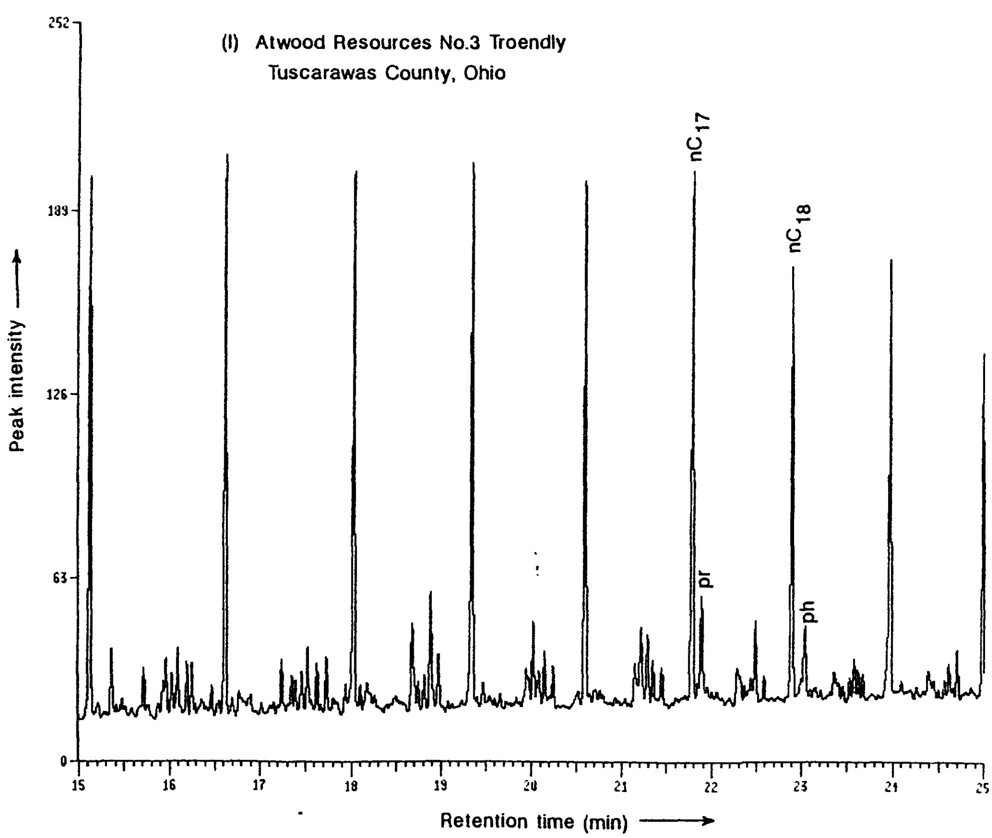


Figure 22. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample I, Atwood Resources No. 3 Troendly well, Tuscarawas County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

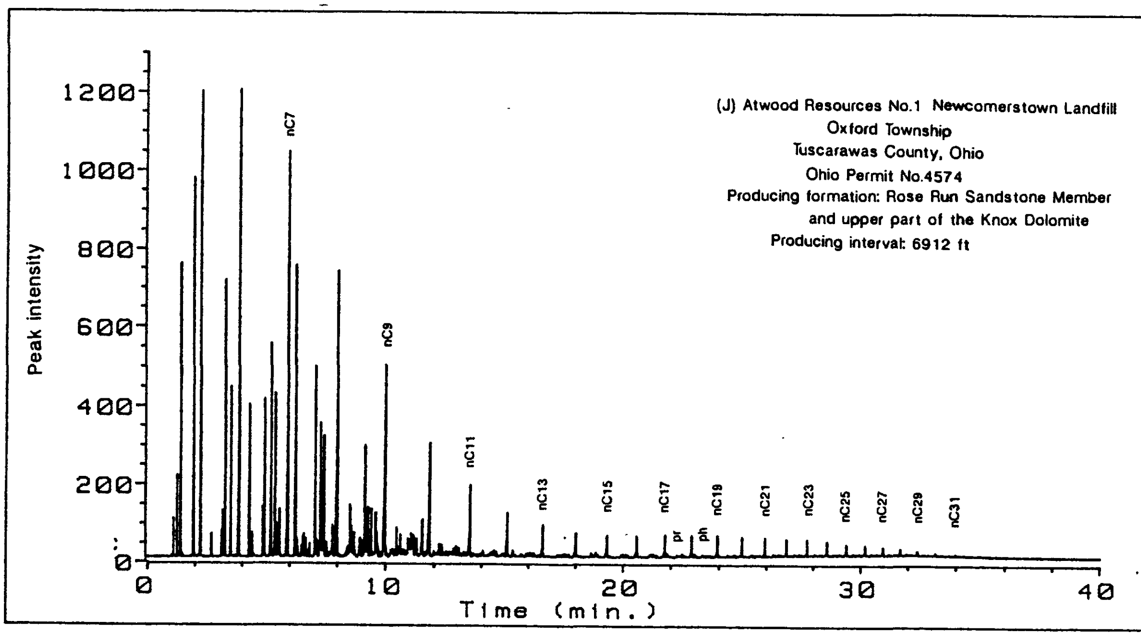


Figure 23. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample J, Atwood Resources No. 1 Newcomerstown Landfill well, Tuscarawas County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

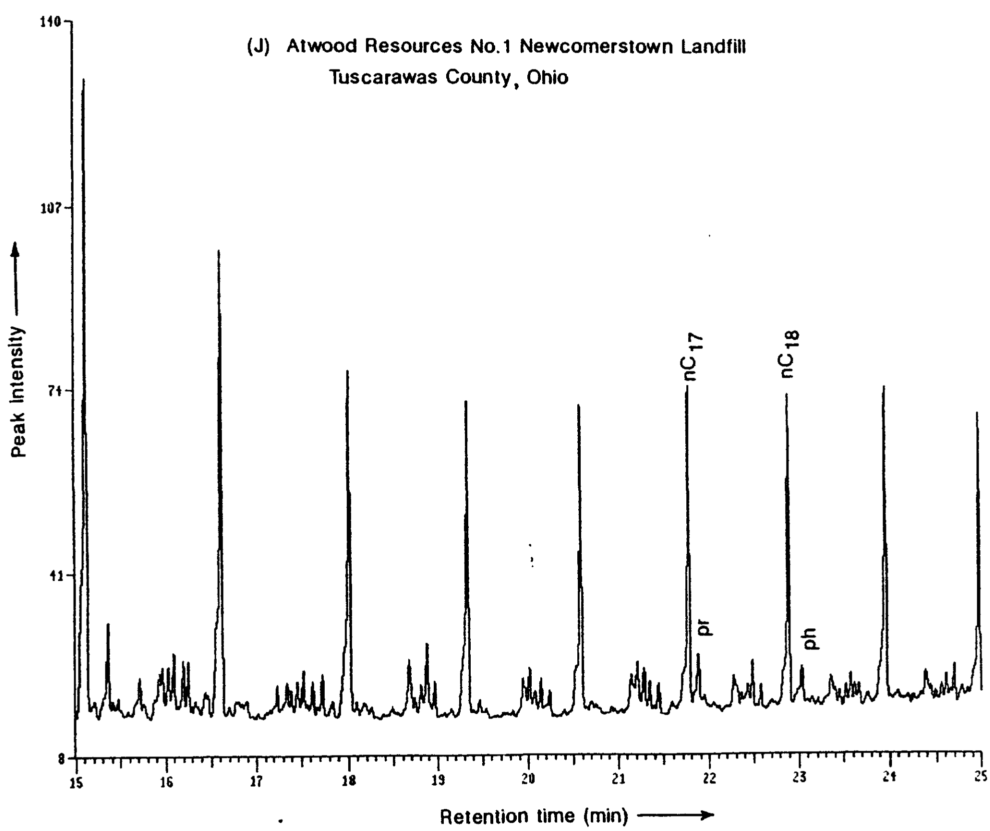


Figure 24. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample J, Atwood Resources No. 1 Newcomeratown Landfill well, Tuscarawas County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

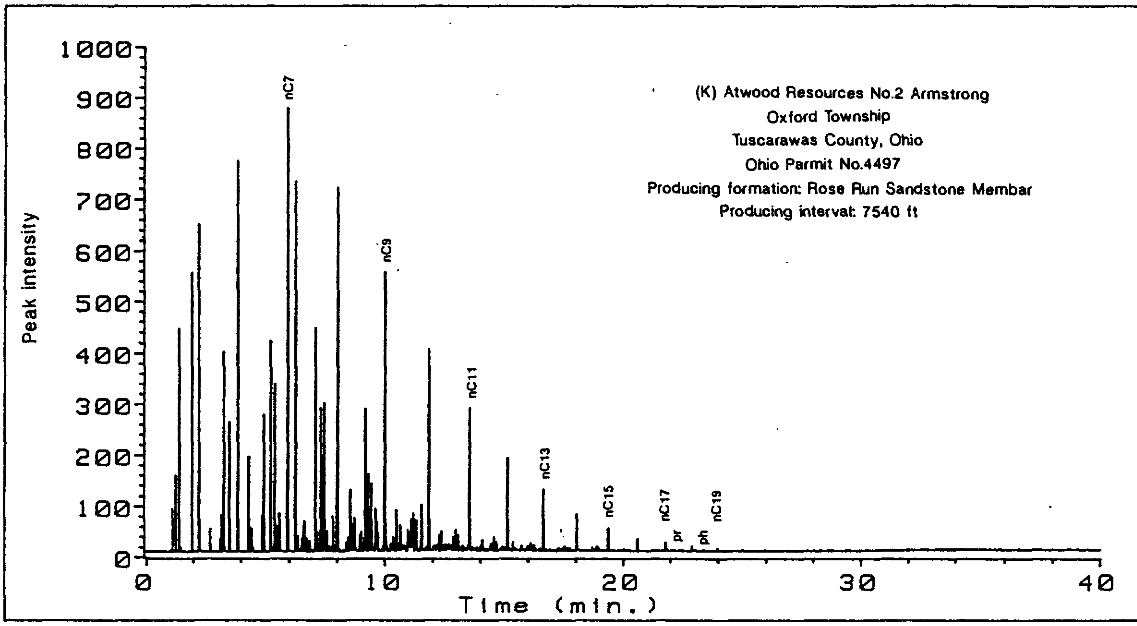


Figure 25. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample K, Atwood Resources No. 2 Armstrong well, Tuscarawas County, Ohio. The C_7 through C_{19} n-alkanes are identified. The isopranoids pristane (pr) and phytane (ph) cannot be identified.

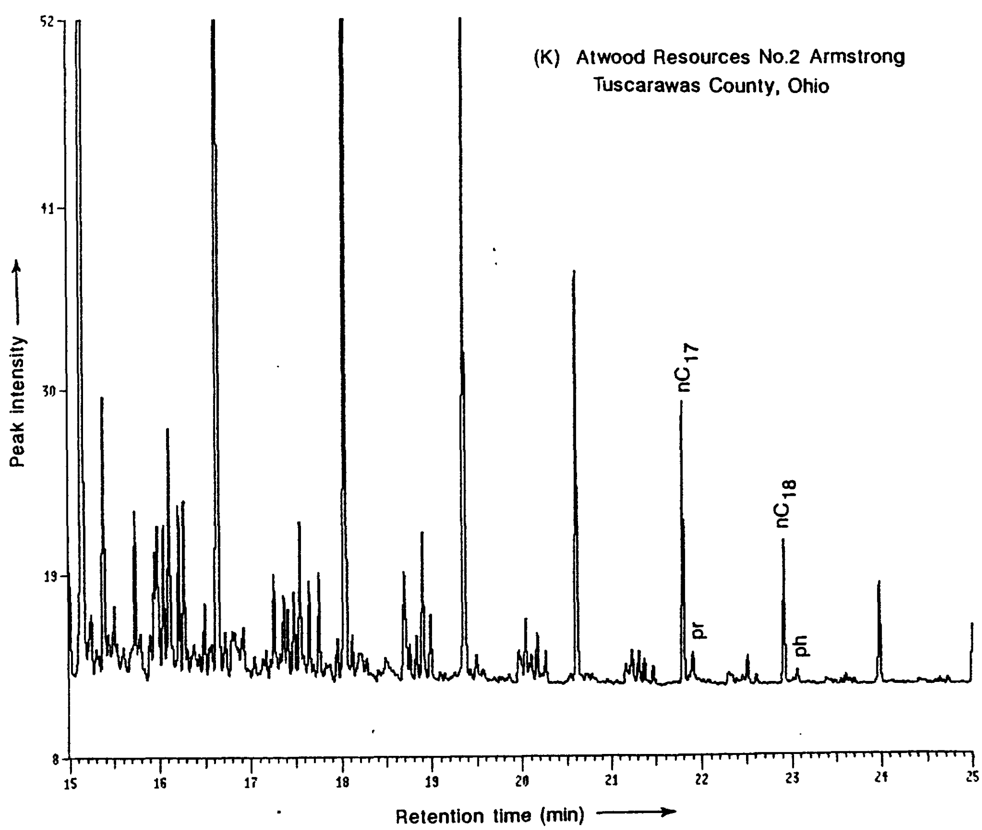


Figure 26. Partial gas chromatogram (expanded acale) of the saturated hydrocarbon fraction of oil sample K, Atwood Resources No. 2 Armstrong well, Tuscarawas County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

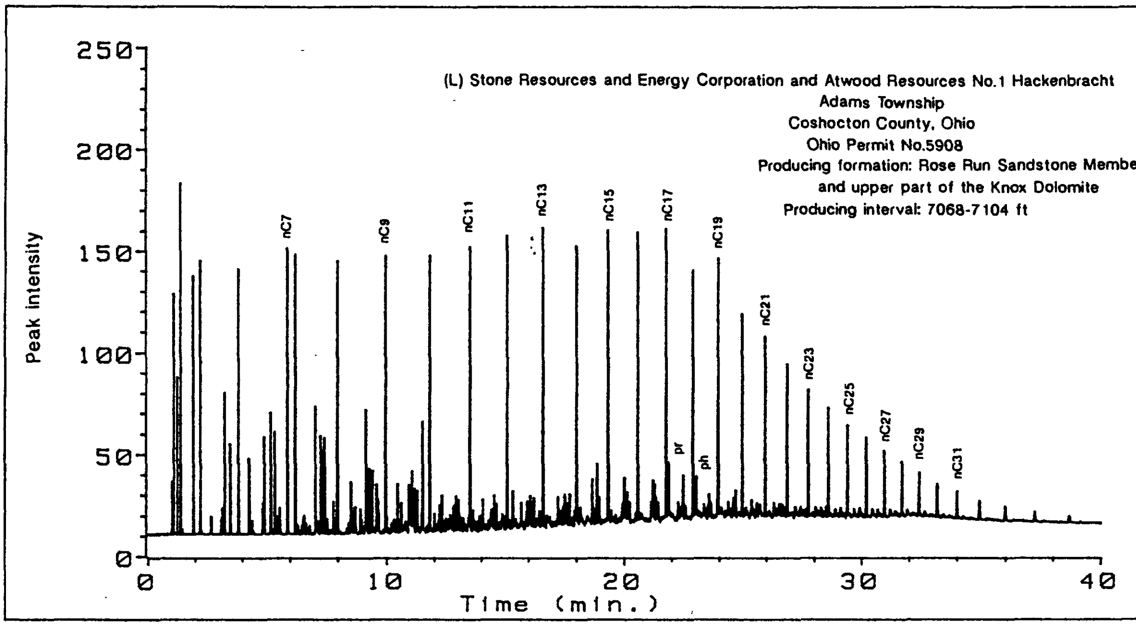


Figure 27. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample L, Stone Resource and Energy Corporation and Atwood Resources No. 1 Hackenbracht well, Coshocton County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

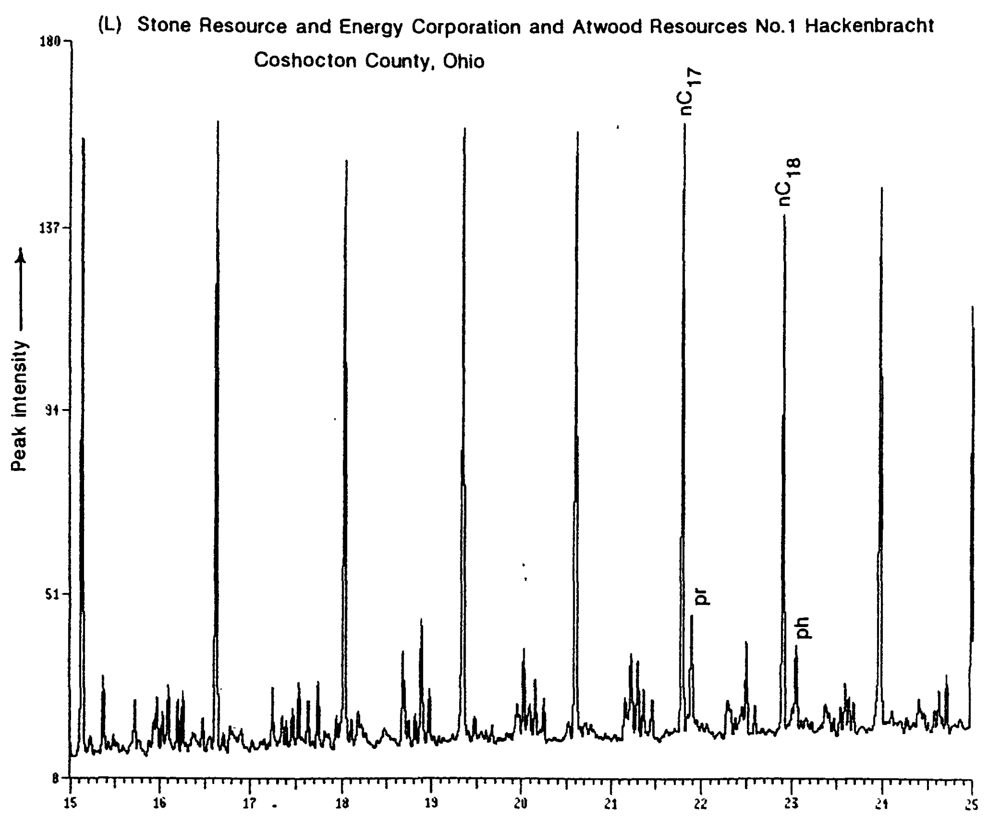


Figure 28. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample L, Stone Resource and Energy Corporation and Atwood Resources No. 1 Hackenbracht well, Coshocton County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

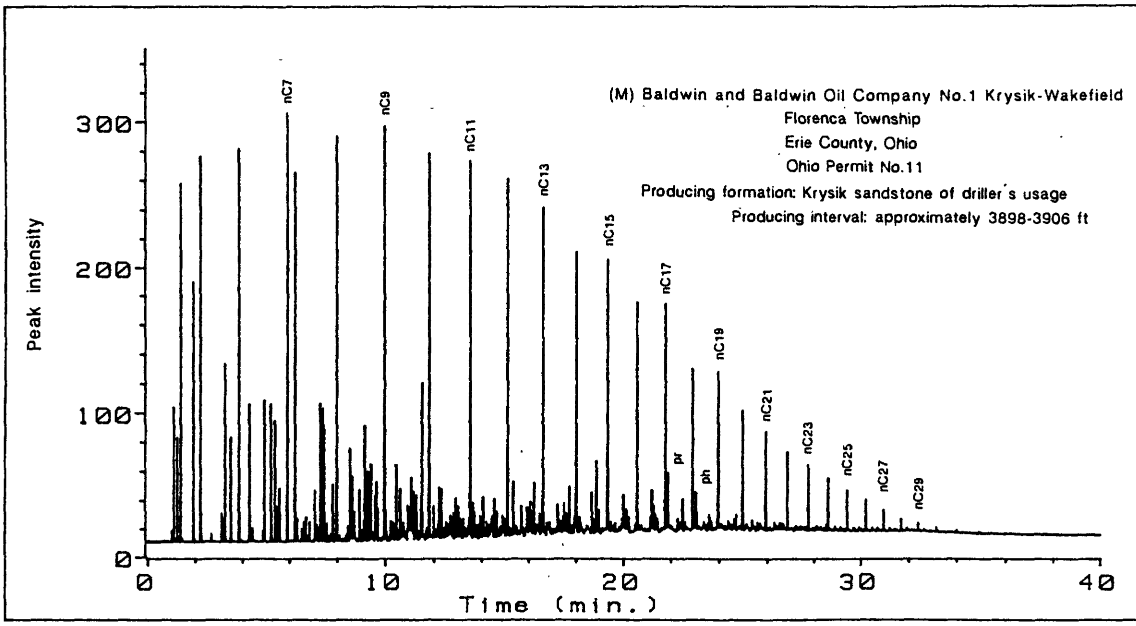


Figure 29. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample M, Baldwin and Baldwin Oil Company No. 1 Krysik-Wakefield well, Erie County, Ohio. The C_7 through C_{29} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

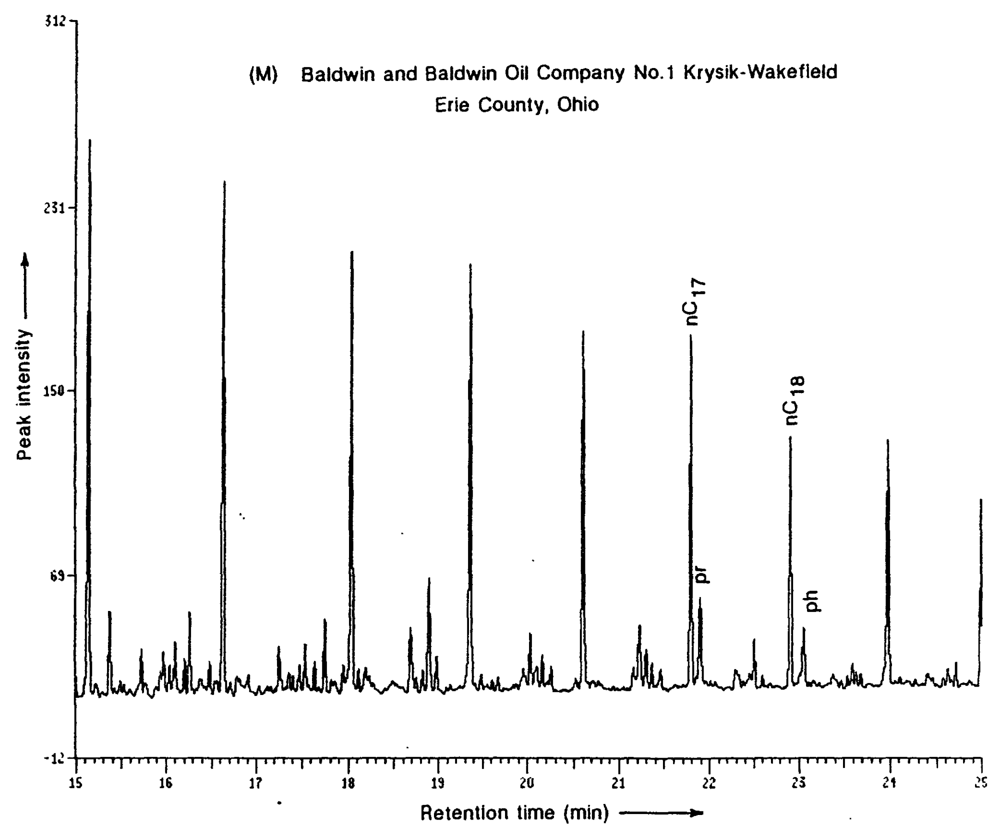


Figure 30. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample M, Baldwin and Baldwin Oil Company No. 1 Krysik-Wakefield well, Erie County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

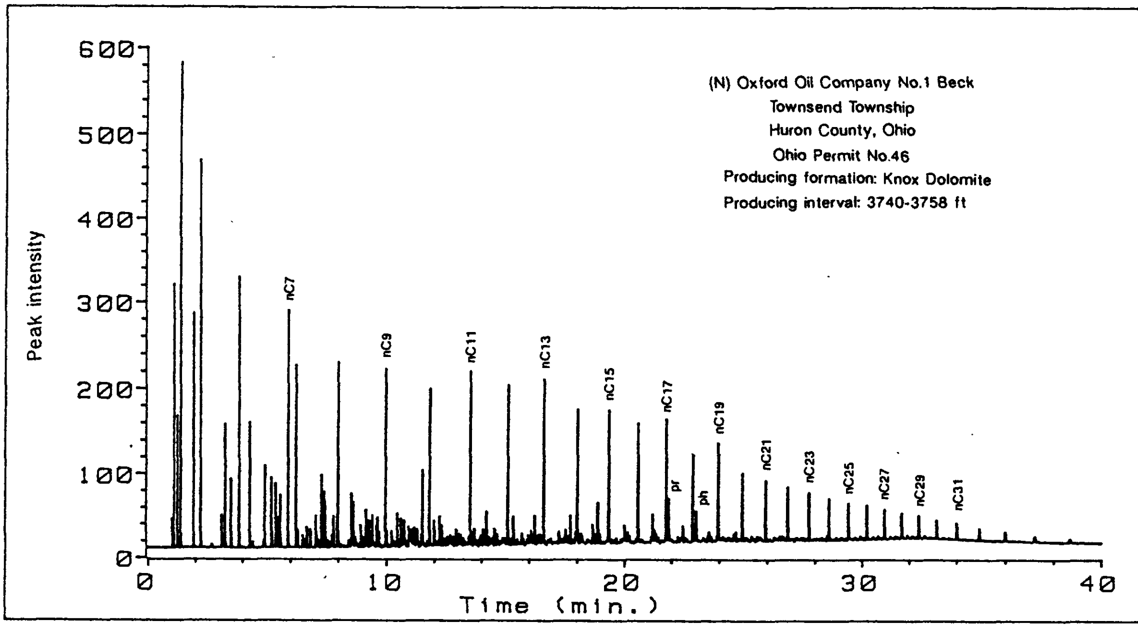


Figure 31. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample N, Oxford Oil Company No. 1 Beck well, Huron County, Ohio. The C_7 through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

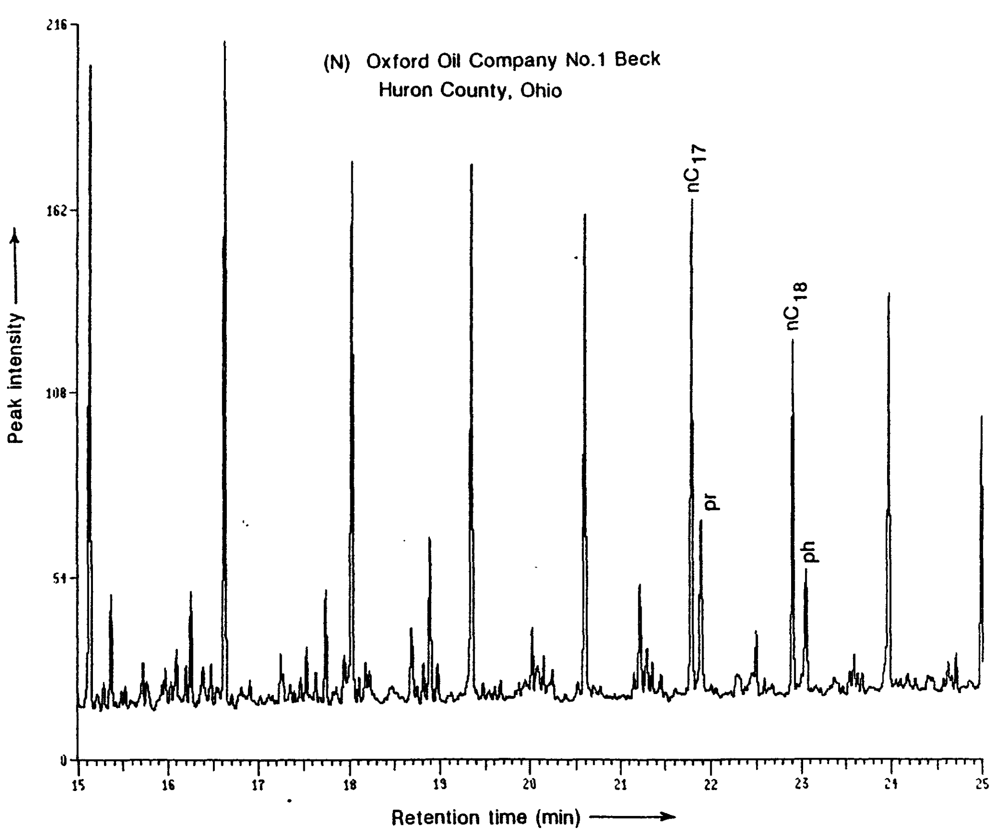


Figure 32. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample N, Oxford Oil Company No. 1 Beck well, Huron County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

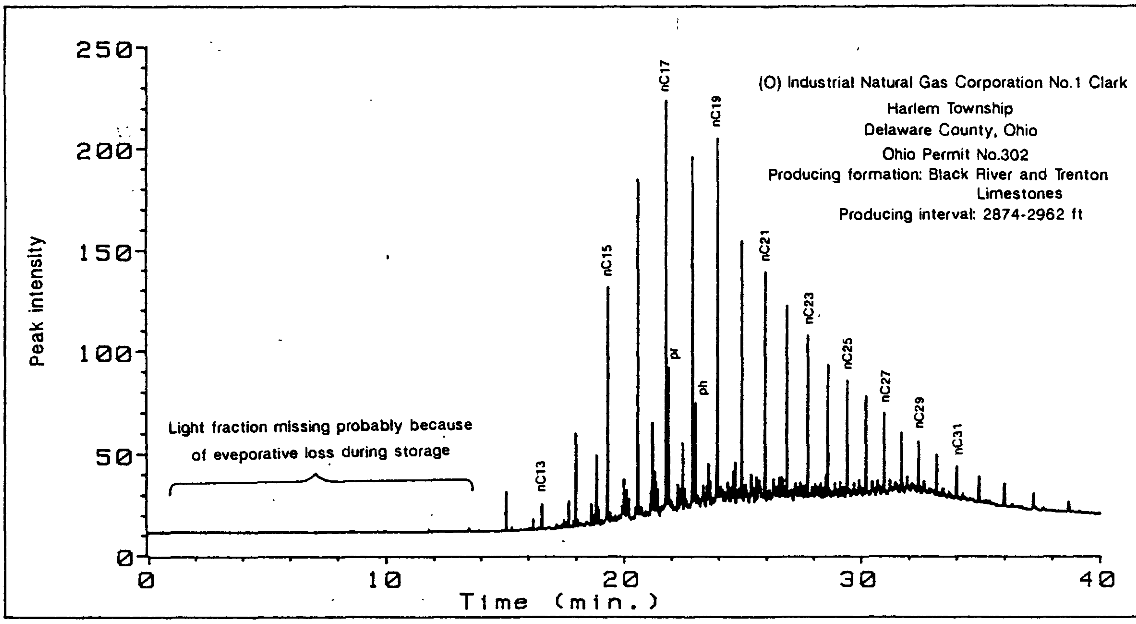


Figure 33. Gas chromatogram of the C_5+ saturated hydrocarbon fraction of oil sample O, Industrial Natural Gas Corporation No. 1 Clark well, Delaware County, Ohio. The C_{13} through C_{31} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

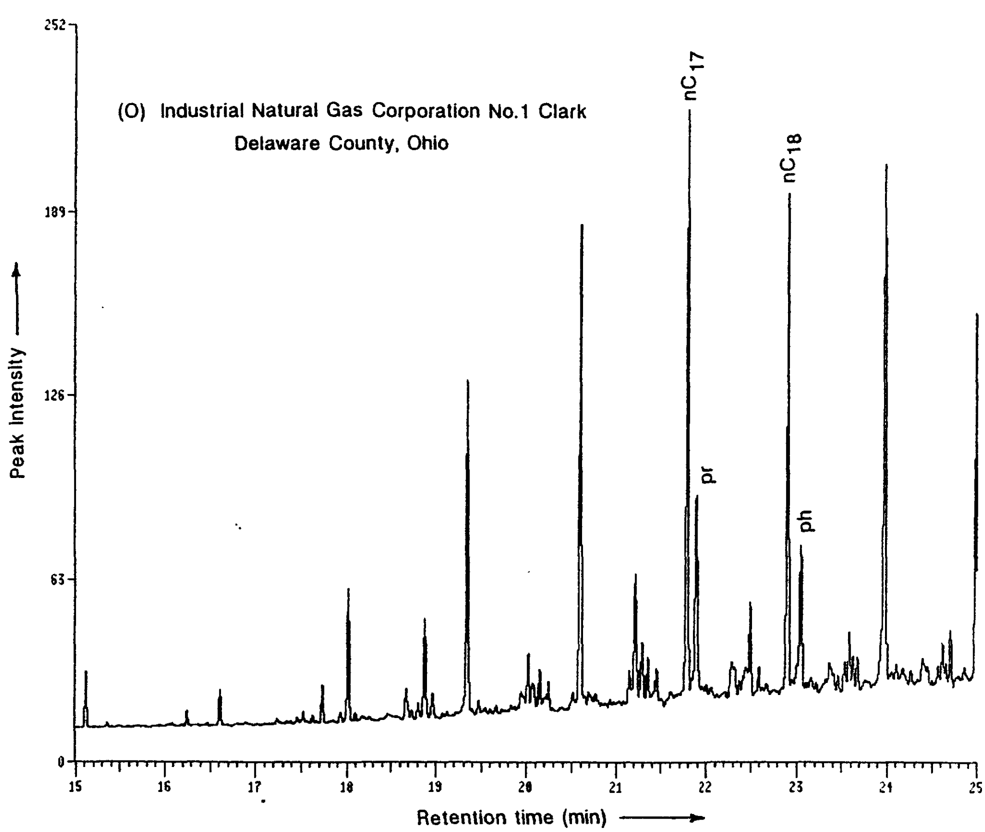


Figure 34. Partial gas chromatogram (expanded scale) of the saturated hydrocarbon fraction of oil sample O, Industrial Natural Gas Corporation No. 1 Clark well, Deleware County, Ohio. The C_{17} and C_{18} n-alkanes and the isoprenoids pristane (pr) and phytane (ph) are identified.

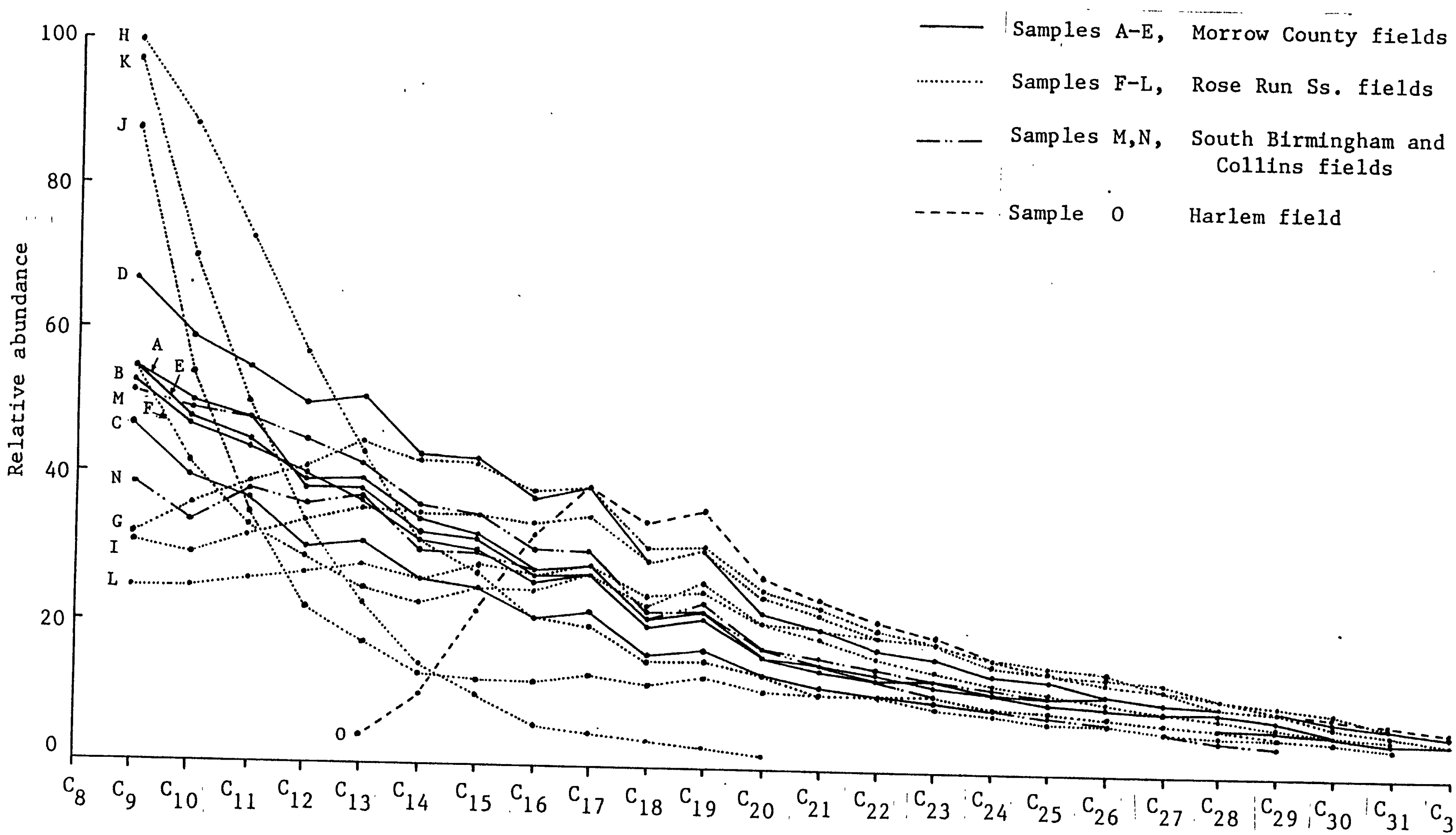


Figure 35. Distribution of the C_9+ n-alkanes in oil samples A through O (all oil samples).

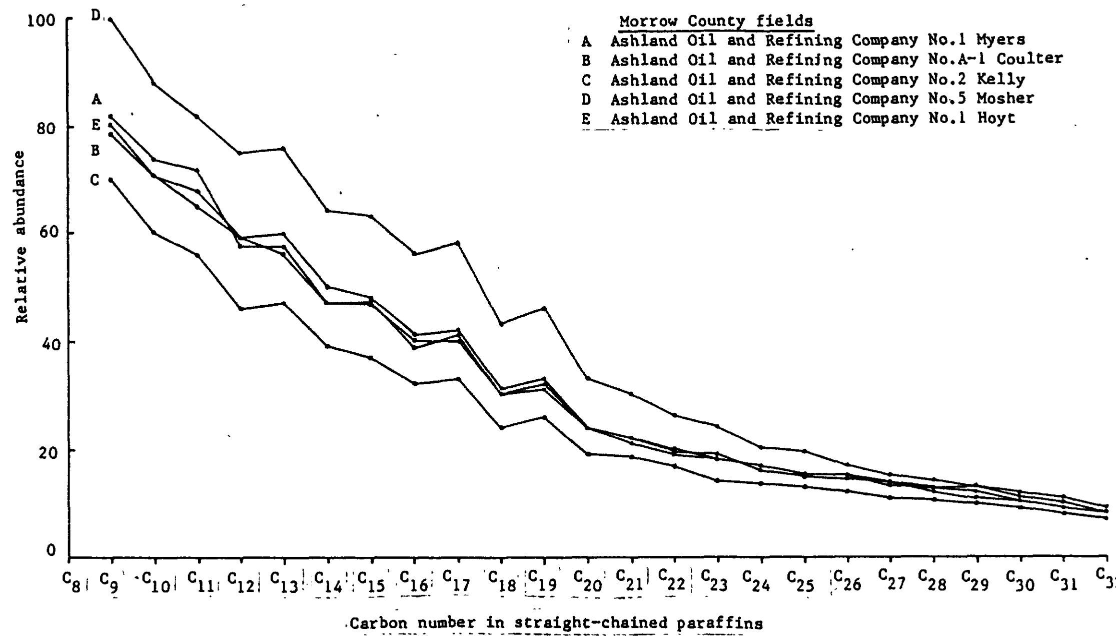


Figure 36. Distribution of the C_9+ n-alkanes in oil samples A through E (Morrow County group of oils).

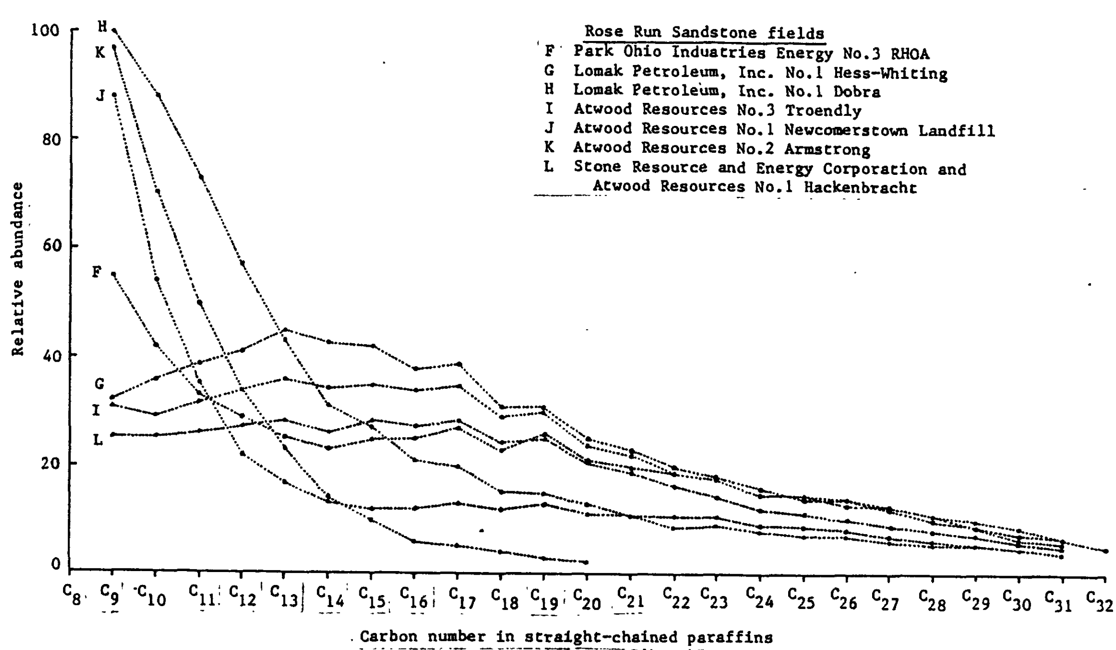


Figure 37. Distribution of the C_9+ n-alkanes in oil samples F through L (Rose Run Sandstone group of oils).

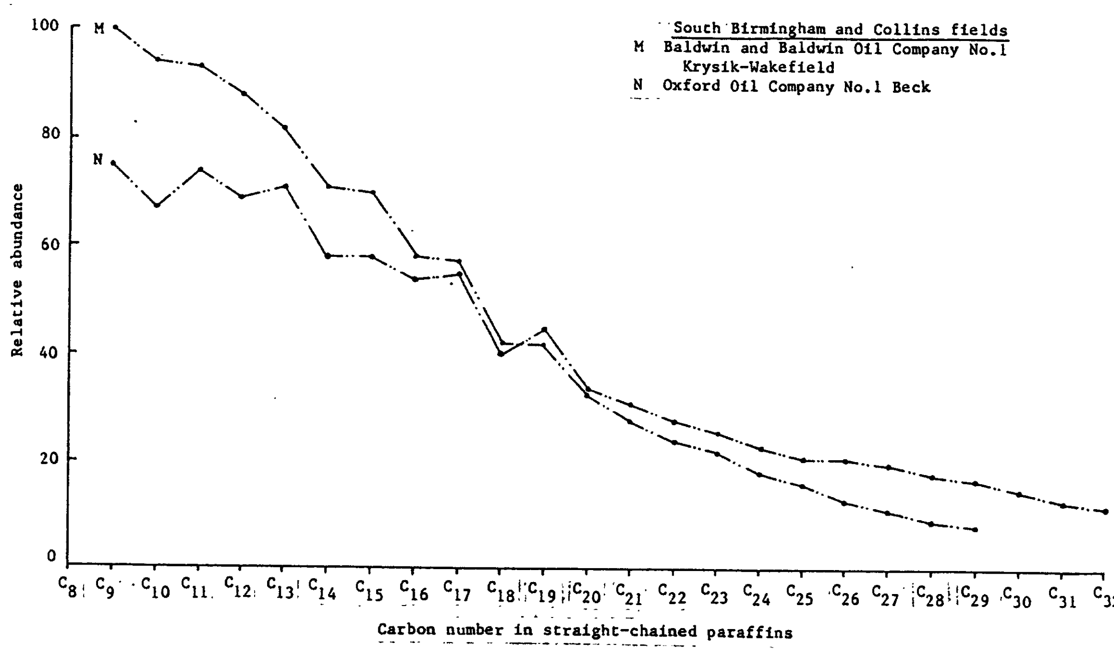


Figure 38. Distribution of the C_9+ n-alkanes in oil samples M and N (oils from the South Birmingham and Collins fields).

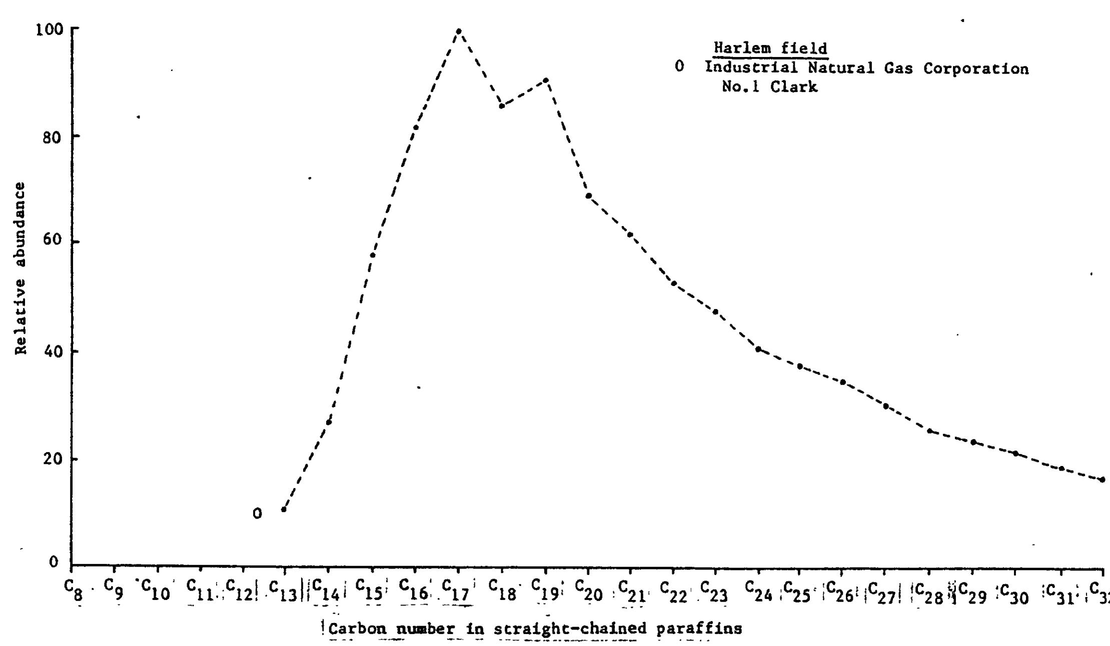


Figure 39. Distribution of the C_9+ n-alkanes in oil sample O (oil from the Harlem field).

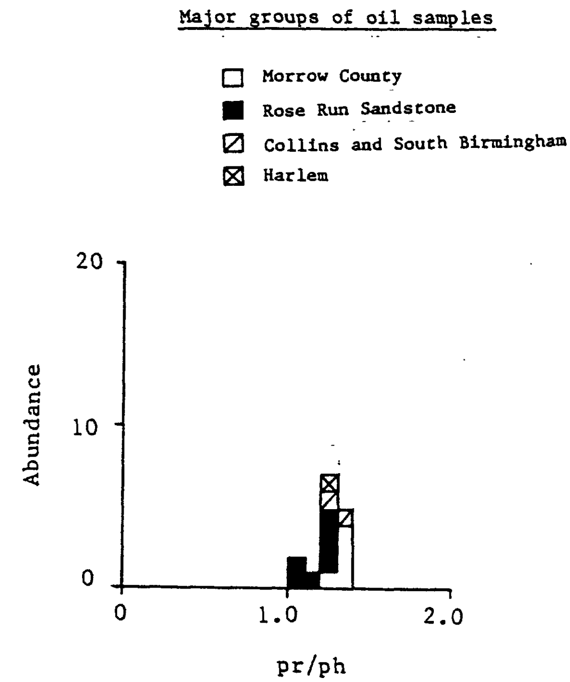


Figure 40. Distribution of pristane (pr)/phytane (ph) in the Ohio oils.

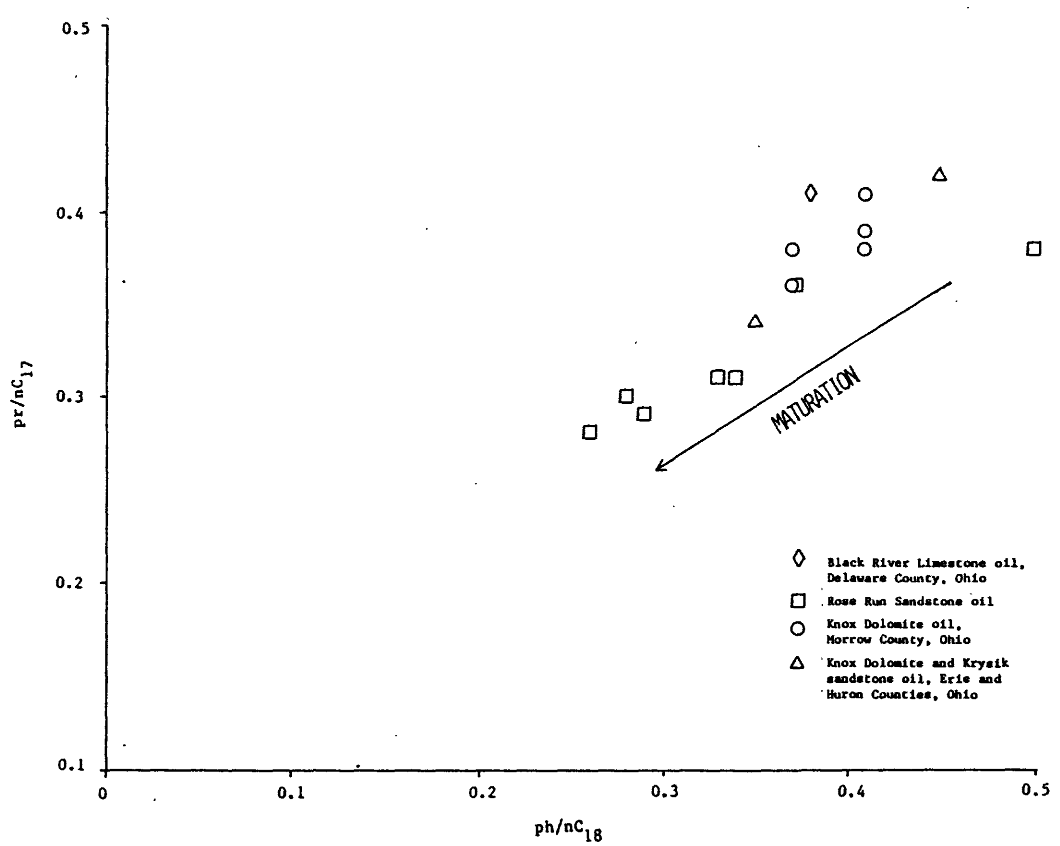
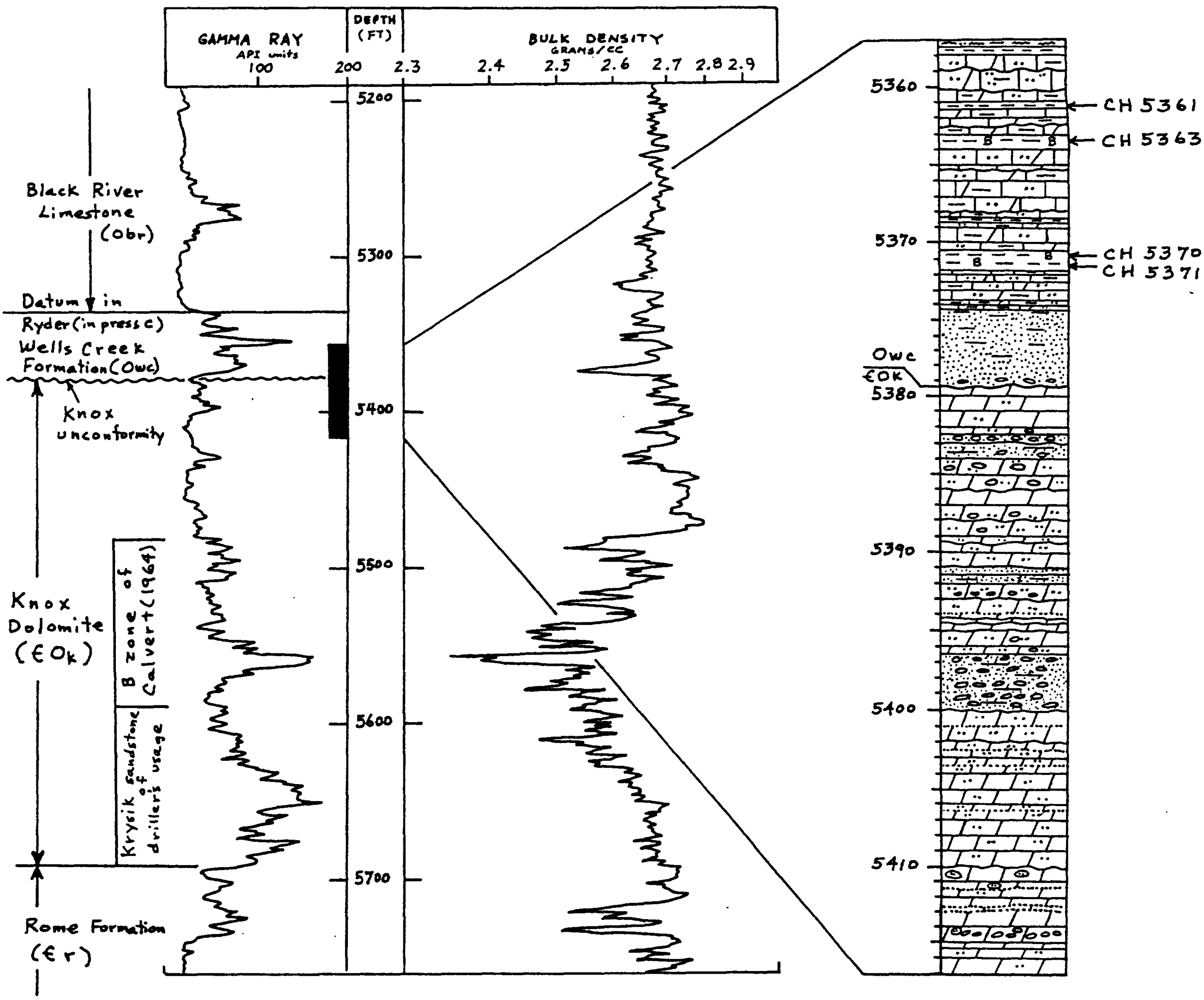


Figure 41. Plot of pr/nC_{17} vs. ph/nC_{18} for the Ohio oils.

(1)
Calhio Chemicals Incorporated No. 1 Calhio Chemicals Incorporated, Perry Township, Lake County, Ohio
Ohio Permit No. 142



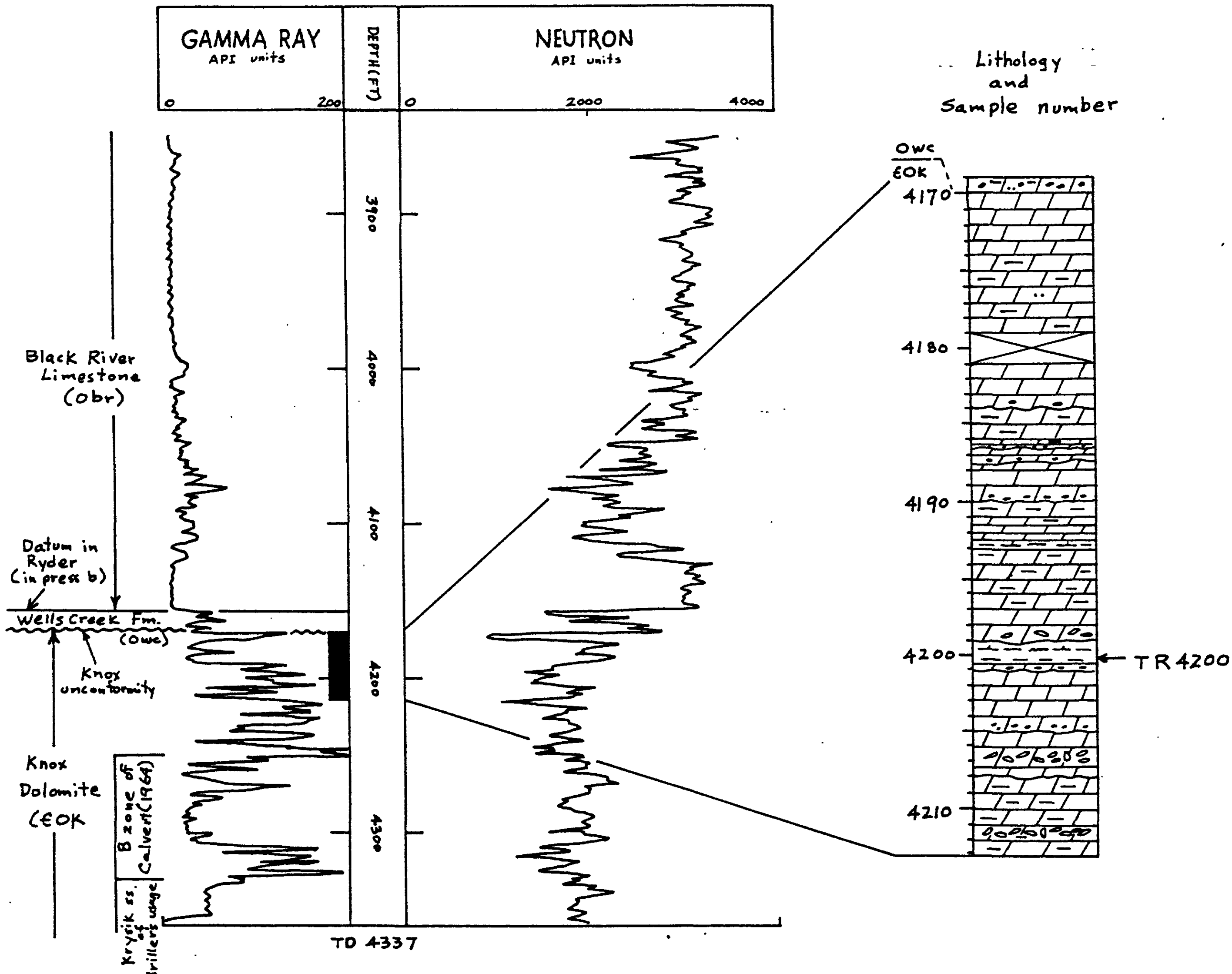
Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
CH5361	0.25	448	0	280	0.0	0.0	5361.25	248.9	0.0	0.0	0.70	0.0
CH5363	1.19	451	23	45	0.33	0.03	5363.5	71.0	0.14	0.28	0.54	0.51
CH5370	0.29	422	13	168	0.25	0.0	5370.75	221.1	0.01	0.04	0.49	0.08
CH5371	1.52	455*	28	34	0.26	0.04	5371.5	32.4	0.15	0.43	0.52	0.82

Figure 42. Organic carbon content and Rock-Evel pyrolysis yields of selected core samples from the Calhio Chemicals Incotporated No. 1 Calhio Chemicals Incorporated drill hole, Lake County, Ohio. Abbreviated geochemical terms are defined in Appendix A. The Tmax temperature marked with an asterisk and the underlined PI values are considered reliable indicators of thermal maturity and are plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (1) is the identification number of this drill hole used in figure 4 and table 2.

(2)

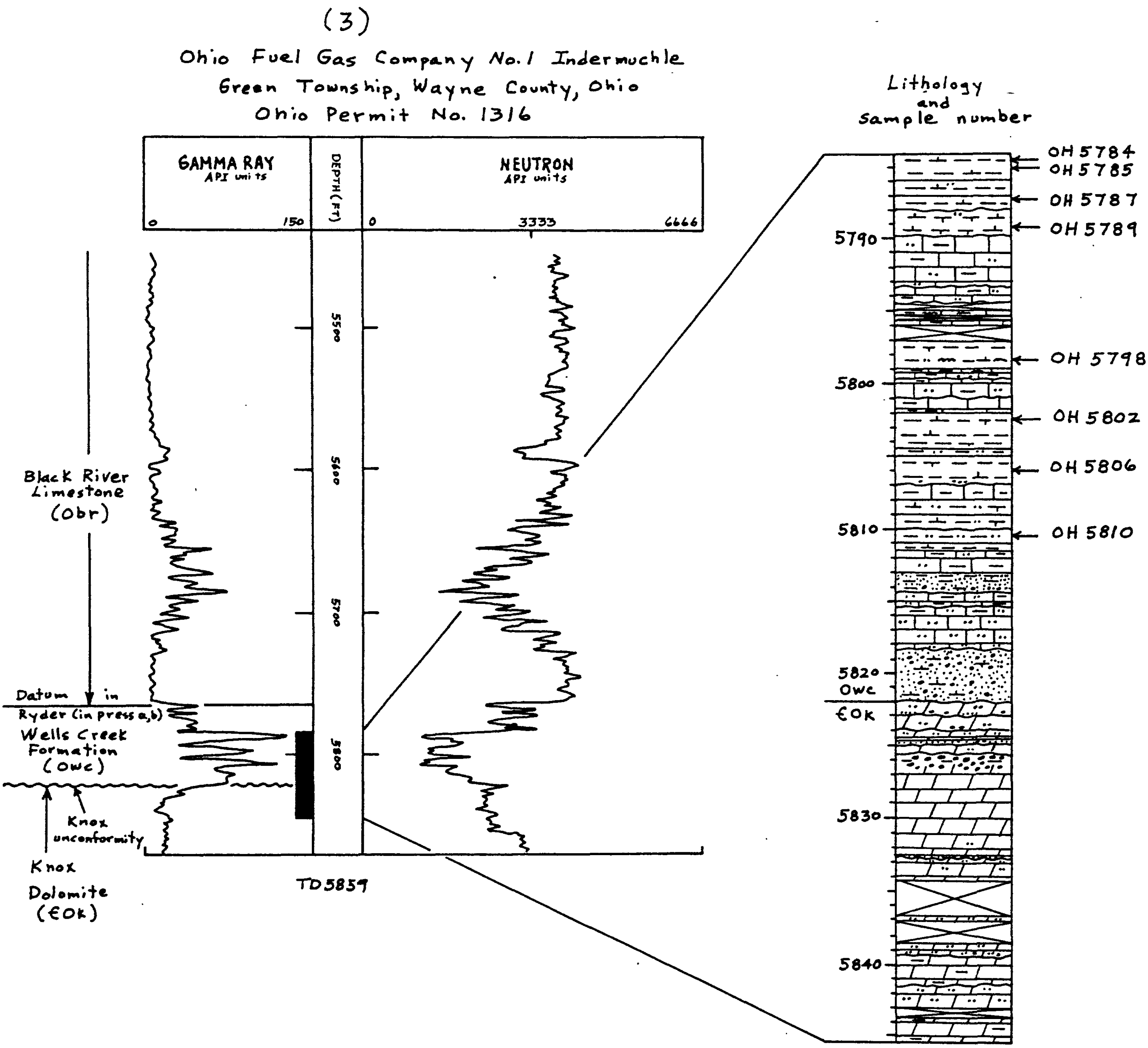
Floto and Associates No. 3 Troxel
Clear Creek Township, Ashland County, Ohio
Ohio Permit No. 2382



Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
TR4200	0.07	—	0	342	0.0	0.0	4200.25	194.2	0.0	0.0	0.24	0.0

Figure 43. Organic carbon content and Rock-Eval pyrolysis yields of a selected core sample from the Floto and Associates No. 3 Troxel drill hole, Ashland County, Ohio. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (2) is the identification number of this drill hole used in figure 4 and table 2.



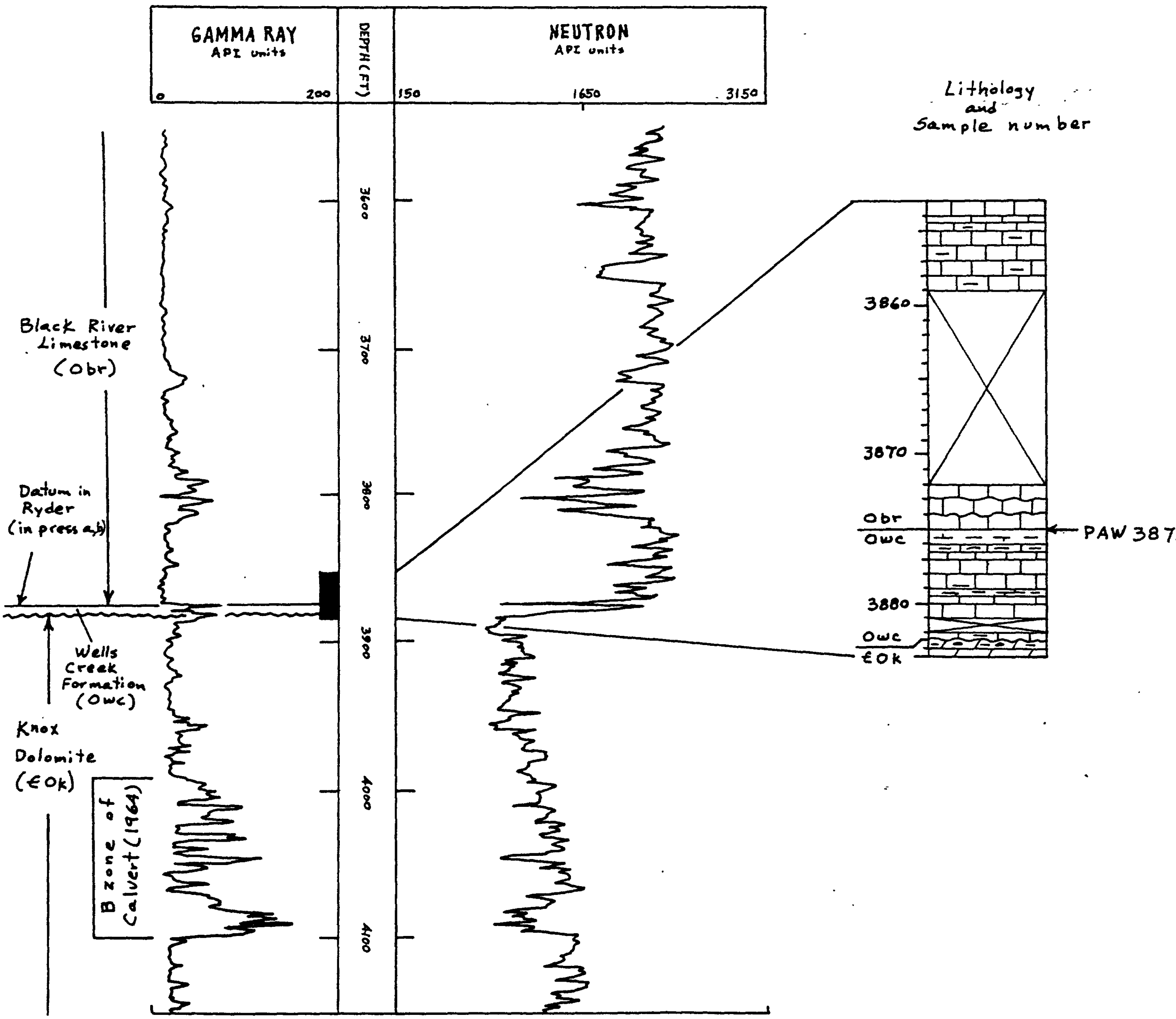
Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
OH5784	0.35	—	0	171	0.0	0.0	5784.5	241.7	0.0	0.0	0.60	0.0
OH5785	0.08	406	112	612	0.10	0.0	5785	240.2	0.01	0.09	0.49	0.18
OH5787	0.22	—	45	645	0.50	0.01	5787.25	196.4	0.10	0.10	1.42	0.07
OH5789	0.33	—	6	200	0.0	0.0	5789.25	242.0	0.0	0.02	0.66	0.03
OH5798	0.20	—	0	675	0.0	0.0	5798.25	245.8	0.0	0.0	1.35	0.0
OH5802	0.42	—	2	300	0.0	0.0	5802.5	227.1	0.0	0.01	1.26	0.0
OH5806	0.18	422	55	388	0.0	0.0	5806	247.5	0.0	0.10	0.70	0.14
OH5810	0.19	—	0	594	0.0	0.0	5810.5	226.1	0.0	0.0	1.13	0.0

Figure 44. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Ohio Fuel Gas Company No. 1 Indermuchle drill hole, Wayne County, Ohio. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (3) is the identification number of this drill hole used in figure 4 and table 2.

(4)

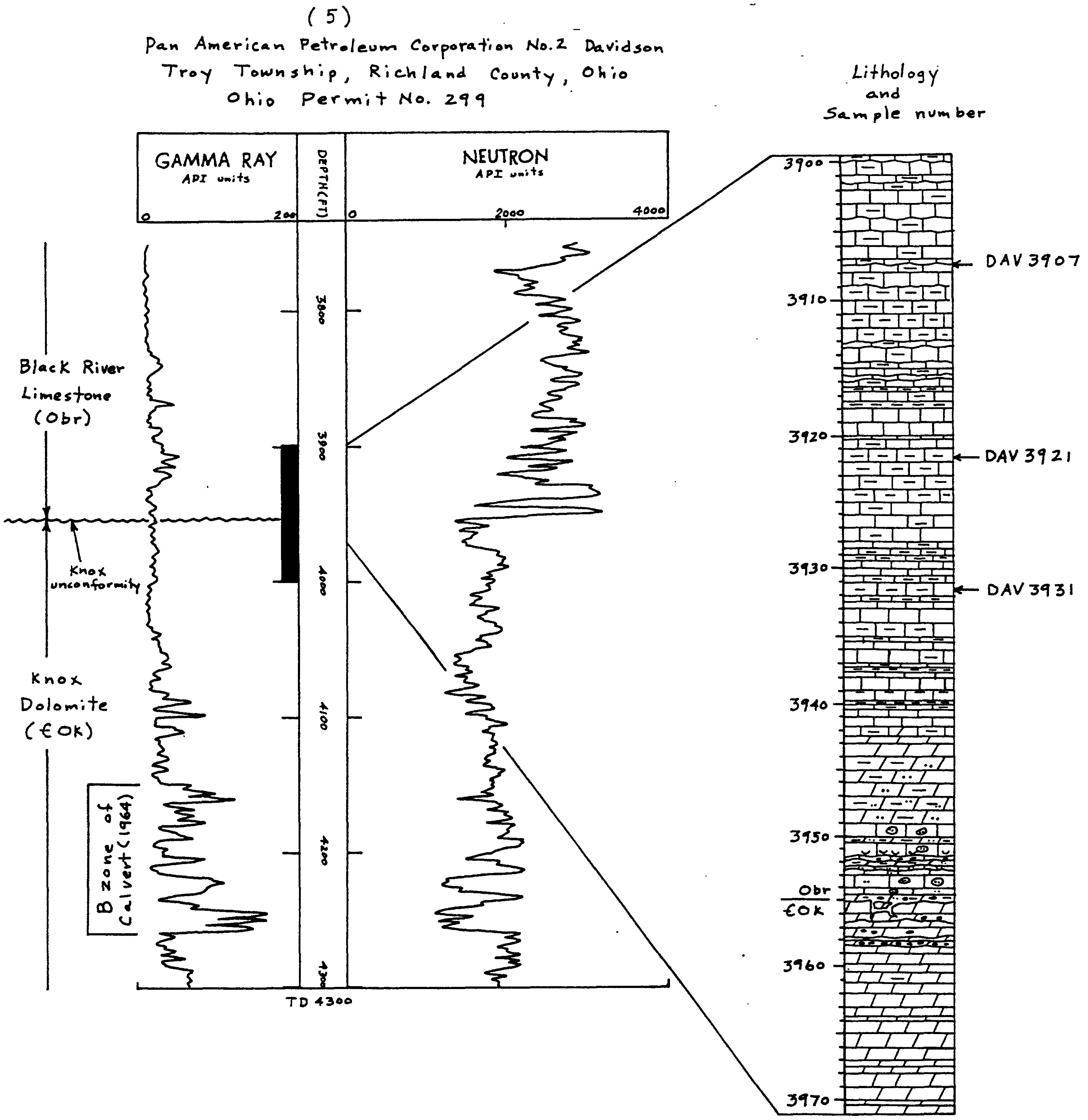
Pan American Petroleum Corporation No. 1 Windbigler
Troy Township, Morrow County, Ohio
Ohio Permit No. 47



Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
PAW3875	0.37	423	67	254	0.0	0.02	3875	228.4	0.0	0.25	0.94	0.26

Figure 45. Organic carbon content and Rock-Eval pyrolysis yields of a selected core sample from the Pan American Petroleum Corporation No. 1 Windbigler drill hole, Morrow County, Ohio. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (4) is the identification number of this drill hole used in figure 4 and table 2.



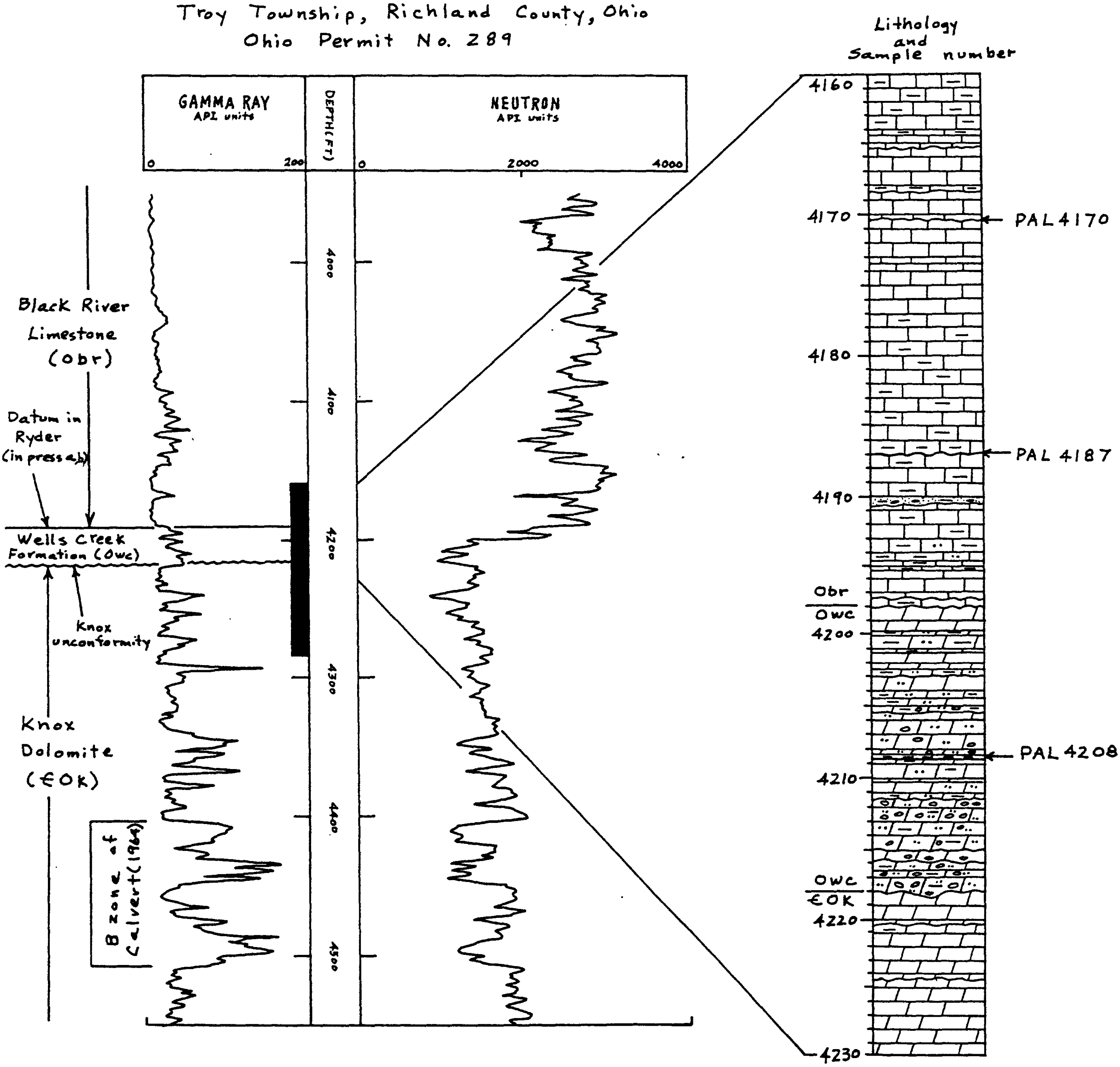
Organic carbon content and Rock-Eval pyrolysis yields.

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
DAV3907	0.13	430	84	130	0.37	0.01	3907.5	248.9	0.06	0.11	0.17	0.64
DAV3921	0.43	431*	95	79	0.34	0.05	3921.75	216.8	0.21	0.41	0.34	1.20
DAV3931	0.09	—	122	277	0.44	0.01	3931.5	244.2	0.08	0.11	0.25	0.44

Figure 46. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Pan American Petroleum Corporation No. 2 Davidson drill hole, Richland County, Ohio. Abbreviated geochemical terms are defined in Appendix A. The Tmax temperature marked with an asteriak is considered a reliable indicator of thermal maturity and is plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (5) is the identification number of this drill hole used in figure 4 and table 2.

(6)

Pan American Petroleum Corporation No. 1 Palmer
Troy Township, Richland County, Ohio
Ohio Permit No. 289

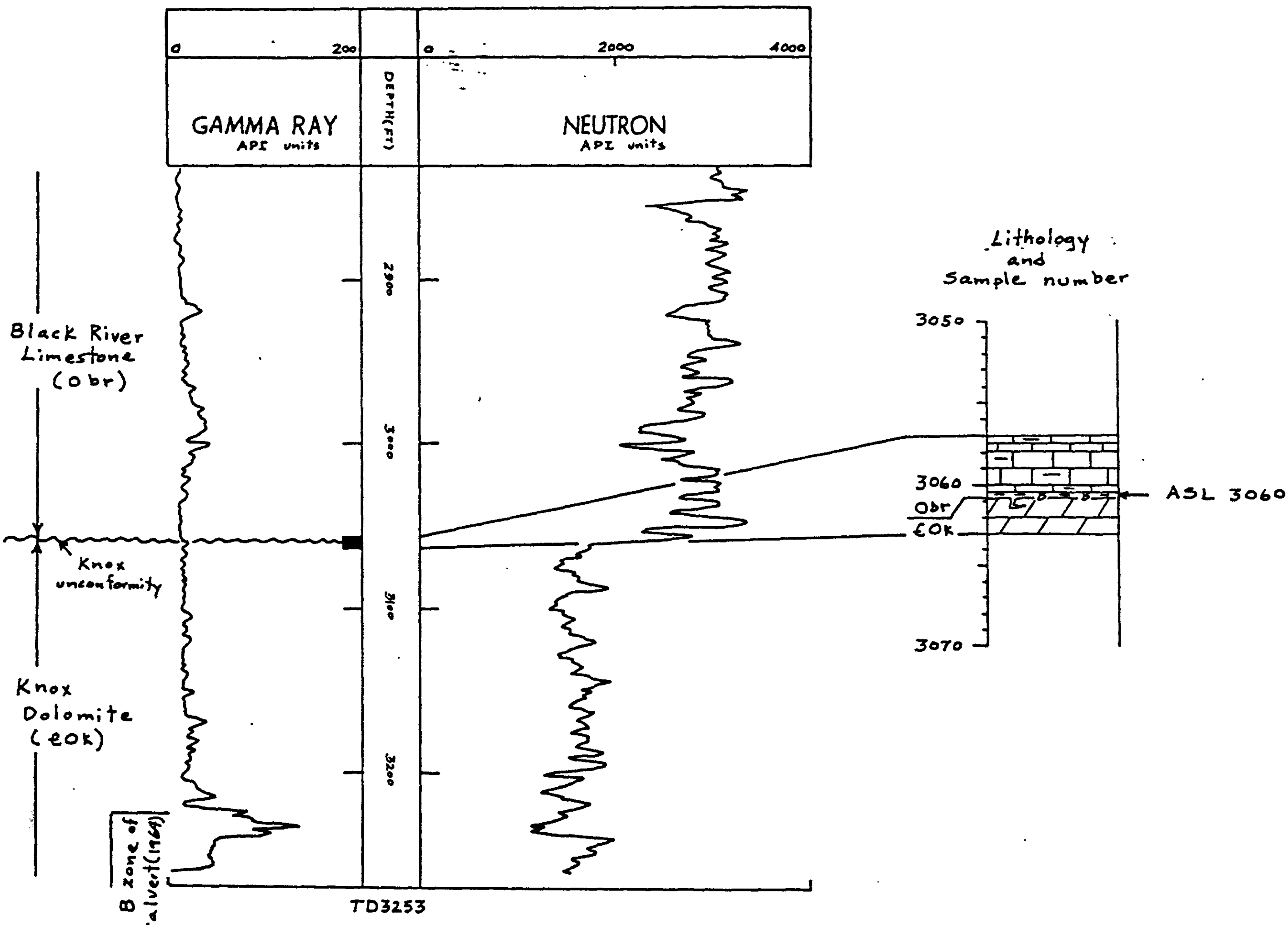


Organic carbon content and Rock-Eval pyrolysis yields --

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
PAL4170	0.19	414	31	357	0.17	0.0	4170.25	229.1	0.01	0.06	0.68	0.08
PAL4187	0.49	433*	136	151	0.07	0.06	4187	144.9	0.05	0.67	0.74	0.90
PAL4208	0.41	419	51	102	0.09	0.01	4208.5	240.5	0.02	0.21	0.42	0.50

Figure 47. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Pan American Petroleum Corporation No. 1 Palmer drill hole, Richland County, Ohio. Abbreviated geochemical terms are defined in Appendix A. The Tmax temperature marked with an asteriak is considered a reliable indicator of thermal maturity and ia plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (6) is the identification number of this drill hole used in figure 4 and table 2.

(7)
Ashland Oil and Refining Corporation No. 2 Mosher
Cardington Township, Morrow County, Ohio
Ohio Permit No. 866



Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
ASL 3060	1.72	442*	94	36	0.13	0.15	3060.5	28.7	0.24	1.63	0.62	2.62

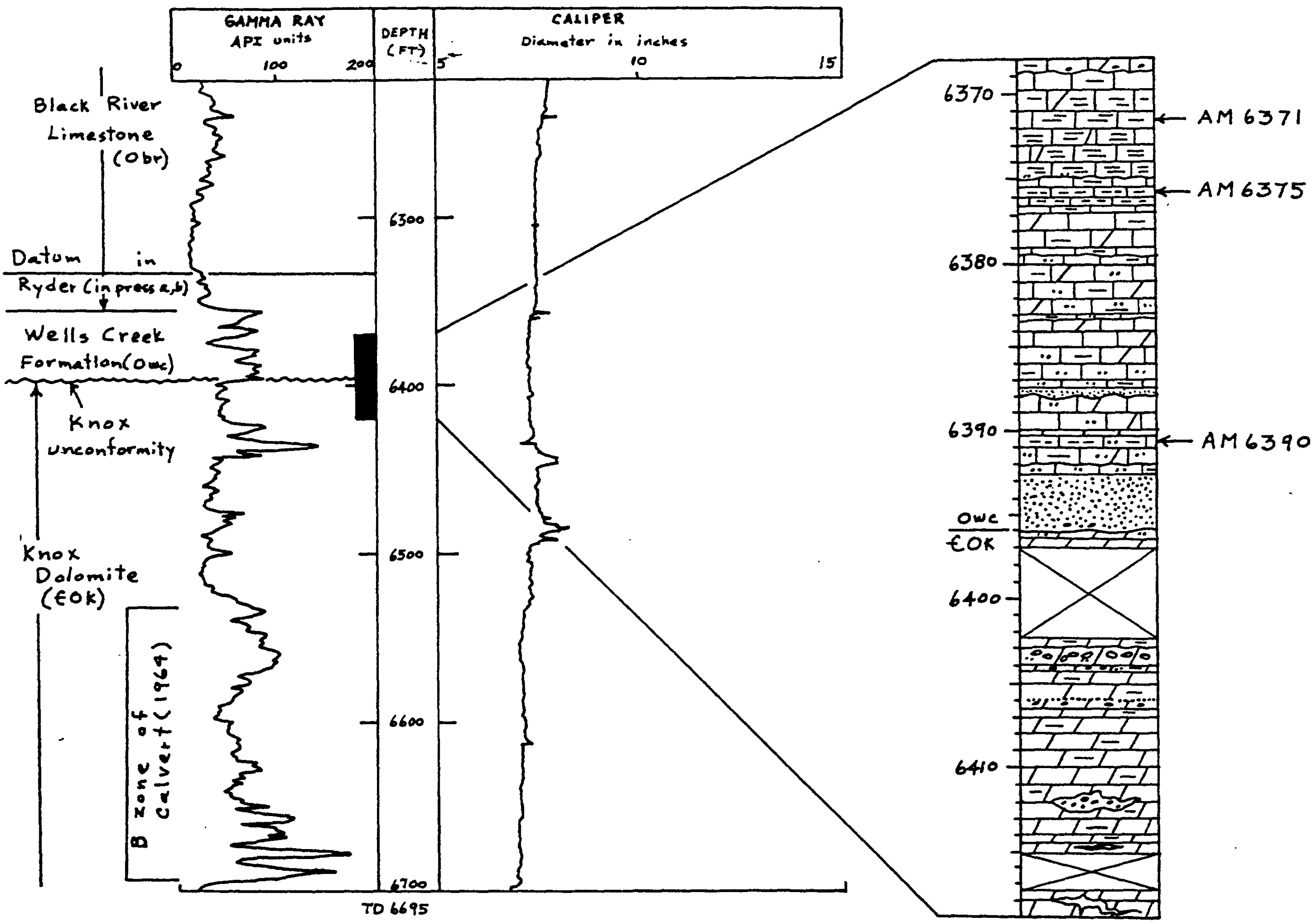
Figure 48. Organic carbon content and Rock-Eval pyrolysis yields of a selected core sample from the Ashland Oil and Refining Corporation No. 2 Mosher drill hole, Morrow County, Ohio. Abbreviated geochemical terms are defined in Appendix A. The Tmax temperature marked with an asterisk and the underlined PI value are considered reliable indicators of thermal maturity and are plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (7) is the identification number of this drill hole used in figure 4 and table 2.

(8)

Amerada Petroleum Corporation No. 1 Geib

Berlin Township, Holmes County, Ohio

Ohio Permit No. 1297



Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
AM6371	0.19	–	21	252	0.0	0.0	6371.5	245.1	0.0	0.04	0.48	0.08
AM6375	0.28	–	3	200	0.0	0.0	6375.75	205.4	0.0	0.01	0.56	0.01
AM6390	0.18	–	11	200	0.0	0.0	6390.5	233.8	0.0	0.02	0.36	0.05

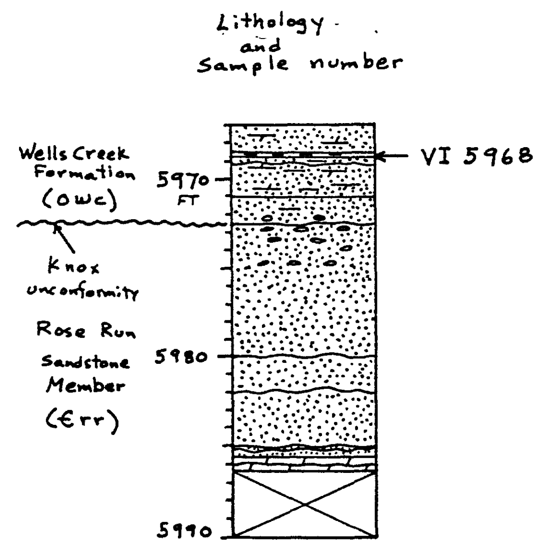
Figure 49. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Amerada Petroleum Corporation No. 1 Geib drill hole, Holmes County, Ohio. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (8) is the identification number of this drill hole used in figure 4 and table 2.

(9)

Gallagher No. 1 Vickers

Virginia Township, Coshocton County, Ohio

Ohio Permit No. 2268



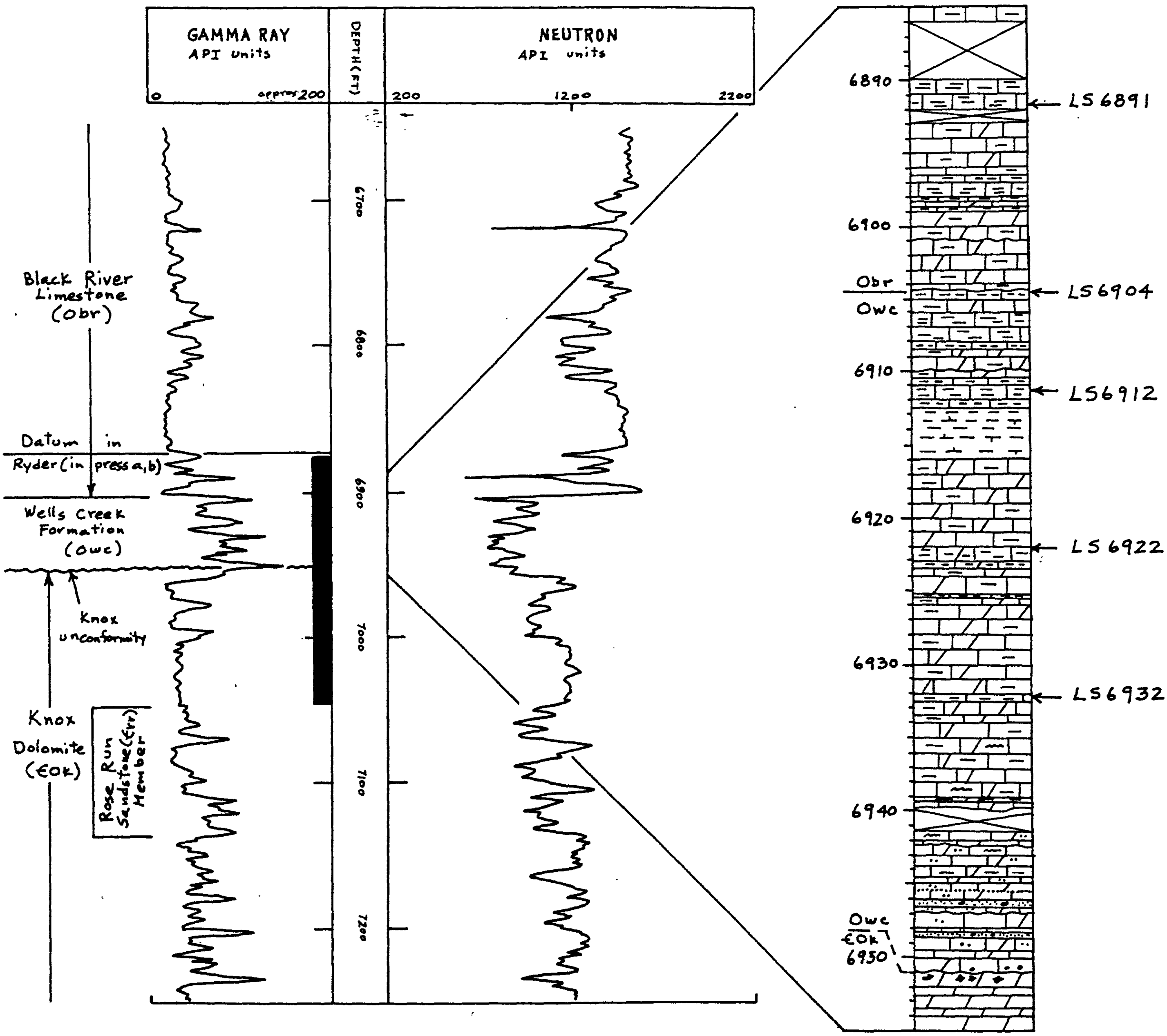
Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
VI5968	0.08	–	0	437	0.0	0.0	5968.75	250.0	0.0	0.0	0.35	0.0

Figure 50. Organic carbon content and Rock-Eval pyrolysis yields of a selected core sample from the Gallagher No. 1 Vickers drill hole, Coshocton County, Ohio. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (9) is the identification number of this drill hole used in figure 4 and table 2.

(10)

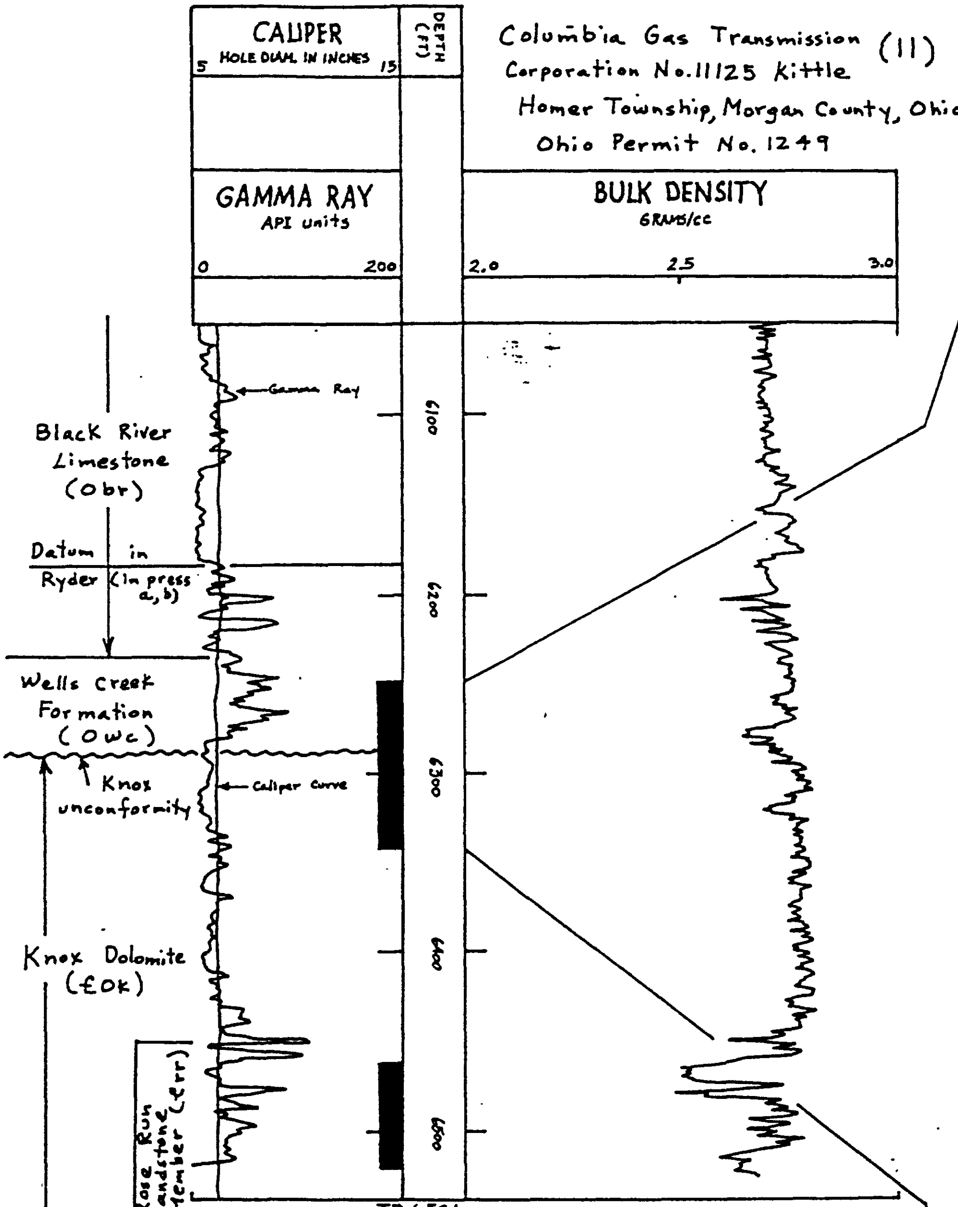
Lakeshore Pipeline Company No. 1 Marshall Community, Adams Township, Guernsey County, Ohio, Ohio Permit No. 782

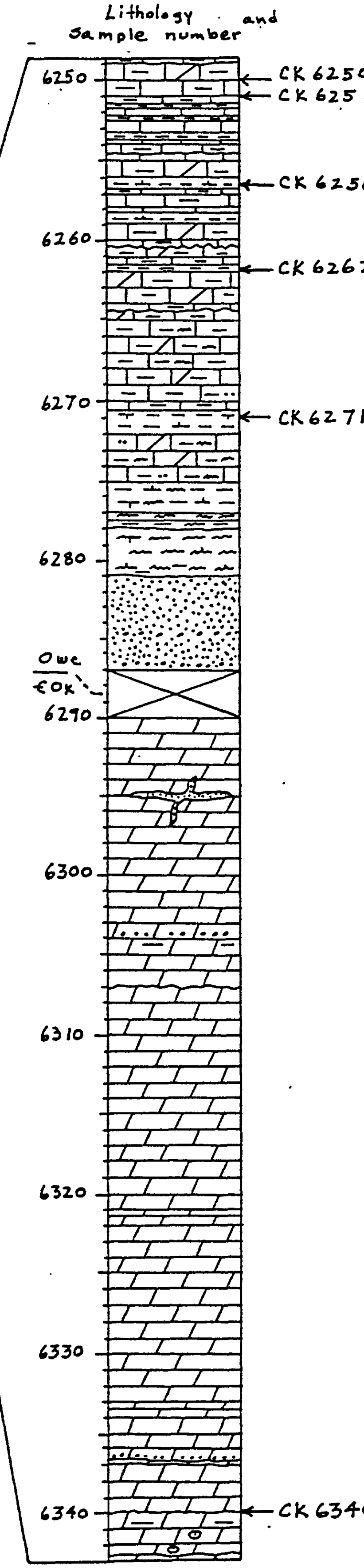


Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
LS6891	0.40	—	57	90	—	0.03	6891.75	227.5	—	—	0.36	0.63
LS6904	0.26	—	65	276	—	0.02	6904.5	190.1	—	—	0.72	0.23
LS6912	0.51	420*	86	98	0.07	0.03	6911.5	231.2	0.03	0.44	0.50	0.88
LS6922	0.42	—	14	140	0.0	0.0	6922	236.0	0.0	0.06	0.59	0.10
LS6932	0.30	—	23	163	0.0	0.0	6932.25	236.5	0.0	0.07	0.49	0.14

Figure 51. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Lakeshore Pipeline Company No. 1 Marshall drill hole, Guernsey County, Ohio. Abbreviated geochemical terms are defined in Appendix A. The Tmax temperature marked with an asterisk and the underlined PI value are considered reliable indicators of thermal maturity and are plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (10) is the identification number of this drill hole used in figure 4 and table 2.



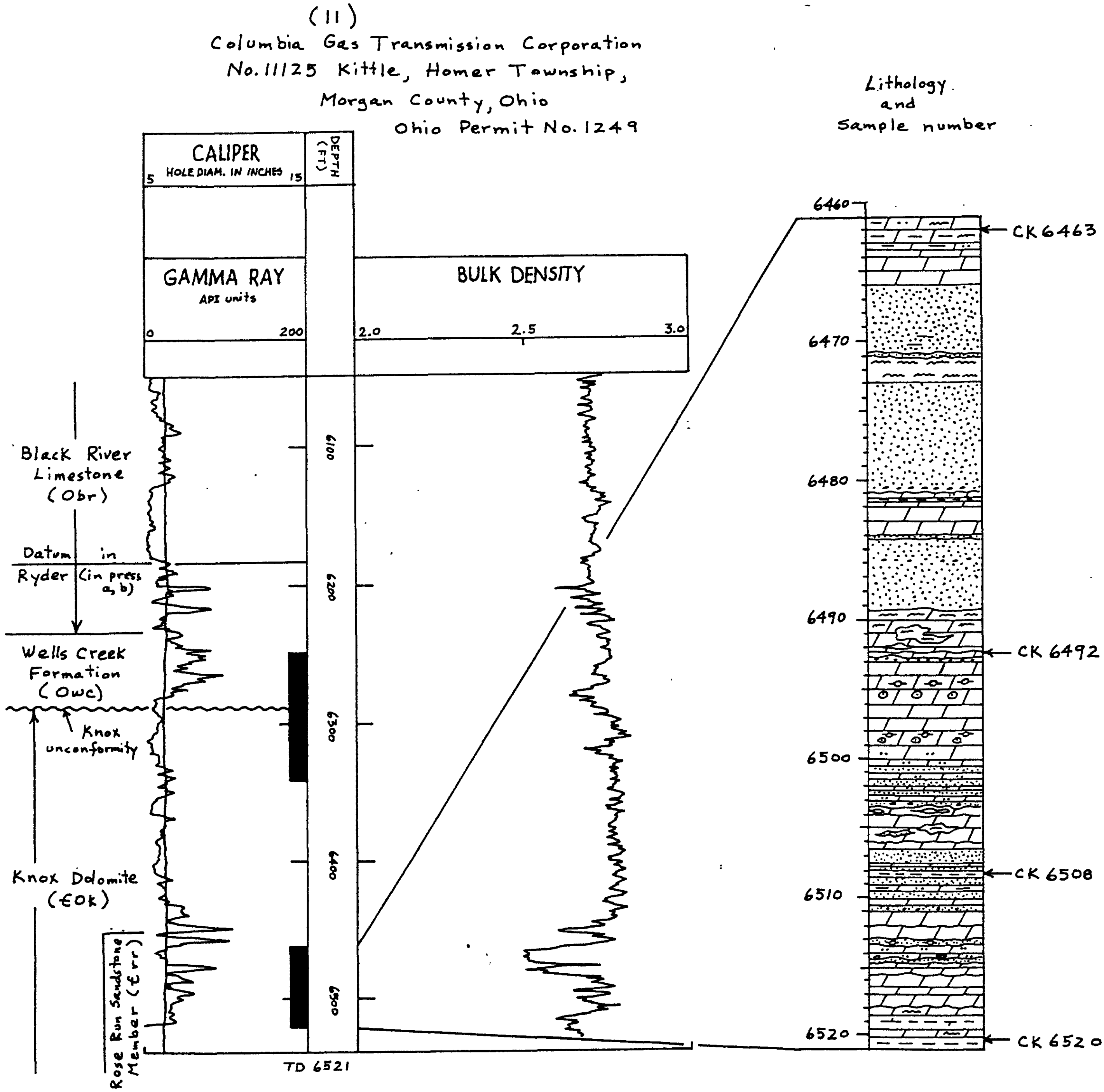


Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)
CK6250	0.23	—	8	195	0.50	0.0	6250
CK6251	0.28	424	89	207	0.08	0.02	6251
CK6256	0.24	—	8	333	0.0	0.0	6256.5
CK6262	0.18	425	61	238	0.0	0.0	6262
CK6271	0.14	—	7	421	0.0	0.0	6271
CK6340	0.14	—	0	621	0.0	0.0	6340

SAMPLE #	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
CK6250	243.7	0.02	0.02	0.45	0.04
CK6251	115.3	0.02	0.25	0.58	0.43
CK6256	208.8	0.0	0.02	0.80	0.02
CK6262	206.4	0.0	0.11	0.43	0.25
CK6271	245.1	0.0	0.01	0.59	0.01
CK6340	238.0	0.0	0.0	0.87	0.0

Figure 52. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Columbia Gas Transmission Corporation No. 11125 Kittle drill hole, Morgan County, Ohio. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (11) is the identification number of this drill hole used in figure 4 and table 2.



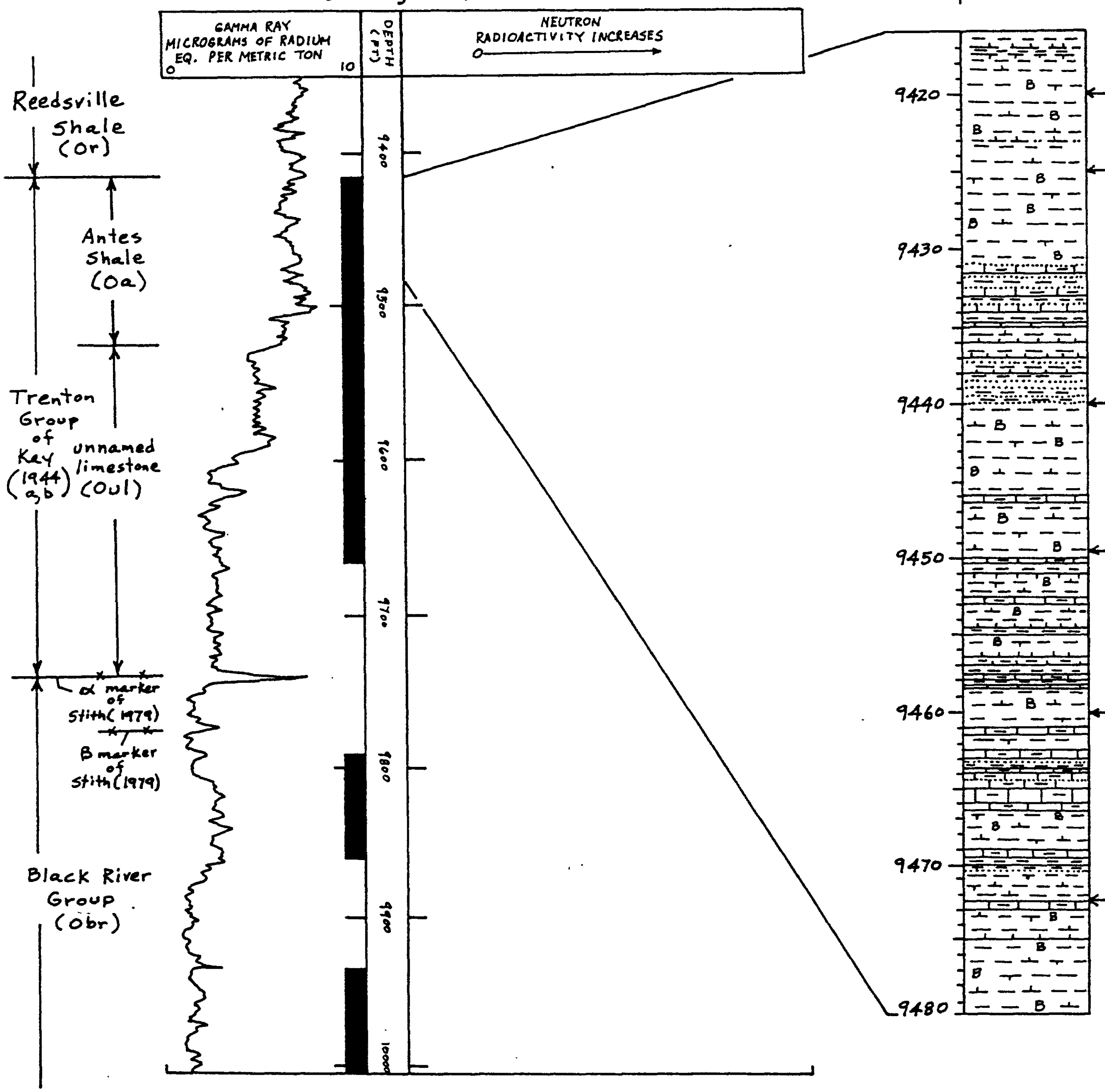
Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
CK6463	0.53	427	35	86	0.18	0.01	6462	202.3	0.04	0.19	0.46	0.41
CK6492	0.02	—	0	500	0.0	0.0	6492.25	193.4	0.0	0.0	0.10	0.0
CK6508	0.54	429	22	122	0.08	0.01	6508.25	183.0	0.01	0.12	0.66	0.18
CK6520	0.01	—	0	600	0.0	0.0	6520.25	227.3	0.0	0.0	0.06	0.0

Figure 53. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Columbia Gas Transmission Corporation No. 11125 Kittle drill hole, Morgan County, Ohio. Abbreviated geochemical terms are defined in Appendix A. The underlined PI values are considered reliable indicators of thermal maturity and are plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (11) is the identification number of this drillhole used in figure 4 and table 2.

(12)

Hope Natural Gas Company No. 9634 · Power Oil Company
Walker District, Wood County, West Virginia
West Virginia Permit No. 351



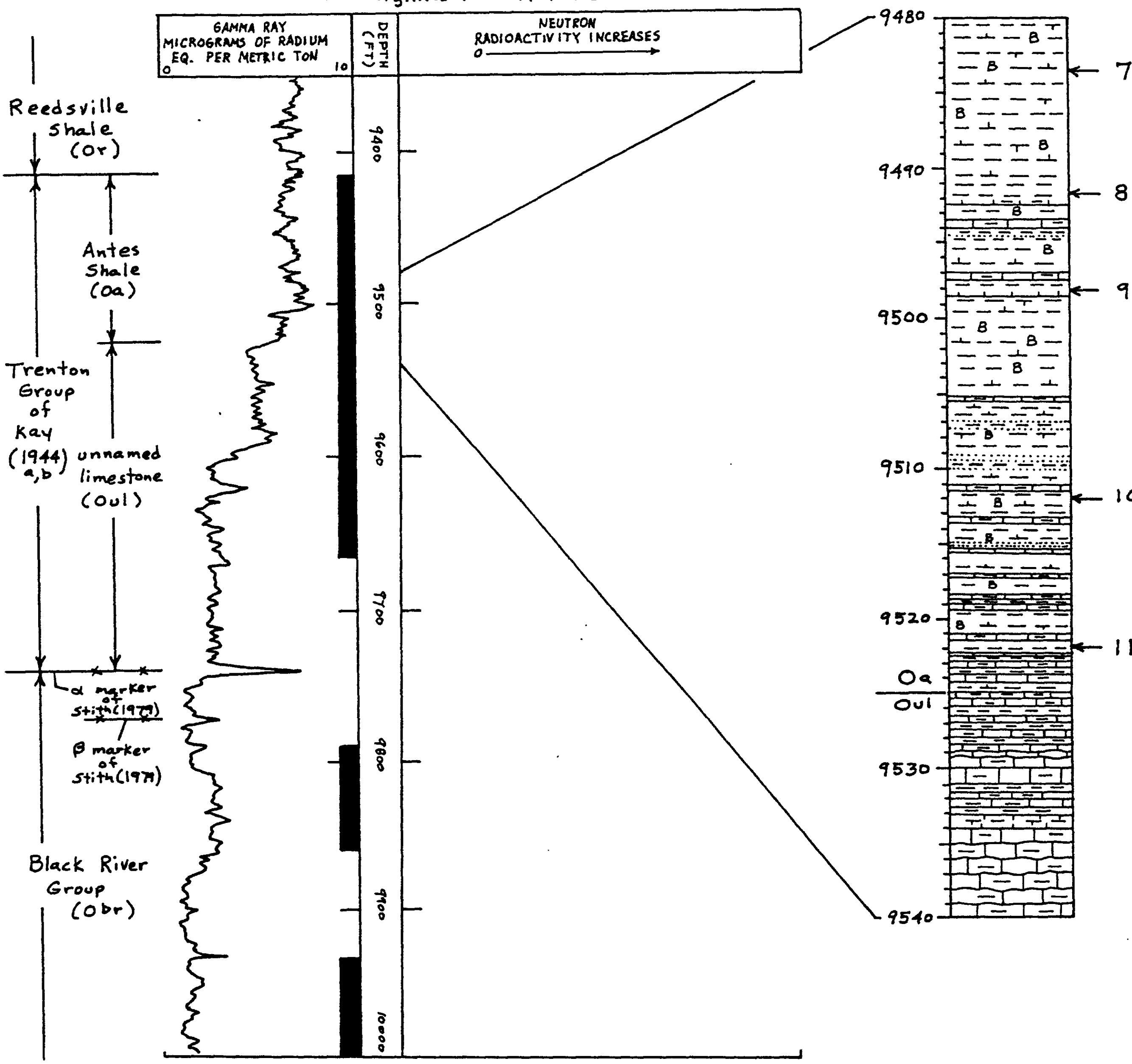
Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
9420	1	162.3	–	0.01	0.05	0.23	0.17	0.21	0	0.43	11	53
9425	2	145.9	–	0.01	0.04	0.26	0.25	0.15	0	0.41	9	63
9440	3	148.8	–	0.01	0.03	0.22	0.25	0.13	0	0.47	6	46
9449.5	4	173.7	–	0.02	0.04	0.23	0.33	0.17	0	0.64	6	35
9460	5	19.1	–	0.68	0.68	0.36	0.5	1.88	0.11	0.5	136	72
9472.25	6	15.5	–	1.22	1.67	0.32	0.42	5.21	0.24	1.13	147	28

Figure 54. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms are defined in Appendix A. The underlined PI values are considered reliable indicators of thermal maturity and are plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (12) is the identification number of this drill hole used in figure 4 and table 2.

(12)

Hope Natural Gas Company No. 9634 Power Oil Company
Walker District, Wood County, West Virginia
West Virginia Permit No. 351



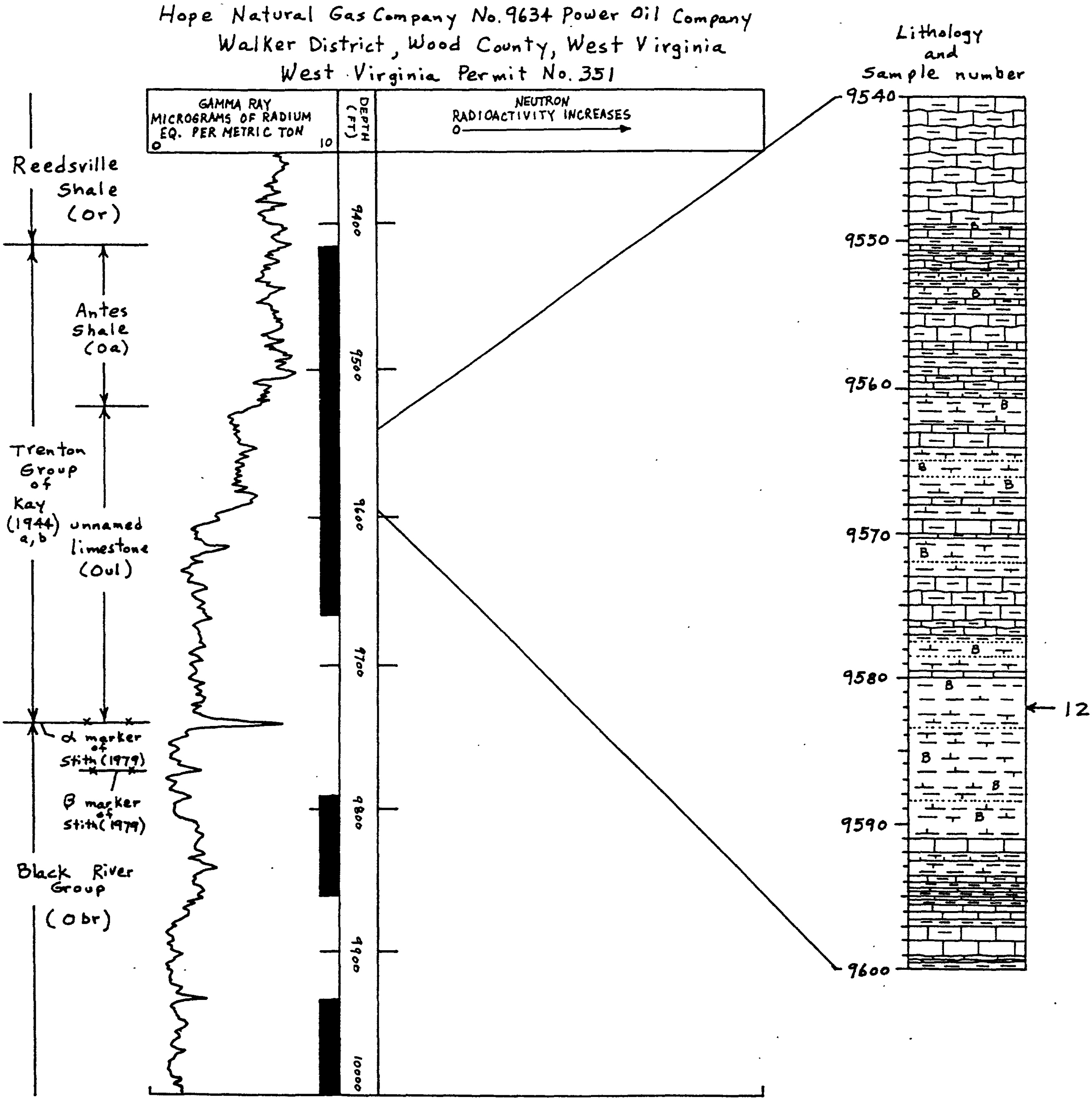
Organic carbon content and Rock-Eval pyrolysis yields.

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
9483.5	7	14.7	–	1.15	1.29	0.34	0.47	3.79	0.2	1.63	79	20
9491.5	8	10.3	–	1.16	1.55	0.38	0.43	4.07	0.22	1.82	85	20
9498.25	9	32.4	–	0.49	0.61	0.37	0.45	1.64	0.09	1.44	42	25
9512	10	20.7	–	0.48	0.77	0.33	0.39	2.33	0.1	2.87	26	11
9522	11	15	–	0.8	0.86	0.53	0.48	1.62	0.13	1.43	60	37

Figure 55. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms are defined in Appendix A. The underlined PI values are considered reliable indicators of thermal maturity and are plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (12) is the identification number of this drill hole used in figure 4 and table 2.

(12)

Hope Natural Gas Company No. 9634 Power Oil Company
Walker District, Wood County, West Virginia
West Virginia Permit No. 351



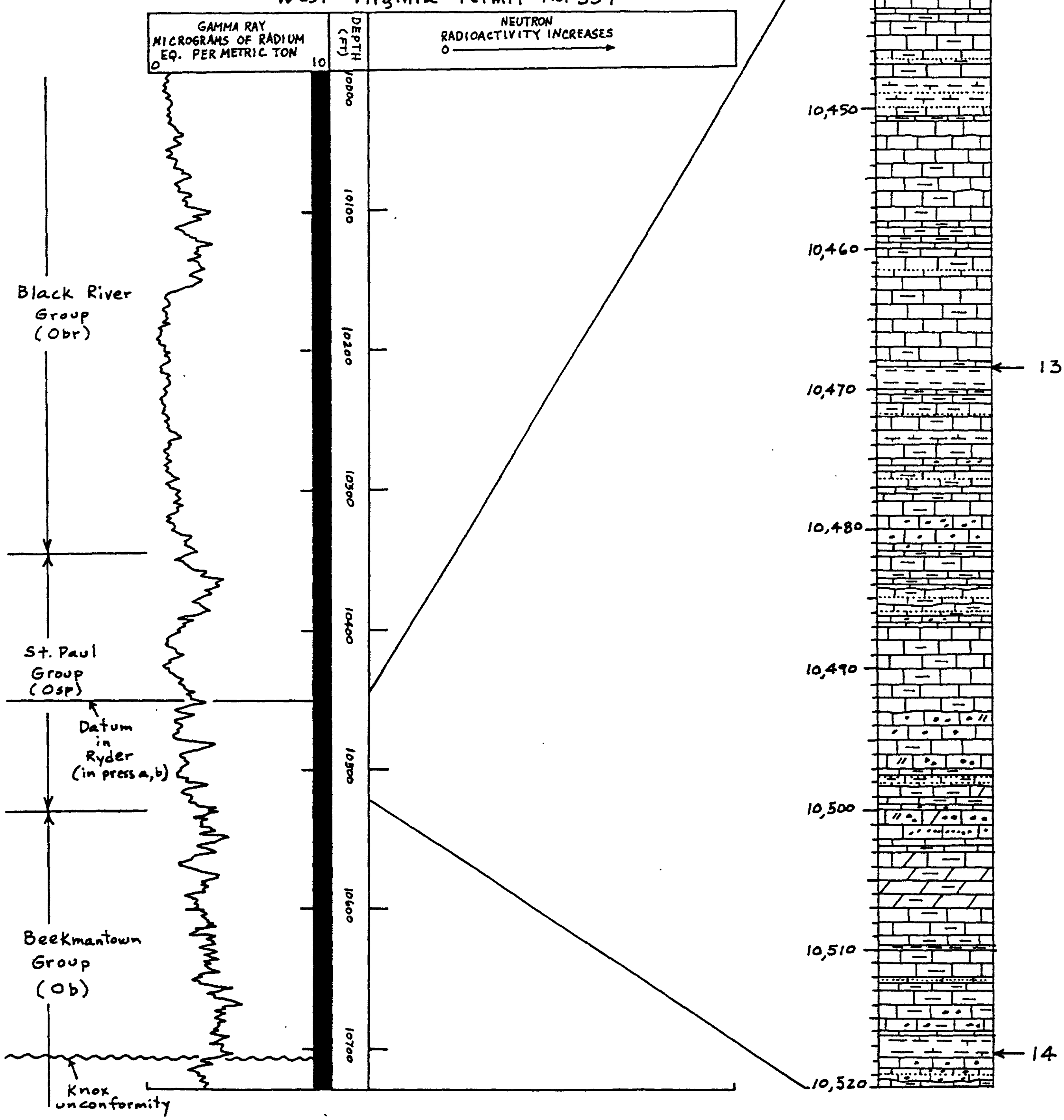
Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
9582	12	15.8	—	0.75	0.82	0.44	<u>0.48</u>	1.86	0.13	1.12	73	39

Figure 56.. Organic carbon content and Rock-Eval pyrolysis yields of a selected core sample from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms are defined in Appendix A. the underlined PI value is considered a reliable indicator of thermal maturity and is plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (12) is the identification number of this drill hole used in figure 4 and table 2.

(12)

Hope Natural Gas Company No. 9634 Power Oil Company
Walker District, Wood County, West Virginia
West Virginia Permit No. 351



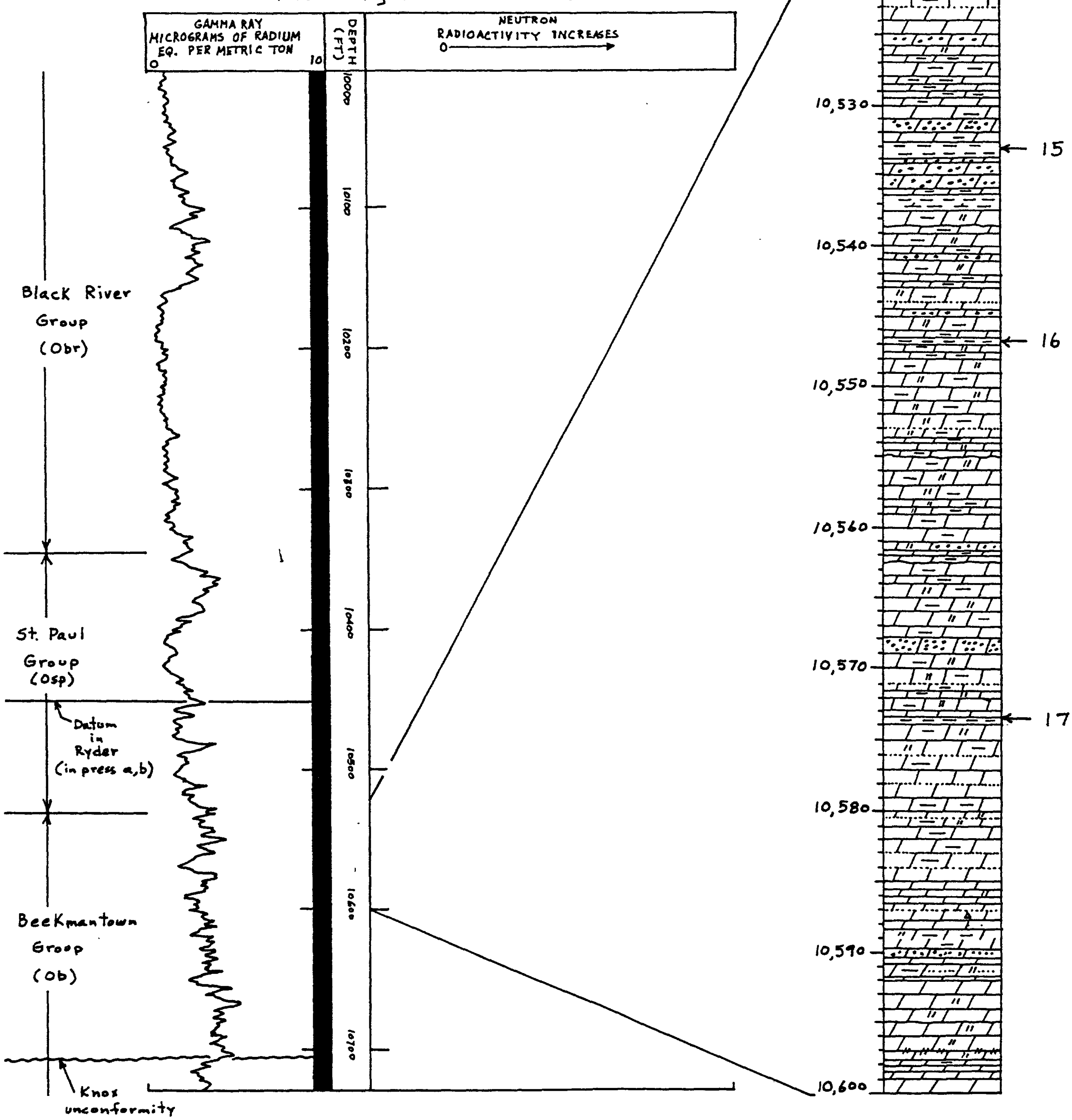
Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
10468.5	13	103.9	–	0.19	0.21	0.27	0.47	0.77	0.03	0.33	63	81
10517.5	14	142.3	–	0.1	0.14	0.33	0.42	0.42	0.02	0.36	38	91

Figure 57. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (12) is the identification number of this drill hole used in figure 4 and table 2.

(12)

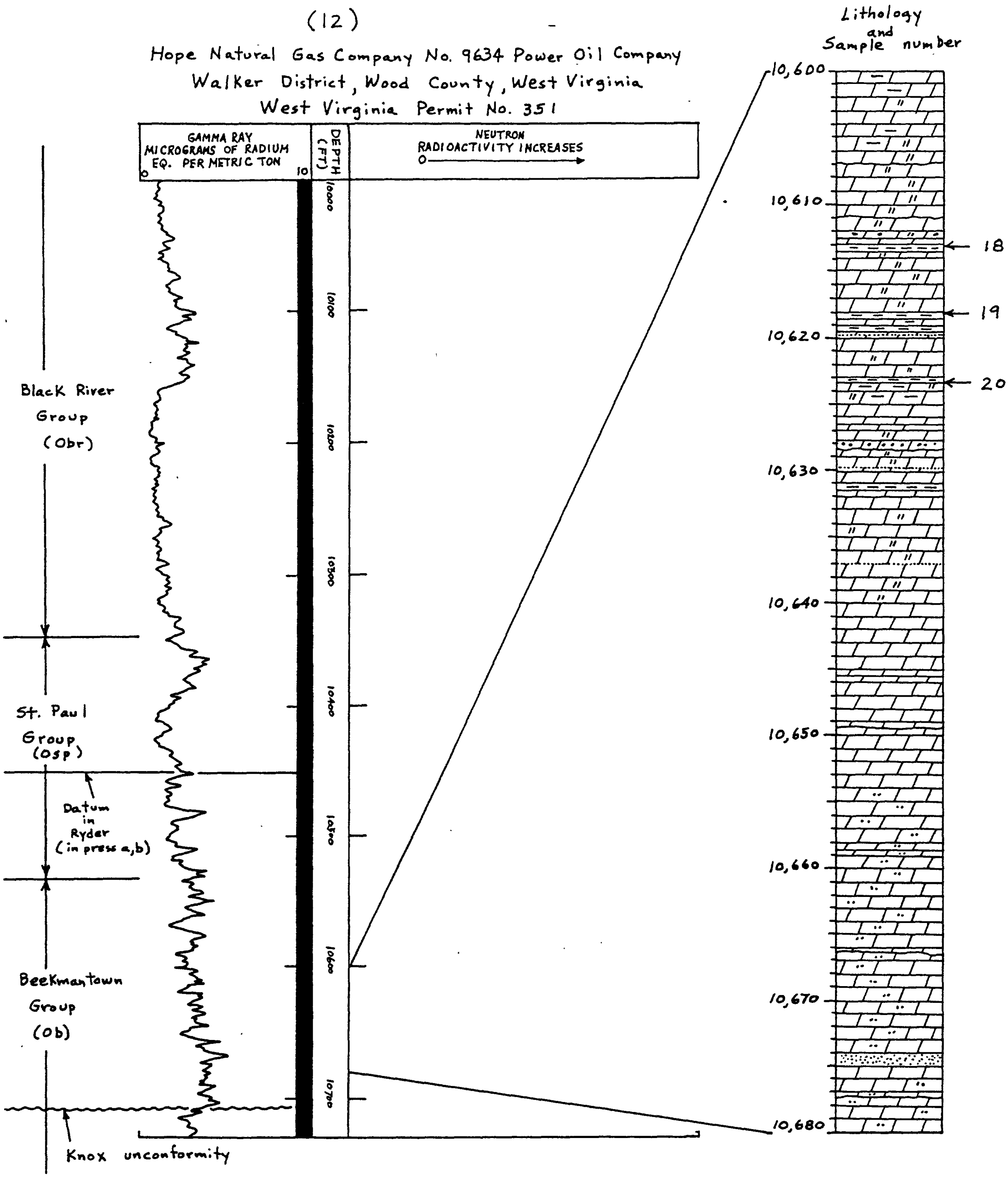
Hope Natural Gas Company No. 9634 Power Oil Company
Walker District, Wood County, West Virginia
West Virginia Permit No. 351



Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
10533	15	13.8	—	1.01	1.01	0.36	0.5	2.8	0.16	0.46	219	78
10546.75	16	12.4	—	3.06	3.54	0.32	0.46	11.06	0.55	0.96	368	33
10573.5	17	98.9	—	0.13	0.16	0.31	0.46	0.51	0.02	0.38	42	81

Figure 58. Organic carbon content and Rock-Eval pyrolyais yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, Weat Virginia. Abbreviated geochemical terms are defined in Appendix A. The underlined PI value is considered a reliable indicator of thermal maturity and is plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (12) is the identification number of this drill hole used in figure 4 and table 2.



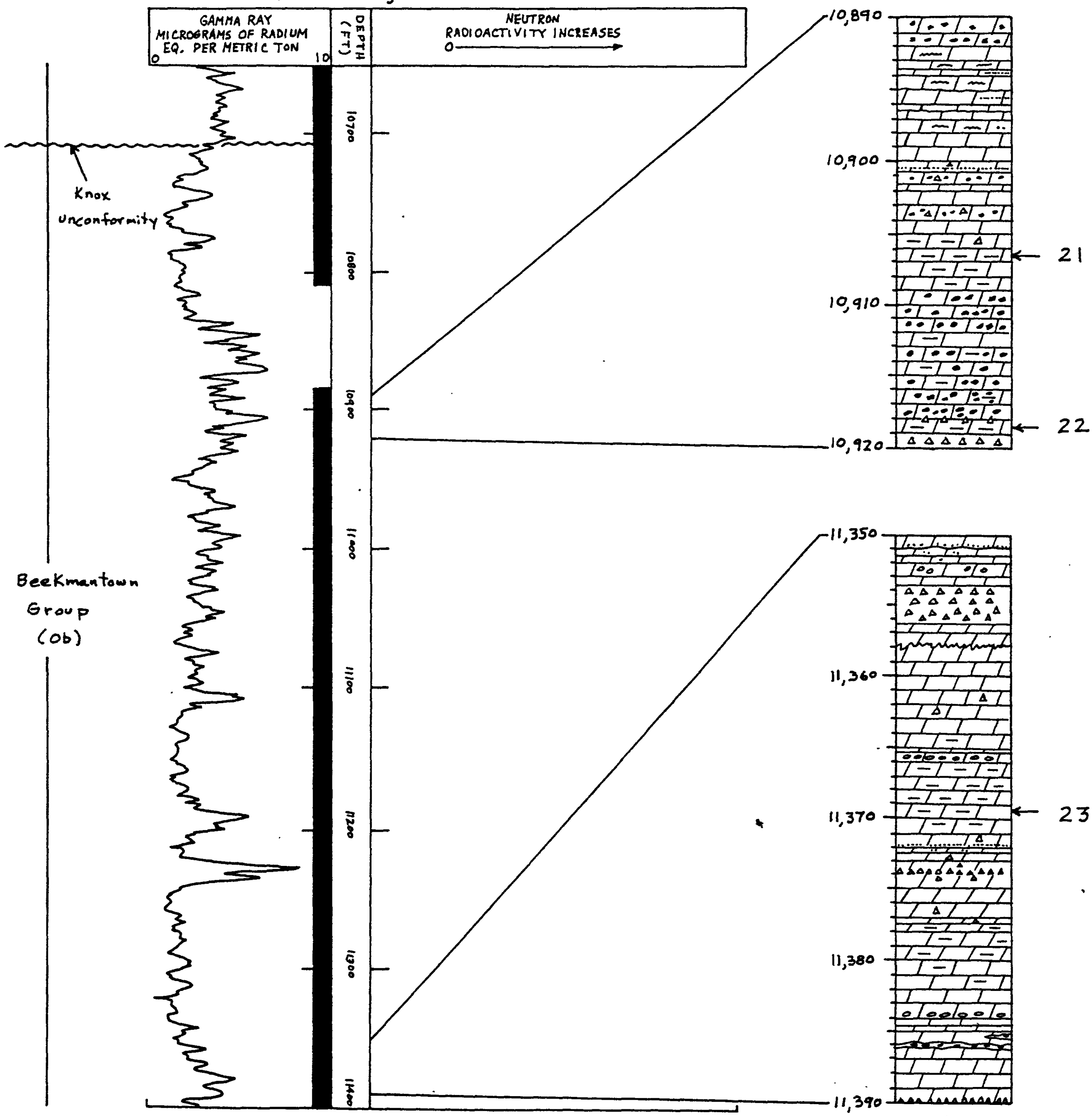
Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
10613	18	167.9	–	0.04	0.07	0.19	0.4	0.36	0	0.28	25	67
10618	19	169.2	–	0	0.01	0.22	0	0.04	0	0.52	1	42
10623.5	20	177.7	–	0	0.01	0.31	0	0.03	0	0.23	4	134

Figure 59. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (12) is the identification number of this drill hole used in figure 4 and table 2.

(12)

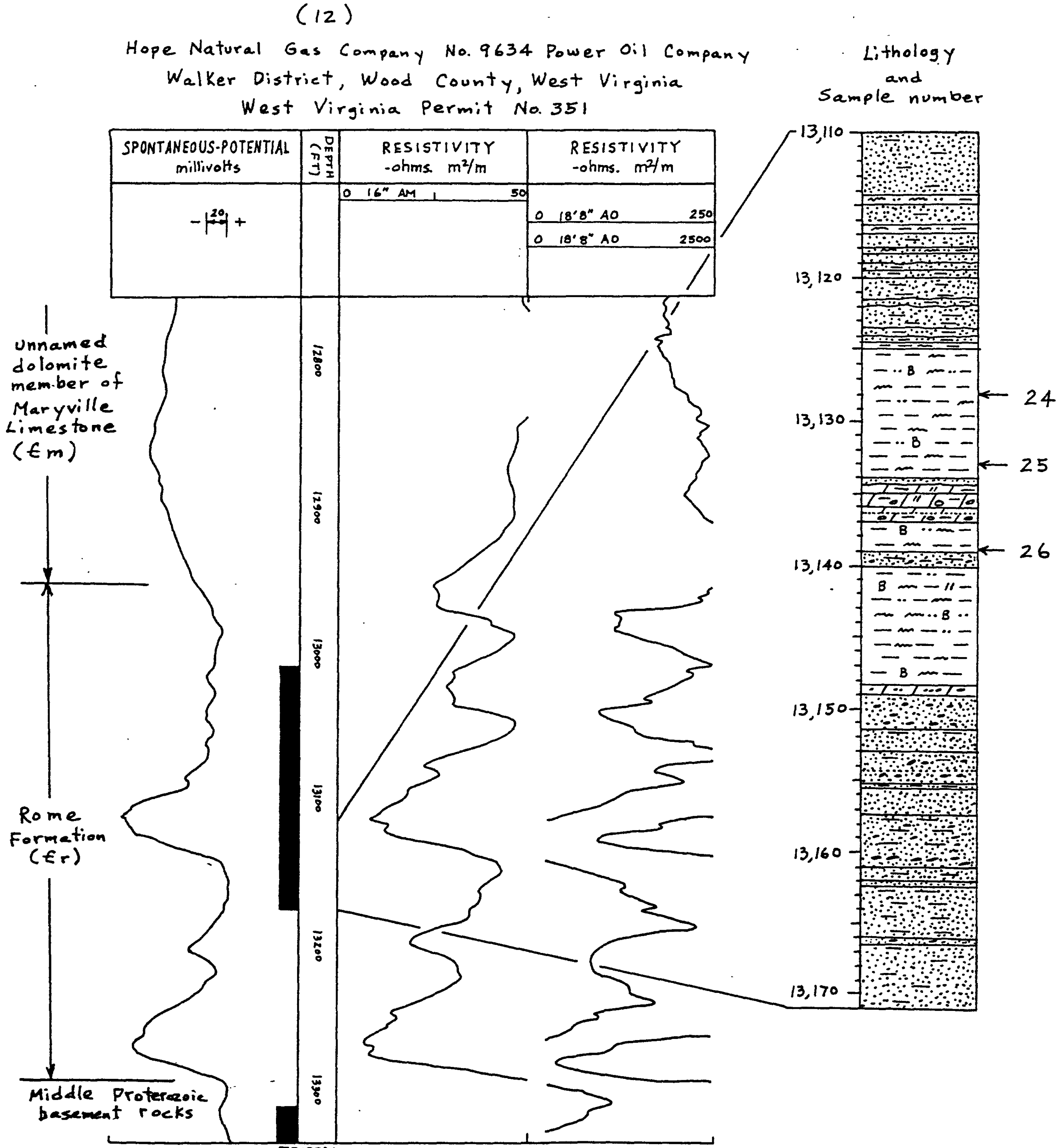
Hope Natural Gas Company No. 9634 Power Oil Company
Walker District, Wood County, West Virginia
West Virginia Permit No. 351



Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
10906.5	21	184.4	—	0	0.01	0.18	0	0.05	0	0.37	2	48
10918.5	22	138.2	—	0	0.01	0.28	0	0.03	0	0.37	2	75
11369.5	23	140.3	—	0.23	0.24	0.13	0.5	1.84	0.03	0.47	51	27

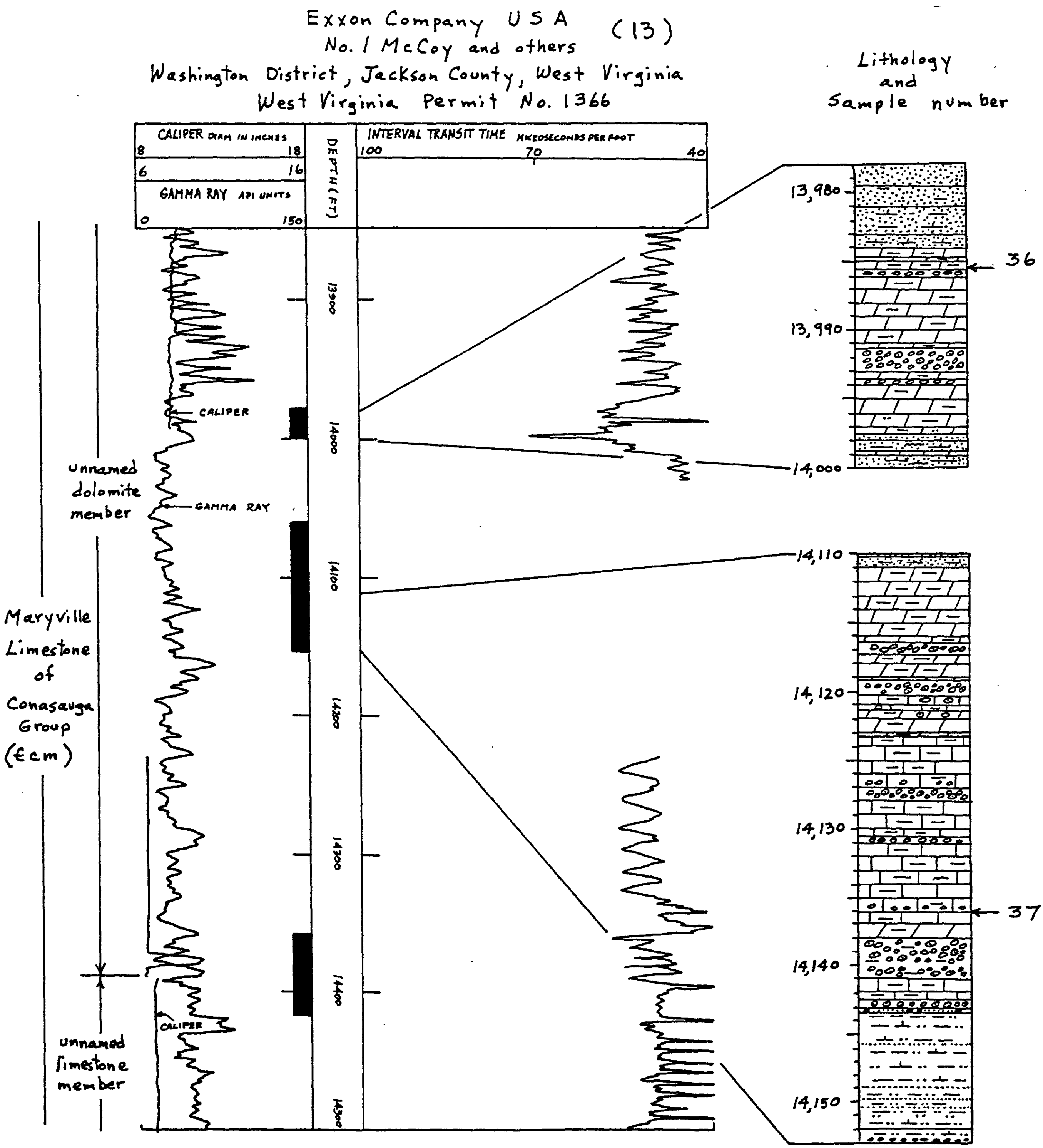
Figure 60. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (12) is the identification number of this drill hole used in figure 4 and table 2.



Organic carbon content and Rock-Eval pyrolysis yields --

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
13128	24	96.2	–	0.31	0.39	0.28	0.44	1.39	0.05	0.18	216	155
13133	25	126.8	–	0	0	0.23	0	0	0	0.18	0	127
13139.75	26	108.7	–	0	0.01	0.27	0	0.03	0	0.08	12	337

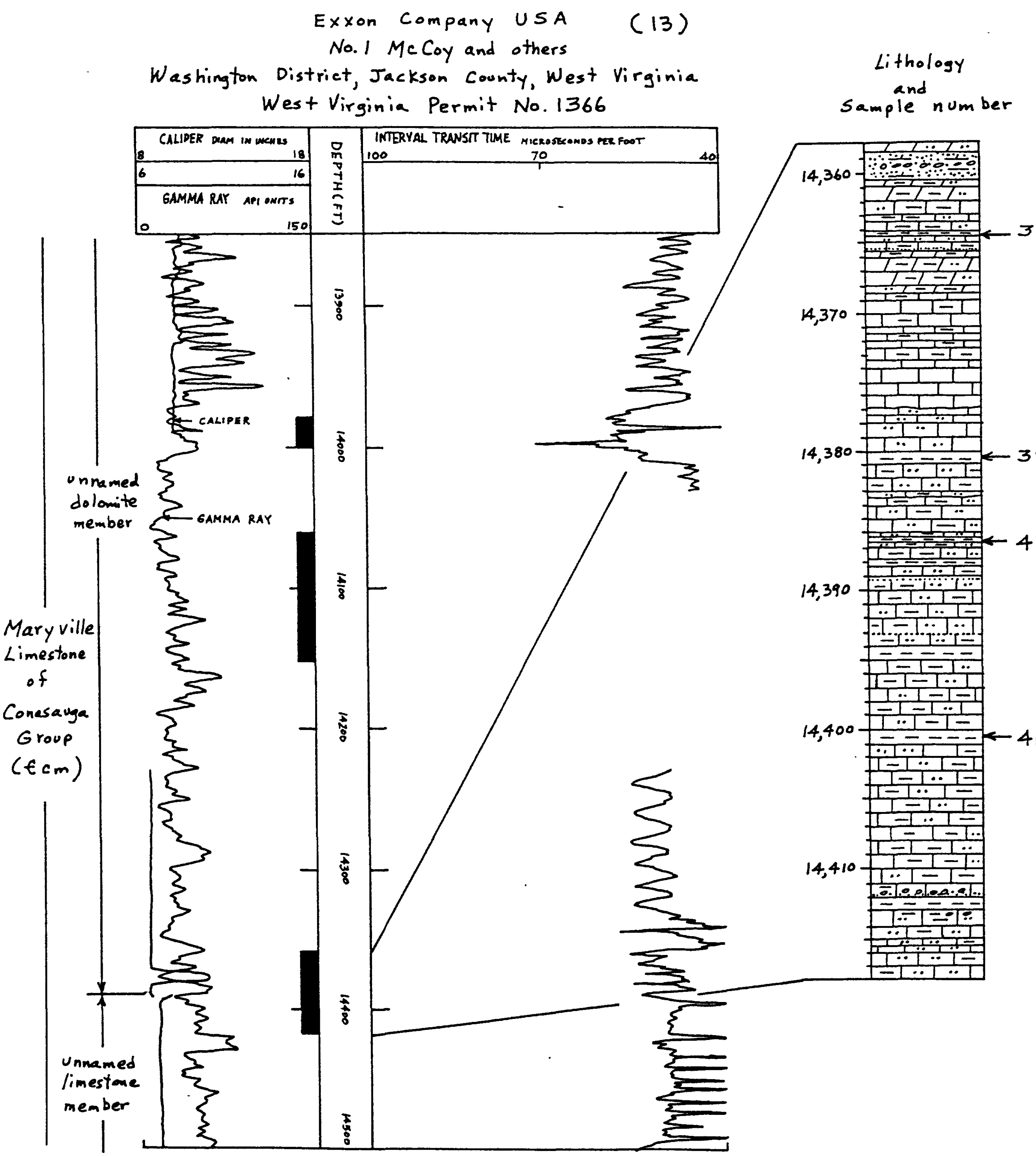
Figure 61. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Hope Natural Gas Company No. 9634 Power Oil Company drill hole, Wood County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (12) is the identification number of this drill hole used in figure 4 and table 2.



Organic carbon content and Rock-Eval pyrolysis yields:

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
13985.5	36	162.2	—	0.03	0.07	0.33	0.3	0.21	0	0.34	20	97
14136	37	205.6	—	0.04	0.07	0.32	0.4	0.21	0	0.36	19	88

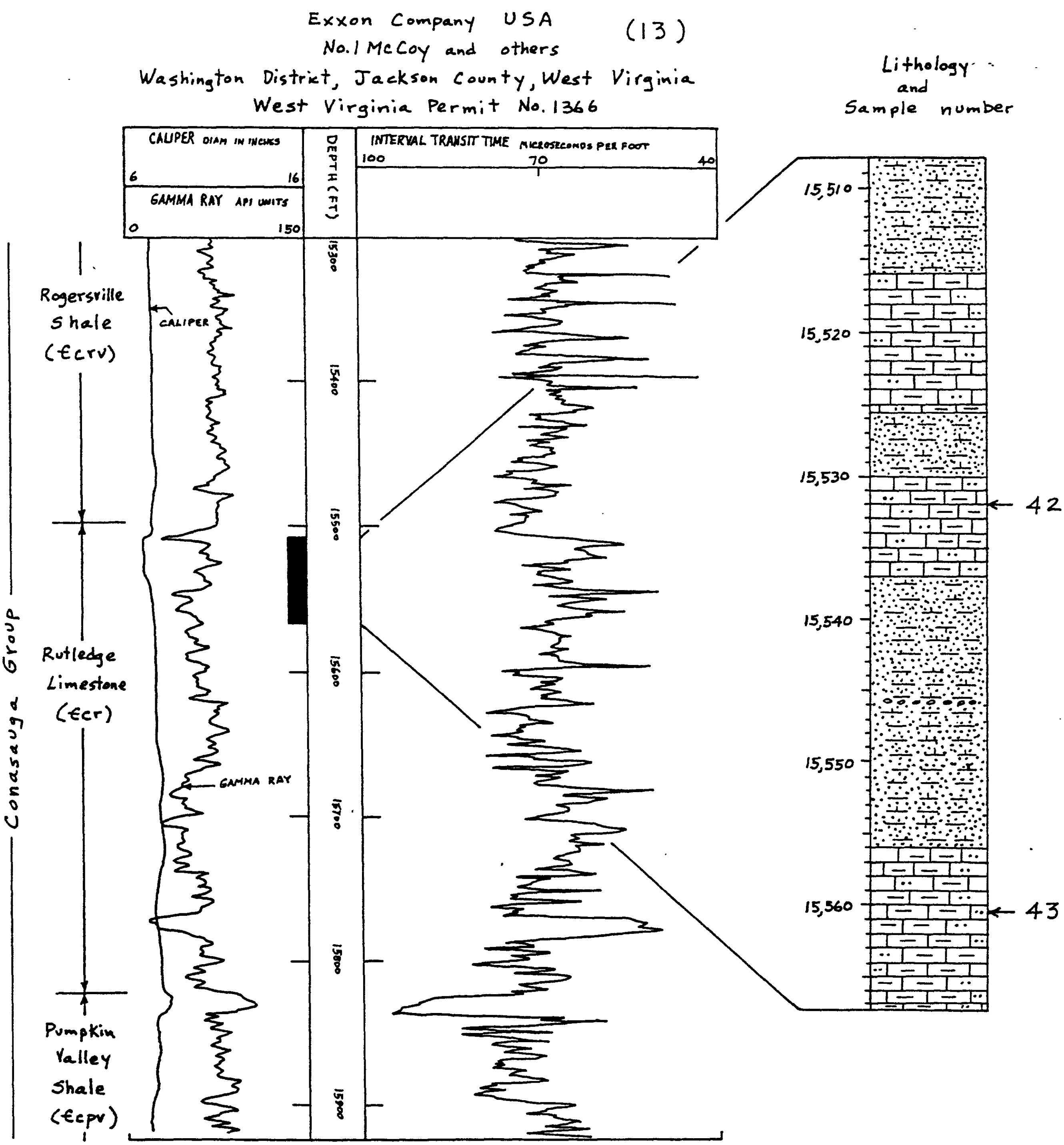
Figure 62. Organic carbon content and Rock-Eval pyrolysis yielda of selected core samples from the Exxon Company USA No. 1 McCoy and others drill hole, Jackson County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (13) is the identification number of this drill hole used in figure 4 and table 2.



Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
14364.5	38	179.8	—	0.02	0.05	0.38	0.33	0.13	0	0.19	26	200
14380.5	39	194.9	—	0.13	0.11	0.32	0.54	0.34	0.02	0.59	18	54
14386.5	40	221.8	—	0.09	0.1	0.28	0.5	0.35	0.01	0.25	40	112
14400.5	41	182.6	—	0.12	0.15	0.44	0.46	0.34	0.02	0.51	29	86

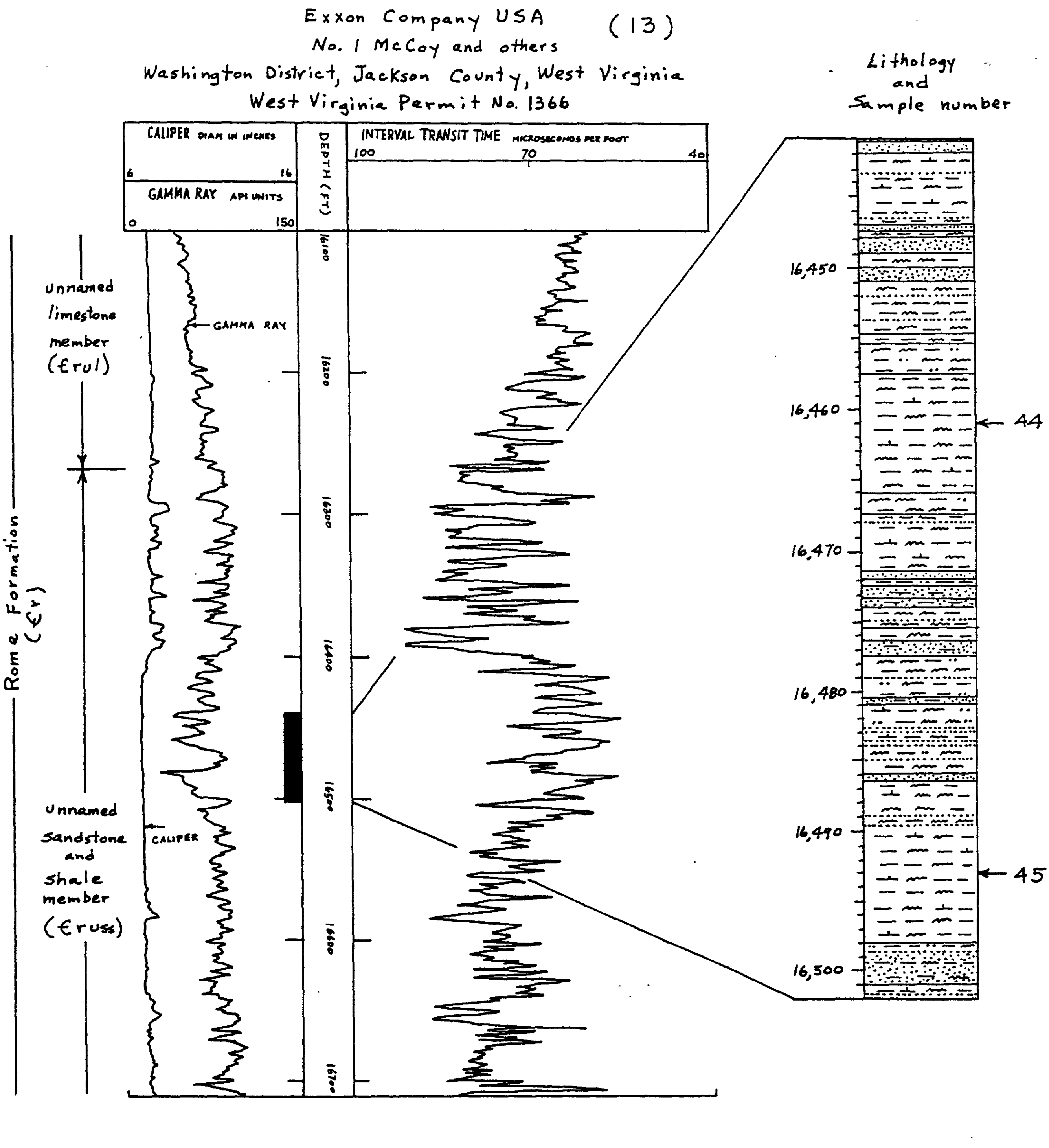
Figure 63. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Exxon Company USA No. 1 McCoy and others drill hole, Jackson County, West Virginia. Abbreviated geochemical terms are defined in Appendix A. The underlined PI value is considered a reliable indicator of thermal maturity and is plotted on figure 72. The lithologic symbols are defined in Appendix B. Number (13) is the identification number of this drill hole used in figure 4 and table 2.



Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
15532	42	158.7	–	0.13	0.14	0.25	0.5	0.56	0.02	0.29	48	86
15560.5	43	179.9	–	0.03	0.05	0.38	0.37	0.13	0	0.33	15	115

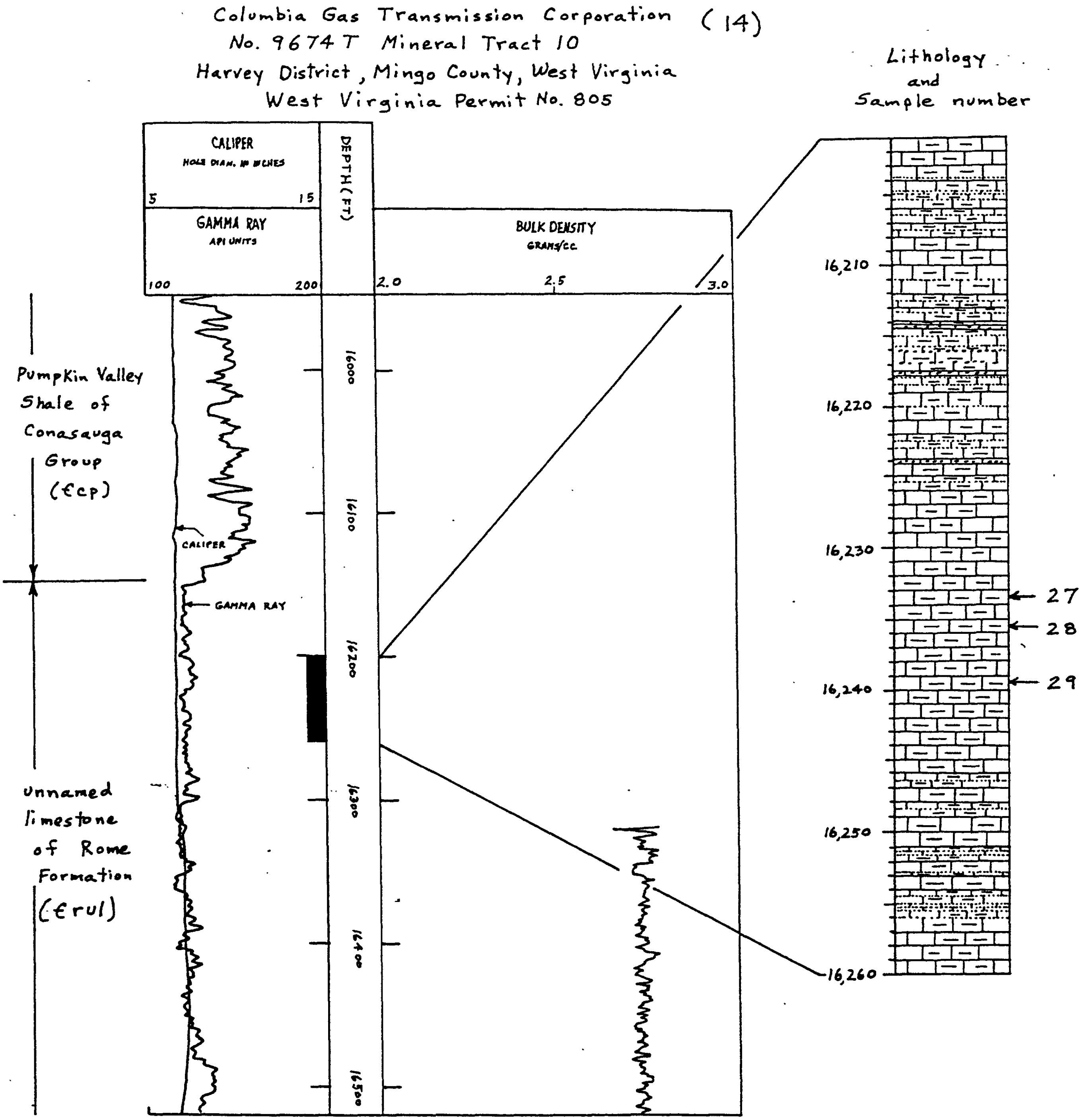
Figure 64. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Exxon Company USA No. 1 McCoy and others drill hole, Jackson County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (13) is the identification number of this drill hole used in figure 4 and table 2.



Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample#	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
16461	44	179.2	—	0.05	0.08	0.16	0.42	0.5	0.01	0.09	88	177
16493	45	174.8	—	0.05	0.07	0.21	0.42	0.33	0.01	0.11	63	190

Figure 65. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Exxon Company USA No. 1 McCoy and others drill hole, Jackson County, West Virginia. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (13) is the identification number of this drill hole used in figure 4 and table 2.



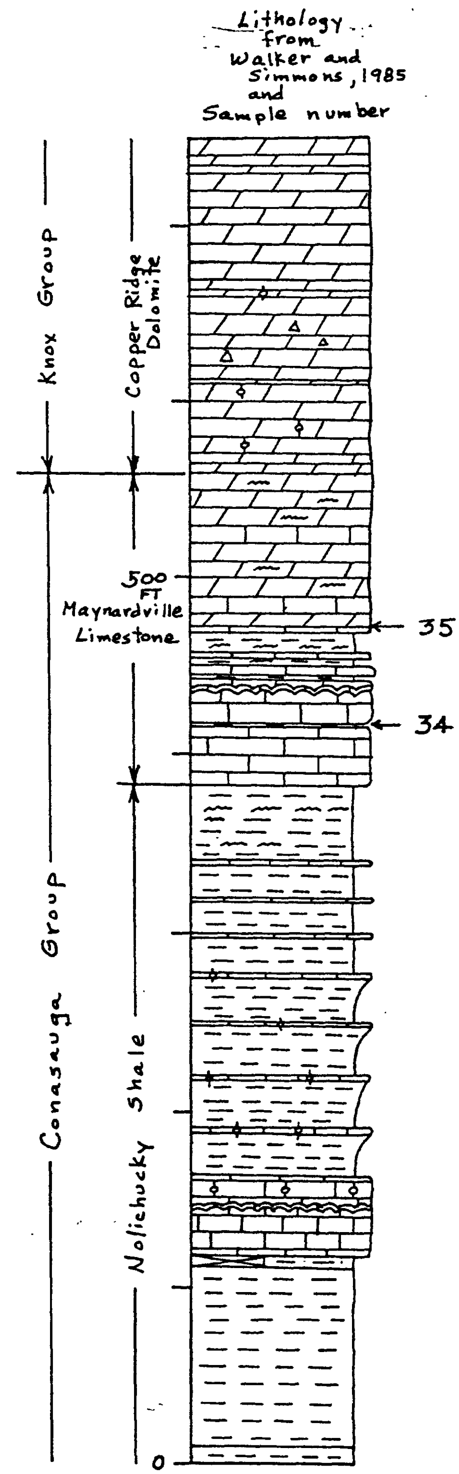
Organic Carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample#	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
16233.5	27	133.6	–	0.04	0.05	0.27	0.5	0.18	0	0.15	33	180
16235.5	28	172.5	–	0.12	0.08	0.28	0.6	0.28	0.01	0.51	15	54
16239.5	29	198.3	–	0.15	0.09	0.27	0.62	0.33	0.02	0.58	15	46

Figure 66. Organic carbon content and Rock-Eval pyrolysis yields of selected core samples from the Columbia Gas Transmission Corporation No. 9674T Mineral Tract 10 drill hole, Mingo County, West Virginia. Abbreviated geochemical terms are defined in Appendix A. The underlined PI values are considered reliable indicators of thermal maturity and are plotted of figure 72. Lithologic symbols are defined in Appendix B. Number (14) is the identification number of this drill hole used in figure 4 and table 2.

(15)

Thorn Hill outcrop section
along U.S. Highway 25E
Grainger County, Tennessee

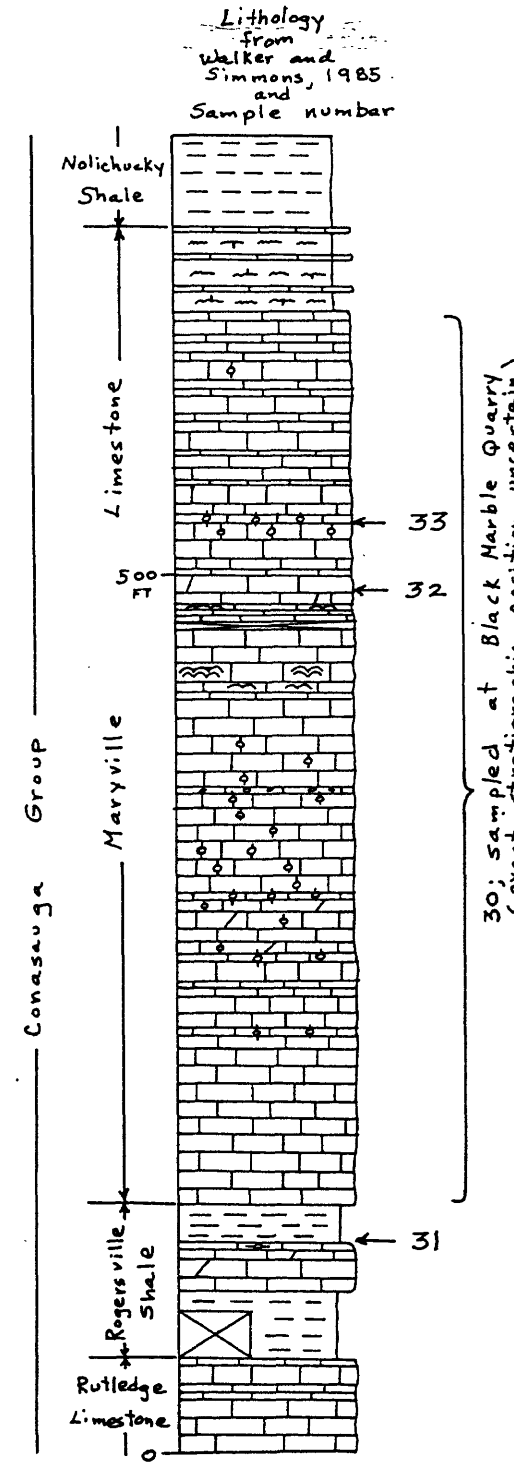


Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample #	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
—	34	185.4	—	0.01	0.02	0.12	0.5	0.16	0	0.05	40	240
—	35	197.8	—	0	0.02	0.26	0	0.07	0	0.11	18	236

Figure 67. Organic carbon content and Rock-Eval pyrolysis yields of selected rock samples from the Thorn Hill outcrop section, Grainger County, Tennessee. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (15) is the identification number of this outcrop section used in figure 4 and table 2.

(15)
Thorn Hill outcrop section
along U.S. Highway 25E
Grainger County, Tennessee



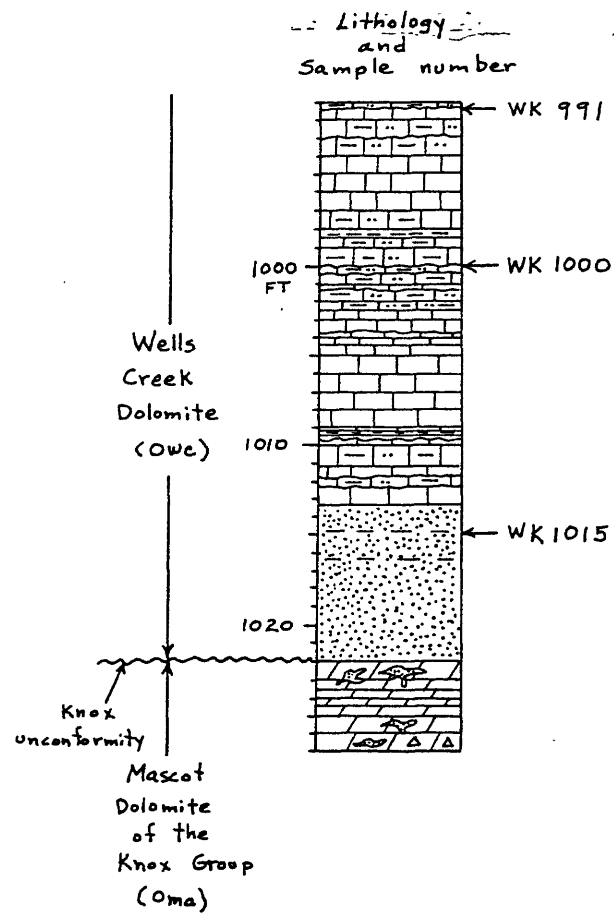
Organic carbon content and Rock-Eval pyrolysis yields

Depth, ft	Sample#	WGHT, mg	Tmax	S1, mg/g	S2, mg/g	S3, mg/g	PI	S2/S3	PC	TOC	HI	OI
—	30	224.8	—	0.01	0.03	0.19	0.25	0.15	0	0.05	60	380
—	31	187.7	—	0.19	0.22	0.11	0.47	2	0.03	0.12	183	91
—	32	173	—	0.3	0.31	0.28	0.5	1.1	0.05	0.58	53	48
—	33	197.3	—	0.03	0.06	0.23	0.37	0.26	0	0.36	16	63

Figure 68.. Organic carbon content and Rock-Eval pyrolysis yields of selected rock samples from the Thorn Hill outcrop section, Grainger County, Tennessee. Abbreviated geochemical terms are defined in Appendix A. The underlined PI value is considered a reliable indicator of thermal maturity and is plotted on figure 72. Lithologic symbols are defined in Appendix B. Number (15) is theidentification number of this outcrop section used in figure 4 and table 2.

(16)

Marathon Oil Company core hole
No. 12 Kyle Farm
Trousdale County, Tennessee



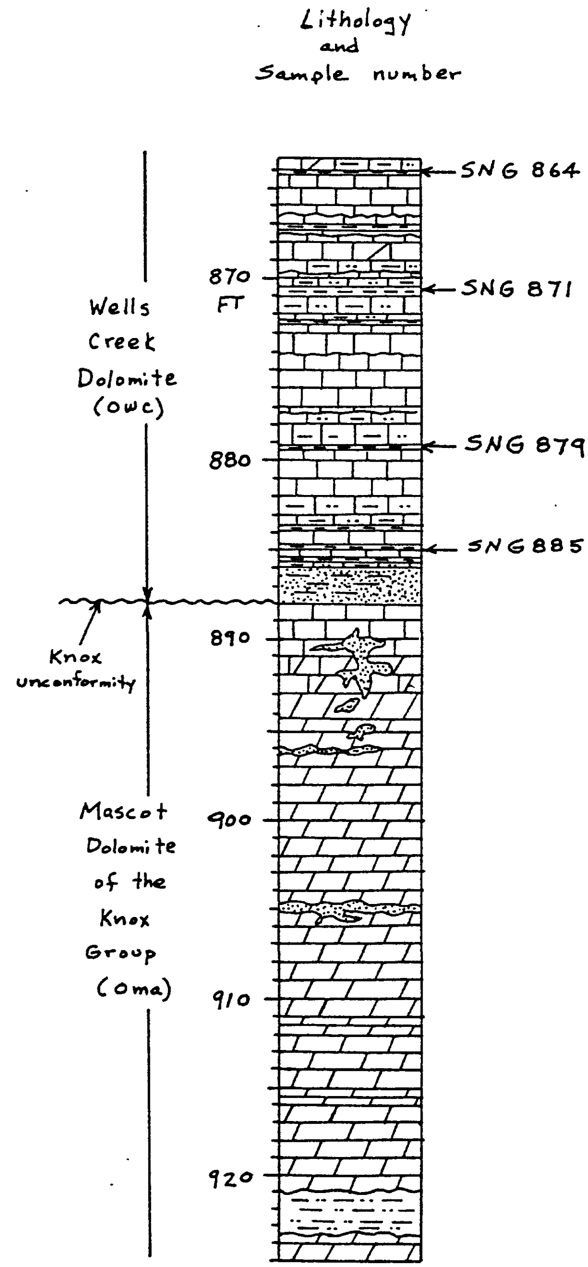
Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH (ft)	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
WK991	0.20	—	50	90	0.17	0.01	991.25	234.4	0.02	0.10	0.18	0.55
WK1000	0.19	—	31	178	0.25	0.0	1000	185.8	0.02	0.06	0.34	0.17
WK1015	0.19	—	36	115	0.25	0.0	1015	210.2	0.02	0.07	0.22	0.31

Figure 69. Organic carbon content and Rock-Eval pyrolysis yields of selected rock samples from the Marathon Oil Company No. 12 Kyle farm core hole, Trousdale County, Tennessee. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (16) is the identification number of this core hole used in figure 4 and table 2.

(17)

Marathon Oil Company core hole
No. SGN-33 Kyle Farm
Trousdale County, Tennessee



Organic carbon content and Rock-Eval pyrolysis yields

SAMPLE #	TOC	Tmx	HI	OI	PI	PC	DEPTH	WGHT	S1mg/g	S2mg/g	S3mg/g	S2/S3
SNG864	0.15	—	20	120	0.0	0.0	864	221.9	0.0	0.03	0.18	0.16
SNG871	0.09	—	22	244	0.0	0.0	870.5	239.8	0.0	0.02	0.22	0.09
SNG879	0.37	403	16	72	0.17	0.0	879	233.3	0.01	0.06	0.27	0.22
SNG885	0.22	—	36	118	0.12	0.0	885	227.7	0.01	0.08	0.26	0.30

Figure 70. Organic carbon content and Rock-Eval pyrolysis yields of selected rock samples from the Marathon Oil Company No. SGN-33 Kyle farm core hole, Trousdale County, Tennessea. Abbreviated geochemical terms and lithologic symbols are defined in Appendices A and B, respectively. Number (17) is the identification number of this core hole used in figure 4 and table 2.

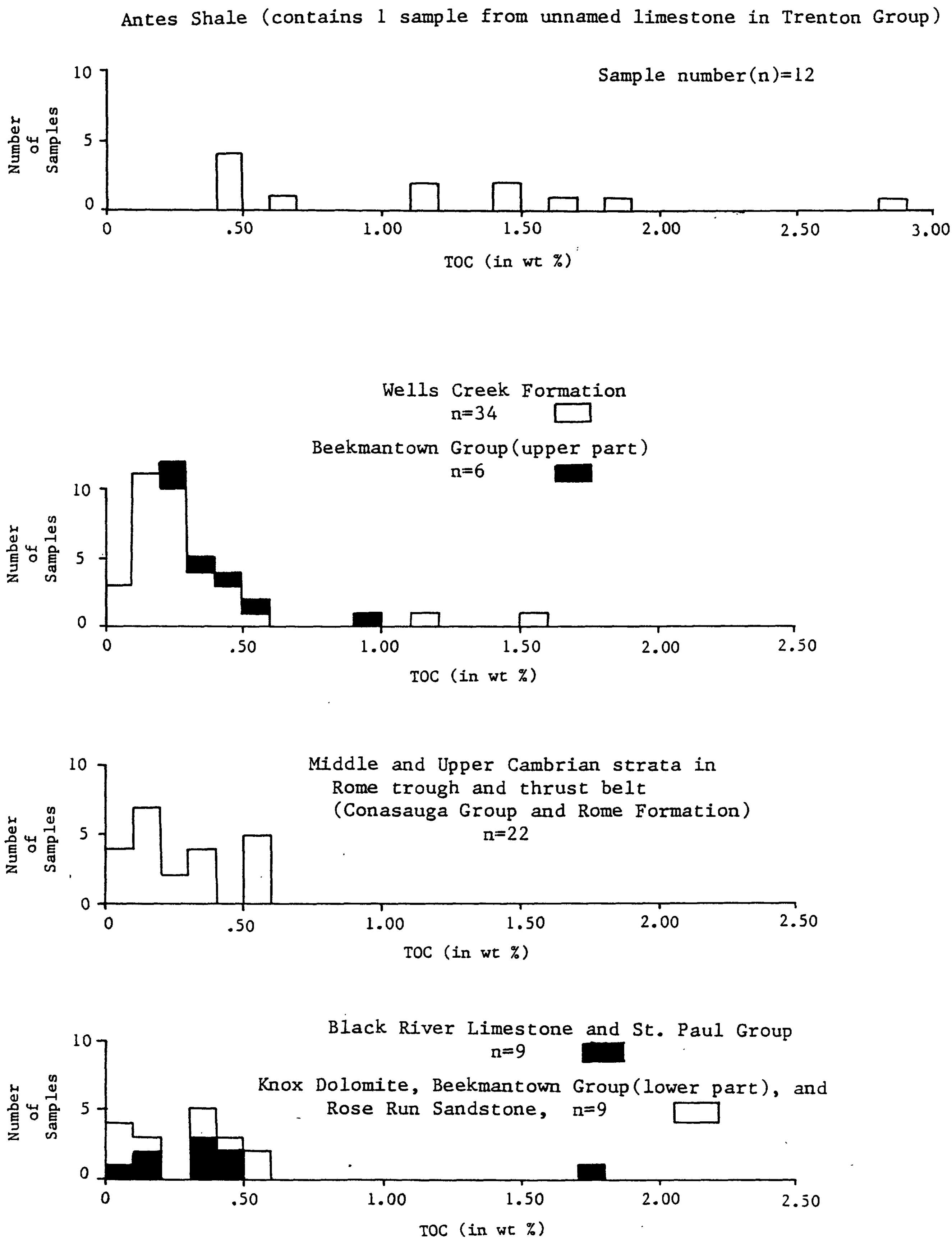


Figure 71. TOC content of selected rock samples grouped by stratigraphic interval.

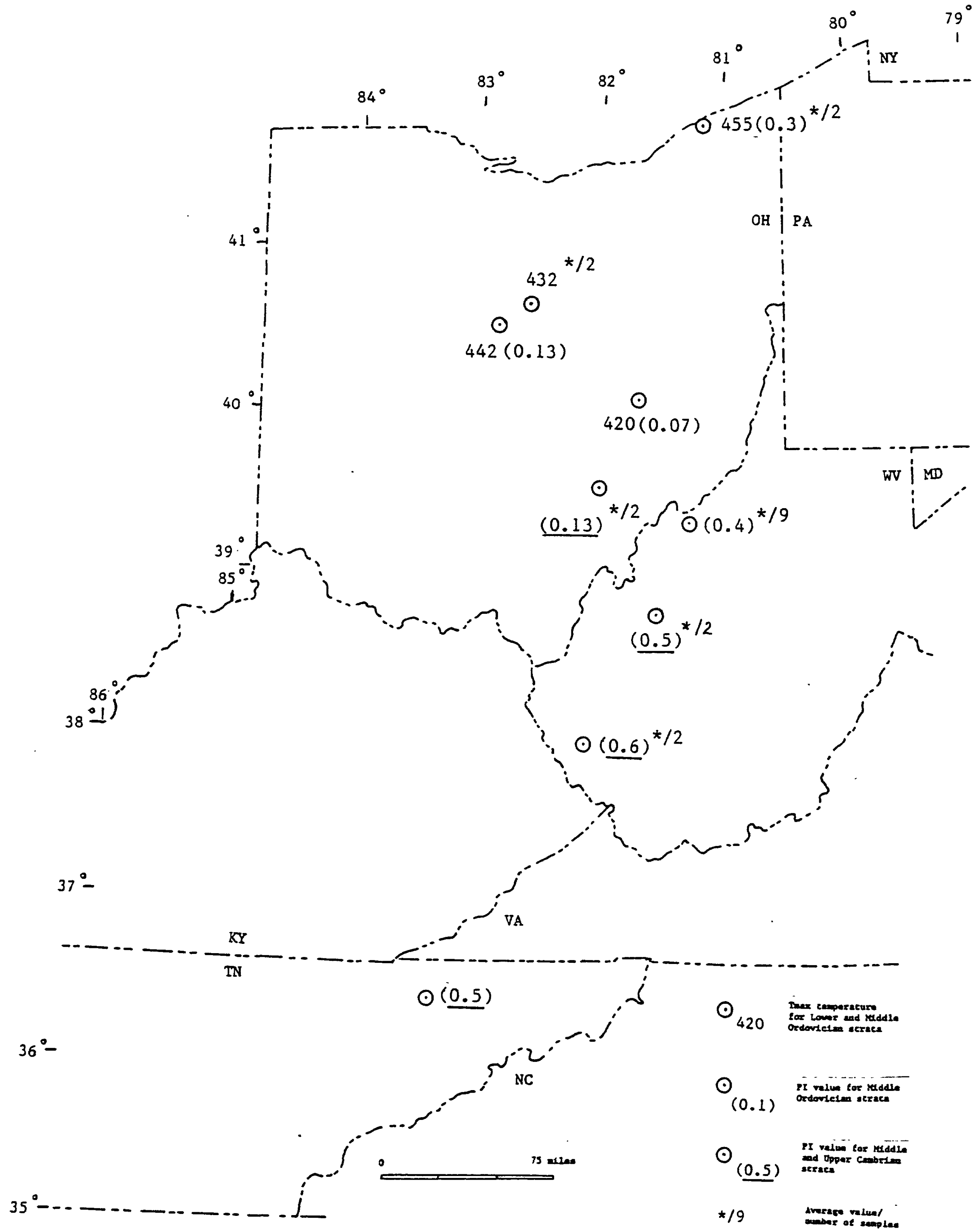


Figure 72. Map showing Tmax temperatures and PI values derived from this study that are considered to be reliable indicators of thermal maturity. Reliable Tmax temperatures were calculated from samples with S_2 values greater than 0.04 mg/g and reliable PI values were calculated from samples with TOC greater than 0.5.

Table 1. Name and location of wells sampled for oil. Identification letter, depth, and stratigraphic interval of the oil samples are also shown. Samples are located on figure 4.

Oil Sample Letter	Field Group	Well name	Ohio permit No.	County	Township and 7½' quad	Latitude and Longitude	Total Depth (ft)	Producing Interval (ft)	Producing Formation
A	Morrow County fields	Ashland Oil and Refining Company No. 1 Myers (originally drilled by United Producing Company)	10	Morrow	Canaan Twp. Denmark	40° 34' 10" N 82° 54' 40" W	3174	2908 and 3031	Knox Dolomite (Copper Ridge Dolomite part, drillers usage)
B	Morrow County fields	Ashland Oil and Refining Company No. A-1 Coulter	2065	Morrow	Canaan Twp. Denmark	40° 35' 42" N 82° 56' 40" W	3024	2880-2892	Knox Dolomite (Copper Ridge Dolomite part, drillers usage)
C	Morrow County fields	Ashland Oil and Refining Company No. 2 Kelly	2033	Morrow	Gilead Twp Mount Gilead	40° 35' 04" N 82° 52' 08" W	3246	3026-3080	Knox Dolomite (Copper Ridge Dolomite part, drillers usage)
D	Morrow County fields	Ashland Oil and Refining Company No. 5 Mosher	1407	Morrow	Cardington Twp. Mount Gilead	40° 30' 23" N 82° 52' 09" W	3241	≅ 3090-3110	Knox Dolomite (Copper Ridge Dolomite part, drillers usage)
E	Morrow County fields	Ashland Oil and Refining Company No. 1 Hoyt	2914	Morrow	Peru Twp. Olive Green	40° 22' 12" N 82° 50' 23" W	3340	≅ 3248-3268	Knox Dolomite (Copper Ridge Dolomite part, drillers usage)
F	Rose Run Sandstone fields	Park Ohio Industries Energy No. 3 RHOA	1847	Ashtabula	New Lyme Twp. Orwell	41° 36' 46" N 80° 46' 57" W	7136	6148-6168	Rose Run Sandstone Member
G	Rose Run Sandstone fields	Lomak Petroleum, Inc. No. 1 Hess-Whiting	1109	Geauga	Burton Twp. Burton	41° 27' 53" N 81° 09' 56" W	6701	6343-6349	Rose Run Sandstone Member
H	Rose Run Sandstone fields	Lomak Petroleum, Inc. No. 1 Dobra	1456	Geauga	Troy Twp. Burton	41° 25' 20" N 81° 08' 48" W	6685	6422-6474	Rose Run Sandstone Member
I	Rose Run Sandstone fields	Atwood Resources No. 3 Troendly	4462	Tuscarawas	Bucks Twp. Baltic	40° 23' 08" N 81° 40' 12" W	6768	6768	Rose Run Sandstone Member
J	Rose Run Sandstone fields	Atwood Resources No. 1 Newcomerstown Land fill	4574	Tuscarawas	Oxford Twp. Newcomerstown	40° 15' 49" N 81° 36' 17" W	6912	6912	Rose Run Sandstone Member and Knox Dolomite (Beekmantown Dolomite part, driller's usage)
K	Rose Run Sandstone fields	Atwood Resources No. 2 Armstrong	4497	Tuscarawas	Oxford Twp. Kimbolton	40° 14' 24" N 81° 33' 15" W	7540	7540	Rose Run Sandstone Member
L	Rose Run Sandstone fields	Stone Resource and Energy Corporation / Atwood Resources No. 1 Hackenbracht	5908	Coshocton	Adams Twp. Fresno	40° 19' 19" N 81° 37' 56" W	7295	7068-7104	Rose Run Sandstone Member and Knox Dolomite (Beekmantown Dolomite part, driller's usage)
M	South Birmingham and Collins fields	Baldwin and Baldwin Oil Company No. 1 Krysik-Wakefield (originally drilled by) Sun Oil Company	11	Erie	Florence Twp. Kipton	41° 18' 16" N 82° 21' 02" W	4463	≅ 3898-3906	Krysik sandstone of driller's usage
N	South Birmingham and Collins fields	Oxford Oil No. 1 Beck (originally drilled by Hefner Production Company)	46	Huron	Townsend Twp. Berlin Heights	41° 15' 35" N 82° 28' 06" W	3950	3740-3758	Knox Dolomite (Copper Ridge Dolomite part, driller's usage)
O	Harlem field	Industrial Natural Gas Corporation No. 1 Clark	302	Delaware	Harlem Twp. Sunbury	40° 10' 54" N 82° 48' 03" W	3300	2874-2962	Trenton and Black River Limestones

Table 2. Name, identification number, and location of wells and outcrops where rock samples were collected for Rock-Eval analysis. Depth (where applicable) and stratigraphic interval of the rock samples are also shown.

ID No.	Well (or) outcrop name	State	County	Township (or) District and 7½' quad.	Latitude and Longitude	State Permit No.	Total Depth (ft)	Sampled interval (ft) n = number of samples	Age and stratigraphic name of sampled interval
1	Calhio Chemicals Incorporated No. 1 Calhio Chemicals Incorporated	OH	Lake	Perry Twp. Perry	41° 45' 03" N 81° 09' 35" W	142	6,076	5,361.25-5,371.5 n = 4	Middle Ordovician Wells Creek Formation
2	Floto and Associates No. 3 Troxel	OH	Ashland	Clear Creek Twp. Olivesburg	40° 58' 59" N 82° 23' 28" W	2382	4,337	4,200.25, n = 1	Upper Cambrian Knox Dolomite of Janssens (1973)
3	Ohio Fuel Gas Company No. 1 Indermuehle	OH	Wayne	Green Twp. Rittman	40° 53' 24" N 81° 50' 20" W	1316	5,859	5,784.5 - 5810.5 n = 8	Middle Ordovician Wells Creek Formation
4	Pan American Petroleum Corporation No. 1 Windbigler	OH	Morrow	Troy Twp. Blooming Grove	40° 41' 26" N 82° 40' 54" W	47	4,890	3,875, n = 1	Middle Ordovician Wells Creek Formation
5	Pan American Petroleum Corporation No. 2 Davidson	OH	Richland	Troy Twp. Mansfield South	40° 38' 47" N 82° 36' 30" W	299	4,300	3,907.5 - 3,931.5 n = 3	Middle Ordovician Black River Limestone
6	Pan American Petroleum Corporation No. 1 Palmer	OH	Richland	Troy Twp. Mansfield South	40° 38' 55" N 82° 35' 21" W	289	4,775	4,170.25 - 4,187 n = 2	Middle Ordovician Black River Limestone
								4,208.5, n = 1	Middle Ordovician Wells Creek Formation
7	Ashland Oil and Refining Corporation No. 2 Mosher	OH	Morrow	Cardington Twp. Mount Gilead	40° 30' 23" N 82° 52' 02" W	866	3,253	3,060.5, n = 1	Middle Ordovician Black River Limestone
8	Amerada Petroleum Corporation No. 1 Geib	OH	Holmes	Berlin Twp. Berlin	40° 32' 21" N 81° 48' 24" W	1297	6,693	6,371.5 - 6,390.5 n = 3	Middle Ordovician Black River Limestone
9	Gallagher No. 1 Vickers	OH	Coshocton	Virginia Twp. Conesville	40° 10' 15" N 81° 55' 32" W	2268	6,013	5,968.75, n = 1	Middle Ordovician Wells Creek Formation
10	Lakeshore Pipeline Company No. 1 Marshall	OH	Guernsey	Adams Twp. Bloomfield	40° 02' 12" N 81° 43' 11" W	782	8,602	6,891.75, n = 1	Middle Ordovician Black River Limestone
								6,904.5 - 6,932.25 n = 4	Middle Ordovician Wells Creek Formation
11	Columbia Gas Transmission Corporation No. 11125 Kittle	OH	Morgan	Homer Twp. Jacksonville	39° 29' 46" N 82° 01' 29" W	1249	6,521	6,250 - 6,271 n = 5	Middle Ordovician Wells Creek Formation
								6,340, n = 1	Upper Cambrian Knox Dolomite of Janssens (1973)
								6,462 - 6,520.25 n = 4	Upper Cambrian (?) Rose Run Sandstone Member

Table 2 (continued). Name, identification number, and location of wells and outcrops where rock samples were collected for Rock-Eval analysis. Depth (where applicable) and stratigraphic interval of the rock samples are also shown.

ID No.	Well (or) outcrop name	State	County	Township (or) District and 7½' quad	Latitude and Longitude	State Permit No.	Total Depth (ft)	Sampled interval (ft) n = number of samples		Age and stratigraphic name of sampled interval
12	Hope Natural Gas Company No. 9634 Power Oil Company	WV	Wood	Walker District Willow Island	39° 15'25" N 81° 16'21" W	351	13,331	9,420 - 9,522 n = 11		Middle and Upper Ordovician Antes Shale of Trenton Group
								9,582, n = 1		Middle Ordovician unnamed limestone of Trenton Group of Kay (1944a, b)
								10,468.5 - 10,517.5 n = 2		Middle Ordovician St. Paul Group
								10,533 - 10,623.5 n = 6	above Knox unconf.	Lower and Middle Ordovician Beekmantown Group
								10,906.5 - 10,918.5 n = 2; 11,369.5, n = 1	below Knox unconformity	Lower and Middle Ordovician Beekmantown Group
								13,128 - 13,139.75 n = 3		Lower (?) and Middle Cambrian Rome Formation
13	Exxon Company USA No. 1 McCoy and others	WV	Jackson	Washington District Kentuck	38° 43'50"N 81° 34'10"W	1366	17,675	13,985.5, n = 1; 14,136, n = 1; 14,364 - 14,386.5 n = 3	Maryville Limestone, Unnamed dolo. member	Middle and Upper Cambrian Conasauga Group
								14,400.5, n = 1	Maryville Limestone, Unnamed ls. mbr.	Middle and Upper Cambrian Conasauga Group
								15,532 - 15,560.5 n = 2	Rutledge Limestone	Middle and Upper Cambrian Conasauga Group
								16,461 - 16,493 n = 2		Lower (?) and Middle Cambrian Rome Formation
14	Columbia Gas Transmission No. 9674T Mineral Tract 10	WV	Mingo	Harvey District Trace	37° 54'16"N 82° 10'10"W	805	19,591	16,233.5 - 16,239.5 n = 3		Lower (?) and Middle Cambrian Rome Formation

Table 2 (continued). Name, identification number, and location of wells and outcrops where rock samples were collected for Rock-Eval analysis. Depth (where applicable) and stratigraphic interval of the rock samples are also shown.

ID No.	Well (or) outcrop name	State	County	Township (or) District and 7½' quad	Latitude and Longitude	State Permit No.	Total Depth (ft)	Sampled interval (ft) n = number of samples	Age and stratigraphic name of sampled interval
15	Thorn Hill outcrop Section	TN	Grainger	— Avondale and Howard Quarter	36°22'32"N 83°26'23"W to 36°22'18"N 83°26'21"W	—	—	Approx. 90-140 ft below top of Conasauga Group n=2	Maynardville Limestone; Middle and Upper Cambrian Conasauga Group
								Approx. 930-1320 ft below top of Conasauga Group n=3	Maryville Limestone; Middle and Upper Cambrian Conasauga Group
								Approx. 1340 ft below top of Conasauga Group n=1	Rogersville Shale; Middle and Upper Cambrian Conasauga Group
16	Marathon Oil Company Core hole No. 12 Kyle Farm	TN	Trousdale	— Dixon Springs	36°22'10"N 86°07'17"W	—	1,820	991.25-1,015 n=3	Middle Ordovician Wells Creek Dolomite
17	Marathon Oil Company core hole No. SGN-33 Kyle Farm	TN	Trousdale	— Bellwood	36°21'55"N 86°07'42"W	—	1,850	864 - 885 n=4	Middle Ordovician Wells Creek Dolomite

Appendix A. Glossary of geochemical terms and abbreviations used in the test and figures

(Tissot and Welte, 1984; Woodward and others, 1984)

S_1 - Integral of the first hydrocarbon peak produced by heating a rock sample in an inert atmosphere at about 250°C for a specified time (commonly 5 min.). The hydrocarbons evolved during this step are pre-existing free or adsorbed volatile hydrocarbons contained in the rock.

S_2 - Integral of the second hydrocarbon peak produced by heating a rock sample in an inert atmosphere from about 250°C to 550°C at a rapid rate (usually 25°C/min.). The hydrocarbons evolved during this step are produced mainly from the breakdown of the kerogen in the rock. S_2 provides a measure of the remaining hydrocarbon-generating capacity of organic matter.

S_3 - Integral of the third peak, from the carbon dioxide yield produced during pyrolysis of organic matter. Very high yields (>200 mg $CO_{2/g}$ organic carbon) probably indicate carbonate rock decomposition rather than CO_2 from organic matter.

Tmax - Temperature at which the S_2 peak occurs. Tmax is related in part to the level of thermal maturity of the organic matter. The transition from immature to mature with respect to oil generation occurs at a Tmax between about 430 and 440°C. The transition from the oil generation zone to the gas generation zone occurs at about 460°C.

TOC - Total organic carbon in a rock sample expressed in weight percent.

HI (Hydrogen Index) - S_2 yield from pyrolysis normalized by organic carbon content (mg hydrocarbon/g organic carbon). The Hydrogen Index in conjunction with the OI provides an indication of the type, or hydrocarbon-generating capacity, of organic matter in a rock.

OI (Oxygen Index) - S_3 yield (CO_2) from pyrolysis of organic matter normalized by organic carbon content (mg $CO_{2/g}$ organic carbon). The Oxygen Index in conjunction with the Hydrogen Index, provides an indication of the type of organic matter in a rock. Very high yields of CO_2 from carbonate rock decomposition can obscure CO_2 from organic matter.

PI (Production Index); also known as Transformation Ratio - Ratio of volatile hydrocarbon yield to total hydrocarbon yield in a rock sample ($S_1/S_1 + S_2$). According to Espitalié and others (1977), the oil generation zone occurs between PI values of 0.1 and 0.4.

n-alkane - The term for the straight-chained compounds in the methane series ($C_n H_{2n} + 2$). Also known as normal paraffin.

Rock-Eval - Method of source rock characterization and evaluation that uses a special pyrolysis device developed by Espitalié and others (1977).

PC - Pyrolytic carbon

APPENDIX B. Explanation of lithologic symbols used in figures 42-70

Dominant Lithology | Lithologic Modifiers (used in conjunction with Dominant Lithology pattern) | Other