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Stratigraphic framework of the Devonian black shales of the Appalachian basin

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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INTRODUCTION

General background

The energy shortage of the 1970's prompted the United States government to initiate research programs to study the unconventional-source hydrocarbons. In 1976, under the auspices of the Energy Research and Development Administration, now the U.S. Department of Energy, the Eastern Gas Shales Project was organized to stimulate development of the gas-bearing Devonian black shales of the Appalachian basin through extensive geologic and geochemical studies. The project was administrated by the U.S. Department of Energy's Morgantown Energy Technology Center, Morgantown, West Virginia.

The U.S. Geological Survey in cooperation with the Eastern Gas Shale Project under an interagency agreement with the U.S. Department of Energy was responsible for the regional basinwide geology, the geochemistry, and an assessment of the in-place gas resource of the Devonian black shales.

Purpose of report

The purpose of this report is to present to the Morgantown Energy Technology Center the results of the regional stratigraphic study of the Middle and Upper Devonian black shales and related rocks of the Appalachian basin (plate 1). The report consists of a basin-wide network of gamma-ray log cross sections, distribution and isopach maps, structure maps, and other related diagrams. A brief text includes acknowledgments, an annotated chronologic list of pertinent literature, and an explanation of the methods of study.

Acknowledgments

Support for the Geological Survey's Devonian black shale program was provided through the Eastern Gas Shales Project of the Morgantown Energy Technology Center, Department of Energy by Interagency agreement DE-A121-79MC10866. The cooperation of those individuals in the Department of Energy who administered the Eastern Gas Shales Project from the Morgantown Energy Technology Center is appreciated. Gratitude is expressed for the administrative and technical assistance of William C. Overby, Jr., Arlen E. Hunt, Charles A. Komar, Charles W. Byers, Jeffery B. Smith and Roberta D. Manilla.

Several state agencies and universities participated in the Eastern Gas Shales Project under contractual agreement with the Morgantown Energy Technology Center. Individuals from these organizations assembled and interpreted basic data for their specific areas of responsibility. These data, with additional data generated by or collected by the U.S. Geological Survey, form the data base for the Geological Survey's basin-wide stratigraphic interpretations presented in this report. The cooperation of the following geologists in supplying basic stratigraphic data is gratefully acknowledged: Edward N. Wilson and Jaffrey S. Zafar, formerly of the Kentucky Geological Survey; Frank R. Ettensohn of the University of Kentucky; Lawrence V. Rickard of the New York Geological Survey; Arthur M. Van Tyne, formerly of the New York Geological Survey; Adriaan A. Janssens and Frank L. Majchszak formerly of the Ohio Geological Survey, John A. Harper of the Pennsylvania Geologic Survey; Stephen A. Krajewski and Robert G. Piotrowski, formerly of the Pennsylvania Geologic Survey; Robert C. Milici, formerly of the Tennessee Geological Survey and Douglas G. Patchen and Joseph F. Schwietering of the West Virginia Geological Survey.

Members of the Department of Geology of the University of Cincinnati were involved in various Devonian black shale studies under the auspices of the Eastern Gas Shale Project of the Morgantown Energy Technology Center. Discussions with Paul E. Potter and J. Barry Maynard concerning black shale problems and approaches to regional basin studies were very helpful.

The Universities of Cincinnati, Kentucky, and West Virginia were provided financial support through the Eastern Gas Shales Project for graduate study programs that concentrated on various black shale problems. Graduate students at these universities that provided data and assistance in the study of the Devonian black shales were Ronald F. Broadhead, Linda P. Fulton, Victor V. Van Beuren, Thomas V. Stenbeck, Donald R. Swager, Lance S. Barron, Scott B. Dillman, Mary E. Dowse, Donald W. Neal, and S. M. Duffield.

U.S. Geological Survey personnel who contributed to the stratigraphic study are mentioned below. Mareta N. West, during 1976 to 1978, prepared a preliminary stratigraphic section along the eastern margin of the basin and evaluated well cuttings and logs from New York. Laure G. Wallace assisted in many phases of the study from 1976 to 1980 and is gratefully acknowledged for preparation of stratigraphic sections and compilation of structure and isopach maps. Roy C. Kepferle studied the Devonian black shales exposed in the southern part of the basin from the inception of the project in 1976 until the end of 1981. His detailed stratigraphic studies and consultation on black shale problems of the southern Appalachian contributed considerably to the project. Gail E. Anderson, throughout 1980, is acknowledged for her assistance in the preparation of the final basin-wide stratigraphic network in addition to various studies and tasks related to the Devonian shale stratigraphy. At different times throughout the duration of the project Kimm M. Harty, Susan M. Moore, Barbara J. Patterson, Catherine B. Sherertz, and Linda G. Wood ably assisted the preparation of the various reports resulting from this study.

RECENT LITERATURE

The volume of literature concerning the black shales and related rocks of Devonian age in the Appalachian basin is at the very least overwhelming; even the contributions of more recent years are significant in number. For that reason, a selected annotated bibliography of the literature from 1931 that is most relevant to this report is presented below. Those listings without annotation have a sufficiently explanatory title. Much of the work within the last several years has been published by the Morgantown Energy Technology Center/Eastern Gas Shales Project; however, distribution of those publications is limited. They may be available from the U.S. Department of Energy's Morgantown Energy Technology Center, Morgantown, West Virginia 26505 or from the National Technical Information System, U.S. Department of Commerce, Springfield, Virginia 22161. The bibliography is chronologic except where publications of similar subject matter are grouped for convenient annotation.

Hard, E. W., 1931, Black shale deposition in central New York: American Association of Petroleum Geologists Bulletin, v. 15, no. 2, p. 165-181.

A characterization study of the Devonian black shales of central New York. The study was initiated on the assumption that the conventional hydrocarbon resources would soon be exhausted and the organic-carbon rich shales could be distilled for oil. Study includes stratigraphy, petrography, laboratory distillation, and an interpretation of the depositional environment and paleogeography. Hard proposed a relatively quiet, shallow water, toxic environment of deposition with sediment source to the east. A hinge line was interpreted from a significant change in water depth in the basin.

Bradley, W. H. and Pepper, J. F., 1938, Structure and gas possibilities of the Oriskany Sandstone in Steuben, Yates and parts of adjacent counties, Part 1 of geologic structure and occurrence of gas in part of southwestern New York. U.S. Geological Survey Bulletin 899-A.

Surface structure of Steuben, Yates, and adjacent counties in the Finger Lakes region were mapped as an aid to locating and delineating possible reservoirs for natural gas in the Oriskany Sandstone of Early Devonian age. Key surface units of Late Devonian age were mapped to define the subsurface structure. Chadwick traced the key units in from the west. Nomenclature used was that of the New York State Museum.

Cooper, G.A., and others, 1942, Correlation of Devonian sedimentary formations of North America: Geological Society of America Bulletin, v. 53, chart 4, p. 1729-1793.

The first comprehensive correlation chart prepared for the stratigraphic units of the Devonian System of North America.

Grossman, W. L., 1944, Stratigraphy of the Genesee Group of New York: Geological Society of America Bulletin, v. 55, p. 41-76.

A lithostratigraphic study of the Genesee Formation including a history of nomenclature. Grossman named the Penn Yan and Milo tongues of the West River Shale.

Pepper, J. F. and de Witt, Wallace, Jr., 1950, Stratigraphy of the Upper Devonian Wiscoy Sandstone and equivalent Hanover Shale in western and central New York: U.S. Geological Survey Oil and Gas Investigation Series Chart OC-37.

A detailed study of various critical sections to evaluate and revise correlations proposed by previous workers. Twenty sections were measured from Dunkirk on Lake Erie to Addison in Steuben County, New York. Includes isopach maps of the combined Wiscoy sandstone, gray Hanover Shale, and black Pipe Creek Shale; and massive black shale in the lower part of the Dunkirk Shale.

Pepper, J. F. and de Witt, Wallace, Jr., 1951, Stratigraphy of the Late Devonian Perrysburg Formation in western and west-central New York: U.S. Geological Survey Oil and Gas Inv. Chart OC-45.

Defined the Perrysburg Formation and used 18 detailed stratigraphic sections to delineate the extent of the Dunkirk Shale Member and related rocks in the formation from Lake Erie east to Steuben County.

Hass, W. H., 1956, Age and correlation of the Chattanooga shale and the Maury formation: U.S. Geological Survey Professional Paper 286, 47 p.

A comprehensive study of the conodont faunas of the Chattanooga Shale and related rocks in central Tennessee and adjacent states. Age of members were determined, and correlations proposed to other stratigraphic units of Devonian age including the Ohio Shale in Ohio and units in the classic sequence of western New York. Considers the Chattanooga to be mainly of Late Devonian age with the possibility that the oldest beds may be late Middle Devonian in age.

Pepper, J. F., de Witt, Wallace, Jr., and Colton, G. W., 1956, Stratigraphy of the Late Devonian West Falls Formation in western and west-central New York: U.S. Geological Survey Oil and Gas Investigation Series Chart OC-55.

Proposed term West Falls Formation for sequence of deltaic rocks in western and central New York. An east-west schematic facies diagram illustrates relationship of the members including the extensive black Rhinestreet Shale Member. Results based on correlation of a series of measured stratigraphic sections from Lake Erie to Steuben County, New York.

Colton, G. W., and de Witt, Wallace, Jr., 1958, Stratigraphy of the Sonyea Formation of Late Devonian age in western and west-central New York: U.S. Geological Survey Oil and Gas Investigations Series Chart OC-54.

Revived the name Sonyea after it was abandoned by Chadwick (1933) who thought it correlated with the Ithaca Formation. Proposed standard reference section to be the outcrops along Buck Creek, northwest of Sonyea, Mount Morris Township, Livingston County, New York. Showed the extent and thickness of the black Middlesex Shale Member. Diagrammatic stratigraphic sections illustrate previous nomenclature and facies interpretions and that proposed by the authors. Results based on 31 measured stratigraphic sections from Lake Erie to Seneca Lake.

de Witt, Wallace, Jr. and Colton, G. W., 1959, Revised correlations of Lower Upper Devonian Rocks in Western and Central New York: American Association of Petroleum Geologists Bull. v. 43, no. 12, p. 2810-2828.

Revised and redefined units in the Genosee Formation, the Genesee Group of Clarke, and established reference section for the Genesee Shale. Showed correlation of units in classic sections on the Genesee River and in the area of the Finger Lakes.

Sutton, R. G., 1959, Use of flute casts in stratigraphic corelation: American Association of Petroleum Geologists, v. 43, p. 230-237.

Proposed correlations to resolve the stratigraphic problems in the correlation of various units in the Genesee, Sonyea, and West Falls Formations between Seneca and Cayuga Lakes, New York. Correlations based on continuity of the black shale units, orientation of flute casts and gross lithologic properties. Revised the correlations of Caster (1933) Chadwick (1935), Grossman (1944) and Williams (1951).

de Witt, Wallace, Jr., 1960, Java Formation of Late Devonian age in western and central New York: American Association of Petroleum Geologists Bulletin, v. 44, no. 12, p. 1933-1936.

Proposed the name Java Formation for the cycle of deposition containing the previously named Wiscoy Sandstone, Hanover Shale, and Pipe Creek Shale. Wiscoy, Hanover, and Pipe Creek reduced to member status within the Java. Type section for Java Formation is designated for exposures along Beaver Meadow Creek above Angel Falls, Java Township, Wyoming County, New York.

Hoover, K. V., 1960, Devonian-Mississippian shale sequence in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Information Circular No. 27, 154 p.

An extensive review of the literature on the black shales of Devonian and Mississippian age prepared to achieve a better understanding of the sequence and to define areas where further study is needed. Of the 10 topics suggested (Hoover, 1960, p. 4) for further study, more than half have been addressed to varying degrees by the U.S. Geological Survey and other organizations in the Department of Energy's Eastern Gas Shales Project. Contains an annotated bibliography and a chart listing the fauna and flora and their associated stratigraphic units in the Devonian-Mississippian shale sequence of Ohio.

Conant, L. C., and Swanson, V. E., 1961, Chattanooga Shale and related rocks of central Tennessee and nearby areas: U.S. Geological Survey Professional Paper 357, 91 p.

A study prepared at the request of the Atomic Energy Commission to report on the geology and uranium potential of the Chattanooga Shale. Work was carried out in conjunction with that of Hass (1956). A detailed stratigraphic study and evaluation which to date the most comprehensive available for the area of study even though completed more than twenty years ago.

Sutton, R. G., 1963, Correlation of Upper Devonian strata in south-central New York *in* Shepps, V. C., ed., Symposium on Middle and Upper Devonian Stratigraphy of Pennsylvania and adjacent states: Pennsylvania Geological Survey General Geology Report G39, p. 87-101.

A summary of the stratigraphy of the Upper Devonian rocks from the Watkins-Corning area to the Walton area in south-central New York. Demonstrates the relationship between the black shales and associated rocks in the west with rocks of the Catskill lithofacies to the east. Applies mineralogy, petrology,

and size analysis techniques to interpret paleoenvironmental conditions. Summarizes and re-evaluates the work of de Witt and Colton (1959), Sutton (1959), and Sutton and others (1962).

Rickard, L. V., 1964, Correlation of the Devonian rocks in New York State: New York State Museum and Science Service Map and Chart Series no. 4.

An earlier version of the author's 1975 Devonian correlation chart. See 1975 entry for L. V. Rickard.

Roen, J. B., Miller, R. L., and Huddle, J. W., 1964, The Chattanooga Shale (Devonian and Mississippian) in the vicinity of Big Stone Gap, Virginia: U.S. Geological Survey Professional Paper 501-B, p. B43-B48.

A revision of the stratigraphic units and nomenclature of the black shale sequence in southwest Virginia based on lithologic criteria and mappability. The revision essentially re-established the initial divisions of M. R. Campbell (1894). Paleontologic data from Huddle's conodont study delineates the lithologic zone representing the transition period from Devonian to Mississippian time.

Oliver, W. A., Jr., de Witt, Wallace, Jr., Dennison, J. M., Hoskins, D. H., and Huddle, J. W., 1967, Devonian of the Appalachian basin, United States, in Oswald, D. H., ed., International symposium on the Devonian System: Alberta Society of Petroleum Geologists, v. 1, p. 1001-1040.

Oliver, W. A., Jr., de Witt, Wallace, Jr., Dennison, J. M., Hoskins, D. M., and Huddle, J. W., 1971, Isopach and lithfacies maps of the Devonian in the Appalachian basin: Pennsylvania Geological Survey, Series 4, Progress Report 182.

Comprehensive reports that include isopach and lithofacies maps for the stages or combination of stages for Devonian system of the Appalachian basin. Cross sections show lithofacies relations across the basin and a correlation chart shows the temporal relationship of the stratigraph units.

Schwietering, J. F., 1970, Devonian shales of Ohio and their eastern equivalents: The Ohio State University, unpublished Ph.D. dissertation, 79 p.

Schwietering, J. F., 1979, Devonian shales of Ohio and their eastern and southern equivalents: U.S. Department of Energy, Morgantown Energy Technology Center Contractor's Report METC/CR-79/2, 68 p.

First regional subsurface study of the stratigraphy of the Devonian black shale sequence using gamma-ray and sample logs correlated the Upper Devonian black shale units exposed in central Ohio with the subsurface equivalents in Ohio, eastern Kentucky, West Virginia, Pennsylvania, and New York. Schwietering's dissertation and subsequent DOE publication confirmed Hass' (1947, 1956) correlations. Schwietering's study with that of Rickard (1964, 1975, written commun., 1977-1979) formed a foundation for the present study.

Schopf, J. M., and Schwietering, J. F., 1970, The Foerstia zone of the Ohio and Chattanooga shales: U.S. Geological Survey Bulletin 1294-11, 15 p.

Explains the restricted stratigraphic nature of the fossil algae Foerstia. Lists localities and stratigraphic position of the fossil. Foerstia has proven to be extremely important in regional correlation.

Heckel, P. H., 1973, Nature, origin, and significance of the Tully Limestone: Geological Society of America Special Paper 138, 244 p.

A regional detailed lithologic, paleontologic, and stratigraphic study leading to an interpretation of the paleogeography and depositional history of the Tully Limestone, a unique stratigraphic marker in the Catskill delta complex. Cites previous work on the paleontology and stratigraphy and, in particular, believes Grabau (1917) and Cooper and Williams (1935) added significantly to the understanding of the depositional history and facies relationships of the Tully.

Murphy, J. L., 1973, Protosalvinia (Foerstia) Zone in the Upper Devonian sequence of eastern Ohio, northwestern Pennsylvania and western New York: Geological Society of America Bulletin, v. 84, p. 3405-3410.

Documents localities where Foerstia has been collected in northwestern Pennsylvania and adjacent Chautauqua County, New York. Demonstrates the stratigraphic position of Foerstia in the post Perrysbury rocks of extreme western Chautauqua County.

Dennison, J. M., and Boucot, A. J., 1974, Little War Gap at Clinch Mountain provides standard reference section for Silurian Clinch Sandstone and most nearly complete Devonian section in eastern Tennessee: Southeastern Geology, v. 16, p. 79-101.

The section contains ash beds, associated black shales, and a conodont fauna critical to understanding the Middle and Late Devonian black-shale stratigraphy in eastern Tennessee and southwest Virginia.

Janssens, A. and de Witt, Wallace, Jr., 1976, Potential natural gas resources in the Devonian shales in Ohio: Ohio Geological Survey Geological Survey Geological Note no. 3, 12 p.

de Witt, Wallace, Jr., Perry, W. J., Jr., and Wallace, L. G., 1975, Oil and gas data from Devonian and Silurian rocks in the Appalachian basin: U.S. Geological Survey Miscellaneous Investigations Series Map I-917B, 4 sheets.

Maps showing the thickness and extent of the Devonian rocks, the net thickness and extent of the black shale facies determined from drill cuttings, areas of hydrocarbon production, and a generalized cross section showing the facies relationship. Data used to compile black shale isopach from sample studies by C. R. Fettke, L. B. Freeman, R. E. Lamborn, J. H. Martens, E. R. McAuslan, J. F. Pepper, Gordon Rittenhouse, G. G. Shearrow, I. H. Tesmer, W. R. Wagner, J. W. Wiggins, and Geolog Sample Company.

Rickard, L. V., 1975, Correlation of Silurian and Devonian rocks in New York State: New York State Museum and Science Service, Map and Chart Series no. 24, 16 p. and 4 plates.

A comprehensive report on the stratigraphic correlations of the Silurian and Devonian rocks of New York State presented in a unique series of charts, cross sections and an explanatory text. The correlation charts depict the areal extent of the rock units, thickness, type localities, distinctive fossils, and lateral facies relationship. The text presents the basis for the author's interpretations and a pertinent bibliography.

Patchen, D. G., and Larese, R. E., 1976, Stratigraphy and petrology of the Devonian "brown" shale in West Virginia in Devonian shale production and potential, Proceedings, Seventh Annual Appalachian Petroleum Geology Symposium: U.S. Energy Research and Development Adminstration, Morgantown Energy Research Center Special publication MERC/SP-76/2, p. 4-14.

Relates gas producing zones to primarily dark gray [N3] to brown [5 YR 2/1] shale. For color designations see Goddard and others (1948).

Dennison, J. M., and Textoris, D. A., 1977, Tioga bentonite time - marker associated with Devonian shales in Appalachian basin, in Shott, G. L., and others, eds., Preprints, First Eastern Gas Shales Symposium: Energy Research and Development Administration, Morgantown Energy Research Center, Morgantown, West Virginia, p. 113-129.

Describes the areal extent, stratigraphy, and petrology of the Tioga ash bed, an important lithostratigraphic marker near the base of the Devonian black shale sequence in the Appalachian basin. The ash bed marks the top of the Onesquethaw stage.

Larese, R. E. and Heald, N. T., 1977, Petrography of selected Devonian shale core samples from the CGTC 20403 and CGTC 11940 wells, Lincoln and Jackson counties, West Virginia: U.S. Energy Research and Development Administration, Morgantown Energy Research Center Contractor Report MERC/CR-77/6 27 p.

Well sample cuttings and temperature logs indicate gas shows are significant from dark gray shales with N3 color value. In West Virginia the "brown" [5 YR 2/1] shale composes the principal pay zone in 26 shale-gas fields.

Patchen, D. G., 1977, Subsurface stratigraphy and gas production of the Devonian shales in West Virginia: Energy Research and Development Administration, Morgantown Energy Research Center Contractor Report MERC/CR-77-5, 35 p.

An initial report outlining the preliminary lithologic subdivisions and facies relationship of the Devonian "Brown shales" and their equivalents in West Virginia. These brown or dark gray to black shales which yield gas are strongly radioactive, producing a significant response on the gamma-ray log. Maximum production occurs where shales are highly fractured; therefore, possible areas of exploration lie above the bounding faults of the Rome trough.

Wallace, L. G., Roen, J. B., and de Witt, Wallace, Jr., 1977, Preliminary stratigraphic cross section showing radioactive zones in the Devonian black shales in the western part of the Appalachian basin: U.S. Geological Survey Oil and Gas Investigations Chart OC-80.

Roen, J. B., Wallace, L. G., and de Witt, Wallace, Jr., 1978, Preliminary stratigraphic cross section showing radioactive zones in the Devonian black shales in eastern Ohio and west-central Pennsylvania: U.S. Geological Survey Oil and Gas Investigations Chart OC-82.

Wallace, L. G., Roen, J. B. and de Witt, Wallace, Jr., 1978, Preliminary stratigraphic cross section showing radioactive zones in the Devonian black shales in southeastern Ohio and west-central West Virginia: U.S. Geological Survey Oil and Gas Investigations Chart OC-83.

Kepferle, R. C., Wilson, E. N., and Ettensohn, F. R., 1978, Preliminary stratigraphic cross section showing radioactive zones in the Devonian black shales in the southern part of the Appalachian basin: U.S. Geological Survey Oil and Gas Investigations Chart OC-85.

West, Mareta, 1978, Preliminary stratigraphic cross section showing radioactive zones in the Devonian black shales in the eastern part of the Appalachian basin: U.S. Geological Survey Oil and Gas Investigations Chart OC-86.

Roen, J. B., Wallace, L. G., and de Witt, Wallace, Jr., 1978, Preliminary stratigraphic cross section showing radioactive zones in the Devonian black shales in the central part of the Appalachian basin: U.S. Geological Survey Oil and Gas Investigations Chart OC-87.

A series of six stratigraphic cross sections across the Appalachian basin prepared from gamma-ray logs and selected lithologic logs at the scale of 1 inch equals 100 feet. The regional network was prepared in cooperation with State geological surveys and was the preliminary basis for further stratigraphic studies of the Devonian shale sequence in the basin.

de Witt, Wallace, Jr., and Colton, G. W., 1978, Physical stratigraphy of the Genessee Formation (Devonian) in western and central New York: U.S. Geological Survey Professional Paper 1032-A, 22 p.

Lithologic descriptions, paleontology, isopach maps, and cross sections are presented to describe and delineate the members of the Genesee Formation including the Geneseo and Renwick Shales Members. Presents an interpretation of the depositional environments. Study area extends along the outcrop belt across the Finger Lakes District to Lake Erie.

Harris, L. D., de Witt, Wallace, Jr., and Colton, G. W., 1978, What are possible stratigraphic controls for gas fields in eastern black shale: Oil and Gas Journal, April 3, 1978, p. 162-165.

Two depositional trends of thick black shale lobes are defined. Gas production from the western belt suggests that areas in either belt where the black shale thickness is in excess of 500 feet thick should be tested. Structural traps in older beds in faulted anticlines associated with decollement have accumulated gas whose source was the black shales of the eastern belt.

Schwietering, J. F., and Neal, D. W., 1978, Occurrence of Foerstia (Protosalvinia) in Lincoln County, West Virginia: Geology, v. 6 no. 8, p. 493-494.

Schwietering, J. F., Neal, D. W., and Dowse, M. E., 1978, Tully(?) limestone and Hamilton Group in north-central and east-central West Virginia, in Preprints, Second Eastern Gas Shales Symposium: U.S. Department of Energy, Morgantown Energy Technology Center Special Publication METC/SP-76/6, v. 1, p. 240-250.

Authors suggest that the bed identified as the Tully Limestone of northern West Virginia may be stratigraphically lower and older than the Tully of New York and therefore until positive correlation can be made in West Virginia, the bed should be designated Tully(?) Limestone.

Provo, L. J., Kepferle, R. C., and Potter, P. E., 1978, Division of the black shale - Ohio Shale in eastern Kentucky: American Association of Petroleum Geologists Bulletin, v. 62, no. 9, p. 1703-1713.

Introduction of the term Three Lick Bed for the thin distal portion of the Chagrin shale of Ohio and the middle unit of the Gassaway Member of the Chattanooga Shale of Kentucky and Tennessee.

Baird, Gordon, C., 1979, Sedimentary relationships of Portland Point and associated Middle Devonian Rocks in central and western New York: New York State Museum Bulletin no. 433, 24 p.

Redefines the Portland Point Limestone Member to include the limestone of the Tichenor and Menteth Limestone Members where they merge. Also places the Tichenor at the base of the Moscow Formation.

Collins, H. R., 1979, Devonian bentonites in eastern Ohio: American Association of Petroleum Geologists Bulletin, v. 63, no. 4, p. 655-660.

Proposed the name Belpre bentonite for an ash bed in the lower part of the Devonian black-shale sequence in subsurface eastern Ohio. Discusses distribution and suggests a possible correlation.

Ettensohn, F. R., Fulton, L. P., and Kepferle, R. c., 1979, Use of scintillometer and gamma-ray logs for correlation and stratigraphy in homogeneous black shales: Geological Society of America Bulletin, v. 90, Part II, p. 828-849.

A very useful method for establishing stratigraphic correlations from the surface to subsurface in addition to correlation of widely spaced sections along the outcrop. The method compares "synthetic" gamma-ray logs prepared from measured radioactivity at selected intervals along an outcrop section by a hand-held

Harper, J. A., and Piotrowski, R. G., 1979, Stratigraphic correlation of surface and subsurface Middle and Upper Devonian, southwestern Pennsylvania in 44th Annual Field Conference of Pennsylvania Geologist, Devonian shales of south-central Pennsylvania and Maryland, Dennison, J. M., and Hasson, K. O. Field Trip Coordinators.

Author's studies indicate that the drillers' "Tully" in Erie, Crawford, and Venango Counties, Pa. is probably the Tully Limestone and not an older limestone of Hamilton age.

Nance, S. W. and Zielinski, R. E., 1979, A current assessment of physio-chemical characterization data for the eastern gas shales: unpublished report by Mound Facility, Monsanto Research Corporation, Miamisburg, Ohio.

Relates color to organic carbon content of 407 samples. Of those considered N3 (Munsell Color Chart) 65 percent contained 2 weight percent or greater organic carbon; of those considered N4 only 8 percent contained more than 2 weight percent organic carbon.

Piotrowski, R. G., and Harper, J. A., 1979, Black shale and sandstone facies of the Devonian "Catskill" clastic wedge in the subsurface of western Pennsylvania: U.S. Department of Energy, Morgantown Energy Technology Center Eastern Gas Shales Project Series no. 13, 40 p., 39 plates.

The introduction presents an account of the past and current activity of gas production from the black shale in the state of Pennsylvania. The stratigraphy, which is described in general aspects of the black shale facies and sandstone facies, is based on the detailed interpretation by Piotrowski and Krajewski of a series of nine stratigraphic cross sections composed of about 500 gamma-ray logs. The report is primarily concerned with the areal distribution and structure. Thirty-nine maps present the structure, thickness, and distribution of the mapped black shale and related units. Relevant aspects of the maps are included in a discussion and summary.

Piotrowski, R. G., and Krajewski, S. A., 1979, Preliminary stratigraphic cross section showing radioactive black shale zones and sandstones in the Middle and Upper Devonian, western Pennsylvania - 1977: U.S. Department of the Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project EGSP Ser. 1-9 (no. 1, section C1-C3; no. 2, section A3-D3; no. 3, section AZ-D2; no. 4, section, A1-D1; no. 5, section C4-D4; no. 6, section D3-D-4, no. 7, section B1-B4; no. 8, Section D1-D3; no. 9, section A1-A9) each section consisting of 2 sheets.

A network of nine cross sections showing the stratigraphic correlations of the black shales and related rocks in the central and western part of Pennsylvania. Gamma-ray logs and some GeoLog sample studies were used as the basic data for the study. Datum for the sections is the Marcellus Shale. Includes short explanatory text. Prepared under contract to the U.S. Department of Energy, Morgantown Energy Technology Center for the Eastern Gas Shales Project.

Patchen, D. G., and Duglinski, B. K., 1979, Guidebook, Middle and Upper Devonian clastics, central and western New York State: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project, Morgantown, West Virginia, 170 p.

A guide through the classic area of Devonian black shale stratigraphy in central and western New York. Nearly 200 localities were reviewed and 125 were visited in the preparation of the guidebook. Fifty-seven were selected that most clearly represented the stratigraphy.

Dillman, S. B., and Ettensohn, F. R., 1980, Structure contour map on the base of the Ohio Shale in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 507.

Dillman, S. B., and Ettensohn, F. R., 1980, Structure contour map on the base of the West Falls Formation (Rhinestreet Shale, unit 7) in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP ser. no. 508.

Dillman, S. B., and Ettensohn, F. R., 1980, Structure contour map on the base of the Java Formation/Olentangy shale (unit 6) in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP ser. no. 509.

Dillman, S. B., and Ettensohn, F. R., 1980, Structure contour map on the base of the lower Huron Shale Member (unit 5) of the Ohio Shale in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP ser. no. 510.

Dillman, S. B., and Ettensohn, F. R., 1980, Structure contour map on the base of the middle Huron Shale Member (unit 4) of the Ohio Shale in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP ser. no. 511.

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Dillman, S. B., and Ettensohn, F. R., 1980, Structure contour map on the base of the Cleveland Shale Member (unit 1) of the Ohio Shale in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP ser. no. 514.

Dillman, S. B., and Ettensohn, F. R., 1980, Isopach map of the Devonian black-shale sequence (New Albany - Chattanooga - Ohio Shale) in eastern Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP ser. no. 515.

Kamakaris, D. G., and Van Tyne, A. M., 1980, Isopach of black shale in the Perrysburg Fm. (equivalent section) (from well sample studies) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 105.

Kamakaris, D. G., and Van Tyne, A. M., 1980, Isopach of black shale in the Java Formation (from well sample studies) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 106.

Kamakaris, D. G., and Van Tyne, A. M., 1980, Isopach of black shale in the West Falls Formation (from well sample studies) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shale Project METC/EGSP Ser. 107.

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Kamakaris, D. G., and Van Tyne, A. M., 1980, Isopach of black shale in the Hamilton Group (from well sample studies) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 110.

Van Tyne, A. M., and Kamakaris, D. G., and Corbo, S., 1980, Isopach of radioactive shale in the Perrysburg Fm. (& equivalent section) (>20 API units above shale base line) [New York]: U.S. Department of Energy, Morgantown Energy Technology, Eastern Gas Shales Project METC/EGSP Ser. 125.

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Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Isopach of radioactive shale in the Sonyea Group (>20 API units above shale base line) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 131.

Corbo, Kamakaris, and Van Tyne used two methods, allowing a comparison, to obtain the thickness values of the black shale from the drill hole data: one using the gamma-ray log, the other using well cuttings. Kamakaris and Van Tyne in METC/EGSP Ser. 105, place the stratigraphic position of the Hume Shale Member in the upper part of the Perrysburg Formation well above the basal Dunkirk Shale Member.

Majchszak, F. L., and Honeycutt, Mitchell, 1980, Net thickness of the radioactive shale facies in the Cleveland Member of the Ohio Shale [Ohio]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 300.

Majchszak, F. L., and Honeycutt, Mitchell, 1980, Net thickness of the radioactive shale facies in the Huron and Chagrin Members of the Ohio Shale, [Ohio]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 301, 2 sheets.

Honeycutt, Mitchell, and Majchszak, F. L., 1980, Net thickness of the radioactive shale facies in the "upper" Olentangy shale [Ohio]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 302, 2 sheets.

Majchszak, F. L., and Honeycutt, Mitchell, 1980, Net thickness of radioactive shale facies in the "lower" Olentangy Shale (Hamilton Group) [Ohio]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 303, 2 sheets.

Maps prepared by Majchszak and Honeycutt show the distribution and thickness of the black shale in the Cleveland, Chagrin (as used by Majchszak in Ohio) and Huron Members of the Ohio Shale and the "upper" and "lower" Olentangy Shale in Ohio. Contains a chart suggesting tentative correlations of black shale units between Ohio and New York and presents a sample gamma-ray log with the stratigraphic units designated. Generalized east-west cross section illustrates facies relationship across Ohio.

Roen, J. B., 1980, A preliminary report on the stratigraphy of previously unreported Devonian ash-fall localities in the Appalachian basin: U.S. Geological Survey Open-File Report 80-505, 10 p.

Extends the areal distribution of the Belpre and Center Hill Ash Beds, which are important lithostratigraphic markers. Assigns the stratigraphic position of the ash beds relative to local and regional stratigraphy and nomenclature. Reassigns the stratigraphic position of two earlier described ash-bed localities.

Roen, J. B., 1980, Stratigraphy of the Devonian Chattanooga and Ohio Shales and equivalents in the Appalachian basin: an example of long-range subsurface correlation using gamma-ray logs: U.S. Department of Energy, Morgantown Energy Technology Center Report DOE/METC/10866-21, 26 p.

This report corroborates and extends the regional correlations of Hass (1956) based on conodonts and of Schweitering (1970, 1979) who used gamma-ray logs. The Upper Devonian black shales are correlated from New York to the central Appalachian basin and then southward and eastward to central and eastern Tennessee and southwest Virginia.

Roen, J. B., Milici, R. C., Kepferle, R. C., and Wallace, L. G., the Chattanooga Shale (Devonian and Mississippian) from the Tennessee Division of Geology - U.S. Department of Energy cored drill holes number 1 and 2, Claiborne County, Tennessee: U.S. Department of Energy, Morgantown Energy Technology Center, Contractor Report METC/CR-80/1, 11 p.

Roen, J. B., Milici, R. C., and Wallace, L. G., 1980, The Chattanooga Shale (Devonian and Mississippian) from the Tennessee Division of Geology - U.S. Department of Energy cored drill hole number 3, Hancock County, Tennessee: U.S. Department of Energy, Morgantown Energy Technology Center Report DOE/METC/10866-10, 35 p.

Roen, J. B., Wallace, L. G., and Milici, R. C., 1980, The Chattanooga Shale (Devonian and Mississippian) from the Tennessee Division of Geology - U.S. Department of Energy cored drill holes number 4 and 5, Hawkins County, Tennessee: U.S. Department of Energy, Morgantown Energy Technology Center Report DOE/METC/10866/18, 40 p.

Milici, R. C., and Roen, J. B., 1980, Stratigraphy of the Chattanooga Shale in the Newman Ridge and Clinch Mountain areas, Tennessee: Tennessee Division of Geology Open File report, 10 p.

Reports by Milici, Kepferle, Roen, and Wallace describe the lithology and the stratigraphy of the Chattanooga Shale from drill cores in eastern Tennessee. These cores provided the long-needed stratigraphic link between the Chattanooga Shale of the type area, Chattanooga, Tennessee, and the Chattanooga Shale of southwest Virginia.

Roen, J. B., Wallace, L. G., Kepferle, R. C., Potter, P.E., and Pryor, W. A., 1980, Maps showing location of stratigraphic cross sections and cored drill holes used in the study of the Devonian black shales in the Appalachian basin: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales METC?EGSP Ser. No. 1400, 2 sheets.

Two maps at the scale of 1:1,000,000 showing the location of all stratigraphic cross sections, published and unpublished, prepared by contributors

to the Eastern Gas Shales Project. Includes bibliographic reference to the cross sections. A third map, at the scale of 1:2,500,000, shows the location of all cored drill holes as of 1980, used in the study. A listing gives the operator, well name, location data, and API number.

Schwietering, J. F., 1980, Preliminary cross section[s] of Middle and Upper Devonian in West Virginia: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 207, 209, and 211 (no. 207, section D-D'; no. 209, section B-D'-B'; no. 211, section A'-B'-D"), no. 209 and 211 consist of 2 sheets.

A series of gamma-ray log cross sections across the state of West Virginia prepared for the Eastern Gas Shales Project of the Morgantown Energy Technology Center, U.S. Department of Energy.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Structure contours on the base of the Dunkirk [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 111.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Structure contours on base of the Java Formation [New York]: U.S. Department of Energy, METC/EGSP Ser. 112.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Structure contours on the base of the West Falls Formation [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 113.

Van Tyne, A. M., Kamakaris, D. G., Corbo, S., 1980, Structure contours on base of the Sonyea Group [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 114, 2 sheets.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Structure contours on base of the Genessee Group [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 115, 2 sheets.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Structure contours on base of Hamilton Group [New York]: U.S. Department of Energy, Morgantown Eenrgy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 116, 2 sheets.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Isopach map of Java Formation (U.S.G.S.) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 117.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Isopach map of West Falls Formation (U.S.G.S.) [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 118.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Isopach map of Sonyea Group [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 119, 2 sheets.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Isopach of Genessee Group [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP 120, 2 sheets.

Van Tyne, A. M., Kamakaris, D. G., and Corbo, S., 1980, Isopach map of Hamilton Group [New York]: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 121, 2 sheets.

Van Tyne, A. M., Corbo, S., and Kamakaris, D. G., 1980, Section no. three. Stratigraphic cross section, western New York showing correlation of Middle and Upper Devonian rocks: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 122.

Van Tyne, A. M., Corbo, S., and Kamakaris, D. G., 1980, Section no. five. Stratigraphic cross section, western New York showing correlation of Middle and Upper Devonian rocks: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 124.

Two approximately north-south trending gamma-ray log cross sections in Chautauqua and Erie Counties; and Chemung, Schuyler, Yates, and Ontario Counties, New York.

Harper, J. A., 1981, Stratigraphic cross section[s] of the Upper Devonian Perrysburg and Java Formations and their equivalents, northwestern Pennsylvania-1980: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. 14-23 (no. 14, section A; no. 15, section B; no. 16, section C; no. 17, section D; no. 18, section E; no. 19, section F; no. 20, section G; no. 21, section H; no. 22, section I; no. 23, section J), each section consists of 1 sheet.

A series of gamma-ray log cross sections with some sample control correlating the black shale units of southwestern New York with the equivalent units in northwestern Pennsylvania and Ohio. Explanatory text is included with each section. Prepared for the Eastern Gas Shales Project of the Morgantown Energy Technology Center, U.S. Department of Energy.

Hosterman, J. W., and Whitlow, S. I., 1981, Munsell color value as related to organic carbon in Devonian shale of Appalachian basin: American Association of Petroleum Geologists, v. 65, no. 2, p. 333-335.

Organic carbon in weight percent is plotted against the Munsell color chart values of 880 dark shale samples. Those samples with more than 2 percent organic carbon and more than 5 percent calcite are about one color value darker than those with less than 5 percent calcite. Regardless of how large the carbon content, the color value is never less than N 2.5. Most noticeable color change in shale takes place at about 2 percent by weight organic carbon. At 2 percent carbon the sample's color is about N 4.5; as carbon content increases, color darkens only slightly. Calcite content tends to darken the shale color by allowing more organic material to be free from adsorption by clay minerals.

Hosterman, J. W., and Whitlow, S. I., 1981, Clay mineralogy of Devonian shales in the Appalachian basin: U.S. Geological Survey Open-File report 81-585, 170 p.

Relates the variations of the clay mineralogy to stratigraphic units. Distribution of kaolinite suggests an eastern source area.

Kepferle, R. C., Potter, P. E., and Pryor, W. A., 1981, Stratigraphy of the Chattanooga Shale (Upper Devonian and Lower Mississippian) in vicinity of Big Stone Gap, Wise County, Virginia, with a section on Petrology by T. V. Stenbeck: U.S. Geological Survey Bulletin 1499, 20 p.

The report correlates units in the surface section at Big Stone Gap with units that are recognized in surface and subsurface in the western part of the Appalachian basin. Correlation was established by surface scintillometer profile, gamma-ray logs from oil and gas wells, and the fossil algae, *Foerstia*.

Kepferle, R. C., and Roen, J. B., 1981, Chattanooga and Ohio Shales of the southern Appalachian basin, *in* Roberts, T. G., ed., Guidebooks, Geological Society of America, 1981, Annual Meeting, v. 2, field trip no. 3, p. 259-362.

A comprehensive guidebook to selected key localities demonstrating the stratigraphic relationship of the Upper Devonian black shales in the central and southern Appalachians. Three separate road logs are presented with sections and descriptions of important lithostratigraphic and biostratigraphic markers for the southern part of the basin.

Dillman, S. B., and Ettensohn, F. R., 1981, Isopach map of highly radioactive black shale in the Chattanooga Shale of south-central Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 502.

Dillman, S. B., and Ettensohn, F. R., 1981, Isopach map of highly radioactive black shale in the West Falls Formation in Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 503.

Dillman, S. B., and Ettensohn, F. R., 1981, Isopach map of the highly radioactive black shale in the Java Formation in Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 504.

Dillman, S. B., and Ettensohn, F. R., 1981, Isopach map of highly radioactive black shale in the Three Lick Bed and Huron Shale Member of the Ohio Shale (units 2,3,4,& 5) in Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 505.

Dillman, S. B., and Ettensohn, F. R., 1981, Isopach map of highly radio-active black shale in the Cleveland Shale Member of the Ohio Shale (unit 1) in Kentucky: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 506.

Schweitering, J. F., 1981, the occurrence of oil and gas in Devonian shales and equivalents in West Virginia: U.S. Department of Energy, Technical Information Center DOE/ET/12130-113, 38 p.

A summary report of the stratigraphy, paleontology, and sedimentation of the Devonian shales and related rocks in West Virginia with a discussion on the origin and occurrence of hydrocarbon and area for exploration.

Wilson, E. N., Zafar, J. S., and Ettensohn, F. R., 1982, Rome trough section: A stratigraphic section through the Devonian-Mississippian black-shale sequence in Tennessee, Kentucky, and West Virginia: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shale Project METC/EGSP Ser. no. 500, 2 sheets.

A cross section along the Rome trough based on gamma-ray and sample description logs from oil and gas well. Includes text.

Wilson, E. N., Zafar, J. S., and Ettensohn, F. R., 1982, Southern tie section: a stratigraphic section through the Devonian-Mississippian black-shale sequence in Ohio, Kentucky, West Virgnia, and Virginia: U.S. Department of Energy, Morgantown Energy Technology Center, Eastern Gas Shales Project METC/EGSP Ser. no. 501, 2 sheets.

A cross section from Ohio to Virginia along the Kentucky-West Virginia border. Based on gamma-ray and sample-description logs from oil and gas wells; includes text.

METHODS OF STUDY AND PRESENTATION

The stratigraphic framework presented in this report is based on the detailed examination and correlation of gamma-ray logs from oil and gas wells, sample studies, cored-drill hole descriptions, measured surface sections, and hand-held scintillometer profiles of surface sections. Also, biostratigraphic data from the examination of conodont collections aided in the preparation of the stratigraphic framework. The framework consists of a network of 13 stratigraphic cross sections (plates 3-12) across the western portion of the Appalachian basin (plate 2).

The primary data source for this study was the gamma-ray logs from wells drilled for oil or gas. Where possible, these gamma-ray logs were compared with lithologic logs of either surface sections, subsurface well cuttings or drill cores to establish and maintain lithostratigraphic control, and to define the relationship between the gamma-ray log curve and the lithology. Several hundred logs were examined for this study, and the 139 logs selected for the stratigraphic network are presented in the Locality Register (p. 60). The listing is keyed by number to the index map (plate 2) and the logs shown on the cross sections (plates 3-12).

The gamma-ray log or the scintillometer trace (Ettensohn, Fulton, and Kepferle, 1979) reflects the concentration of the radioactive elements in the rock. The radioactive elements are potassium, uranium and thorium and the products of their decay series. These elements are found in the mica, feldspar, and some other rock-forming minerals and are the main source of gamma radiation recorded on the logs. The response recorded on the log reflects the amount of these radioactive elements contained in the different rock types. Sandstone contains a lesser amount of these elements than a gray shale and consequently produces less deflection on the gamma-ray trace. Limestone and dolomite produce response less than that of a sandstone. Dark gray to grayish black shales that owe their color to organic material have a greater log response because the organic material in the shale traps additional uranium during the transport, sedimentation, and diagenesis. Consequently the darker shales with a greater concentration of uranium bearing organic matter produce bigger peaks on the gamma ray logs than do the lighter colored gray shales. To differentiate the gray shales from the darker shales, a gray shale baseline is drawn along the peaks of the trace produced by the gray shale (fig. 1). Generally, shales that contain more than 1.5 weight percent organic material and are black (N1), grayish black (N2), dark gray (N3), brownish black (5 Y 2/1) or olive black (5 Y 2/1) (color designation from Goddard and others, 1948) produce a greater response or a positive deflection to the right on the gamma-ray trace. Figure 1 shows the comparison of a gamma-ray log to a lithologic log and the relationship of the log response to different types of rock.

Stratigraphic correlations made in the preparation of the 13 cross sections were based, where possible, on the projection of named-surface stratigraphic units into the subsurface. The characteristic configuration of the gamma-ray log trace combined with a known atratigraphic sequence of units was used to project the stratigraphic intervals throughout their extent in the basin.

Much of the nomenclature used on the cross sections has been in use for many years and has been approved by the U.S. Geological Survey; however, the approved usage is restricted in areal extent. In this basin-wide study the formal stratigraphic units and the appropriate nomenclature have been greatly extended and modified from the previously accepted usage of the Geological Survey. In addition, some nomenclature is introduced here that has not previously been used by Survey authors and is not as yet formally accepted by the Survey. Thèrefore, some of the nomenclature and its areal limits of application used in this report remains to be approved by the Geologic Names Committee of the Geological Survey. A formal proposal to adopt the nomenclature developed in this study is inappropriate here because it is not the purpose or within the time constraints of this present report.

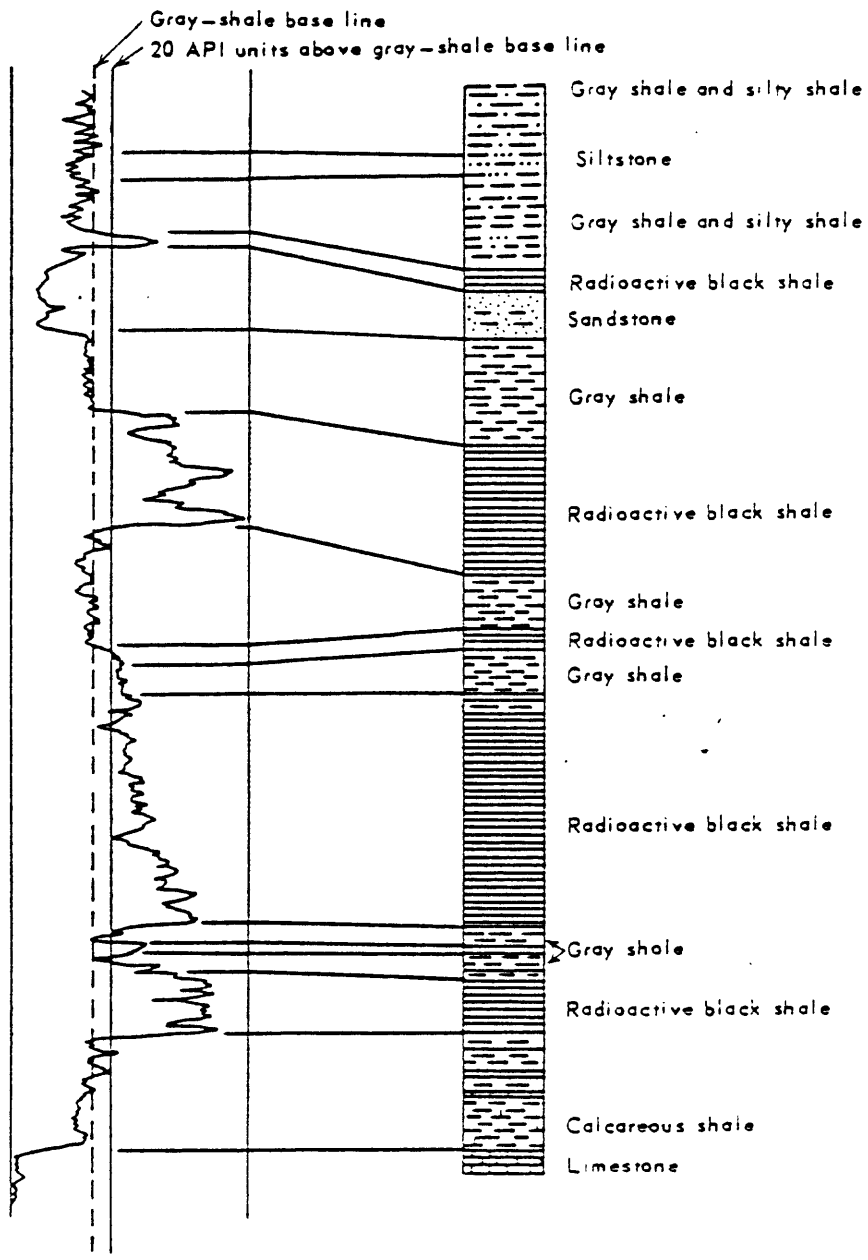

Figure 1. Gamma-ray and lithologic log comparison indicating radioactive response to rock type. API-American Petroleum Institute.

For the historical background on nomenclature and type sections the reader is referred to the Lexicons of Geologic Names of the United States (Wilmarth, 1938; Wilson and others, 1957; Keroher and others, 1966; Keroher, 1970; Keroher, Luttrell, and others, 1981; Swanson and others, 1981). Formal descriptions of each stratigraphic subdivision recognized in this study are not included here.

Thickness data for the black shale is shown on isopach maps as the total net feet of radioactive black shale within the named formational unit. The isopachs were compiled from modified state-wide isopach maps prepared by various agencies under contract with the Eastern Gas Shales Project. Because the tops of the black shale members within the formation are generally gradational and could not be picked with any assured uniformity by various workers in different parts of the basin, the net feet of black shale was measured between the readily defined formational boundaries on the gamma-ray logs. Inasmuch as thickness measurements from different subsurface data sources such as wire line and sample-study logs could be highly variable even for the same well, all measurements were confined to a single data source, the gammy-ray log, to maintain a maximum degree of consistency. Because of availability and basin-wide coverage, more than 1000 gamma-ray logs were used as the principal data source for subsurface mapping. In order to standardize the unit to be measured as black shale on the gamma-ray log, only shales with a radioactive response on the log trace of greater than 20 API units greater in value than the gray shale baseline were measured. Selection of the 20 API minimum above the gray shale baseline was based on the assumption that a deflection of this magnitude was real and normally exceeded any background or mechanically induced departure from the normal or actual radioactive response.

The gamma-ray log response reflects the uranium content of the dark organic-rich shales. The amount of uranium in the dark shales is dependent on the type and amount of organic detritus in the shales. Because these factors are variable throughout the basin, the thickness of the organic-rich shale determined from the gamma-ray log response reflects this variability. The specific amount of variability cannot be quantified; however, thicknesses determined from the gamma-ray log response are considered to be conservative approximations which are less than the true thickness of dark organic-rich shale. Eastward across the basin (plate 1) the Upper Devonian shales become less radioactive and beyond the study area the characteristic log deflection is lost. This lack of response precludes accurate identification and measurement of the dark organic-rich Upper Devonian shales east of the study area in the eastern part of the basin. However, this does not apply to the Marcellus Shale of Middle Devonian age. Throughout the basin the Marcellus produces a consistent log response suggesting that the variables affecting the log response of the Upper Devonian shales were inoperative in the Marcellus sedimentation regime.

The isopach map showing the total net feet of radioactive black shale for the Appalachian basin (plate 23) is a summation of the individual basin-wide isopach maps (plates 16-22) for each of the formations or groups. A selected grid system was overlain on each map. Thickness values were determined for the grid points for each individual isopach map and the sum for all the individual maps at each of those points was used to prepare the total thickness isopach map.

State-wide structure contour maps prepared by Eastern Gas Shales Project contractors were modified and compiled into the regional structure maps for each major black shale unit in the Appalachian basin (plates 24-30). The base of the black shale units, which are sharply defined on the gamma-ray logs, were used as the contoured surface. The structure map on the base of the Devonian black-shale sequence, which is the Marcellus Shale in much of the basin, was used in conjunction with the average elevation map of Diment and Urban (1981) to construct a drilling-depth map (plate 31). The map may be used to approximate within 250± the total footage required to completely penetrate the Devonian black shale sequence at specific locations in the Appalachian basin.

The areal distribution of the stratigraphic units recognized in the cross section network is shown on a series of maps at the scale of 1:7,500,000 (figs. 2-37). In addition to the black shales, many of the intervening stratigraphic units are mapped. The maps show the extended basinwide distribution of the stratigraphic units recognized in the classic outcrop area of New York, Ohio, Tennessee, and Virginia. The maps indicate the application and geographic extent of the stratigraphic nomenclature recognized by this regional study as well as the physical distribution of the litho-stratigraphic units.

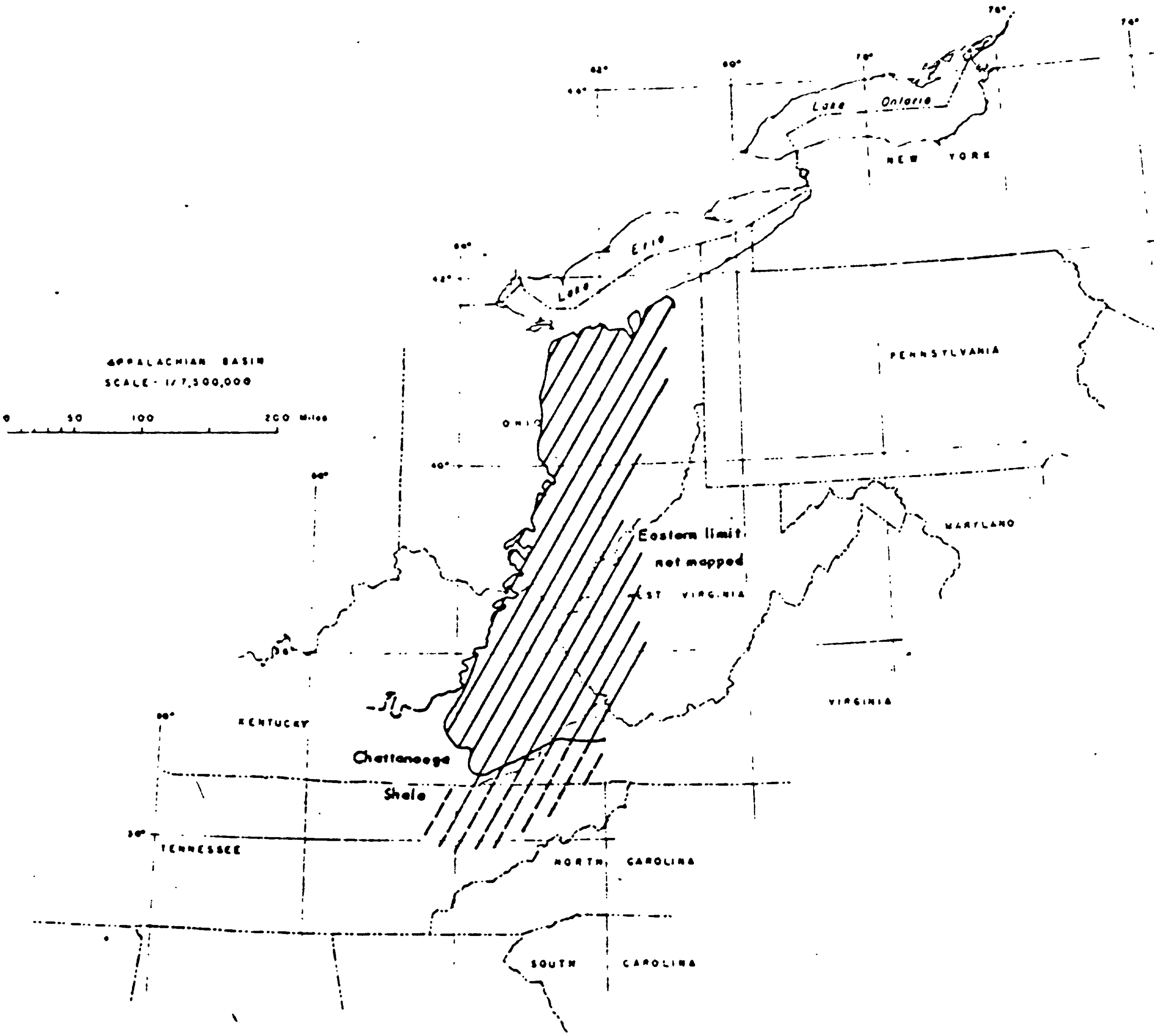

Figure 2 . Map showing the areal extent of the Sunbury Shale. Dashed where Sunbury Shale is used only in subsurface.

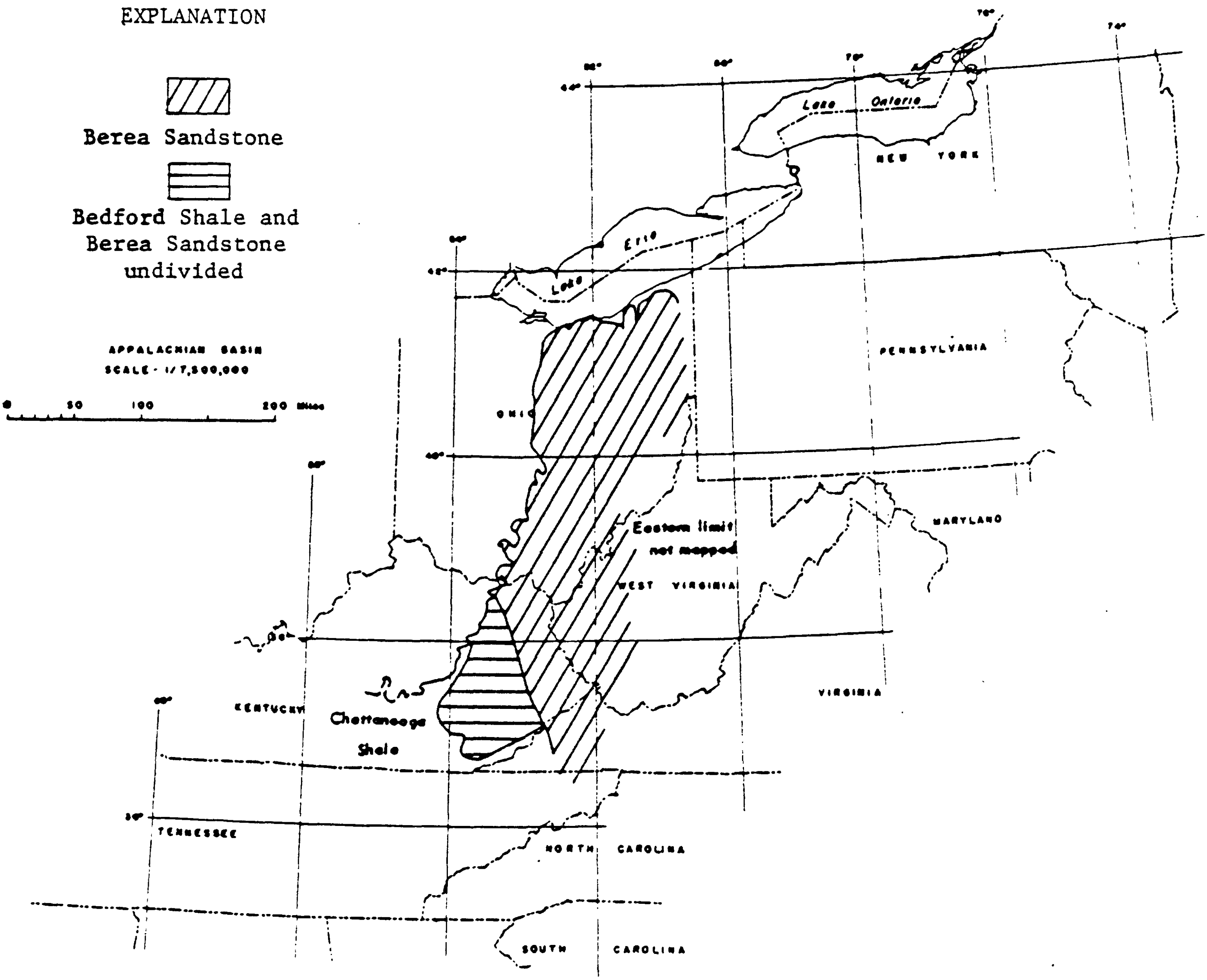

Figure 3 . Map showing the areal extent of the Bedford Shale and the Bedford Shale and Berea Sandstone undivided

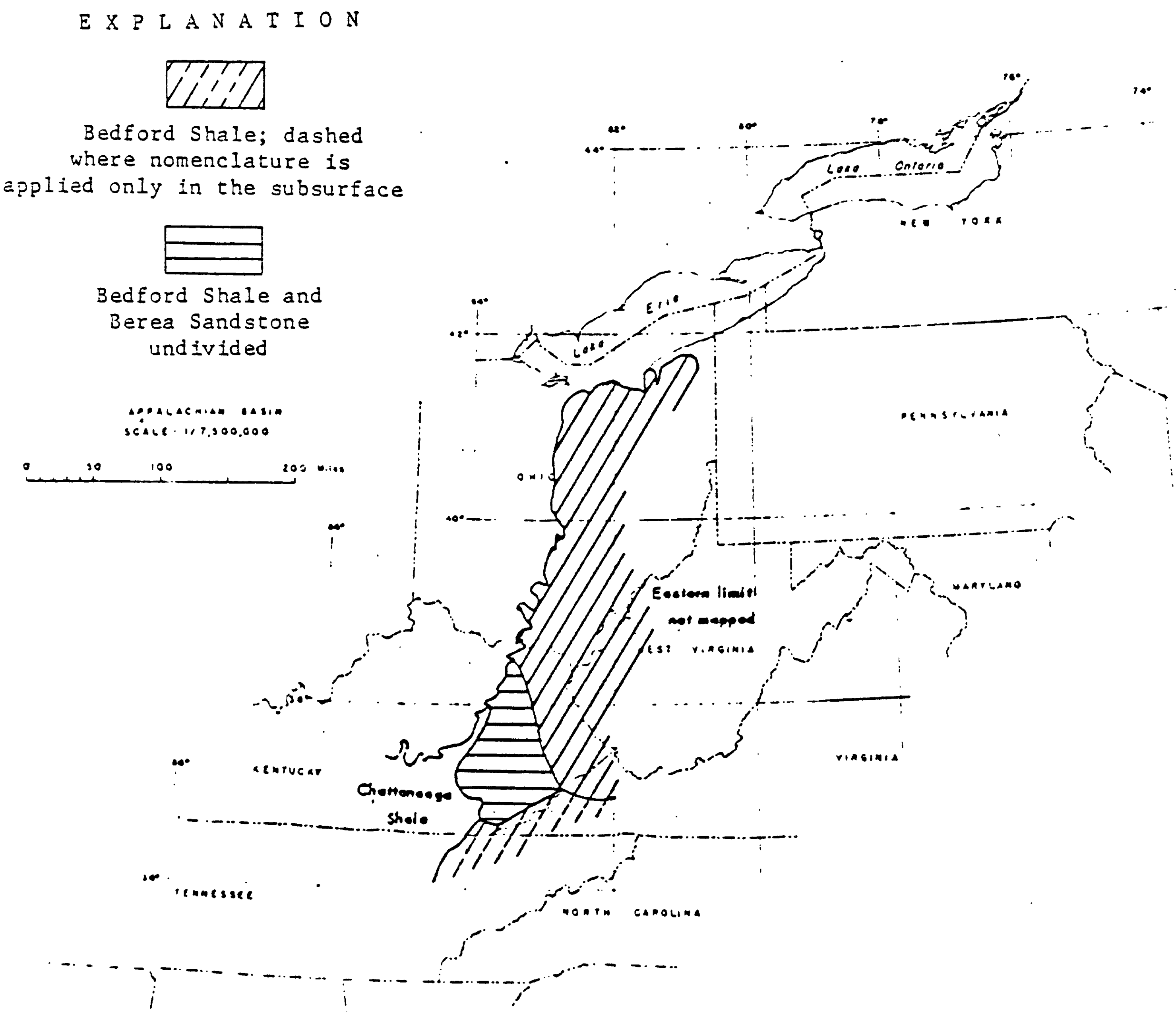

Figure 4. Map showing the areal extent of the Bedford Shale and the Bedford Shale and Berea Sandstone undivided.

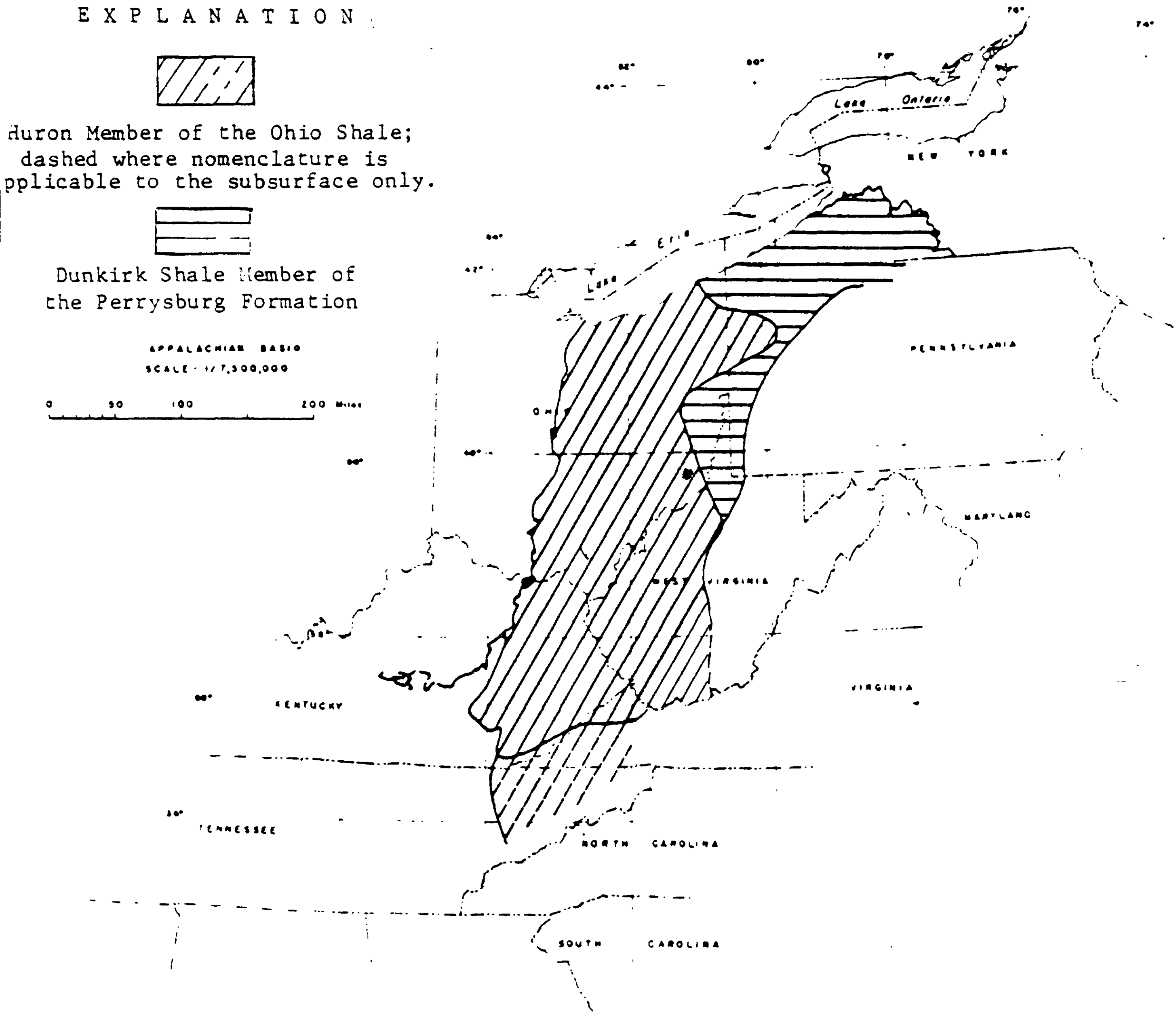

Figure 5 . Map showing the areal extent of the Huron Member of the Ohio Shale and its lateral equivalent, the Dunkirk Shale of the Perrysburg Formation

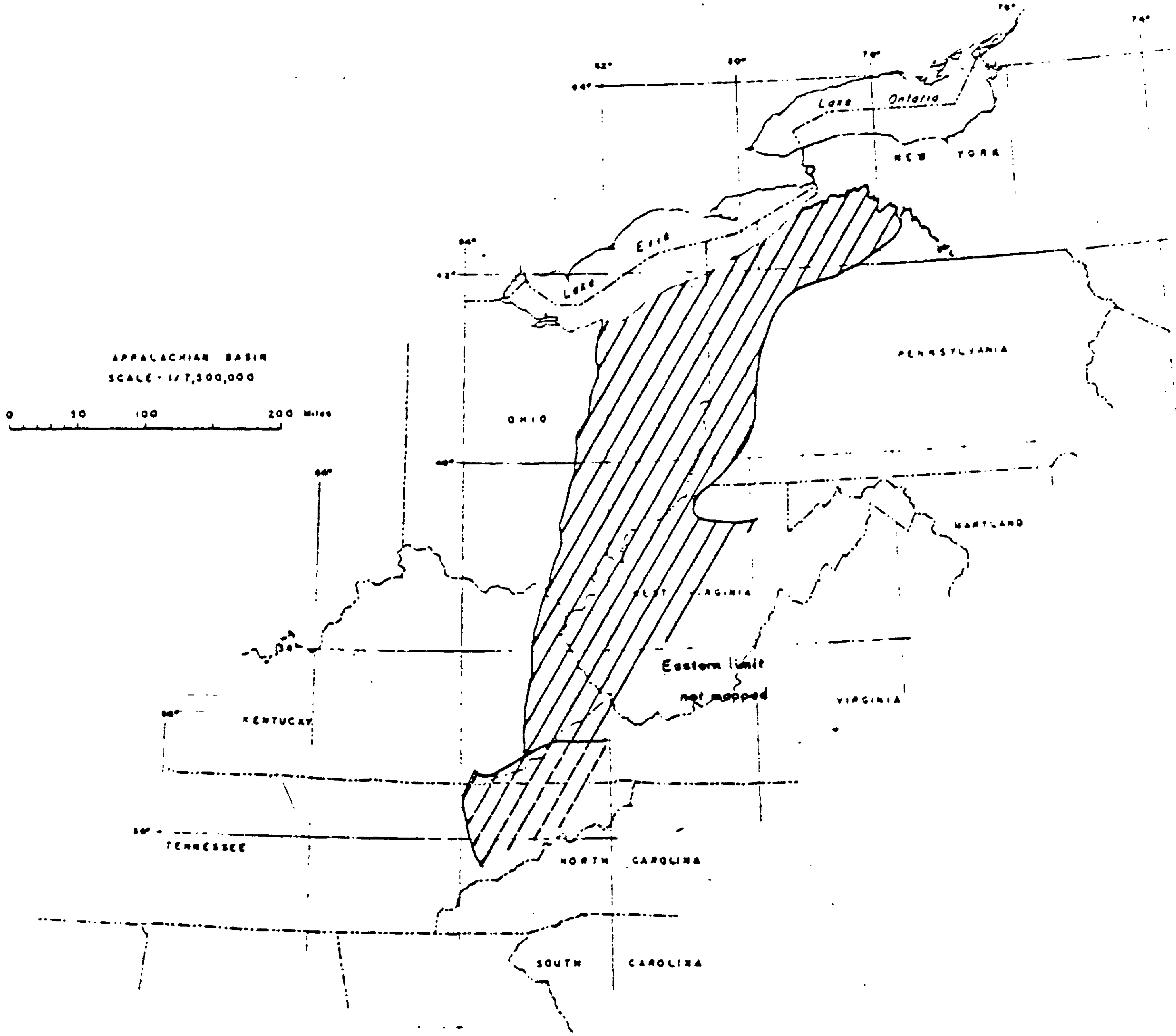

Figure 6 . Map showing the areal extent of the Java Formation. Dashed lines indicate the area where this nomenclature is applicable only in the subsurface.

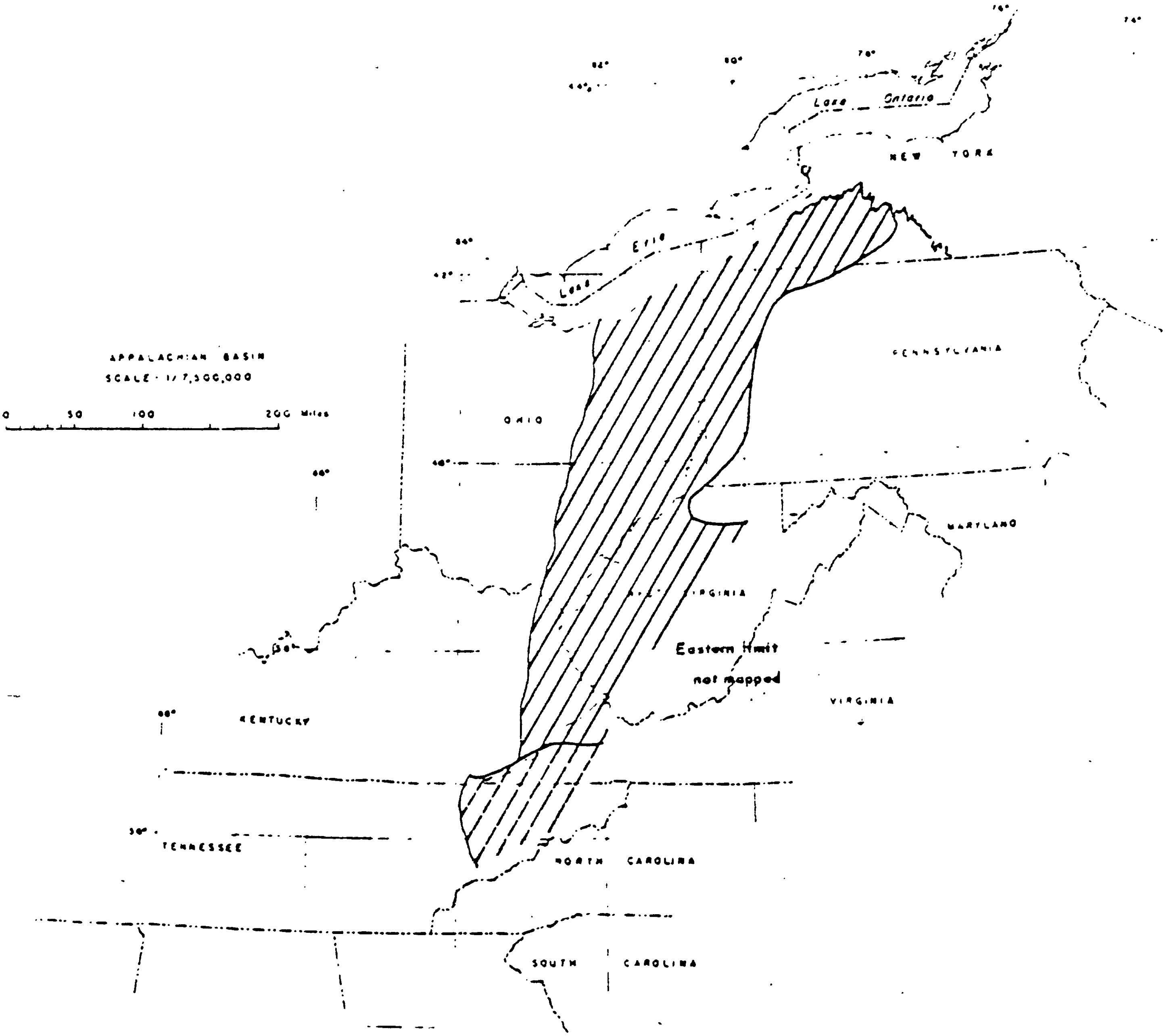

Figure 7. Map showing the areal extent of the Hanover Shale Member of the Java Formation. Dashed pattern indicates the area where this nomenclature is applicable only in the subsurface.

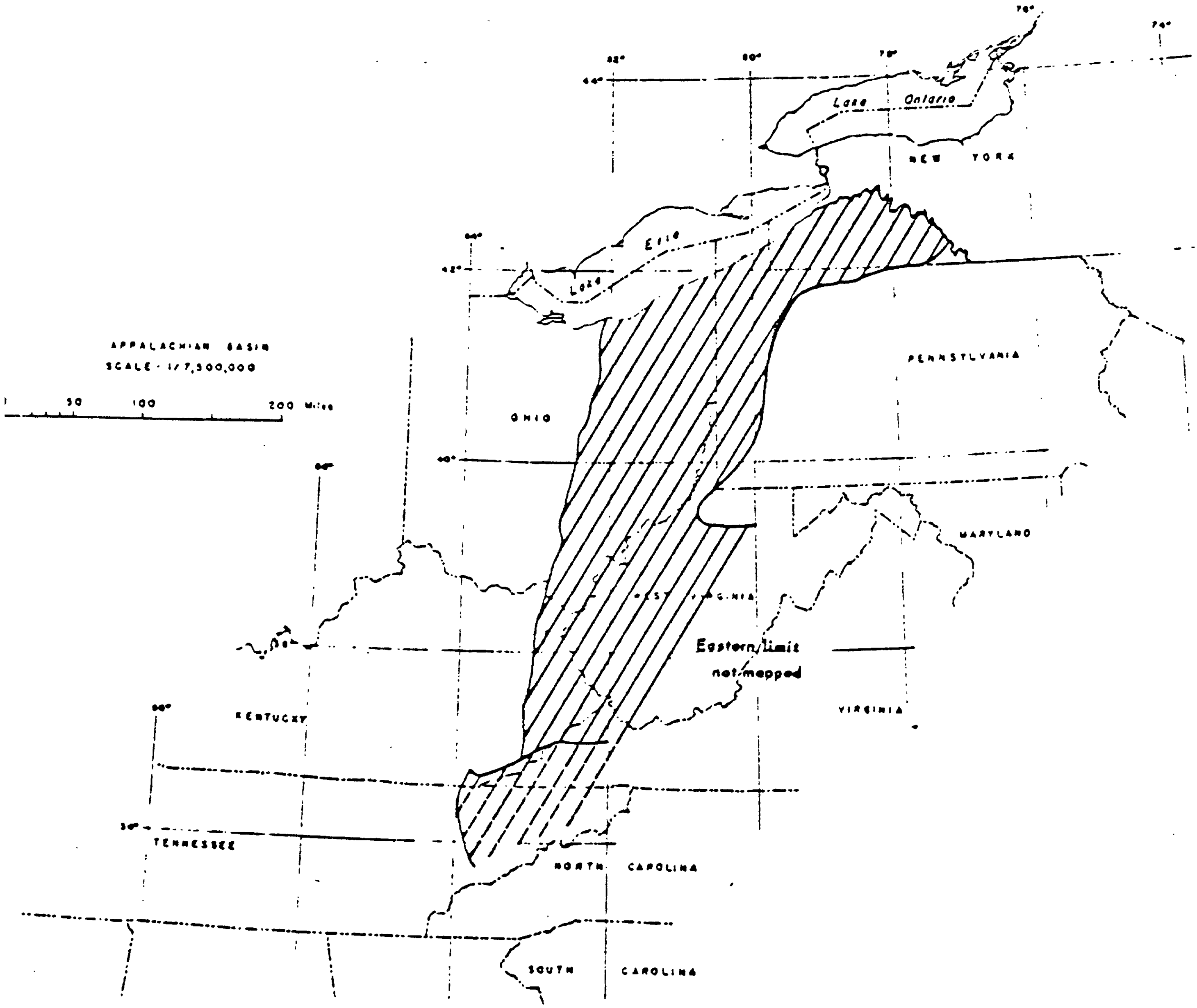

Figure 8 . Map showing the areal extent of the Pipe Creek Shale Member of the Java Formation. Dashed lines indicate the area where this nomenclature is applicable in the subsurface only.

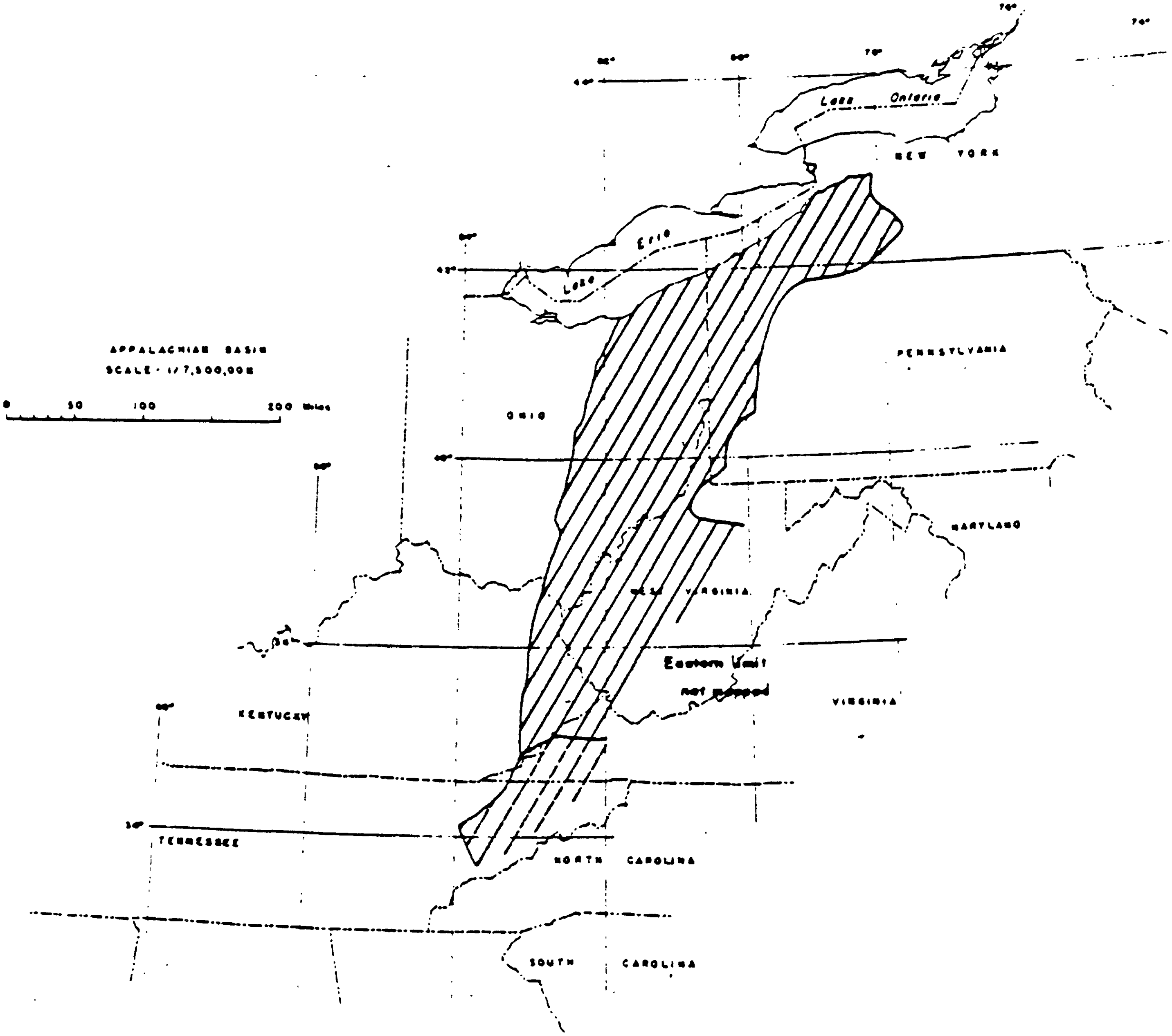

Figure 9. Map showing areal extent of the West Falls Formation where both the Rhinestreet and Angola Shale Members are present. Dashed lines indicate the area where this nomenclature is applicable only in the subsurface.

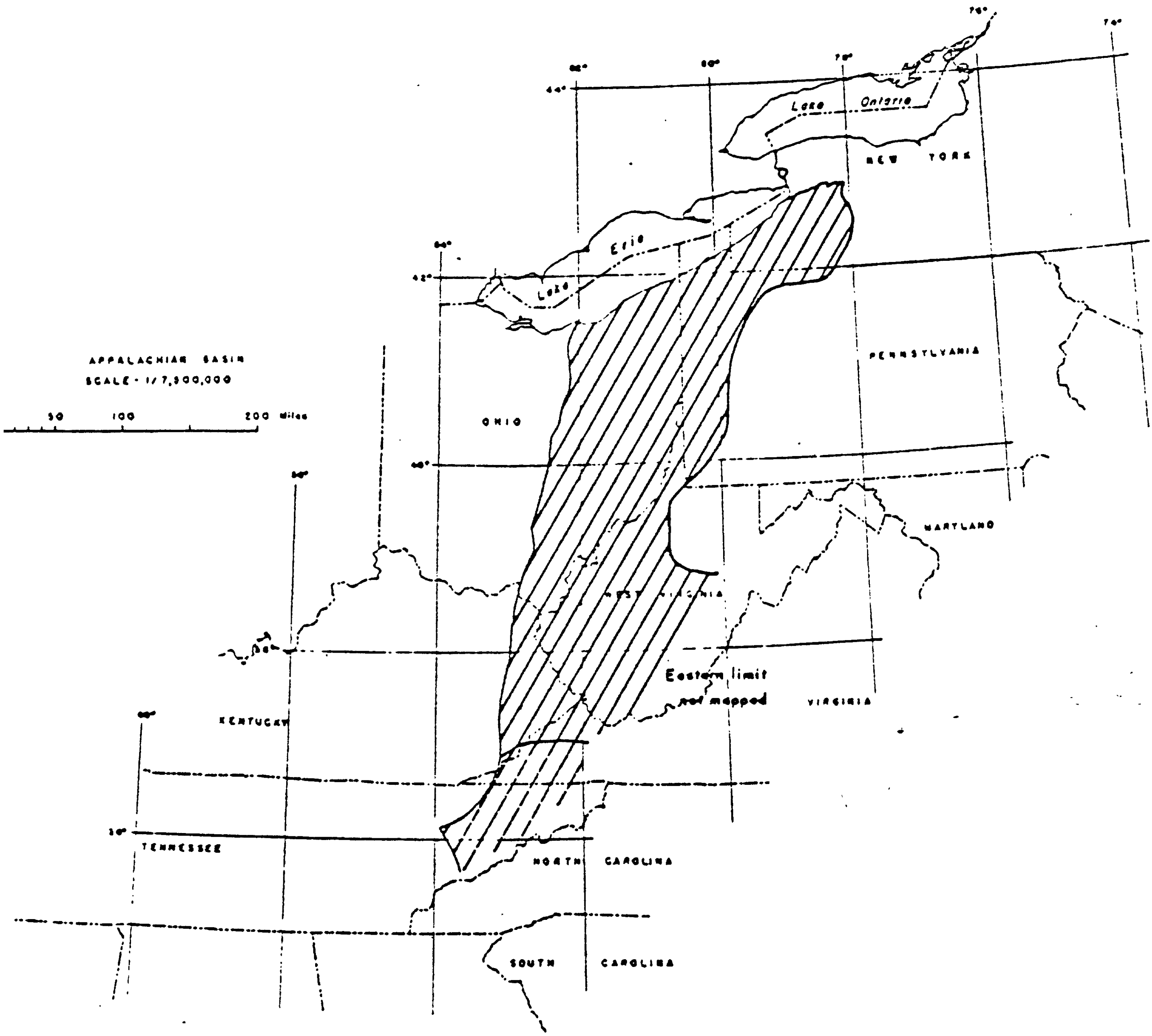

Figure 10. Map showing the areal extent of the Angola Shale Member of the West Falls Formation. Dashed lines indicate the area where this nomenclature is applicable only in the subsurface.

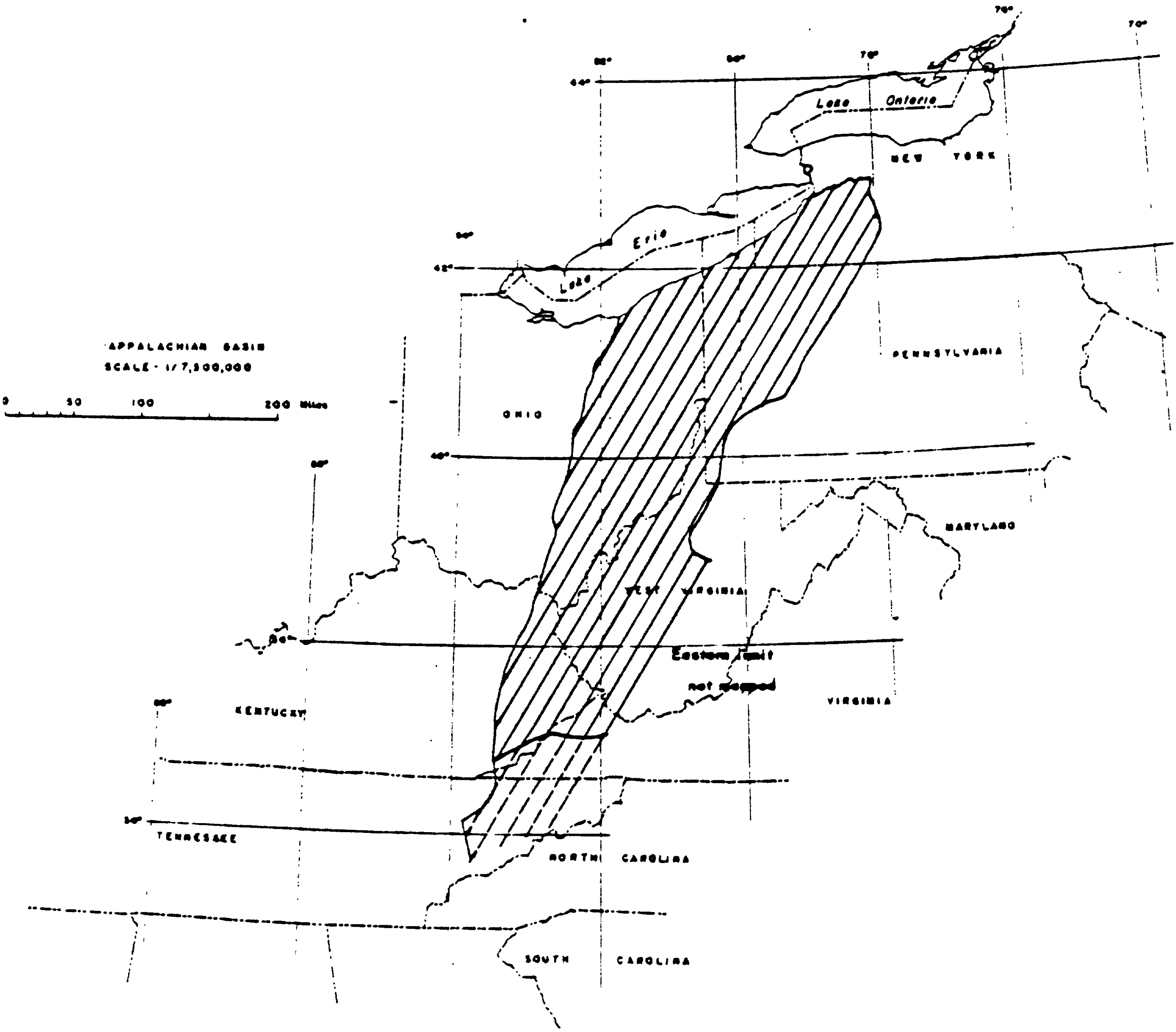

Figure 11. Map showing the areal extent of the Rhinestreet Shale Member of the West Falls Formation. Dashed lines indicate the area where this nomenclature is applicable only in the subsurface.

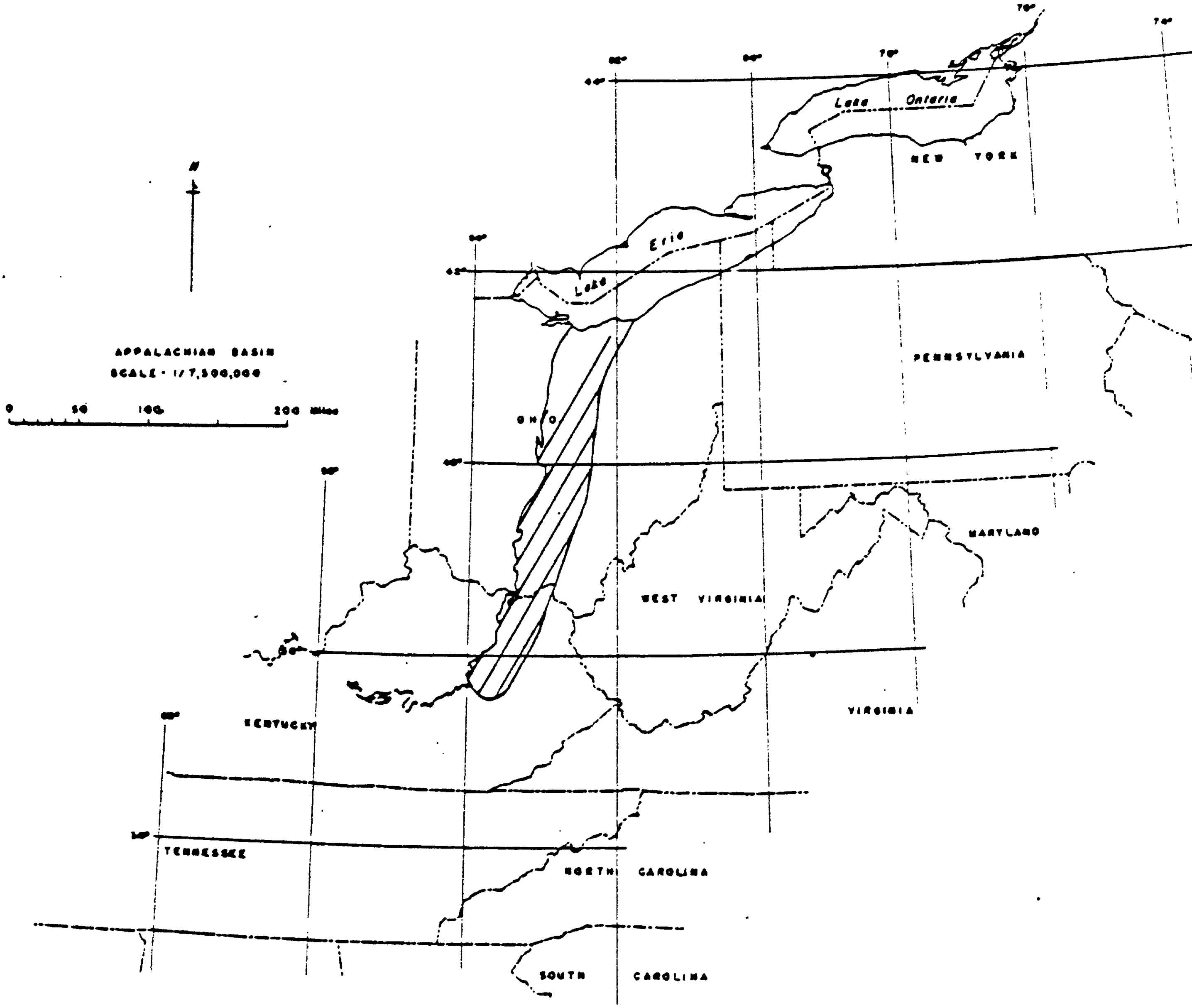

Figure 12. Map showing the areal extent of the Olentangy Shale

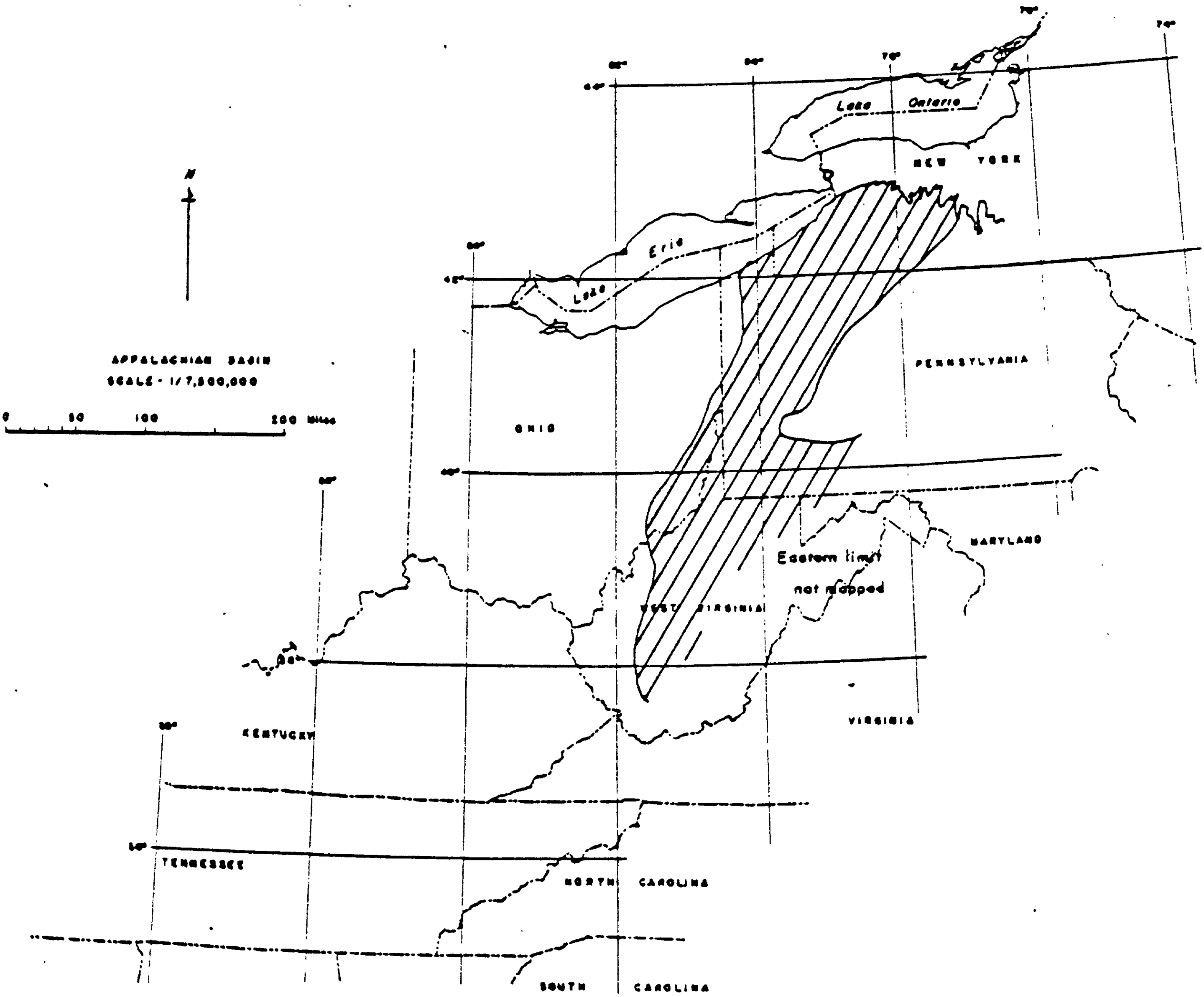

Figure 13 . Map showing the areal extent of the Sonyea Formation where both the Middlesex and Cashaqua Shale Members are present.

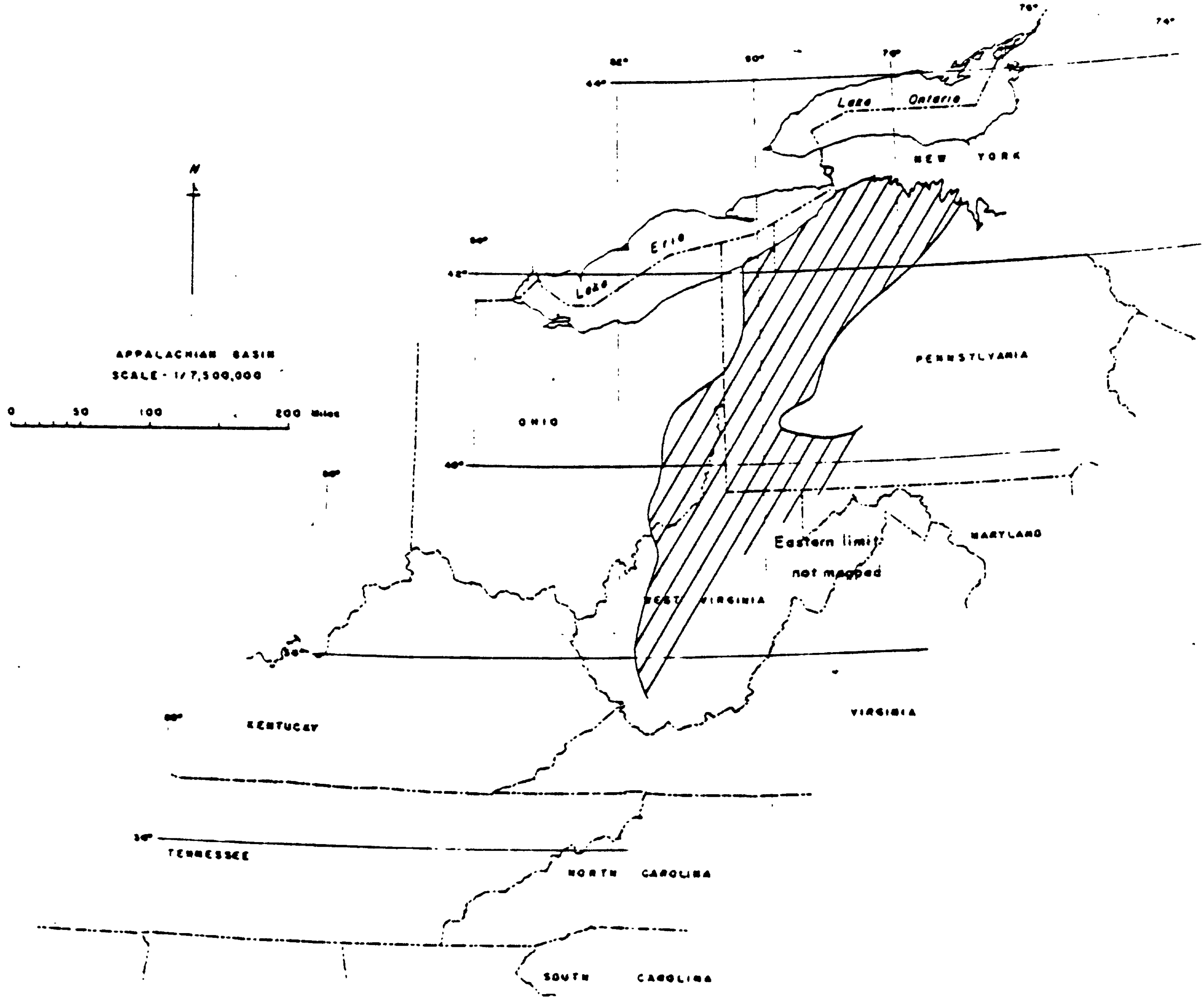

Figure 14 . Map showing the areal extent of the Cashaqua Shale Member of the Sonyea Formation

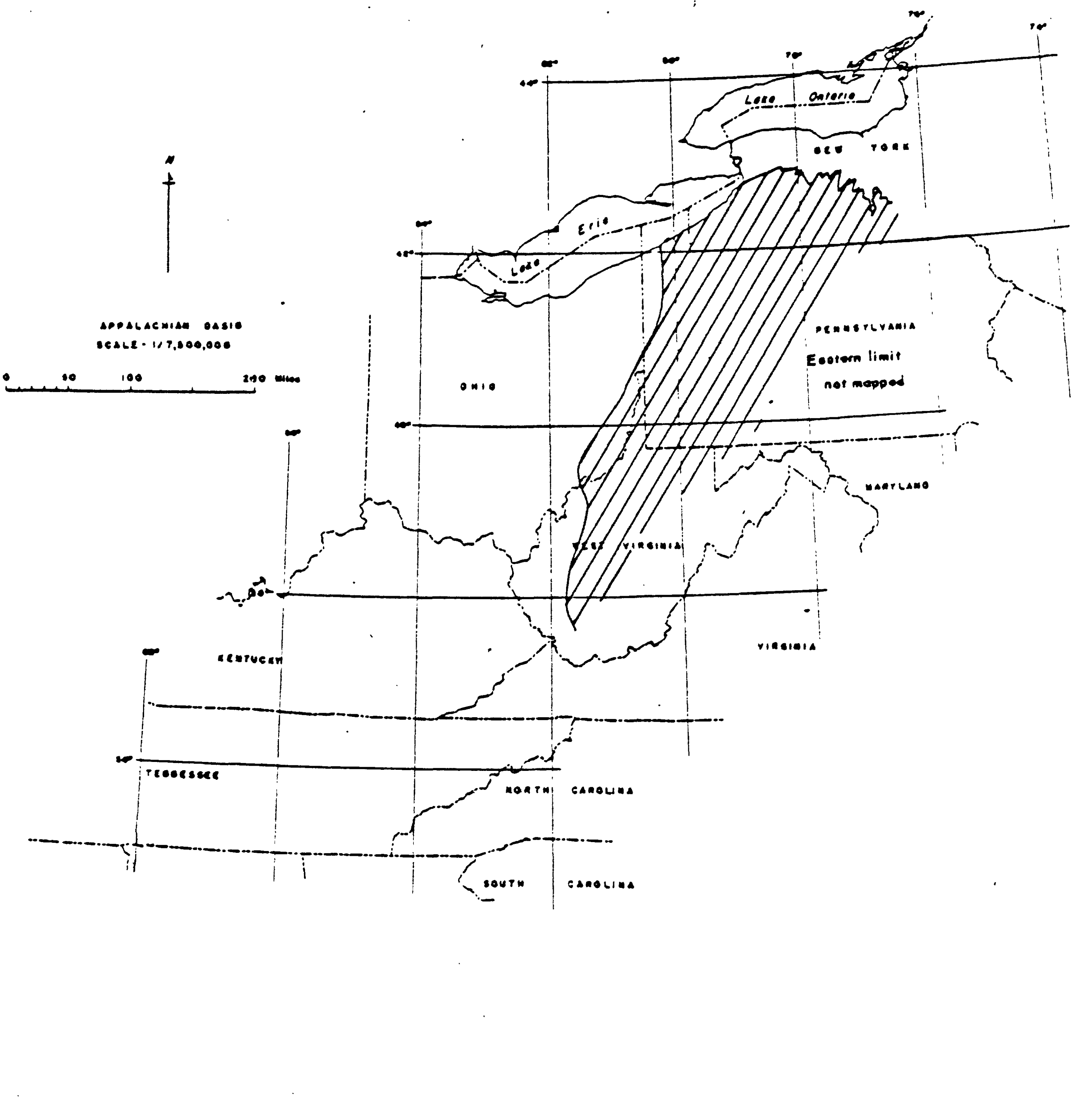

Figure 15. Map showing the areal extent of the Middlesex Shale Member of the Sonyea Formation

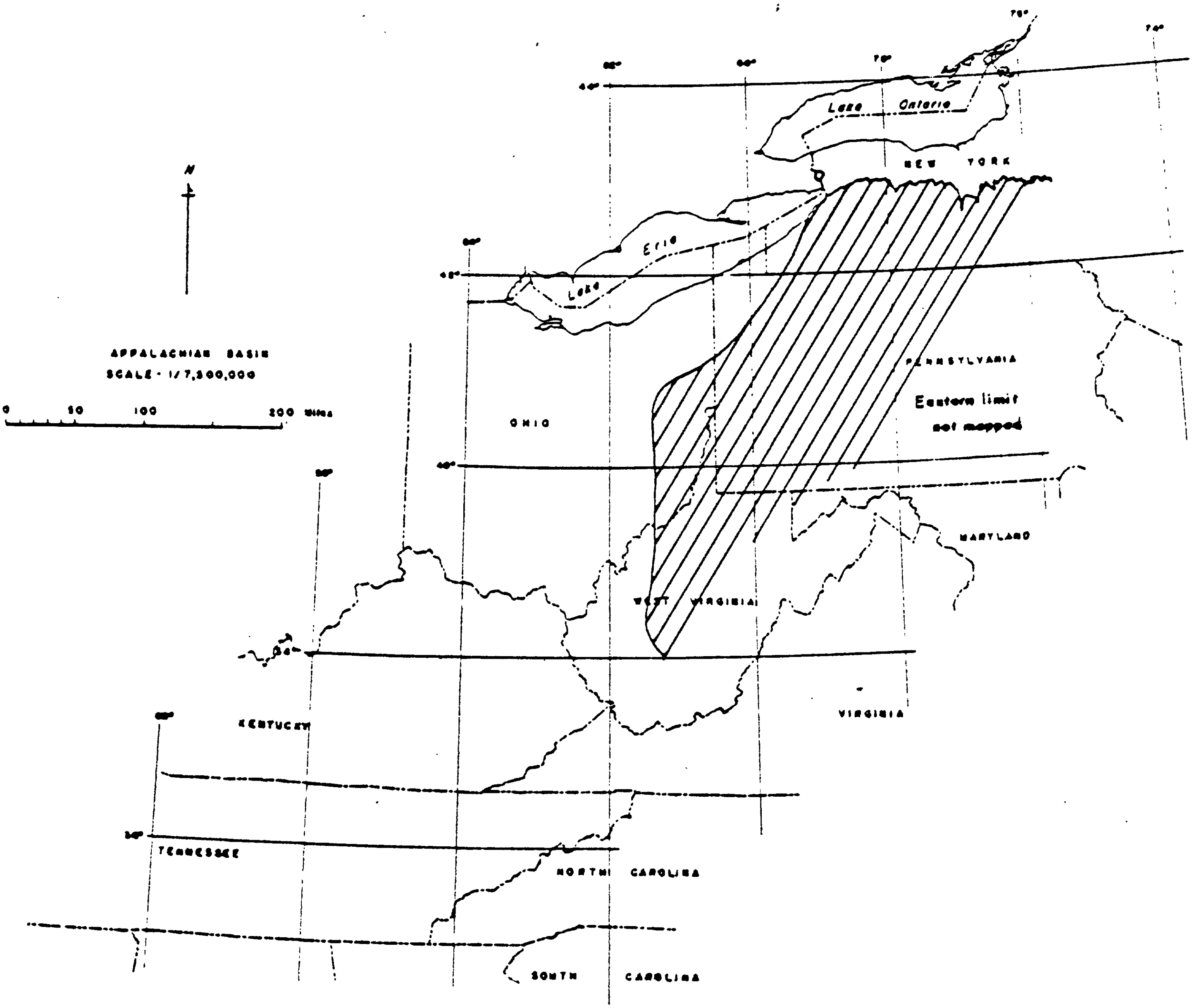

Figure 16. Map showing the areal extent of the Genesee Formation

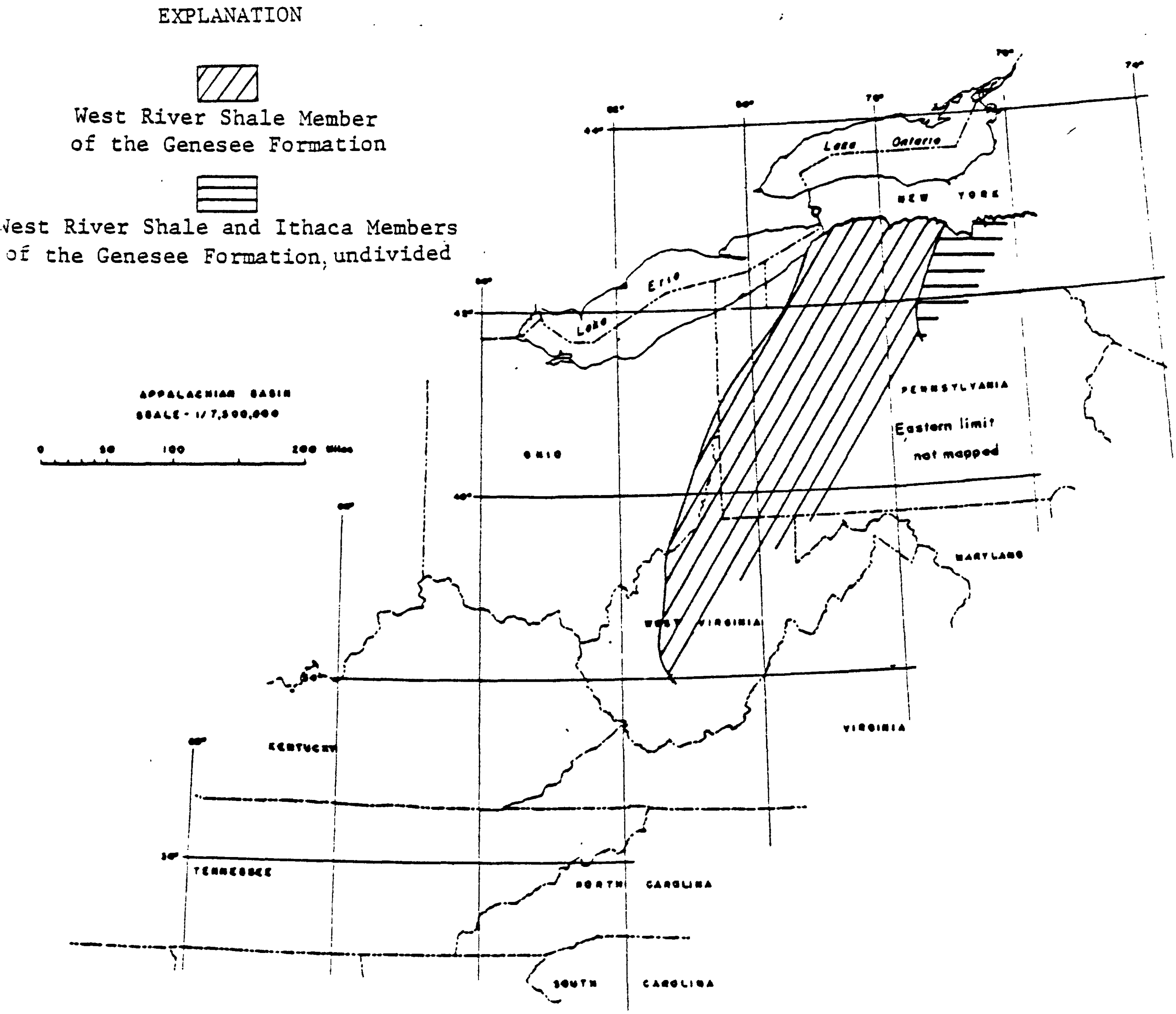

Figure 17. Map showing the areal extent of the West River Shale Member of the Genesee Formation

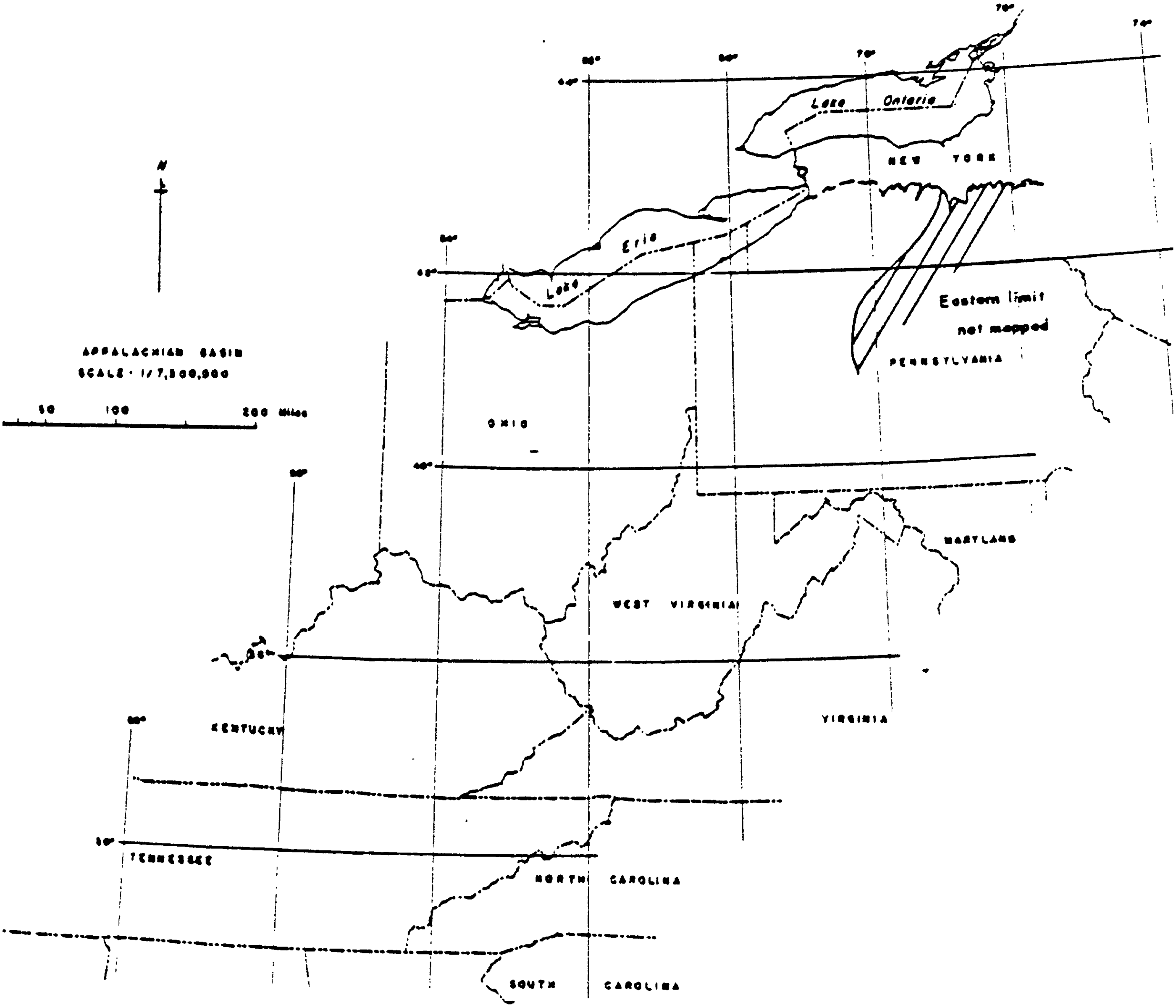

Figure 18. Map showing the areal extent of the horizon "MF" of deWitt and Colton (1978). "MF" represents "Middlesex flags".

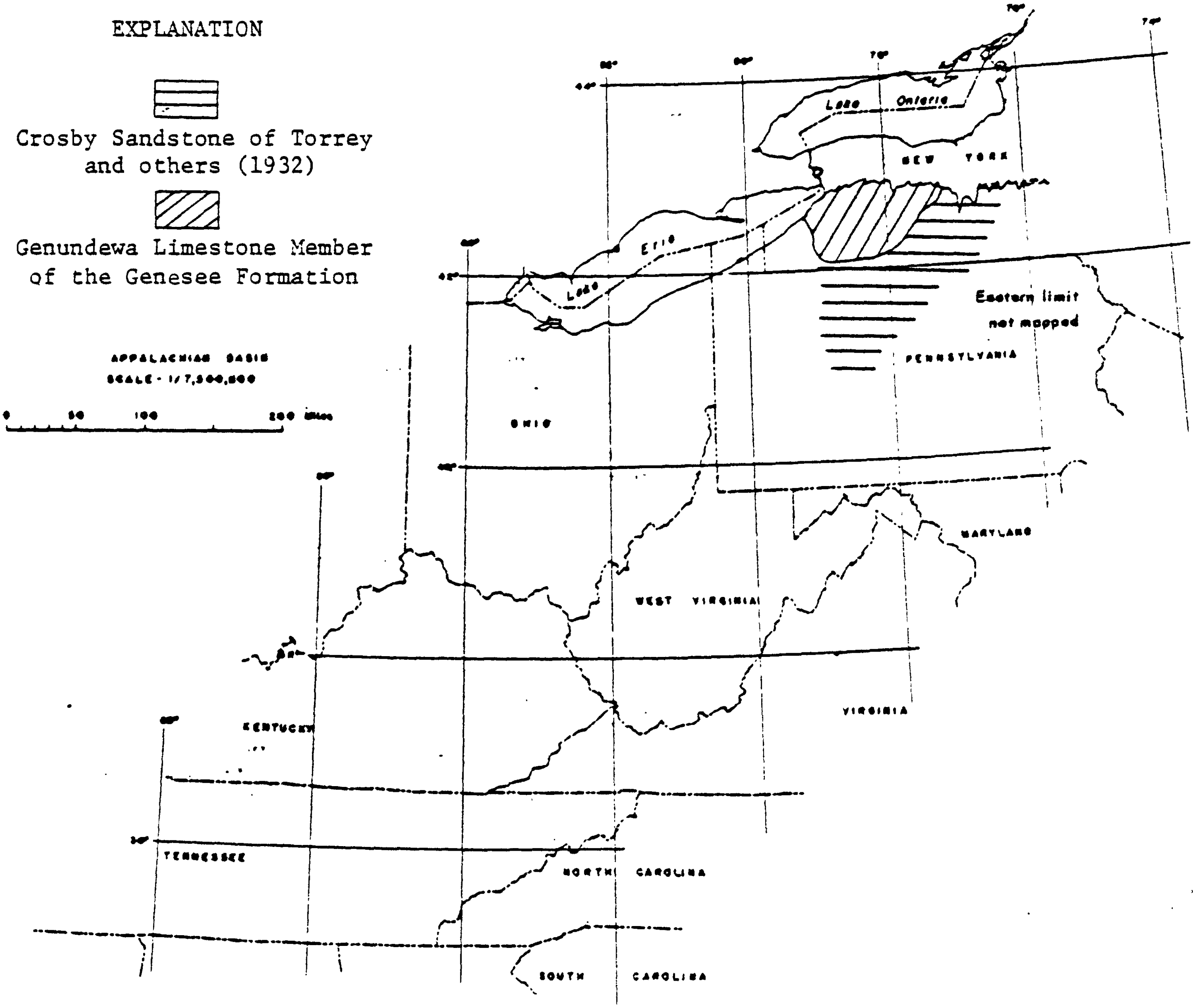

Figure 19. Map showing the areal extent of the Crosby Sandstone of Torrey and others (1932) and its western equivalent, the Genundewa Limestone Member of the Genesee Formation

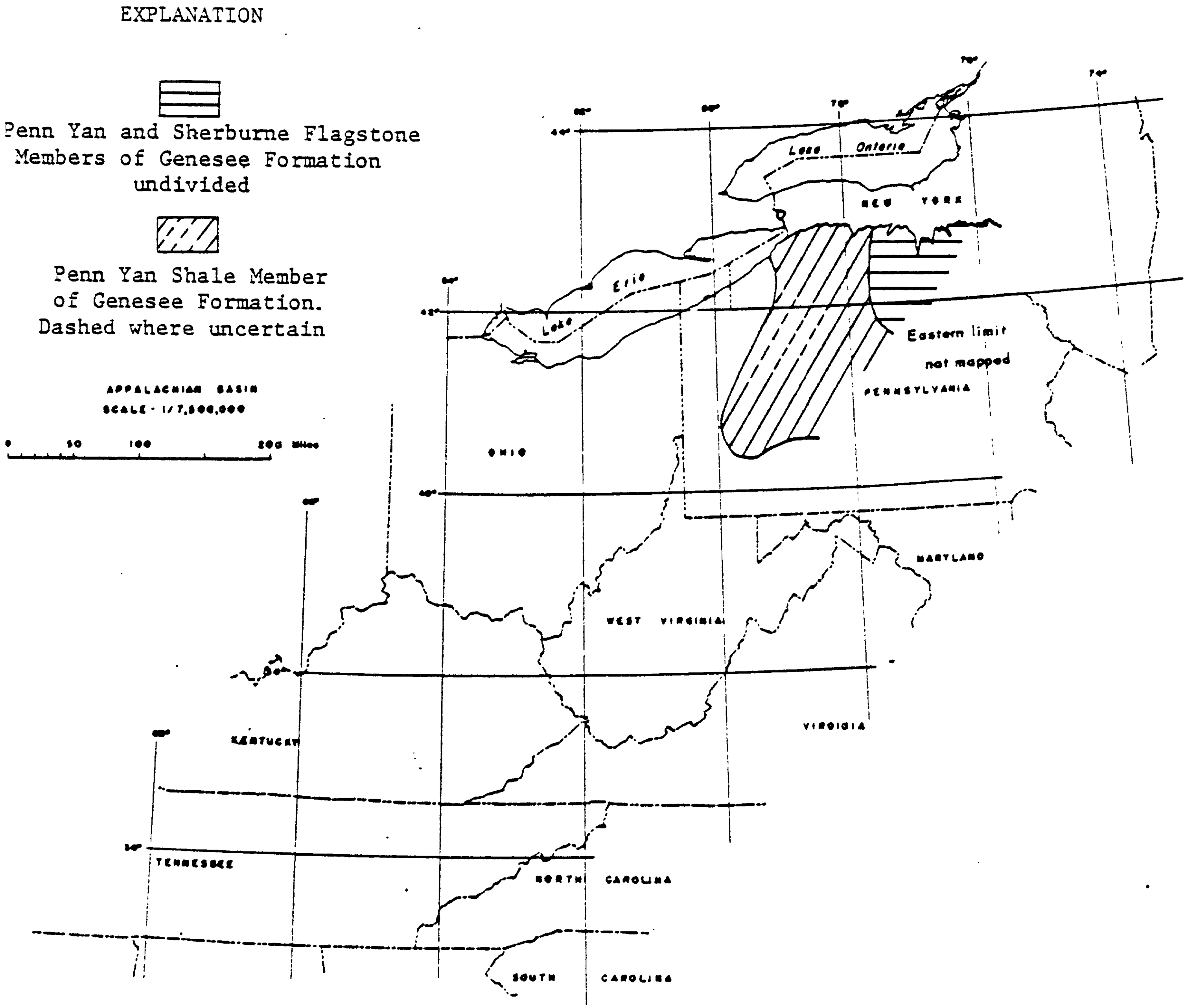

Figure 20. Map showing the areal extent of the Penn Yan and Sherburne Flagstone Members of the Genesee Formation

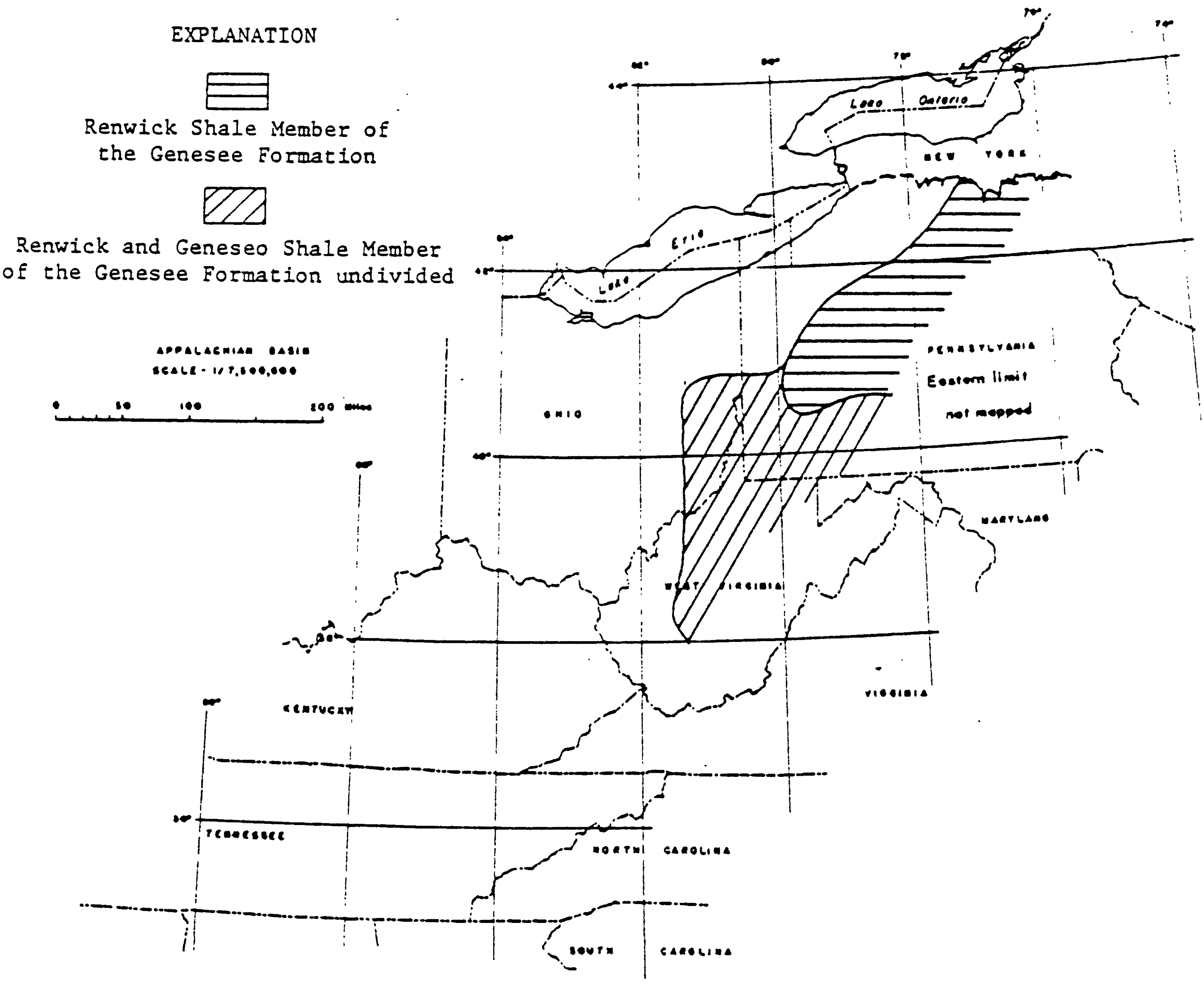

Figure 21. Map showing the areal extent of the Renwick Shale Member and the Renwick and Geneseo Shale Members of the Genesee Formation undivided

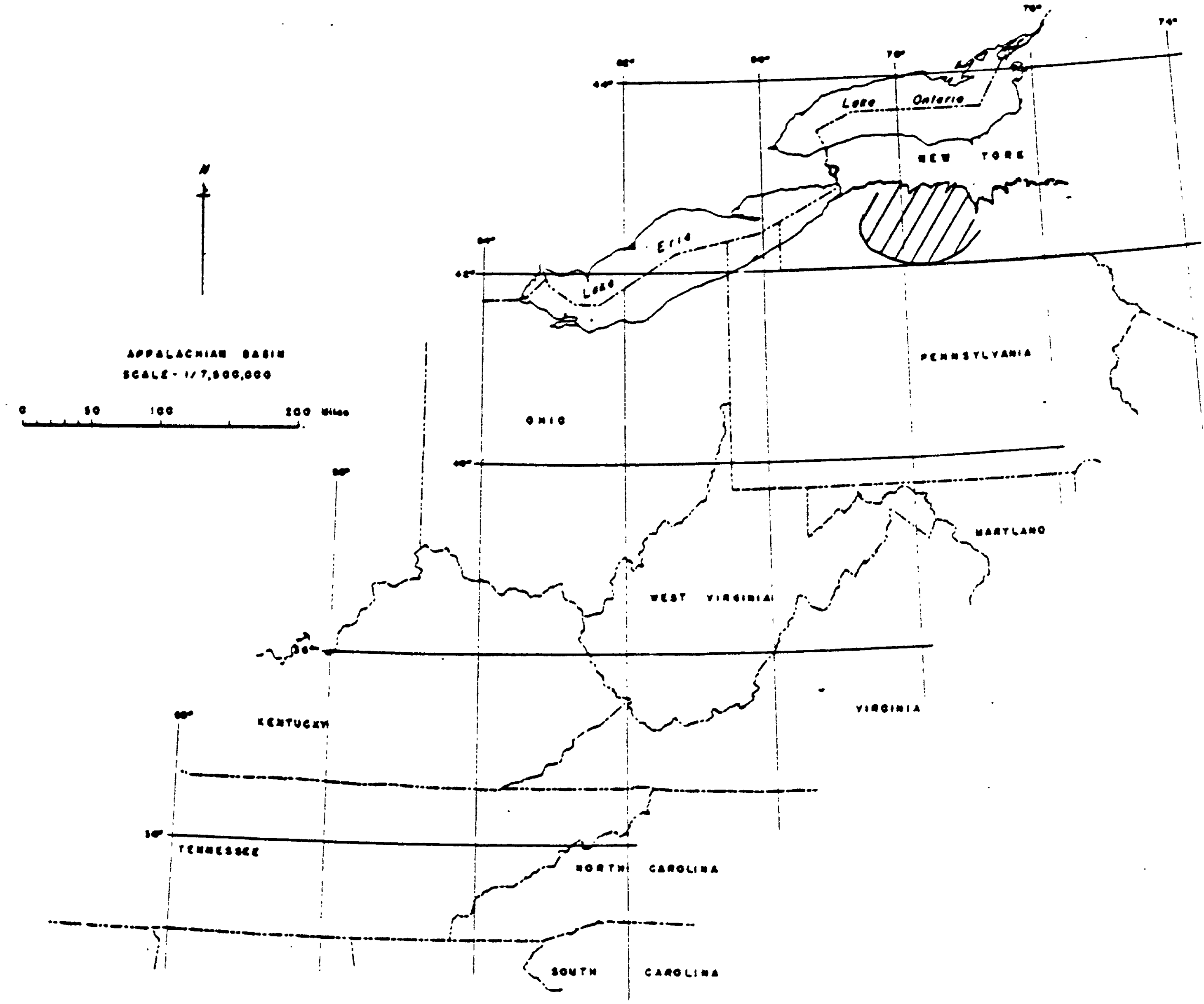

Figure 22 . Map showing the areal extent of the Lodi Limestone of Clarke (1895)

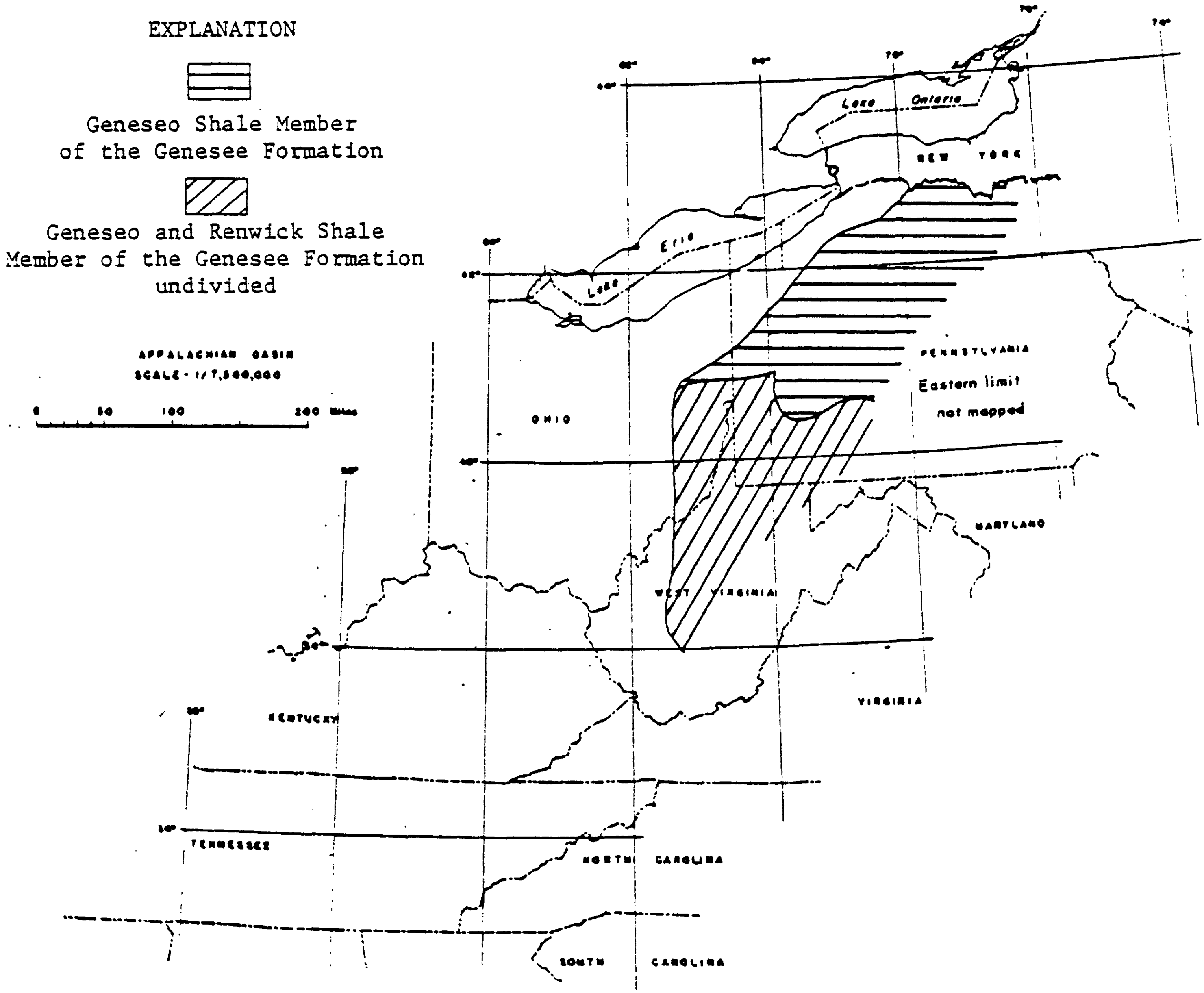

Figure 23 . Map showing the areal extent of the Geneseo Shale Member and the Geneseo and Renwick Shale Member of the Genesee Formation, undivided

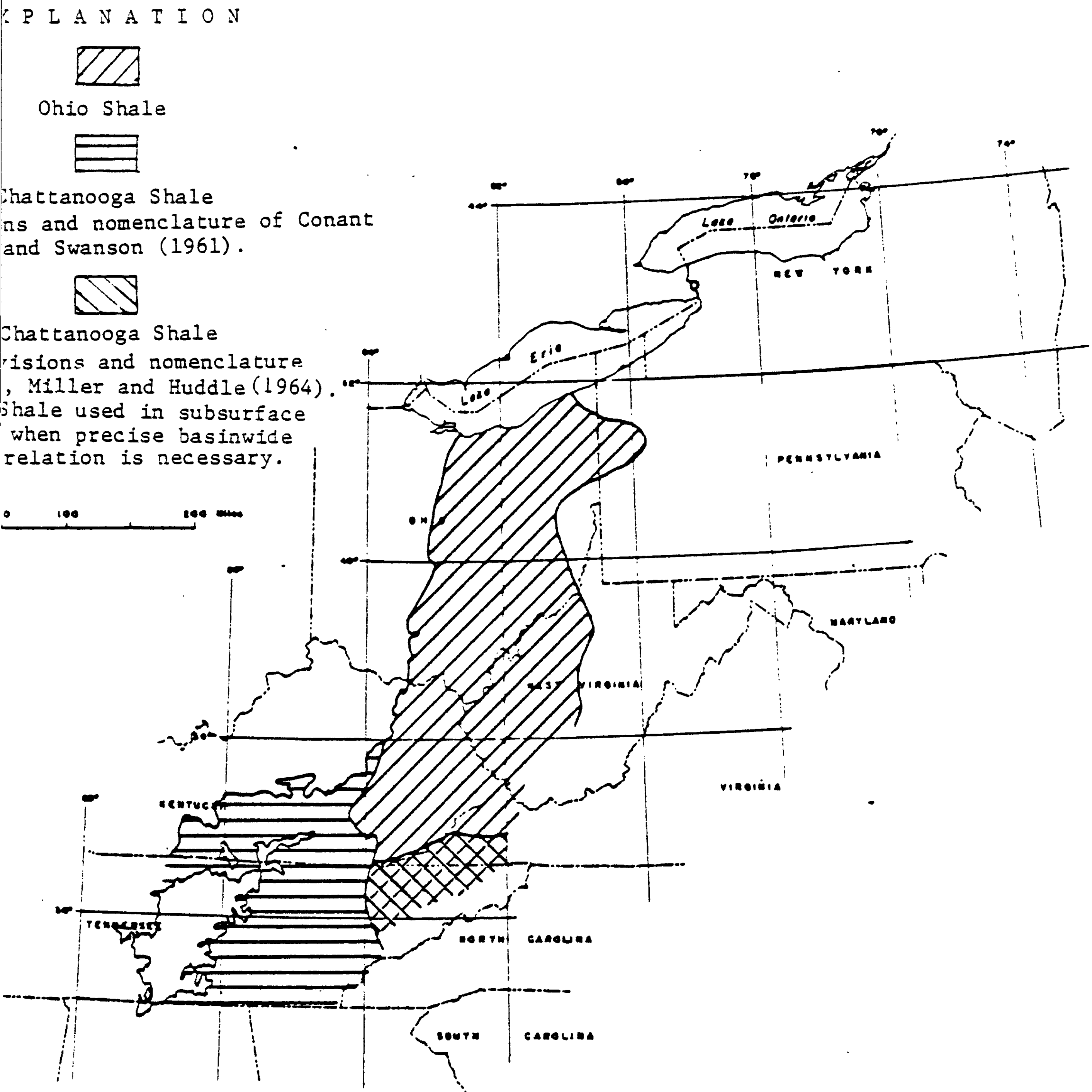

Figure 24. Map showing the areal extent of the Ohio and Chattanooga Shales in the Appalachian basin

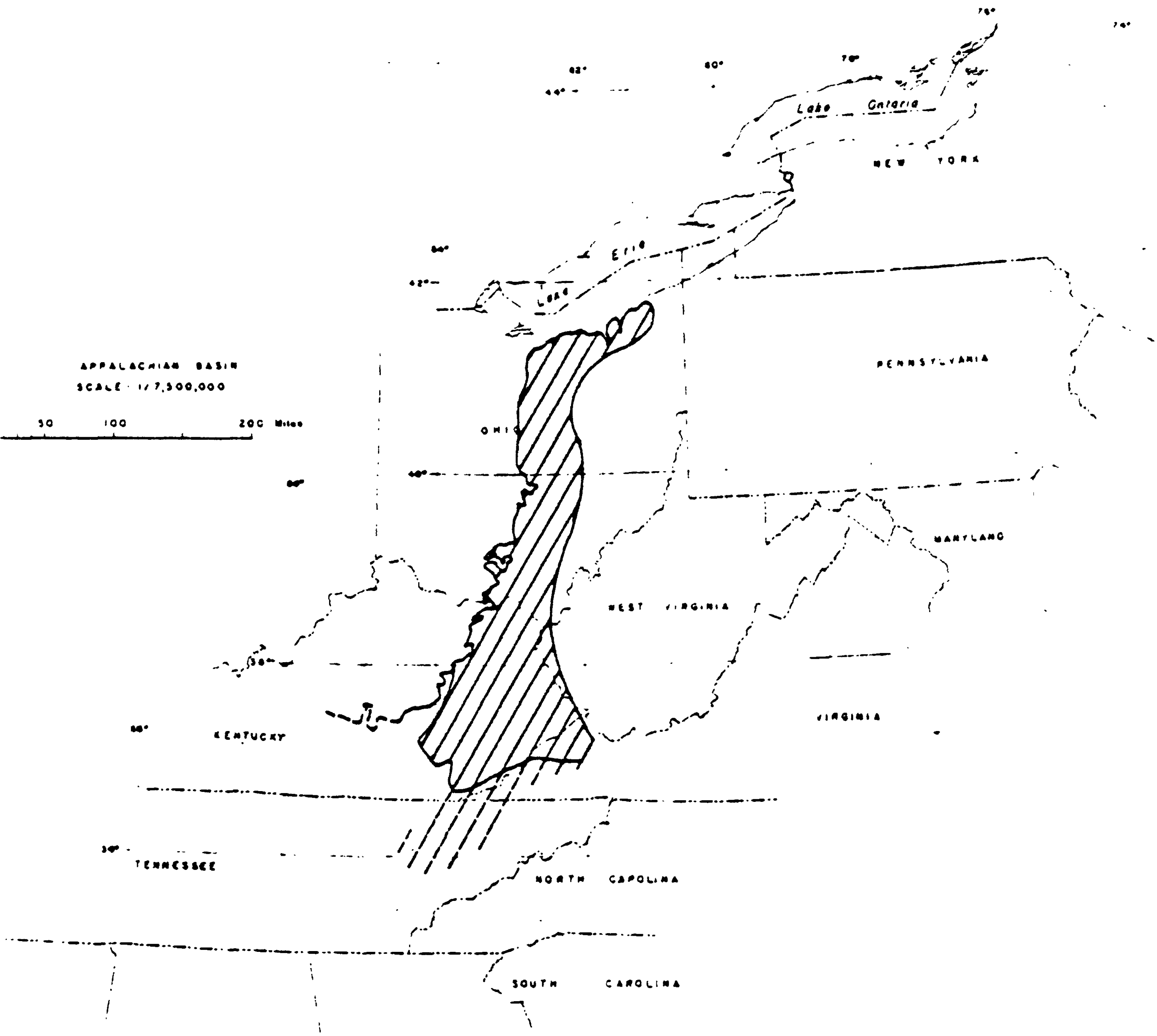

Figure 25. Map showing the areal extent of the Cleveland Member of the Ohio Shale. Dashed where recognized in subsurface only.

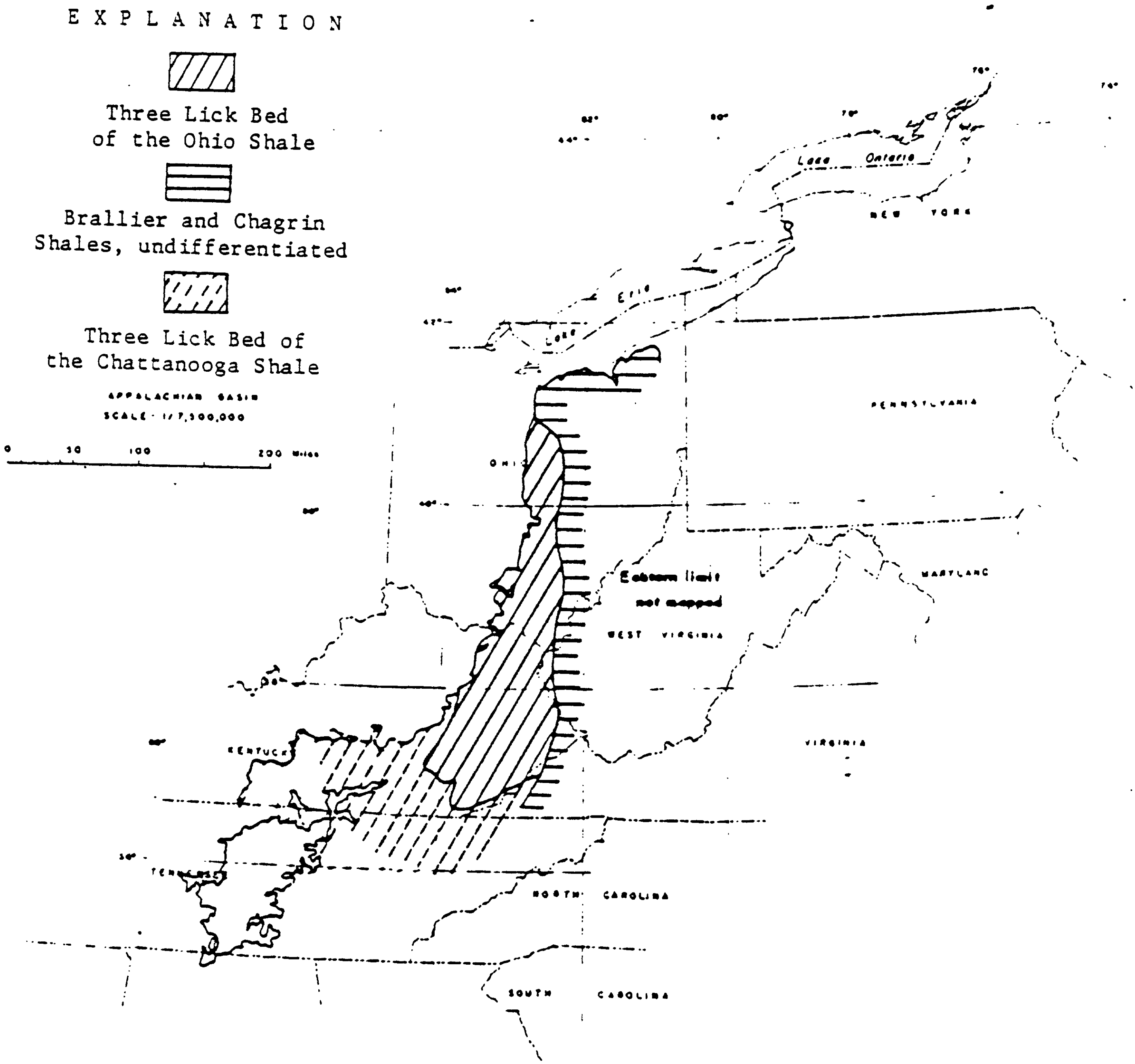

Figure 26. Map showing the distribution of the Three Lick Bed of the Ohio and Chattanooga Shales and the equivalent Chagrin Shale

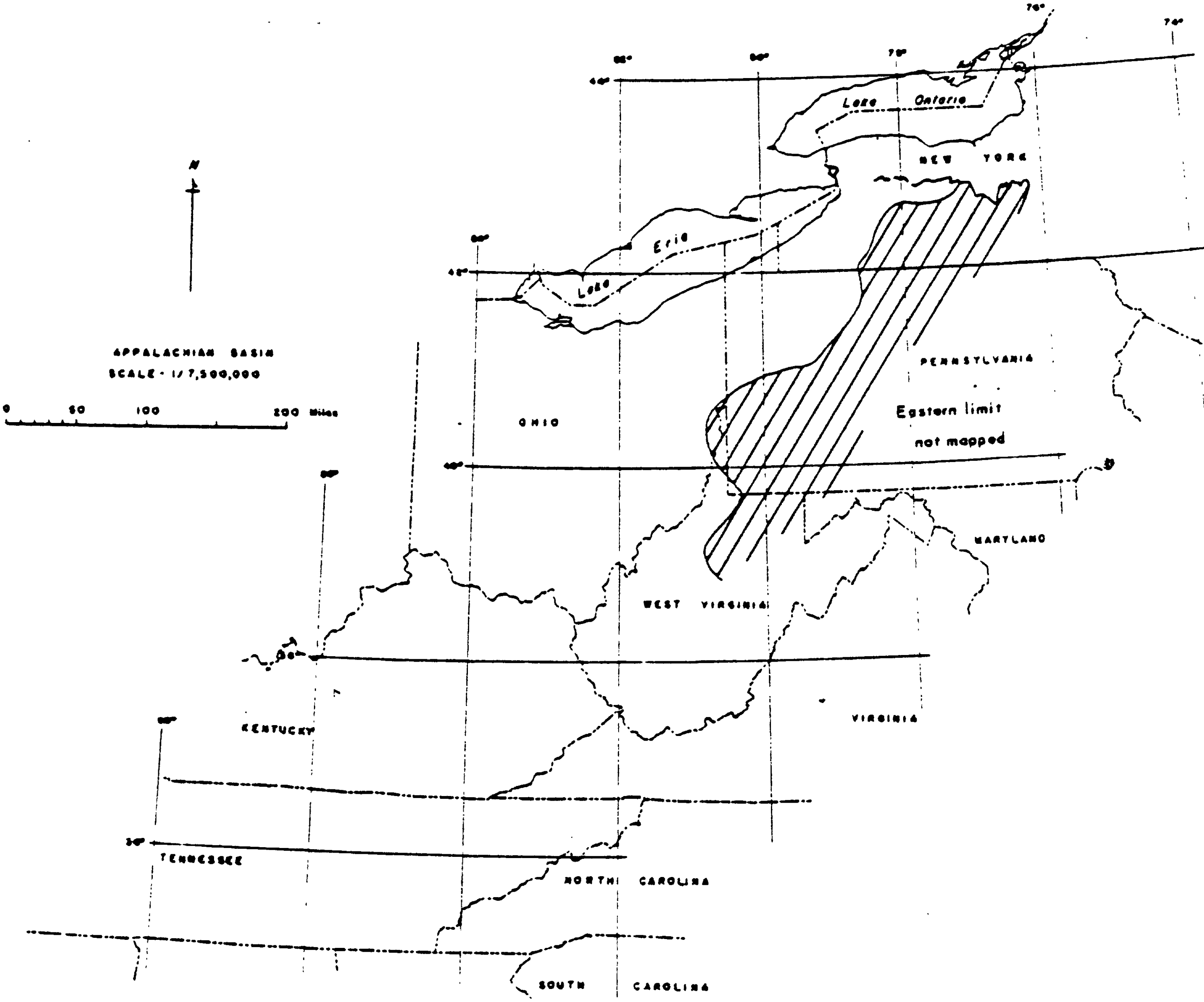

Figure 27. Map showing the areal extent of the Tully Limestone

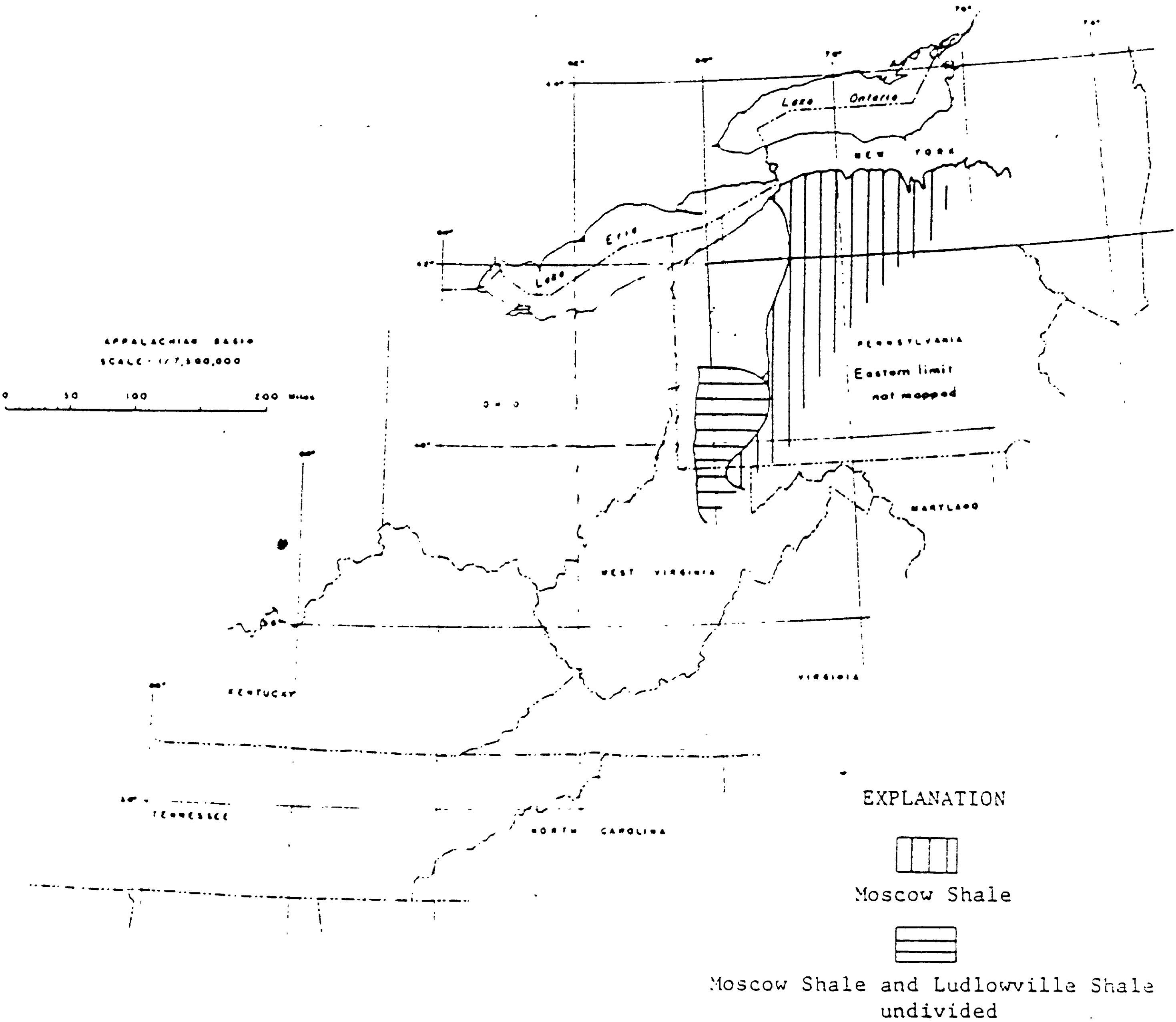

Figure 28. Map showing the areal relationship of the Moscow Shale and the undivided Moscow and Ludlowville Shales

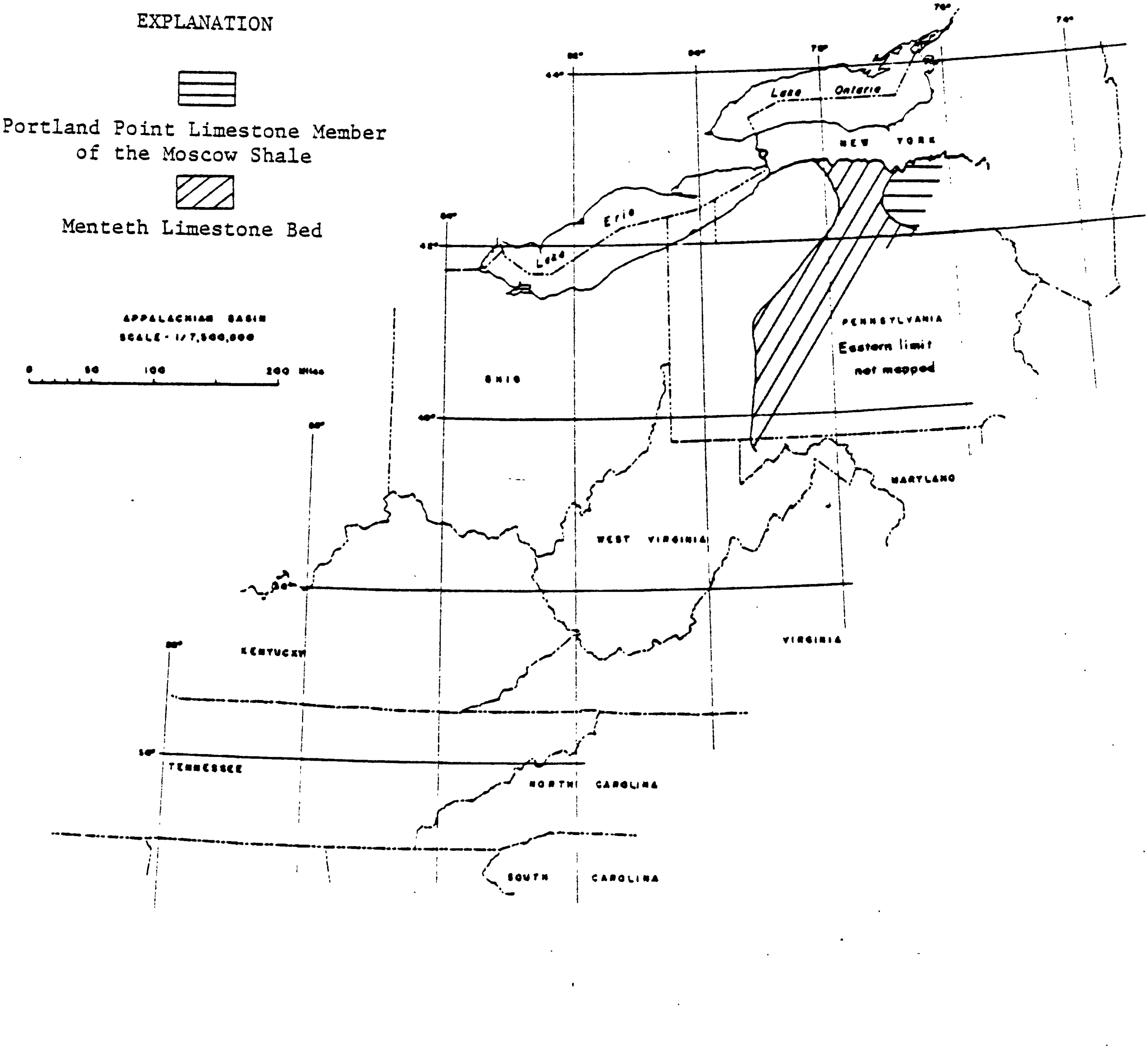

Figure 29. Map showing the areal extent of the Menteth Limestone Bed, the upper tongue of the Portland Point Limestone Member of the Moscow Shale

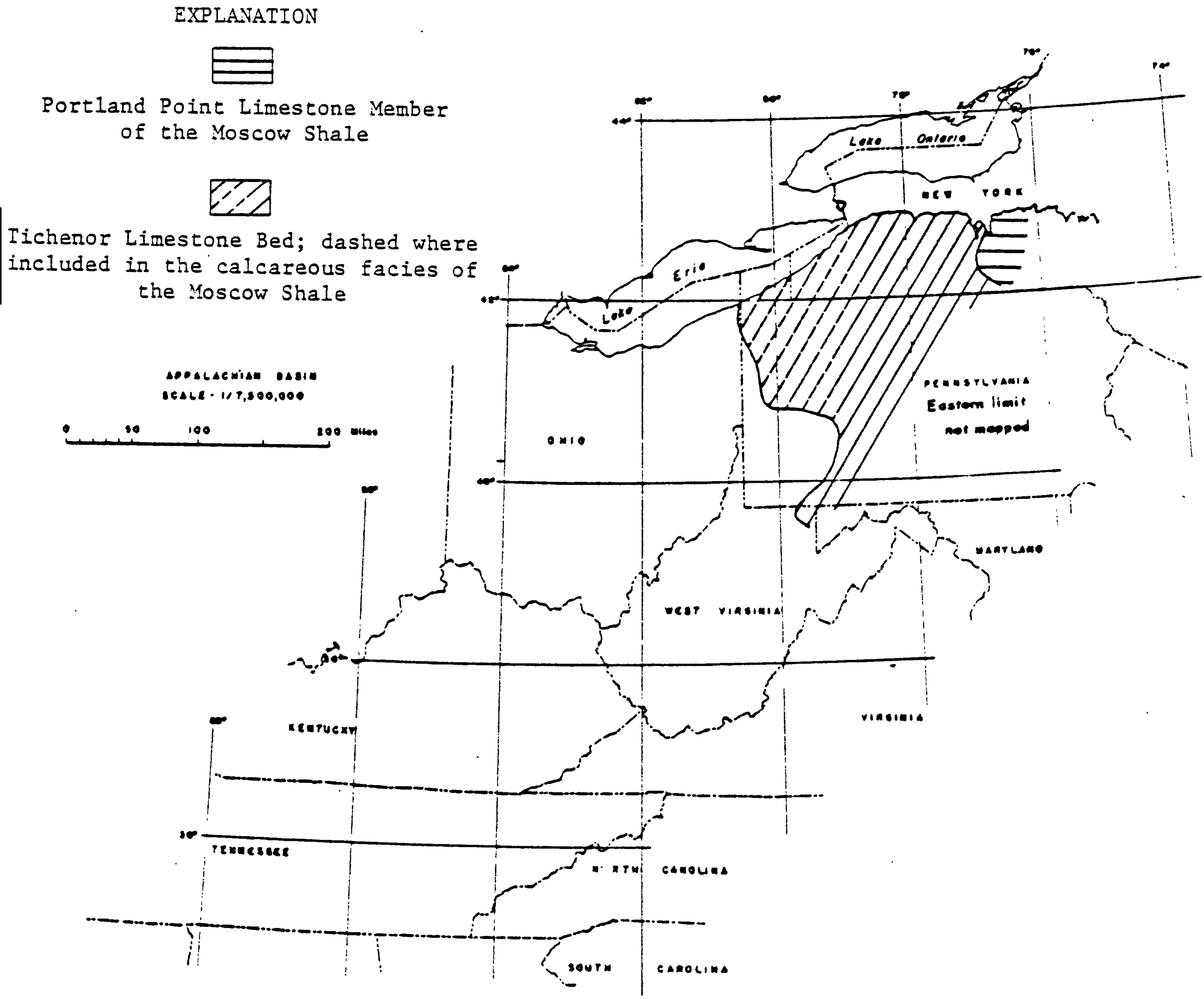

Figure 30. Map showing the areal extent of the Tichenor Limestone Bed, the lower tongue of the Portland Point Limestone Member of the Moscow Shale

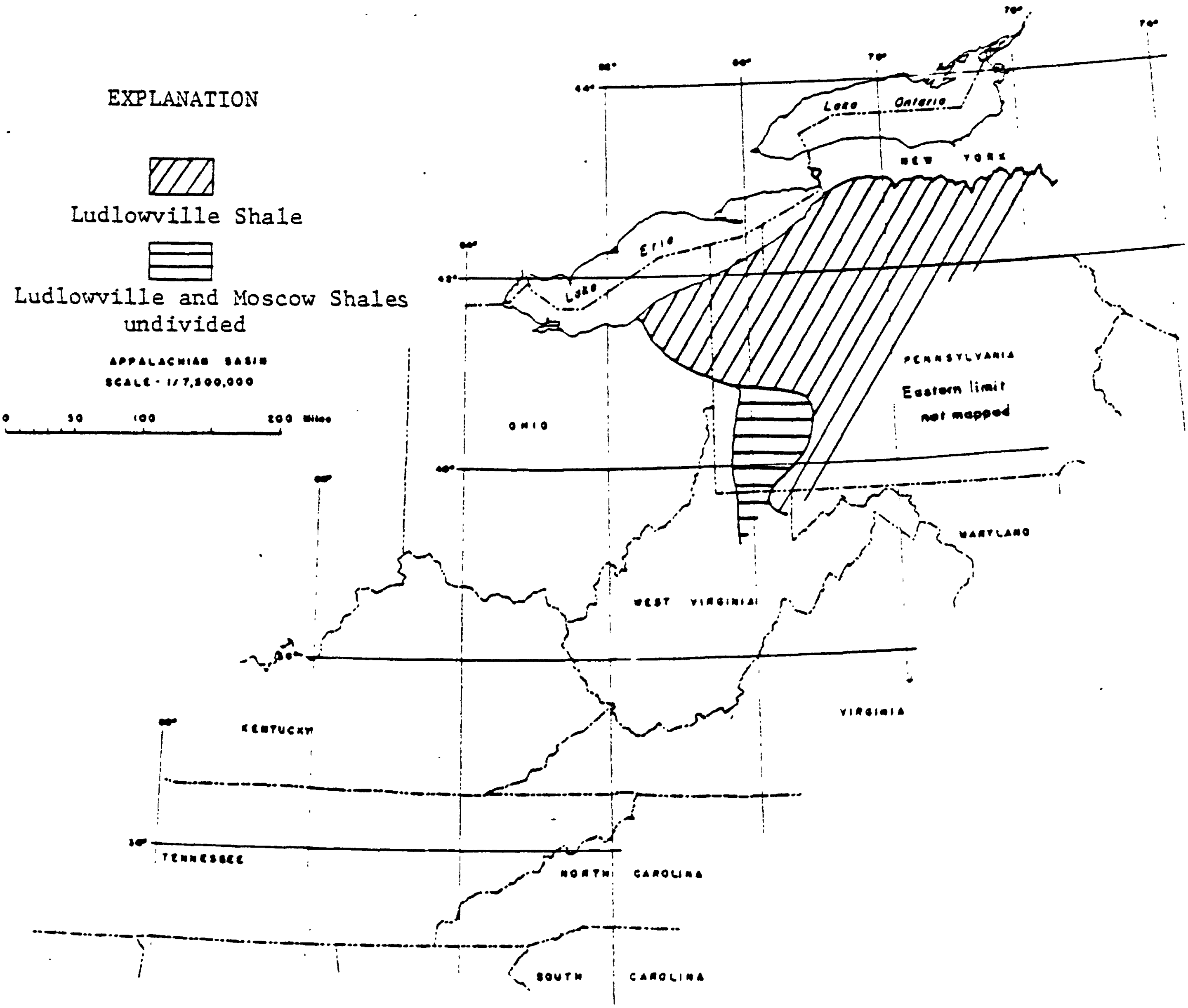

Figure 31. Map showing the areal extent of the discrete Ludlowville Shale and the undivided Ludlowville and Moscow Shales

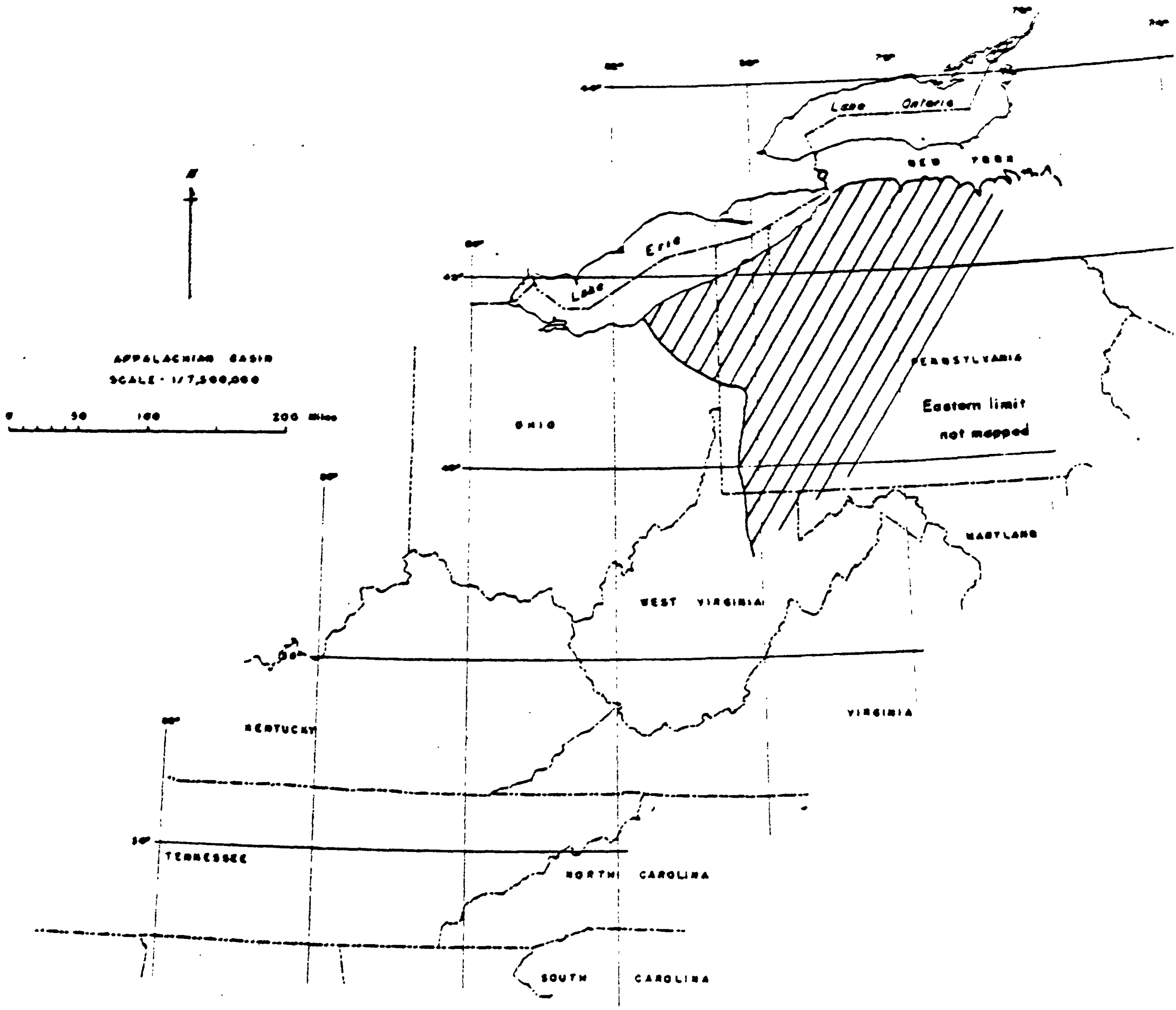

Figure 32. Map showing the areal distribution of the Centerfield Limestone Member of the Ludlowville Shale

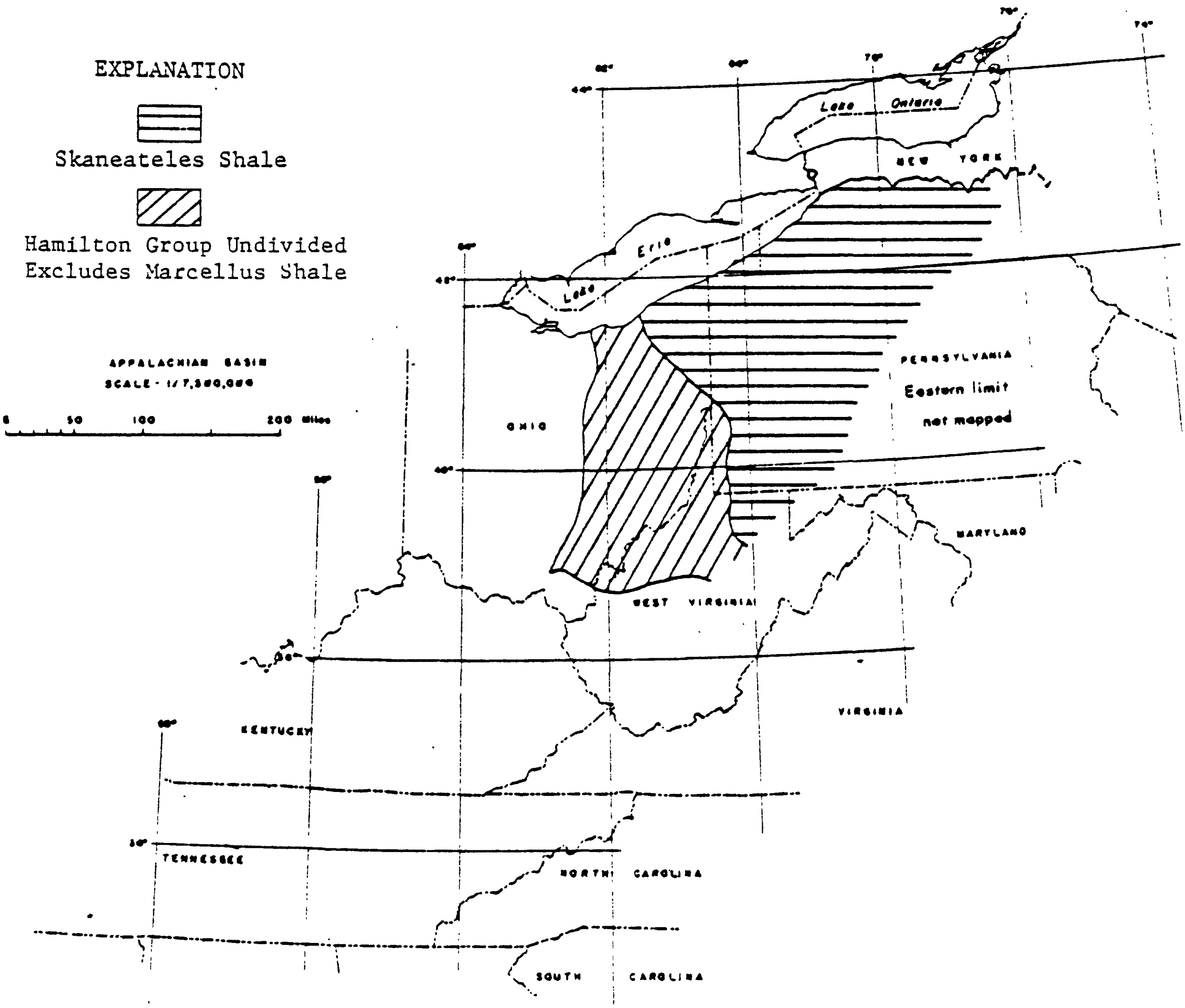

Figure 33. Map showing the areal extent of the discrete Skaneateles Shale and the undivided Hamilton Group, excluding the Marcellus Shale

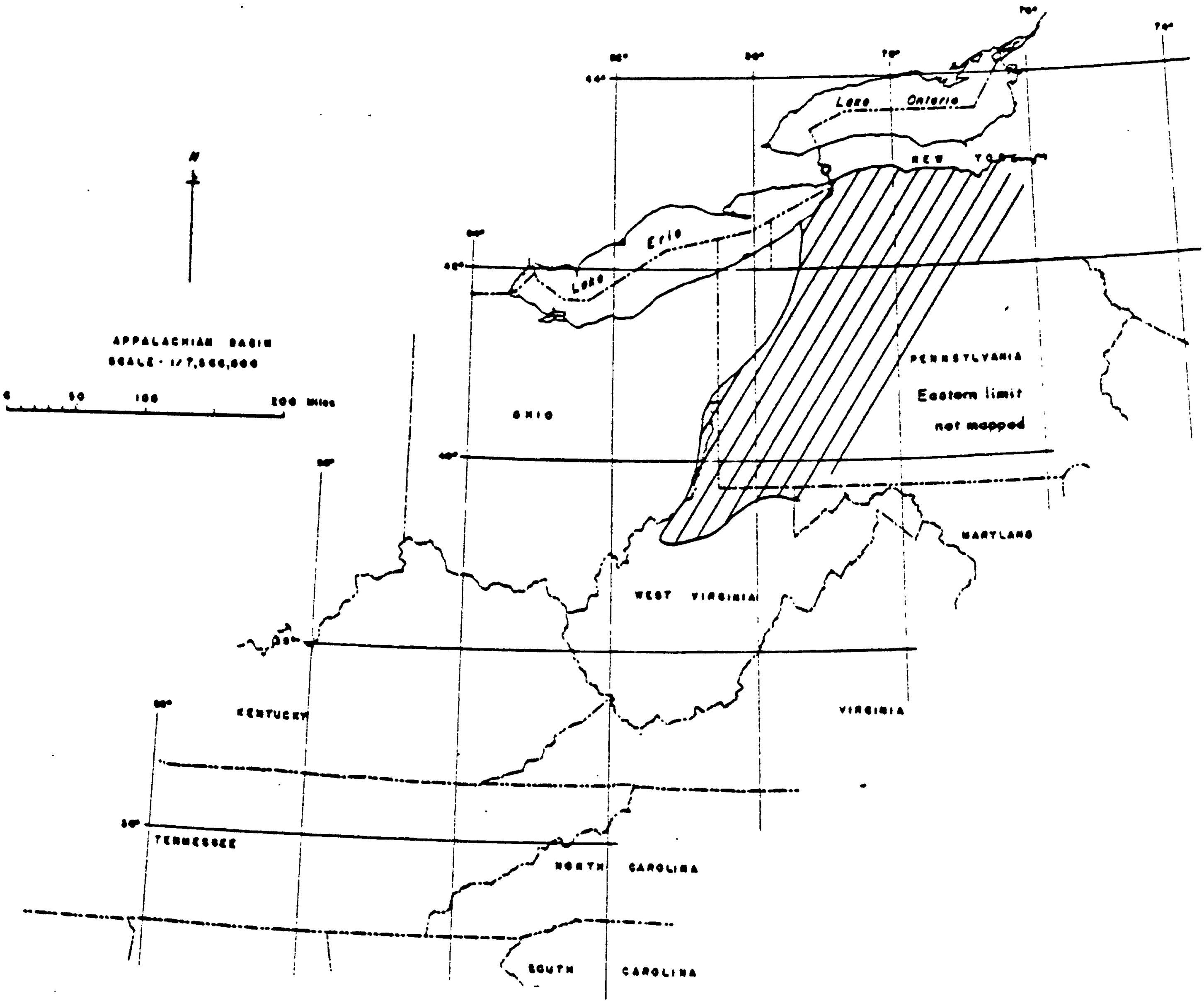

Figure 34. Map showing the areal extent of the Stafford Limestone Member of the Skaneateles Shale

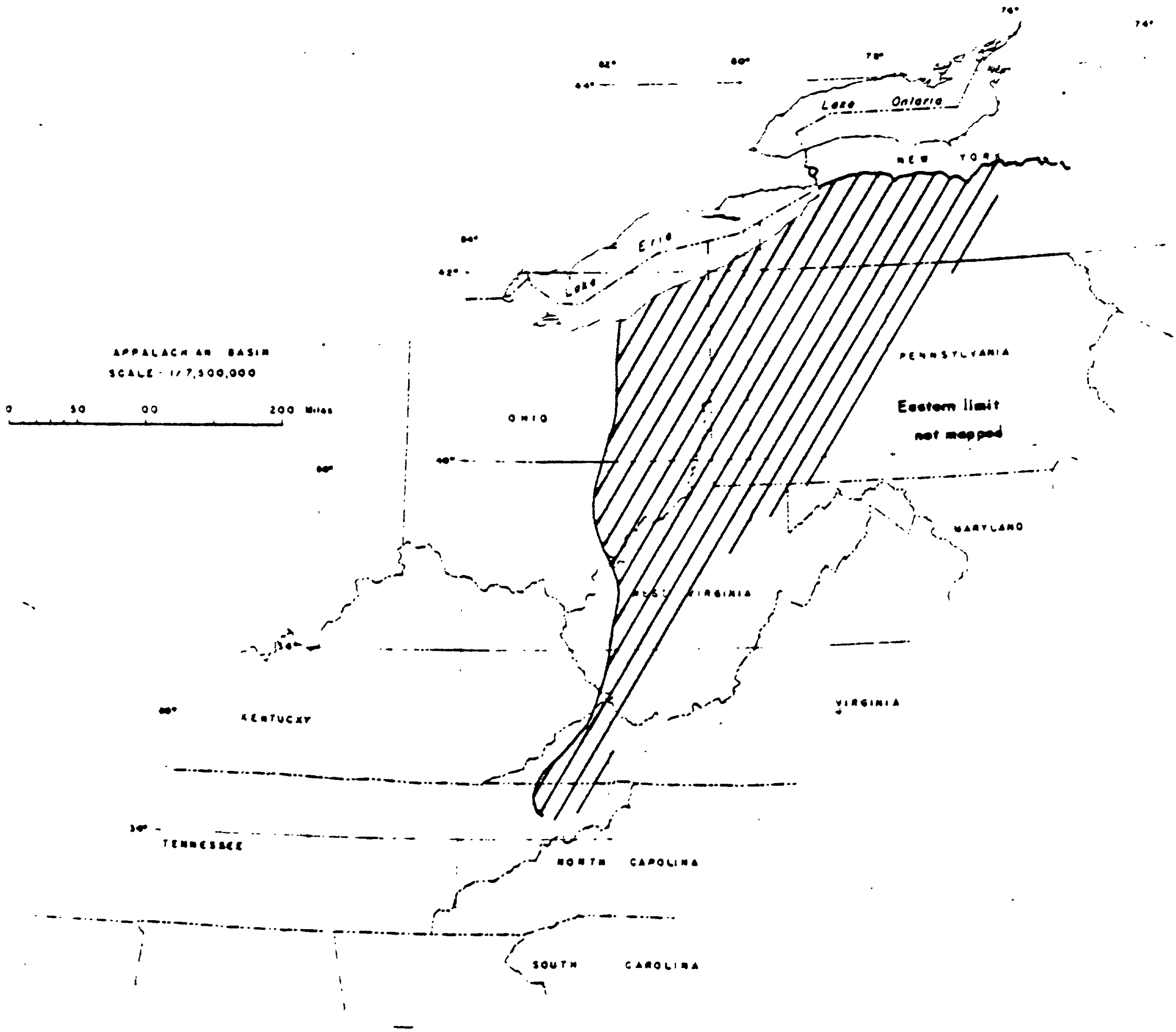

Figure 35. Map showing the areal extent of the Marcellus Shale

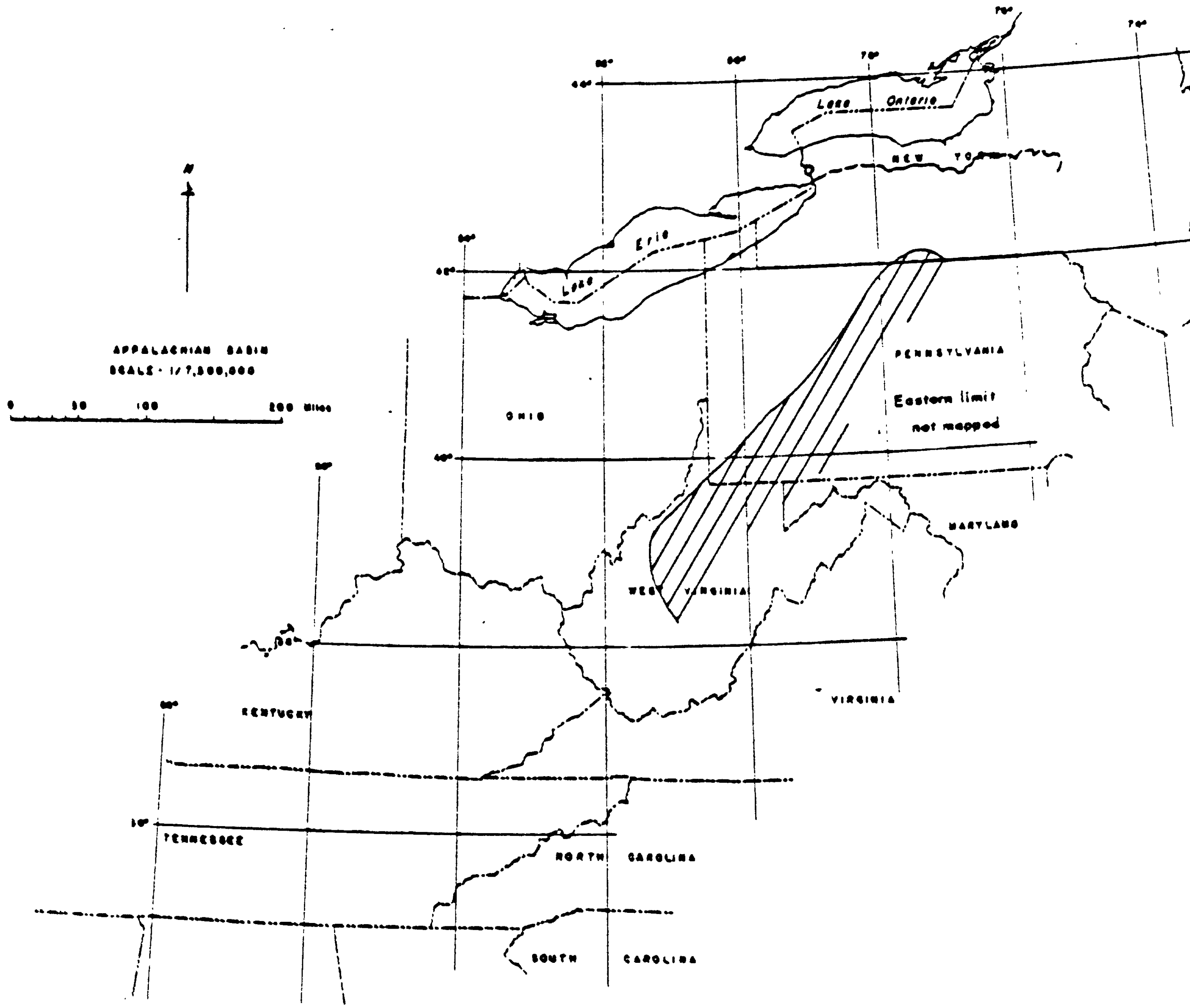

Figure 36. Map showing the areal extent of the Purcell Limestone Member of the Marcellus Shale

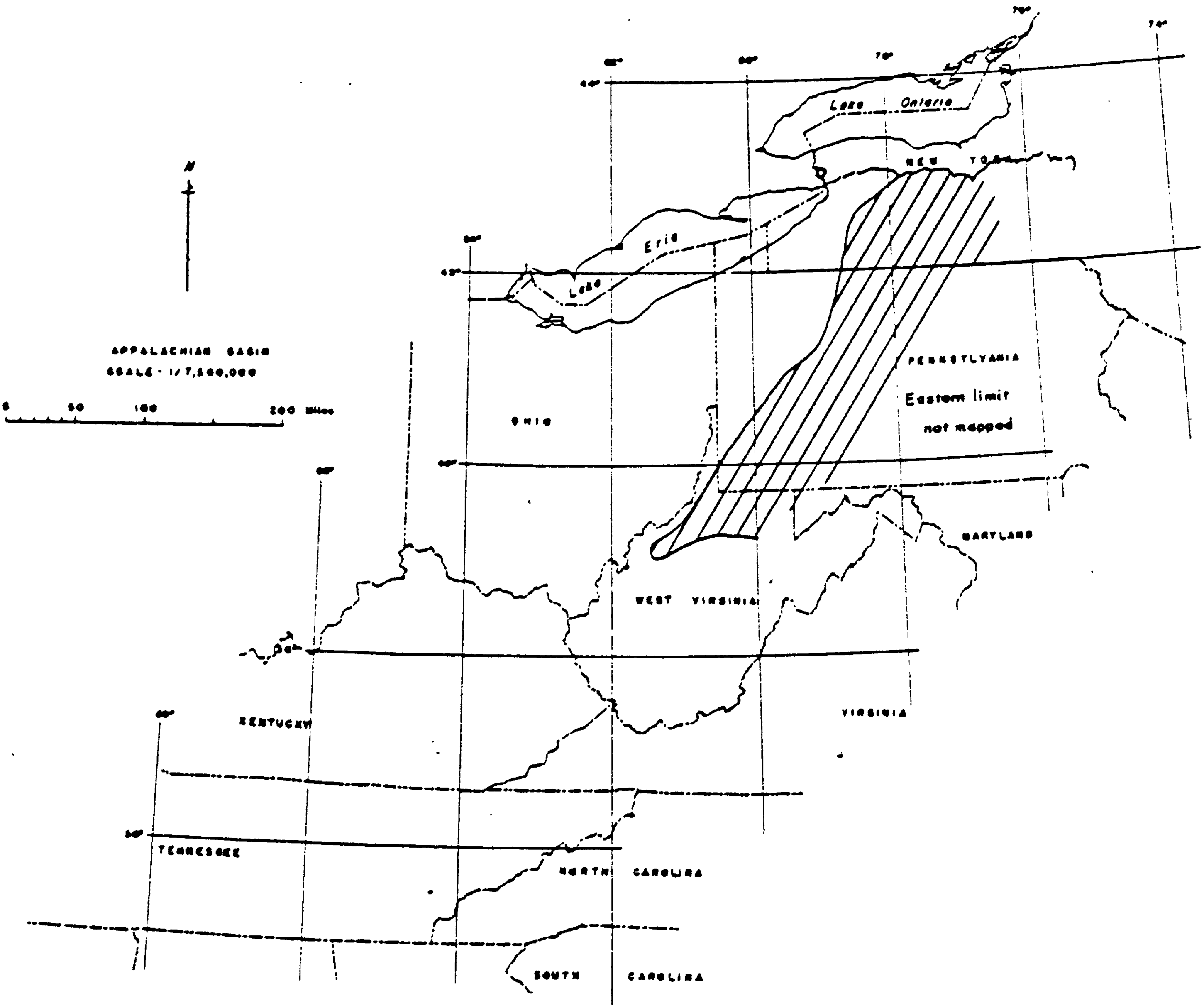

Figure 37. Map showing the areal extent of the Cherry Valley Limestone Member of the Marcellus Shale

LOCALITY REGISTER

List of wells and outcrops used in the stratigraphic cross sections. Numbers are keyed to the index map (plate 2) and the cross sections (plates 3-12). Depth and elevation in feet. TD, total depth; Elev., elevation of well site measured to the kelly bushing (kb), derrick floor (df), or ground level (gl).

1 Scott Co., Tenn.
8-A-62
Howard Atha #1
Ketchen Coal Co.
TD 7533; Elev. 1779 kb

2 Owsley Co., Ky.
22-L-69
Hale #1
Bowman
TD 1442; Elev. 980

3 Rowan Co., Ky.
Interstate I-64
Outcrop Section
(Provo and others, 1977)

4 Rowan Co., Ky.
4-T-75
Jones #1
Pennzoil
TD 4491; Elev. 1199 kb

5 Carter Co., Ky.
3-V-77
Stamper #1
United Fuel Gas Co.
TD 5080; Elev. 857 kb

6 Adams Co., Ohio
Tener Mountain
Outcrop Section
(Provo and others, 1977)

7 Pike Co., Ohio
Seal Twp., Sec. 13
Clarence Anderson #1
Continental Oil Co.
TD 1441; Elev. 696 kb
Permit #24
API #34-131-06001

8 Ross Co., Ohio
Sec. 9
Coffman #1
Hall & Coffman
TD 3809; Elev. 735 gl
(Geo-Log)

9 Licking Co., Ohio
Union Twp.
Garland Adams #1
Burrell Petroleum Co.
TD 4214; Elev. 1076 df, 1074 gl

10 Licking Co., Ohio
Hartford Twp.
F. W. Canaday #1
W. H. Patten Drilling Co.
Elev. 1165
(Geo-Log)

11 Richland Co., Ohio
Troy Twp., Sec. 34
Tony D. Augustine #1
Hadson Ohio Oil Co.
TD 4400; Elev. 1300 gl, 1309 kb
Permit #323

12 Richland Co., Ohio
Butler Twp., Sec. 30
Mast-Johnson Unit #1
Ashland Oil & Refining Co.
TD 4525; Elev. 1142 kb
Permit #389
API #34-139-00094

13 Ashland Co., Ohio
Ruggles Twp.
S.V. Krause #1
Ohio Oil Co.
TD 5252; Elev. 1114
(Fettke, 1961)

14 Lorain Co., Ohio
Grafton Twp.
R. E. Toole #1
(Louis Kapp) Central Oil Field Supply
TD 2653; Elev. 866 kb
Permit #910 Harrison Twp.
API #34-093-00021

15 Medina Co., Ohio
Brunswick Twp.
Gilbert E. Fuller #2
Natol Corp
TD 3335
Permit #1312

16 Geauga Co., Ohio
Auburn Twp.
Sec 3,
R. & E. Timmons #1
(East Ohio Gas Co.) Quaker State Oil and Refining Corp. Well #1127
TD 4110; Elev. 1216 gl
Permit #26
API #34-055-04004

17 Ashtabula Co., Ohio
Windsor Twp.
Clayin Clark "D" #1
Northern Natural Gas Producing Co.
TD 3970; Elev. 1064 kb
Permit #103

18 Ashtabula Co., Ohio
New Lyme Twp.
Raymond & Vera L. Kaderly #1
(Russell McConnell, Inc.) Texaco, Inc.
TD 6367; Elev. 1053.6 kb
Permit #214

19 Crawford Co., Pa.
Conneaut Twp.
Hart #1
Lake Shore Pipe Line Co.
TD 3772; Elev. 1117 gl
API #37-039-00250

20 Crawford Co., Pa.
Girard I 376
C. Z. Clements
James Drilling Co.
TD 4093; Elev. 1258 gl
API #37-039-00060

21 Erie Co., Pa.
Cambridge Springs D11
Washington Twp.
J. Vanco
Redfern & Herd Inc.
TD 4103; Elev. 1463 gl
API #37-049-00543

22 Erie Co., Pa.
Northeast H30
Venango Twp.
B. Dennee N-988
Consolidated Gas Supply Corp.
TD 7465; Elev. 1463 gl
API #37-049-00569

23 Chautauqua Co., N.Y.
Mina Twp.
H. Carnahan #1
Apache Corp. - Hica Corp.
Elev. 1489 df
API #31-013-19100

24 Chautauqua Co., N.Y.
Pomfret Twp.
Lyle H. Bennett #1
Flint Oil & Gas Co.
Elev. 755 gl
API #31-013-04128

25 Chautauqua Co., N.Y.
Sheridan Twp.
Howard Yonkers #1
Rich & Blodgett
TD 1447 Elev. 875
API #31-013-19101
(Tesmer, 1957)

26 Chautauqua Co., N.Y.
Arkwright Twp.
Houck #4
Meridian Expl. Corp.
Elev. 1240 gl
API #31-013-04030

27 Cattaraugus Co., N.Y.
Perrysburg Twp.
Thomasett
Iroquois Gas
API #31-009-04033

28 Erie Co., N.Y.
Town of Concord
Iroquois Gas Corp. #796
TD 2908; Elev. 1560
API #31-029-00506
(Fettke, 1961)

29 Erie Co., N.Y.
Concord Twp.
Edwin P. Heary #1
Consolidated Gas Supply Corp.
Elev. 1647 kb
API #31-029-11439

30 Wyoming Co., N.Y.
Middlebury Twp.
Wellman #1
Transamerican Petroleum Corp.
Elev. 1605 gl
API #31-121-00003

31 Knox Co., Ky.
A. Carnes #2
Petroleum Exploration Co.
TD 5335; Elev. 1050 gl
API #16-121-04001

32 Perry Co., Ky.
Nicholas Combs
Ky. W. Va. Gas Co. #7239
TD 2734; Elev. 1090 kb
API #16-193-28982

33 Floyd Co., Ky.
Hall Heirs #1
Signal Oil and Gas Co.
TD 13,000
API #16-017-04042

34 Martin Co., Ky.
Columbia Gas Trans. Co. #20336
TD 3457; Elev. 944 kb
API #16-159-31020

35 Lincoln Co., W. Va.
Laurel Hill Dist.
Columbia Gas Trans. Corp. #20403
TD 4080; Elev. 1202 kb
Permit # Lincoln 1637
API #47-043-06008

36 Mason Co., W. Va.
Hannan Dist.
W. F. Johnson #8995-T
United Fuel Gas Co.
TD 4370; Elev. 874 df
Permit # Mason 71
API #47-053-00038

37 Jackson Co., W. Va.
Union Dist.
Eastern Star #1-822
Commonwealth Gas Corp.
TD 5200; Elev. 789 kb
Permit # Jackson 1275
API #47-035-04082

38 Wood Co., W. Va.
Harris Dist.
Alton Phillips #9559-T
United Fuel Gas Co.
TD 6115; Elev. 793 kb
Permit # Wood 594
API #47-107-04004

39 Wood Co., W. Va.
Walker Dist.
Hope A-1-P5175
Phillips Petroleum Co.
TD 6499; Elev. 970 kb, 950 gl
Permit # Wood 518

40 Ritchie Co., W. Va.
Grant Dist.
Lester Metz #1
Adena Petroleum, Inc.
TD 5400; Elev. 832 kb
Permit # Ritchie 3242
API #47-085-00001

41 Wetzel Co., W. Va.
Church Dist.
Chas. Stoneking #1
Smith Oil and Gas Co.
Elev. 1056 gl
Permit # Wetzel 410
API #47-103-06001

42 Greene Co., Pa.
Franklin Twp.
Waynesburg E2
Gordon #1
J. A. Fox et al
TD 8659; Elev. 1395 gl, 1405 kb
Permit # Greene 38
API #37-059-00004

43 Washington Co., Pa.
West Pike Run Twp.
Brownsville D2
Duane Duvall #1
Snee & Eberly and
Peoples Natural Gas Co.
TD 8500; Elev. 1270 gl, 1285 kb
Permit # Washington 173
API #37-125-20173

44 Westmoreland Co., Pa.
Franklin Twp.
Greensburg A3
F. H. Sloan #1
Fox-Coen and Sloan
TD 7418
API #37-129-00078

45 Westmoreland Co., Pa.
Washington Twp.
Freeport H1
Sloan #1
Peoples Natural Gas Co.
TD 7108; Elev. 1222 kb
Permit # Washington 422
API #37-129-00079

46 Armstrong Co., Pa.
Elders Ridge D47
Heasley #43
Peoples Natural Gas Co.
TD 7450; Elev. 1969 df
Permit #1594D
API #37-005-04104

47 Armstrong Co., Pa.
Rural Valley E4
Martin #1
Peoples Natural Gas Co.
TD 15574; Elev. 1480 kb
Permit #1201
API #37-005-04017

48 Clarion Co., Pa.
Clarion D6
H. Ausler #1
Fairman Drilling Co.
TD 5825; Elev. 1270 gl
Permit #247
API #37-031-00006

49 Clarion Co., Pa.
Oil City 12
DUNN-UNG #1
Linn and Patrick (Amoco)
Elev. 1624 gl
API #37-031-04024

50 Forest Co., Pa.
Kingsley Twp.
Sheffield G5
Collins and Clinger #1
E. Linn & Patrick Petroleum
Elev. 1609 gl
Permit #898
API #37-053-04112

51 Warren Co., Pa.
Tidioute A5
Dusenbury #1
P. H. Benedum
Elev. 1714 gl
Permit #257
API #37-123-20257

52 Warren Co., Pa.
Warren F9
Lindbloom #1
Thornton Co.
Elev. 2019 gl
API #37-123-00044

53 Warren Co., Pa.
Kinzua A15
F-180, Collins Co. #1
Felmont Oil Co.
Elev. 1689
Permit #982
API #37-123-00003

54 McKean Co., Pa.
Kinzua A16
Kenwanee W. C. #1
Pennzoil United Inc.
Elev. 1474 gl
Permit #7520
API #37-083-27520

55 Cattaraugus Co., N. Y.
New Albion Twp.
D. Heron #1
Humble Oil and Refining
Elev. 1832 df
Permit #4153
API #1-31-009-00093

56 Wise Co., Va.
Penn.-Va. Corp. #20118-T
Columbia Gas Trans. Co.
Elev. 3464
API #45-195-20178

57 Buchanan Co., Va.
Pittston Coal Co. #9781-T
Columbia Gas Trans. Co.
Elev. 1580
API #45-027-04041

58 McDowell Co., W. Va.
Rose L. Dennis #P-618
Consolidated Gas Supply Corp. #11642
Elev. 1370
API #47-047-04165

59 Mingo Co., W. Va.
Mingo and Wyoming Land #9416
United Fuel Gas Co. #786
Elev. 1556
API #47-059-00001

60 Boone Co., W. Va.
Federal Coal Co. #1021
Consolidated Gas Supply Corp. #11313
Elev. 1299
API #47-005-04008

61 Fayette Co., W. Va.
Kanawha Gauley Coke and Coal #216
Columbia Gas Trans. Corp. #9793
Elev. 1085
API #47-019-04041

62 Gilmer Co., W. Va.
William J. Mohr Heirs #1
Westrans Petroleum Inc. #1978
Elev. 959
API #47-021-06001

63 Lewis Co., W. Va.
Freemans Creek District
A. Woofer #A-455
Allegheny Land and Mineral Co.
Elev. 1160 kb
Permit # 1864
API #47-041-04189

64 Marion Co., W. Va.
Ronald Robe #1
Phillips Petroleum Co. #312
Elev. 1774
API #47-049-20312

65 Preston Co., W. Va.
George F. Guthrie #1
1968 United Producers Funds, Inc. #137
Elev. 1982
API #47-077-00040

66 Somerset Co., Pa.
R. D. Shumaker #1
Shell Oil Co. #V + 10 5716-2
Elev. 2494
API #37-111-00005

67 Somerset Co., Pa.
Quemahoning Twp.
Windber Quad.
Robert F. Henninger #1 Ser. F-146
Felmont Oil Corp. #V + 3 2478-3
and Peoples Natural Gas Co.
Elev. 2018 gl; 2031 kb, 2029 df
API#37-111-00004

68 Cambria Co., Pa.
Johnstown H10
F. W. Heidingsfelder #1
Pennzoil United #V + 11 9943
Elev. 2232 kb
Permit #13
API #37-021-20013 or 37-021-00017

69 Cambria Co., Pa.
Johnstown C12
W. Griffith #4611
Peoples Natural Gas Co., #V +11 10465-3
Elev. 2040 kb, 2026 gl
Permit #17

70 Cambria Co., Pa.
Patton Bl
H. Leiden #1-4361
Peoples Natural Gas Co., #V 2923-4
Elev. 1913 kb
Permit #3
API #37-021-00007

71 Clearfield Co., Pa.
Mid Penn Coal Co. #N-808
Houtzdale Dl
New York State Natural Gas Co.#IV 1844-3
Elev. 1580 kb
Permit #356
API #37-033-00332

72 Clearfield Co., Pa.
Boggs Twp.
Houtzdale B4
Haupt Heirs #1-4729
Manufacturers Light and Heat #IV 2919
TD 7810; Elev. 1679 kb
Permit #371
API #37-033-00011

73 Clearfield Co., Pa.
Clearfield Trust Co. #1
New York State Natural Gas Co. #11 2252
Elev. 1437
API #37-033-20354

74 Potter Co., Pa.
Renro West C202
Pa. Dept. of F. and W. #ITR-129
N. Y. State Consolidated
Gas Supply Corp. N-972
Elev. 1870 kb
API #37-105-20182

75 Tioga Co., Pa.
Elkland B36
Linder #1
N. Y. State Natural Gas N-832
Elev. 1918
API #37-117-20017

76 Chemung Co., N. Y.
Richards #1
Rio Oil, Inc. (File #4923)
Elev. 1243
API #31-015-00003

77 Chemung Co., N. Y.
Veteran Twp.
Stephen Boor #1
Rio Oil, Inc. (File #4863)
Elev. 1562 gl; 1529 df
API #31-015-00001

78 Tompkins Co., N. Y.
Enfield Twp.
Grund #1
New York State Natural Gas Corp.
(File #4130)
TD 8903; Elev. 1457 df; 1454 gl
API #31-109-00077

79 Cattarangus Co., N. Y.
Freedom Twp.
Robert J. & Minnie Edmunds #1
Columbia Gas Transmission Corp. #20221
Elev. 1744 gl, 1756 kb, 1754 df
API #31-009-111478

80 Allegany County, New York
Hume Twp.
D. A. Wolfer #1
New York State Natural Gas Corp. N868
TD 7560; Elev. 1560 gl, 1573 kb, 1572

81 Allegany Co., N. Y.
Almond Twp.
E.G.S.P., N. Y. #1
National Fuel Gas Supply Corp.,
New York State Natural Gas #6213
Elev. 1840 gl, 1853 kb, 1852 df

82 Steuben Co., N. Y.
Howard Twp.
Richardson Farm #1
J. V. Pizza
API #31-101-10880

83 Steuben Co., N. Y.
Campbell Twp.
G. D. Scudder #1
Richard W. Harding et al
TD 3445; Elev. 1438 gl, 1441 df
API #31-101-00008

84 Mercer Co., Pa.
West Salem Twp.
Shenango A7
Lihan #1
Bert Fields
TD 4792; Elev. 1165 gl
API #37-085-00024

85 Mercer Co., Pa.
Pymatuming Twp.
Emma McKnight #1
Melben Oil Co.
TD 8211; Elev. 960 kb
API #37-085-00021

86 Mercer Co., Pa.
Stoneboro I10
J. V. Johnson #1
United Natural Gas Co.
TD 6140; Elev. 1587 gl
API #37-085-00012

87 Jefferson Co., Pa.
Punxsutawney A62
J. I. Zeedick #1
Consolidated Gas Supply Corp.
TD 7429; Elev. 1539 gl

88 Ashland Co., Ohio
Lake Twp.
Kenneth & Rex Masher #1
Roy Stewart
Permit #1762
KTD 5480

89 Wayne Co., Ohio
Paint Twp.
John L. Cramer #1
Management Central Corp.
API #34-169-04096

90 Stark Co., Ohio
Sandy Twp.
William Rarrie #1
Texaco, Inc.
Elev. 1035 gl, 1045 kb
Permit #2001

91 Carroll Co., Ohio
Lee Twp.
Raymond M. & Cara L. Goddard #3265
The East Ohio Gas Co.
Elev. 1284 gl, 1294 kb, 1293 df
API #34-019-20901

92 Hancock Co., W. Va.
Clay District
Minesinger #1
Humble Oil & Refining Co.
Elev. 1039 gl, 1052 kb

93 Allegheny Co., Pa.
Forward Twp.
C. E. Power Systems #1 Fee
Elev. 759 gl, 769 kb

94 Westmoreland Co., Pa.
Mt. Pleasant Twp.
Donegal Quad.
C. E. Heibal #1
Felmont Oil Corp. F-151
Elev. 1495 gl, 1506 kb, 1505 df
API #37-129-00017

95 Bedford Co., Pa.
Penn Tract 26-B, No. 1
Phillips Petroleum Company
Elev. 2394 gl, 2409 kb
API #37-009-00032

96 Perry Co., Ohio
Hopewell Twp.
Lawrence & Delpha Mitchell #1
Irvin Producing Co.
TD 2940; Elev. 808 df
Permit #2839
API #34-127-06001

97 Perry Co., Ohio
Harrison Twp.
D. W. & M. J. Potts #1
Quaker State Oil Refining Corp.
TD 3549; Elev. 797 df, 795 gl
Permit #2597
API #34-127-06002

98 Morgan Co., Ohio
Morgan Twp.
Benjamin F. Hammond #1
Ohio Fuel Gas Co.
TD 4898; Elev. 1041 kb
Permit #1203
API #34-115-04020

99 Morgan Co., Ohio
Center Twp.
Delbert McMannis Unit #1
Texaco, Inc.
TD 3870; Elev. 892 gl
Permit #1282
API #34-115-04162

100 Washington Co., Ohio
Adams Twp.
Cecil F. Offenberger
Berry Holding Co.
TD 6095; Elev. 949 kb
Permit #3272
API #34-167-04009

101 Pleasants Co., W. Va.
Grant District
William C. Kerns et al #1-5-815
Commonwealth Gas Corp.
Elev. 1085 kb
Permit #667

102 Ross Co., Ohio
Twin & Paxton Twps.
Copperas Mountain
Surface Section

103 Scioto Co., Ohio
Section 5 Valley Twp.
Shisler #1
Continental Oil Company
TD 1075; Elev. 531 kb
Permit #194

104 Scioto Co., Ohio
Green Twp.
U.S.S. Chemical Division #1 Fee
TD 5607; Elev. 557 kb
Permit #212
API #34-145-06001

105 Boyd County, Ky.
22-W-82
C. E. Fannin Estate #537
Inland Gas Co.
TD 7800; Elev. 708 kb

106 Wayne Co., W. Va.
Butler District
2.88 mi. S. 38°07';
2.24 mi. W. 82°30'
Columbia Gas Trans. Co. #20060-T
TD 3598; Elev. 647 kb
Permit #1576
API #47-099-21578-00

107 Lawrence Co., Ky.
10-S-83
Fieger #9557
Columbia Gas Trans. Co.
TD 4037; Elev. 802 df
API #16-127-04023

108 Martin Co., Ky.
19-Q-84
Jasper James et al #8610T
United Fuel Gas Co.
TD 13172; Elev. 659 kb
API #16-159-00001

109 Pike Co., Ky.
3-K-87
Kentland Coal & Coke #9697
Columbia Gas Trans. Co.
TD 4944; Elev. 1293 df
API #16-195-04060

110 Buchanan Co., Va.
450' S 37°10';
4900' W 82°07'30"
J. W. Pobst #9722-T
Columbia Gas Trans. Co.
TD 7296; Elev. 1683 kb
API #45-027-04032

111 Scott Co., Va.
6400' S 36°40';
4500' E 82°20'
Ed Smith #1
Tidewater - Wolfs Head
TD 7222; Elev. 1468 kb

112 Scott Co., Va.
Duffield 7 1/2' Quad.
Duffield Section
36°42'41" N; 82°47'45" W
1900 FNL; 1200 FWL; 13-C-81

113 Hawkins Co., Tenn.
Kyles Ford 7 1/2' Quad.
Little War Gap Section
36°30'16" N; 83°01'00" W
1600 FSL; 0 FEL; 21-A-78E

114 Hawkins Co., Tenn.
Pressmens Home 7 1/2' Quad.
Anthony Lucas Property
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #4 core hole
761,500 N; 2,855,050 E
TD 1525.1; Elev. 1245 gl
API #41-073-1002

114 Hawkins Co., Tenn.
Pressmens Home 7 1/2' Quad.
Anthony Lucas Property
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #5 core hole
759,000 N; 2,855,900 E
TD 275; Elev. 1350 gl
API #41-073-1002

115 Grainger Co., Tenn.
Bean Station 7 1/2' Quad.
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #8 core hole
724,300 N; 2,783,400 E
TD 915.6; Elev. 1080 gl
API #41-057-1003

116 Grainger Co., Tenn.
Avondale 7 1/2' Quad.
Gruy Federal #1
Eastern Gas Shales Project -
Tennessee #9 core hole
36°18'56" N; 83°24'33" W
710,300 N; 2,762,000 E
TD 1920; Elev. 1140 gl

117 Grainger Co., Tenn.
Avondale 7 1/2' Quad.
Doyle Wynn Property
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #7 core hole
709,550 N; 2,747,000 E
TD 1294.0; Elev. 1130+ gl
API #41-057-1002

118 Grainger Co., Tenn.
Joppa 7 1/2' Quad.
David Wilson Property
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #6 core hole
682,500 N; 2,700,950 E
TD 486.0; Elev. 970+ gl
API #41-057-1001

119 Campbell Co., Tenn.
Jacksboro 7 1/2' Quad.
Lindsay Land #2
Geo. Inc.
36°17'17" N; 84°12'32" W
Elev. 1660+ gl

120 Roane Co., Tenn.
Harriman 7 1/2' Quad.
Emory Gap Section
35°54'53" N; 85°35'39" W
700 FNL; 3200 FEL; 1-8S-59E

121 Bledsoe Co., Tenn.
Melvine 7 1/2' Quad.
Lowe Gap Section
35°43'11" N; 85°01'02" W
1100 FSL; 150 FEL; 9-10S-54E

122 Bledsoe Co., Tenn.
Pikeville 7 1/2' Quad.
Pikeville Section
35°34'53" N; 85°09'47" W.
5300 FSL; 1000 FWL; 5-12S-53E

123 Claiborne Co., Tenn.
Howard Quarter 7 1/2' Quad.
Fred Pearson Farm
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #1 core hole
767,150 N; 2,756,500 E
TD 254.0; Elev. 1100 gl
API #41-025-6001

123 Claiborne Co., Tenn.
Howard Quarter 7 1/2' Quad.
Don Pearson Farm
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #2 core hole
765,900 N; 2,755,300 E
TD 115.6; Elev. 1120 gl
API #41-025-6002

124 Hancock Co., Tenn.
Sneedville 7 1/2' Quad.
Calver Johnson Property
Tennessee Division of Geology
Eastern Gas Shales Project -
Tennessee #3 core hole
803,150 N; 2,836,050 E
TD 755.6; Elev. 1230 gl
API #41-067-1001

125 Wise Co., Va.
Appalachia & Big Stone Gap 7 1/2' Quad.
Big Stone Gap Section
36°52'31" N; 82°46'47" W
3100 FSL; 1100 FWL; 12-E-81E

126 Wise Co., Va.
Rural District
Gladeville Twp.
Flat Gap Quad.
Pennsylvania-Virginia Corp.
Farm Well #20338
Columbia Gas Transmission Corp.
TD 5734; Elev. 2395.47 gl

127 Dekalb Co., Tenn.
Sligo Bridge 7 1/2' Quad.
Sligo Bridge Section
35°58'07" N; 85°42'36" W
700 FSL; 1900 FWL; 8-7S-46E

128 DeKalb Co., Tenn.
Center Hill Dam 7 1/2' Quad.
Hurricane Bridge Section
36°01'58" N; 85°45'05" W
200 FNL; 400 FWL; 20-6S-45E

129 Clay Co., Tenn.
Dale Hollow Dam 7 1/2' Quad.
Pleasant Grove Section
36°32'19" N; 85°26'25" W
1900 FSL; 2000 FEL; 11-A-9E

130 Cumberland Co., Ky.
Burkesville 7 1/2' Quad.
Burkesville Section
36°45'53" N; 85°20'36" W
700 FNL; 1400 FWL; 21-D-50

131 Russell Co., Ky.
Creelsboro 7 1/2' Quad.
Creelsboro Section
36°54'42" N; 85°11'56" W
1800 FNL; 300 FWL; 2-E-52

132 Pulaski Co., Ky.
Delmer 7 1/2' Quad.
Ringgold Road Section
37°06'31" N; 84°41'28" W
3200 FSL; 2250 FEL; 19-11-58

133 Madison Co., Kentucky
Berea 7 1/2' Quad.
Berea Section
37°33'56" N; 84°18'55" W
575 FNL; 600 FWL; 7-M-63

134 Estill Co., Ky.
Panola 7 1/2' Quad.
Good Shepherd Baptist
Church Section
37°42'19" N; 84°02'01" W
1900 FSL; 100 FEL; 13-0-66

135 Powell Co., Ky.
Clay City 7 1/2' Quad.
Clay City Section
37°52'09" N; 83°56'48" W
925 FSL; 900 FWL; 12-Q-67

136 Lewis Co., Ky.
Vanceburg 7 1/2' Quad.
Vanceburg Section
38°35'53" N; 83°19'30" W
700 FNL; 2300 FEL; 25-Z-75

137 Casey Co., Ky.
Liberty 7 1/2' Quad.
Liberty Section
37°20'05" N; 84°54'37" W
500 FSL; 2250 FWL; 25-K-56

138 Casey Co., Ky.
Parksville 7 1/2' Quad.
Minor Branch Section
37°30'42" N; 84°57'15" W
4200 FSL; 1200 FEL; 23-M-55

139 Bullitt Co., Ky.
Brooks 7 1/2' Quad.
Buttonmold Knob Section
38°04'32" N; 85°42'12" W
3200 FSL; 600 FEL; 3-S-46

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