DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1442-B
PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE ALLEGHENY FRONT AND HICKORY CREEK ROADLESS AREAS, WARREN COUNTY PENNSYLVANIA

By

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Studies Related To Wilderness

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses that results of a mineral survey of the Allegheny Front and Hickory Creek Roadless Area, Allegheny National Forest, Warren County, Pa. The two areas were classified as further planning during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The Allegheny Front and Hickory Creek Roadless Areas, hereinafter called the study areas (fig. 1), together comprise 18,123 acres on the western side of the Allegheny National Forest, Warren County, Pa. The Allegheny Front tract comprises 8,696 acres, and the Hickory Creek tract comprises 9,427 acres. The Federal Government owns about 85 percent of the surface rights of the Allegheny Front tract and about 95 percent of the surface rights of the Hickory Creek tract; the remaining surface rights are privately owned. Ninety-six percent of the mineral rights of the Allegheny Front tract and 100 percent of the mineral rights of the Hickory Creek tract are privately owned.

The study areas have a high potential for oil, a moderate potential for gas, and a low potential for salt and construction materials; no evidence of a potential was found for coal or metallic-mineral resources. Oil and gas are the most important mineral resources in the study areas. Natural gas has generally been produced as a byproduct of oil production in the region but is often used as a source of on-site power for pumping units or for local domestic consumption. As of 1980 the Allegheny Front tract contained one producing oil pool and part of another and the Hickory Creek tract contained part of one abandoned gas field and all or parts of three abandoned oil pools; production was from shallow Upper Devonian sandstones. Oil-field development drilling to sandstones of Late Devonian age is taking place near the boundaries of the Allegheny Front tract and scattered exploration drilling has been done near both tracts. Recently, seismic surveys have been conducted in the general region of the study areas.

A bed of salt more than 50 ft thick occurs in the Late Silurian-age Salina Formation under the southwestern part of the Hickory Creek tract. However, this bed lies at a depth of 3,400 ft below sea level and, more accessible salt deposits are available elsewhere in northwestern Pennsylvania and adjacent New York and Ohio.

Shale form the study areas could be used in structual and decorative clay products such as brick and tile, but there is no clay products industry in Warren County at this time. Sand and gravel have been utilized locally for construction purposes.

The conclusions presented here are based on geologic mapping, examinations of quarries and prospects, a study of drilling records, logs, and production records of wells drilled for oil and gas, and data from a geochemical survey of stream sediments and bedrock.

INTRODUCTION

The Allegheny Front and Hickory Creek Roadless Areas together constitute 18,123 acres on the western side of the Allegheny National Forest, Warren County, Pa. The Allegheny Front tract comprises 8,696 acres, and the Hickory Creek tract comprises 9,427 acres. The two tracts are about 7 and 12 mi, respectively, southwest of Warren, Pa.; they are accessible from Warren via State Route 337. About 7.5 mi southwest of Warren, State Route 337 lies near the eastern boundary of the Allegheny Front tract. Continuing for another 5 mi, southward from Warren, Route 337 lies near the northwestern boundary of the

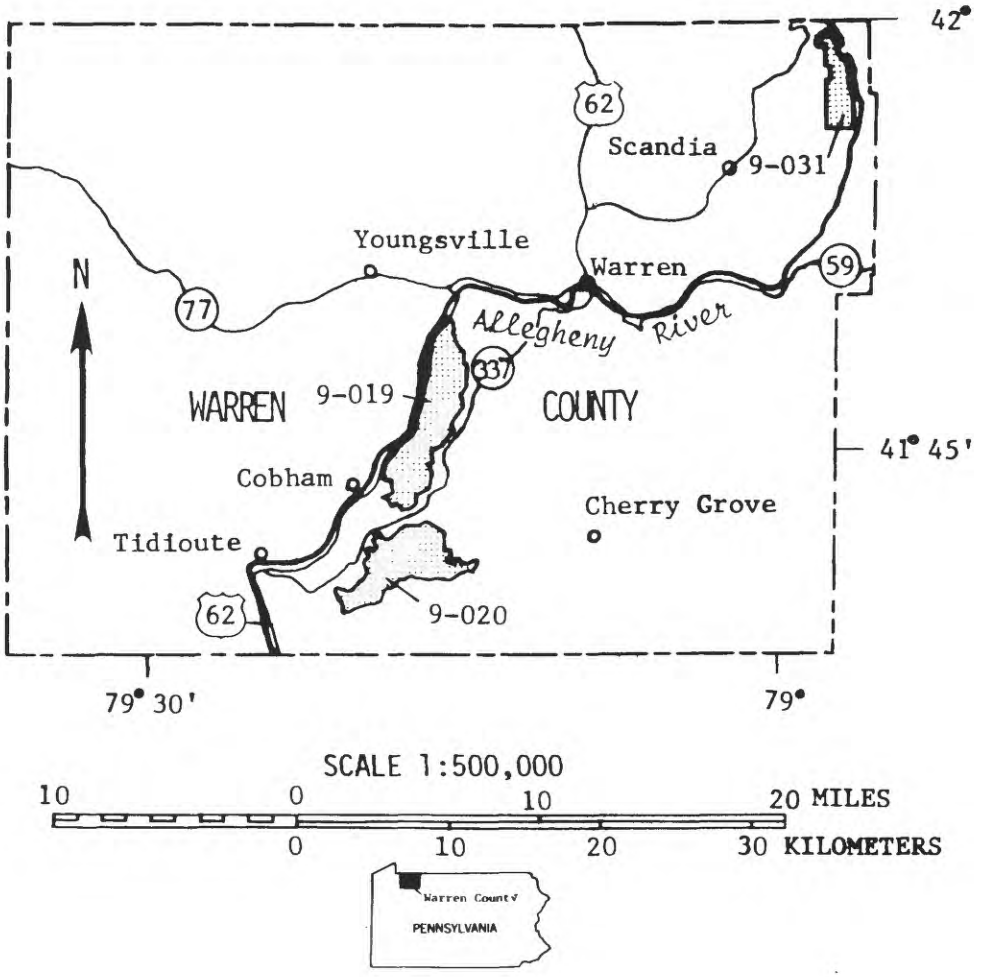

Figure 1.—Index map showing the locations of Allegheny Front (9-019), Hickory Creek (9-020), and Cornplanter (9-031) Roadless Areas, Allegheny National Forest, Warren County, Pennsylvania. Individual tracts (shaded) are designated by their Forest Service numbers. (The Cornplanter area is the subject of a separate report by Lesure and others, 1983.)

Hickory Creek tract. The two tracts are also accessible via U.S. Route 62 which lies along the western boundary of the Allegheny Front tract, and which leads to the Hickory Creek tract via Tidioute, Pa. and Route 337. Several Forest Service and township roads provide additional access to the study area.

Physiographically, the study areas lie within the Kanawha Section of the Appalachian Plateaus Province (Fenneman, 1930). The plateau surface in the study area locally reaches an altitude of about 1,900 ft. Topographic relief averages about 750 ft in the Allegheny Front tract and about 630 ft in the Hickory Creek tract. The study areas lie at the northern edge of the Appalachian coal field.

Past Investigations

The geology of Warren County and of the surrounding area was discussed by Carll (1880 and 1883). Charles Butts (1910) described the geology of the Warren 15-minute quadrangle, which includes a part of the eastern side of the Allegheny Front tract. K. E. Caster (1934) made important contributions to the stratigraphy and paleontology of northwestern Pennsylvania. W. E. Edmunds (1977a, b, c, and d) compiled surface-geologic maps of the Sheffield, Tidioute, Warren, and Youngsville 15-minute quadrangles from field reconnaissance and a variety of other sources; portions of these quadrangles comprise the study areas.

Reports on the oil and gas geology of the Tidioute (Catheart and others, 1938), the Sheffield (Ingham and others, 1956), the Youngsville (McGlade, 1964), and the Warren (Lytle, 1965) 15-minute quadrangles have been published by the Pennsylvania Geological Survey. Oil- and gas-well base maps that include the study areas have been published for a large part of northwestern Pennsylvania (Balogh, 1979a and b). Reports covering other commodities in the general area of Warren County include studies of clay and shale (Leighton, 1941), and coal (Sisler, 1932).

Present Investigations

U. S. Geological Survey (USGS) investigations were conducted by Stanley P. Schweinfurth and Nelson L. Hickling in the fall of 1980. Stratigraphic sections were measured, and mappable units and geologic structures were determined in and adjacent to the study area (Schweinfurth and others, 1982). Hickling, assisted by Schweinfurth, conducted geochemical investigations in October 1980 to test for indistinct or unexposed mineral deposits that might be recognized by their geochemical halos. A total of 37 rock samples and 44 stream-sediment samples were collected. These samples were analyzed for as many as 31 elements, including the common metals having the greatest economic importance (Hickling and others, 1983). J. T. Dutro (written commun. 1981) identified fossils in samples from Upper Devonian strata near the north end of the Allegheny Front tract. Wallace deWitt, Jr. performed an evaluation of the oil and natural gas potential of the study areas

U.S. Bureau of Mines (USBM) field reconnaissance was conducted by Vaughn P. Girol and Donald K. Harrison in the fall of 1979. One gravel pit and numerous oil- and gas-well sites in the near the study areas were examined. Forty-five rock samples of sandstone, siltstone, and shale were collected in or near the study areas for analysis. The Bureau of Mines Reno Research Center, Reno, Nev. analyzed all samples spectrographically for 40 elements, and conducted radiometric analyses for uranium and thorium on 21 selected rock samples and neutron-activation analyses for silica on three samples (Girol, 1982). Oil and gas drilling and production records were examined at the Pennsylvania Geological Survey office in Pittsburgh, Pa. and the U.S. Forest Service office in Bradford, Pa. In the summer of 1980, USBM personnel contacted private industry and state organizations to discuss the resource potential of the study areas.

Acknowledgments

The authors thank Arthur A. Socolow and Thomas M. Berg of the Pennsylvania Geological Survey, Harrisburg, Pa. for providing help and guidance on the geology of northwestern Pennsylvania. Appreciation is extended also to K. D. Abel and John A. Harper of the Pennsylvania Geological Survey, Pittsburgh, Pa., and Arthur M. Van Tyne, Alfred University, N. Y., who was with the New York Geologic Survey when field investigations were carried out, for their assistance in evaluating the hydrocarbon potential of the study areas. Quaker State Oil Company of Bradford, Pa., Monroe Resources of Rochester, N. Y., and Shawnee Clinger Oil Company of Warren, Pa. also provided valuable data on the resource potential of the study areas.

Special thanks are due the following personnel of the Allegheny National Forest, U.S. Forest Service: James Schuler, Ranger of the Sheffield District, and Robert L. White, III, for their help and guidance in the field, Garnet J. Wood for information on bedrock outcroppings, and Roger W. Griffin for oil and gas field data.

SURFACE- AND MINERAL-RIGHTS OWNERSHIP

The surface rights of approximately 85 percent of the Allegheny Front tract and 95 percent of the Hickory Creek tract are owned by the U.S. Government; the remaining surface rights are privately owned (fig. 2). Private interests own 96 percent of the mineral rights in the Allegheny Front tract and 100 percent of the Hickory Creek tract (fig. 2). Subsurface rights are often subdivided and individual formations underlying a given parcel of land may be held by different parties. Oil and gas ownership changes frequently; therefore, individual ownership and lease status has not been presented in this report. Quaker State Oil Company currently holds large leases in both areas (C. J. Carlson, Quaker State Oil Company, written commun., 1980): 2,400 acres in the Allegheny Front tract and 1,600 acres in the Hickory Creek tract (fig. 3). Rights-of-way for several pipelines cut across several corners of the Hickory Creek tract and one pipeline right-of-way cuts across the northern end of the Allegheny Front tract (fig. 2).

GEOLOGY

About 900 ft of sedimentary rocks of Late Devonian, Early Mississippian, and Early and Middle Pennsylvanian age crop out in the study area, and about 10,000 to 11,000 ft of older Paleozoic

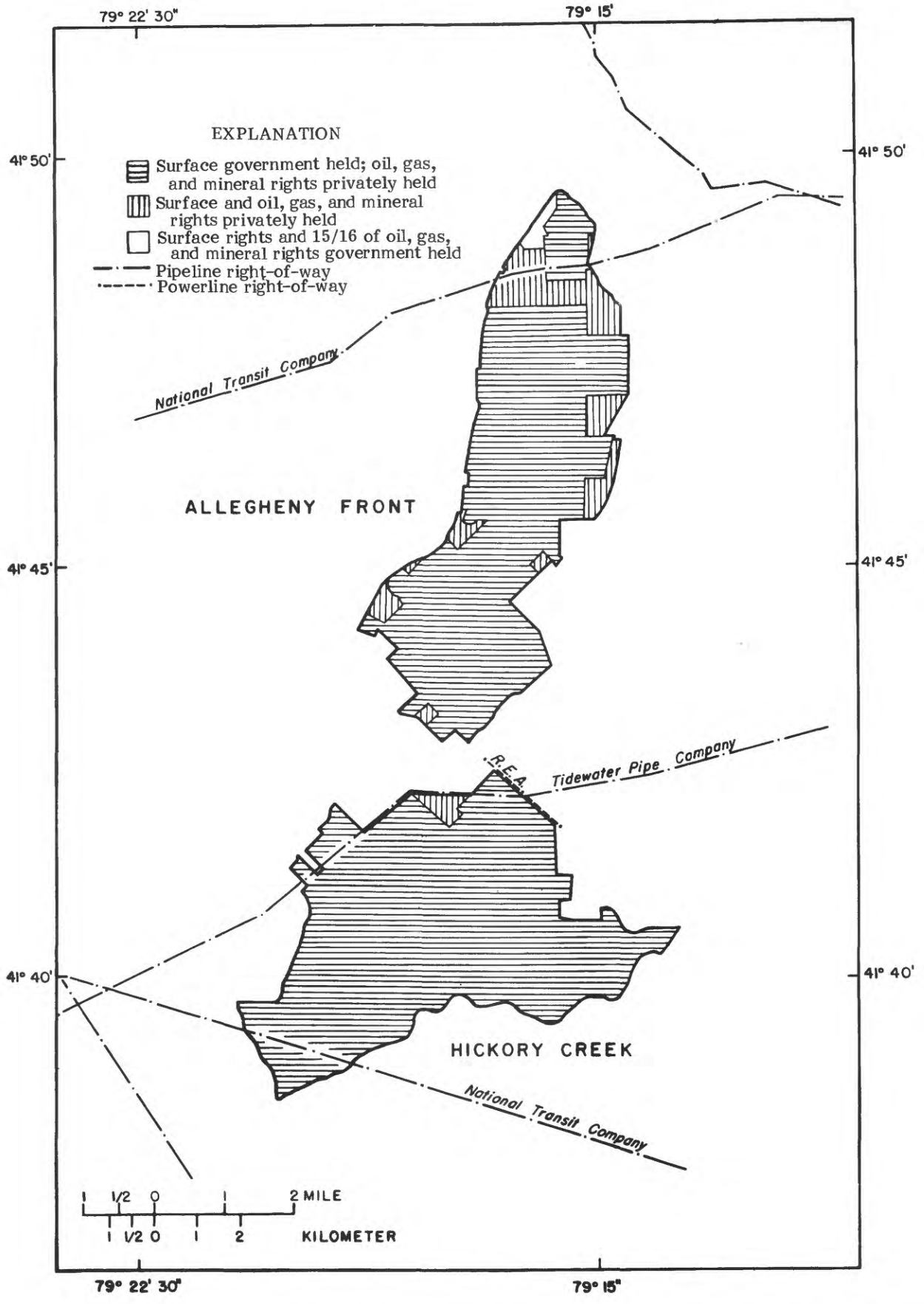

Figure 2.—Surface- and minerals-rights ownership in the Allegheny Front and Hickory Creek Roadless Areas.

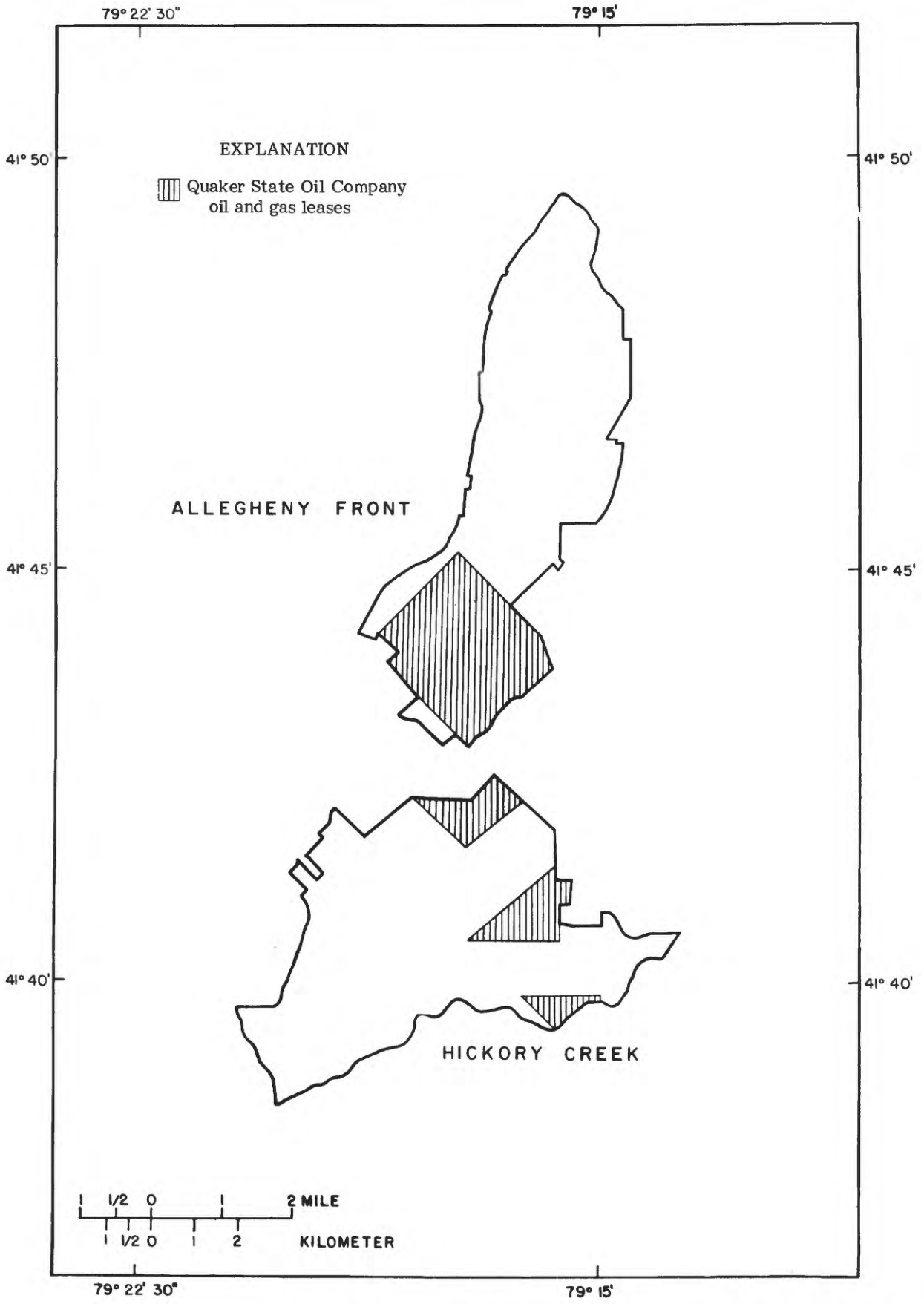

Figure 3.—Oil and gas leaseholdings of the Quaker State Oil Company in the Allegheny Front and Hickory Creek Roadless Areas.

sedimentary rocks may be present in the subsurface (Harris, 1975). The basal part of the exposed stratigraphic section consists of about 305 ft of marine, fine- to coarse-grained clastic rocks which are assigned to the Upper Devonian Venango formation of Lesley (1892). This formation crops out in the lower reaches of stream valleys in the western part of the Allegheny Front tract. The rocks immediately overlying the Venango formation consist of mostly marine, fine- to coarse-grained clastic rocks of Late Devonian and Early Mississippian age. These rocks are very similar to the Venango in texture and color and appear to be conformable with it. This sequence of rocks is not subdivided into separate formations in the study areas as it is elsewhere, and therefore has been mapped as a single unit—the Oswayo and Cuyahoga Formations, undivided—in the study areas (Schweinfurth and others, 1982). The Oswayo-Cuyahoga sequence thickens irregularly from north to south across the study areas, from about 265 to about 460 ft, because of regional tilting to the south-southwest and widespread erosion prior to the deposition of rocks of the overlying Lower Pennsylvanian Olean Formation. Rocks of Late Mississippian age are reported to be absent from the study area (Edmunds and others, 1979, fig. 5).

The Pennsylvanian Olean and Connoquenessing Formations are the uppermost units of consolidated rocks in the study areas and underlie most of the upland surface. These rocks consist of fine-grained to very coarse-grained clastics which appear to be partly marine, or at least near marine, (i.e., brackish) and partly continental in origin (Schweinfurth and others, 1982).

These strata also thicken southward across the study areas from zero in the north to as much as 200 ft in the southeast. This thickening is reversed in the southwestern part of the area, however, because of the absence of the lower member of the Olean Formation. The reduction in thickness due to the absence of the lower member of the Olean is about 40 to 50 ft. The age of the Pennsylvanian rocks in the study areas ranges from late Early to Middle Pennsylvanian (Wanless, 1975, table 2; Edmunds and others, 1979, fig. 5).

Deposits of colluvium mantle most valley slopes. Alluvium, consisting of unconsolidated silt, clay, sand, gravel, and large boulders, underlies many valley floors. Because the study areas are southeast of the maximum extent of Pleistocene glaciation in this area they do not contain accumulations of glacial drift (Butts, 1910, p. 7; Shepps and others, 1959).

A coal bed has been reported to occur at the base of the upper member of the Olean Formation near the study areas (Butts, 1910, p. 6; Ingham and other, 1956, p. 9). This coal bed was correlated with the Upper Marshburg coal bed of Ashburner (1885, p. 325) by Ingham and others (1956, p. 9). They reported that the coal bed is probably too thin and the coal too impure in most of the Sheffield 15-minute quadrangle to be of value except for local use, that it probably does not exceed three feet tin thickness, and that it is generally only one to two feet thick. An abandoned drift coal mine is located in the lowermost part of the upper member of the Olean Formation at a locality a short distance north of the northeastern boundary of the Allegheny Front tract. Butts (1910, p. 9) visited this mine and noted that it had been abandoned sometime before 1910. No additional evidence of coal has been reported by earlier workers or observed by the authors in either of the two roadless areas.

The structural configuration of the study areas is uncomplicated. Evidence of faults or of any other large irregularities was not observed in the rocks exposed at the surface. As reflected by the structure on the top of the Corry Sandstone (Schweinfurth and others, 1982, fig. 4), the pre-Pennsylvanian strata of the area have been tilted slightly downward to the south-southwest and gently warped into several low-amplitude folds that trend southwest. This trend parallels the regional dip, which is only about 20 ft per mile to the southwest. The Pennsylvanian strata of the northern half of the area also dip to the south-southwest, but the amount of dip is slightly less than that of the underlying strata. In the southern half of the area the Pennsylvanian strata are essentially flat lying.

ASSESSMENT OF MINERAL RESOURCES POTENTIAL

Oil and gas are the most important mineral resources in the study areas. Gas has generally been produced as a byproduct of oil production in the region, but is often used as a source of on-site power for pumping units or for local domestic consumption.

Clay, shale, sandstone, and sand and gravel have been produced near the study areas. However, ample supplies of these materials outside of the study areas make development within the study areas unnecessary and unlikely. A thick bed of salt occurs beneath the southwestern part of the Hickory Creek tract but it is deeply buried (3,400 ft below sea level).

Metallic minerals were not observed during the field investigations in or near the study areas and none have been reported in the literature. No major chemical anomalies were found as a result of the geochemical survey (Girol, 1982; Hickling and others, 1983) and the area has a low potential for metallic-mineral resources.

A coal bed has been reported to occur near the study areas (Butts, 1910; and Ingham and others, 1956) but it was not observed in the study areas and the potential for resource of coal in the area is low.

Within the Allegheny Front tract (fig. 4), the Lukens School oil pool, discovered in 1976 on Clark Run, and an unnamed oil pool to the northeast produce oil from sandstone beds of Late Devonian age. At the northern tip of the Allegheny Front tract two test had shows of oil and gas. Pennsylvania Geological Survey records show two plugged oil wells on Charley Run; but no specific data are available.

The Hickory Creek tract has three abandoned oil pools and one abandoned gas field totally or partially contained within its boundaries (fig. 5): the Hickory Creek oil pool, discovered in 1978; the Heart's Content oil pool, discovered in 1934; the Clinger oil pool; and the All Star gas field. All produced from sandstone beds of Late Devonian age. Two tests on Jacks Run also had shows of oil. The Camp Run Field (fig. 5), discovered in 1961 and abandoned in 1964, is a deep gas field which is located immediately to the west of the Hickory Creek tract. This field produced gas from the "Medina" sandstone of Early Silurian age.

Oil produced from the Pennsylvania-New York region has historically served as a standard of quality for the petroleum industry. The oil is a paraffin-base, "sweet", low-sulfur, low-viscosity, and high A.P.I.

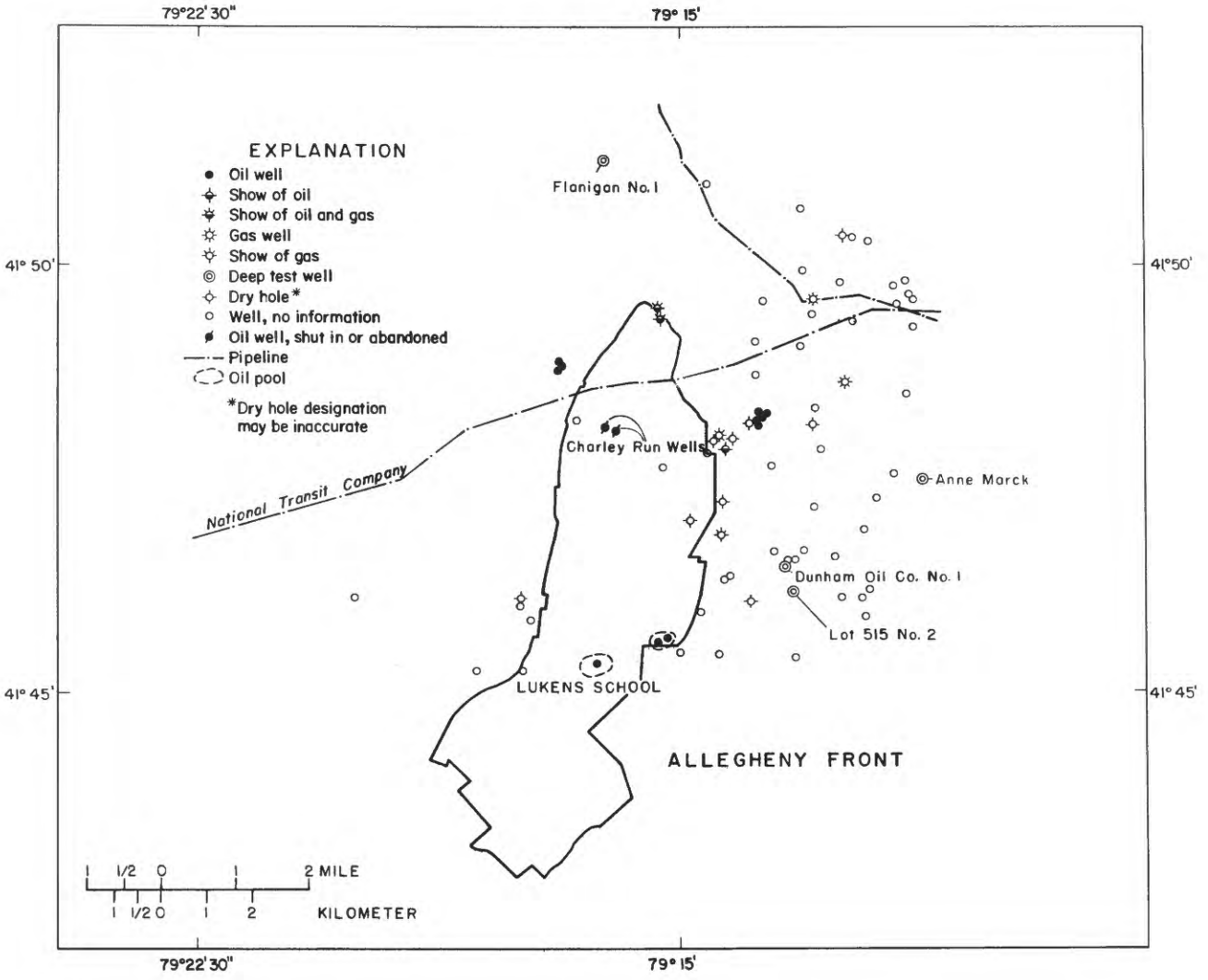

Figure 4.—Oil and gas fields, and shallow and deep oil and gas tests in the near the Allegheny Front Roadless Area.

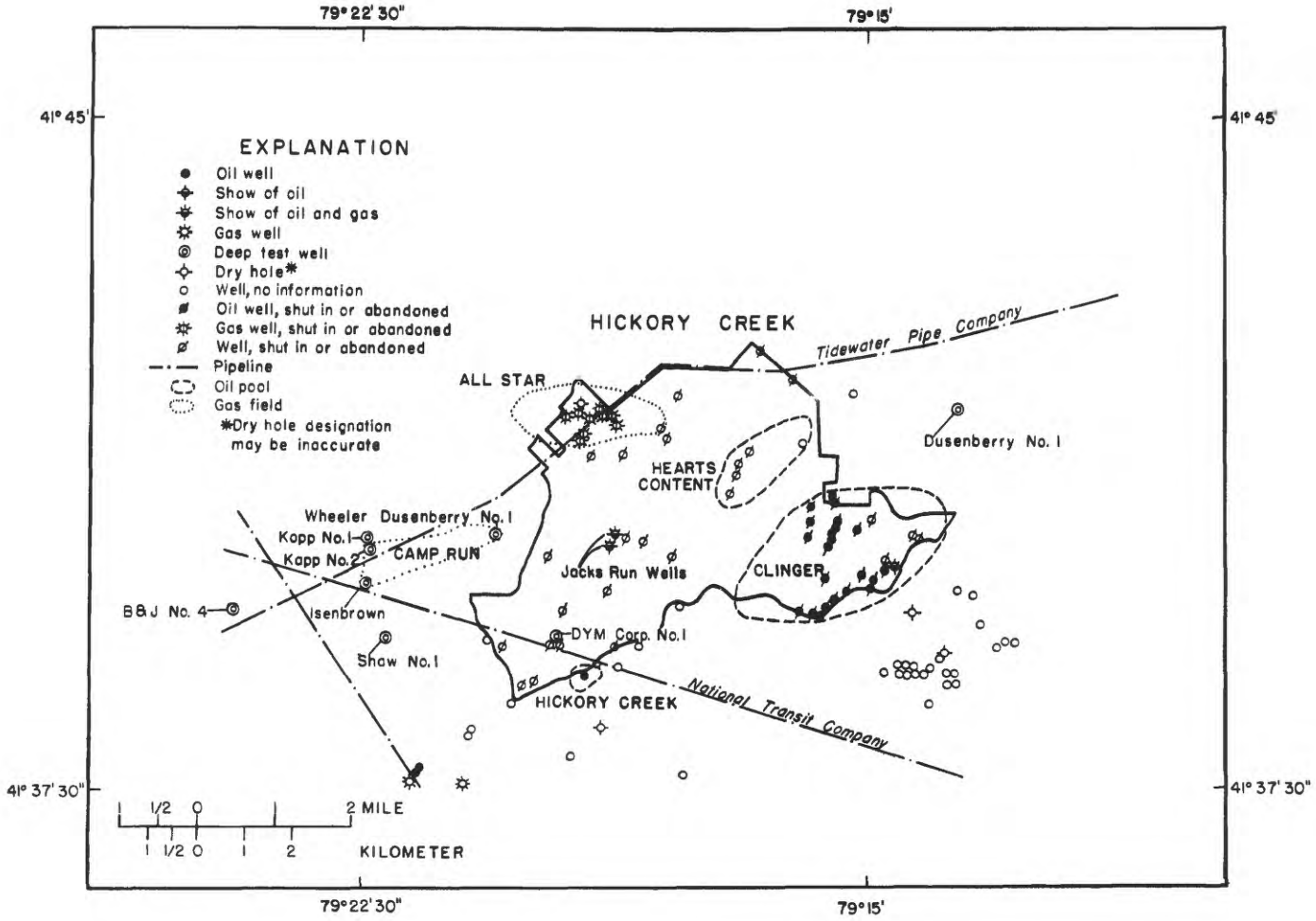

Figure 5.—Oil and gas fields and shallow and deep oil and gas tests in and near the Hickory Creek Raodless Area.

gravity oil that is easily refined. High-quality products are generated without the technical or environmental problems encountered with more abundant high-sulfur oils. Refinery output for oil from this region is 30 to 33 percent lubricating oils, which is 10 to 12 times that of average oil (Van Tyne and Foster, 1980). Thus, despite comprising only 0.5 percent of U.S. crude-oil production, Pennsylvania grade oil is used to manufacture 15 to 20 percent of U.S. lubricating oils (Penn-Bradford Historical Oil Well Museum, 1976) and is in high demand.

Oil and Gas

About 11,000 to 12,000 ft of Paleozoic sedimentary rocks (Harris, 1975), ranging in age from Early Pennsylvanian to Middle(?) Cambrian, underlie the study areas. Of these rocks, sandstone beds of the Upper Devonian Conneaut and Canadaway Groups of Lytle (1965), also known as the well driller's shallow oil and gas sands (Kelly and others, 1970), have a high potential as reservoir rock for oil and gas in the study areas (fig. 6). These sandstone beds are lenticular to sheet-like, fine- to coarse-grained, locally pebbly, and are intercalated in a thick sequence of silty marine shales that contain sufficient organic matter—kerogen—to be the source beds for the oil and gas trapped in the reservoir sandstones. The entire sequence was deposited in the shallow Late Devonian sea adjacent to the Catskill delta complex. The level of thermal maturation of the source rocks adjacent to the sandstone beds reached temperatures adequate for the generation of both oil and gas, as evidenced by the oil and gas fields in Upper Devonian reserviors in and around the study areas (figs. 4, 5, and 7). The potential for additional oil resources in the Upper Devonian reservoirs is high in the study areas, whereas the potential for gas resources in these horizons is moderate because only limited amounts of commerical gas have been discovered in the study areas.

Oil and gas are trapped in the reservoir sandstones by relatively abrupt changes from permable and porous sandstone to tight, impermeable siltstone and shale—typical stratigraphic traps. Locating and exploiting oil and gas in stratigraphic traps is much more difficult in than structural traps because the locations of stratigraphic traps are commonly not evident from overlying strata. The only sure method to determine if the Upper Devonian sandstone beds contain commerical amounts of oil or gas in the study areas is to drill completely through the sandstone sequence, obtain suites of wire-line geophysical logs, and stimulate zones where the logs indicate the possibility of oil, gas, or both.

Much of the 2,500 ft of Upper and Middle Devonian rocks below the oil-bearing sandstone sequence consists of greenish-gray to black marine shale with many intercalated beds of greenish-gray siltstone in the upper part (fig. 6). These shaly rocks, particularly the black shales, are rich in organic detritus—kerogen—and are moderate to good source beds for oil and gas.

Where naturally fractured, the black Devonian shales may be both source and reservoir rock for natural gas. Recent work by Van Tyne and Peterson (1978), Harper and Piotrowski (1978), and Schmoker (1980) shows that these black shales all contain several percent by weight of organic matter and have been locally gas productive to the north of New York (Kreidler and others, 1972; Van Tyne, 1982) and to the north and west in Pennsylvania (Patchen and others, 1982) (fig. 7). The beds of Devonian black shales under the study areas do not appear to be attractive primary drilling targets because of uncertainties in locating and stimulating fractured zones and the considerable drilling depths; however they are certainly secondary targets to be considered in testing the hydrocarbon potential or more deeply buried formations.

The Middle Devonian Onondaga Limestone (fig. 6), which is about 75 to 150 ft thick under the study areas (Oliver and others, 1971), has produced gas from small pinnacle reefs to the northeast in McKean County, Pa., and Steuben County, N.Y. where the sequence is thinner. The reefs appear to be more common and better developed in New York, and the potential for gas resources in the Onondaga Limestone beneath the study areas is low.

The extensive and generally gas-productive Oriskany Sandstone (fig. 6), one of the more important gas sands in the Appalachian basin, underlies the study areas as a sheet less than 25 ft thick (Cate, 1962; Oliver and others 1971; Abel and Heyman, 1981). Deep wells in and adjacent to the study areas encountered noncommercial amounts of gas or oil and generally large amounts of salt water in the Oriskany Sandstone. These data indicate that there is a low potential for resources of gas or oil in the Oriskany beneath the study areas.

The Upper Silurian Bass Islands Dolomite (fig. 6), the uppermost formation in the Silurian sequence in north-central Pennsylvania, or its lateral equivalent, the Akron Dolomite in western New York, has produced 531 thousand cubic ft (MCF) of hydrogen sulfide-containing gas per day from the single-well Boot Jack pool in Elk County, Pa. (Lytle, 1974). It has also produced as much as 500 barrels of oil and 6.53 million cubic feet (MMCF) of gas per day from individual wells along a structural trap in Chautauqua County, N.Y. (Copley and others, 1982; Maslowski, 1983; Petroleum Information, 1983). Noncommerical amounts of gas were found in the Bass Islands Dolomite (Cobleskill Limestone, Fettke, 1961) or the overlying Helderberg Limestone in several deep, cable-tool tests in northwestern Pennsylvania which were drilled prior to 1955 (Fettke, 1950; 1961) (fig. 7). The use of more advanced stimulation techniques and a higher price for gas might well have turned these into commerical wells. Consequently, there is a low to moderate potential for gas resources in the Bass Islands Dolomite beneath the study areas.

The Middle Silurian (Niagaran) Lockport Dolomite (fig. 6) has produced small amounts of gas in southern New York (Van Tyne and Foster, 1980) and western Pennsylvania (Patchen and others, 1982) (fig. 7). A show of gas was encountered in the Biery and Johnson, Kapp No. 1 test, located about 2.1 mi west of the Hickory Creek tract (Girol, 1982) (fig. 5). An area of "reefs" in the Lockport Dolomite has been identified about 5 mi northwest of the study area (Fergusson and Prather, 1968) (fig. 7) and the possibility exists that the reefs may extend southeastward under the study areas. There is a low potential for gas resource in the Lockport dolomite beneath the study area.

Several extensive beds of fine-grained, low-permeability, quartzose sandstone, the "Medina" sandstones of western New York and northwestern Pennsylvania and the equivalent Clinton Formation of Ohio, make up much of the lower Silurian sequence

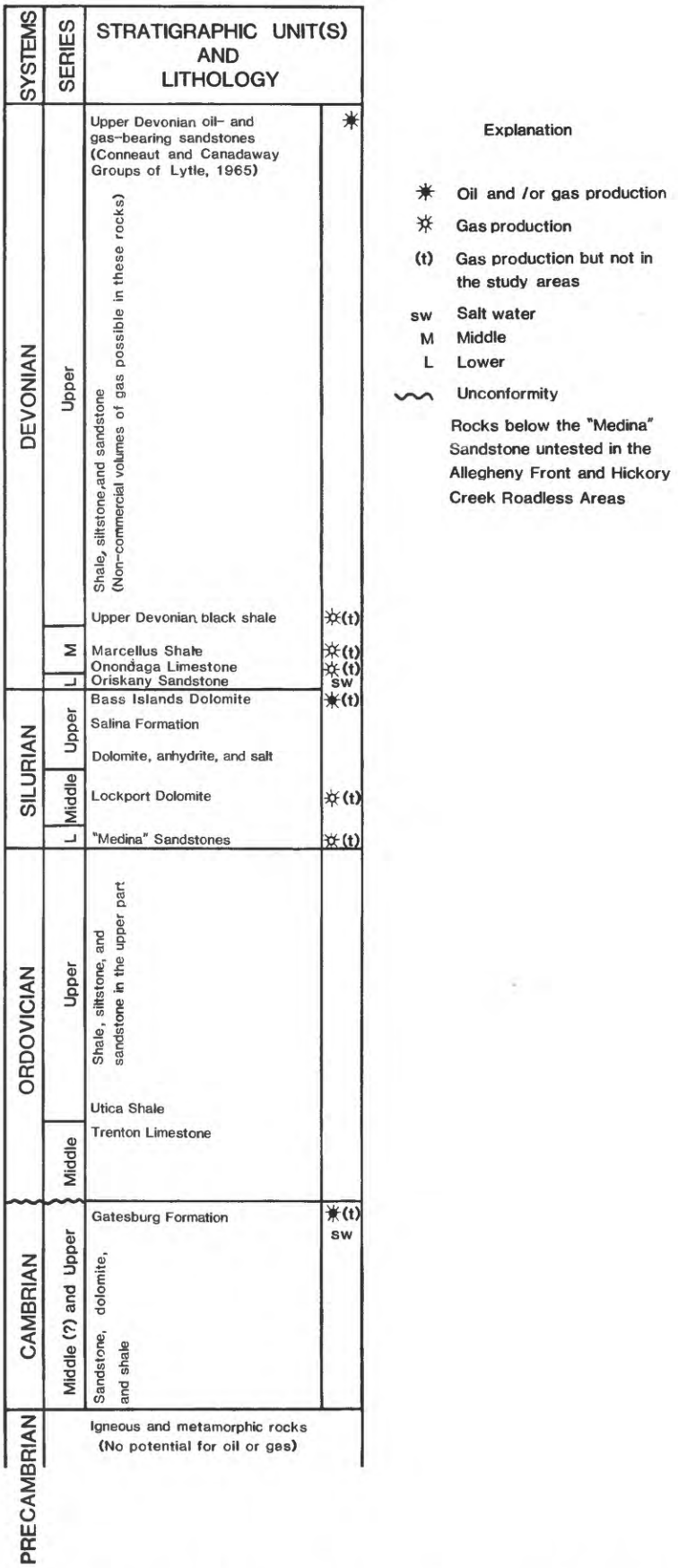

Figure 6.—Relative stratigraphic position of selected subsurface units beneath the Allegheny Front and Hickory Creek Roadless Areas.

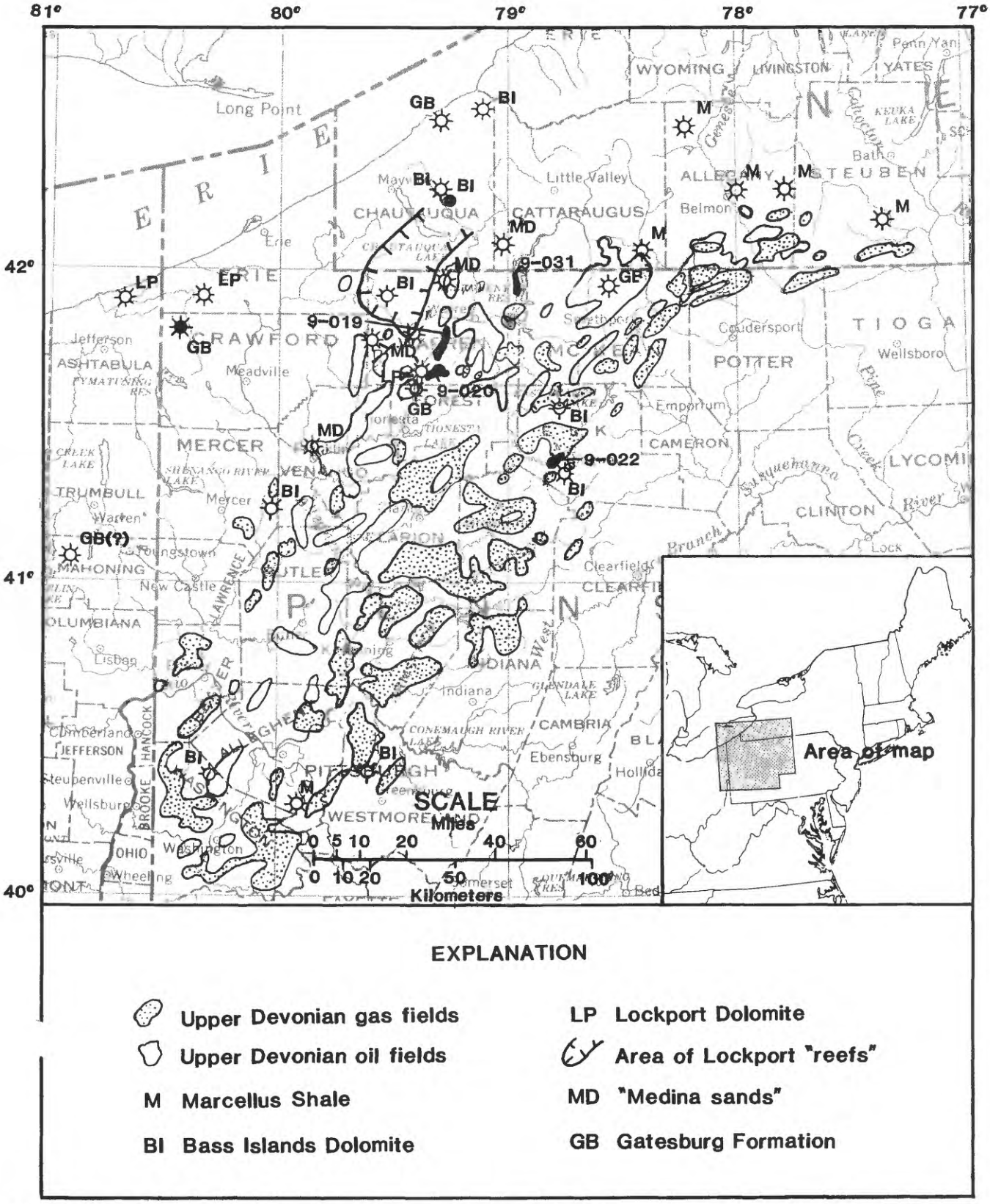

Figure 7.—Map showing the relationship of the Allegheny Front (9-019), Hickory Creek (9-020), Clairon River (9-022), and Cornplanter (9-031) Roadless Areas (solid black) to the oil and gas fields, wells, and exploratory tests discussed in the text. Production or significant shows from formations beneath the Upper Devonian reservoirs are shown by well symbols and block letters indicating individual formations. Well symbols are explained in figures 4 and 5; formations are given in figure 6. (The Clarion River area is the subject of a separate report by Schweinfurth and others, 1983; the Cornplanter area is the subject of a separate report by Lesure and others, 1983.)

under the study areas. By common usage these sandstone beds have been identified as the "Medina sands" by well drillers. The "Medina sands" were deposited in a shallow-water, high-energy, near-shore environment adjacent to a large delta complex deriving quartz detritus from an eastern source area. The "Medina" and Clinton sandstone beds are productive of gas and oil in several parts of the Appalachian basin (fig. 7). Beneath the study areas the kerogen in the "Medina" sandstone beds appears too thermally degraded for these beds to contain commerical volumes of oil but it is not so degraded as to indicate that the thermal limits for natural gas have been exceeded (Epstein and others, 1977). Active drilling for gas from the "Medina sands" in the western half of Warren County (Piotrowski, 1981; Patchen and others, 1982) (fig. 7) and the proximity of the Camp Run-Medina gas field to the western edge of the Hickory Creek tract (fig. 5), together indicate a moderate to high potential for gas resources in the "Medina" beneath the study areas. Although the well-cemented "Medina" sandstone beds in north-western Pennsylvania are known to have low-permeability, newly developed and improved well-stimulated techniques, using foam and other types of fluids for hydraulic-fracturing stimulation, may aid in developing commerical production from "Medina sands" tests that would have been abandoned as dry holes before the advent of these techniques.

The Utica Shale, a sequence of dark-brown to black shale beds rich in organic detritus that lies at the base of the Upper Ordovician shales sequence, intergrades with the underlying Trenton Limestone in the top of the Middle Ordovician carbonate-rock sequence (fig. 6). The Utica is a good source rock for hydrocarbons in the northern part of the Appalachian basin. The degree of thermal matruation of the organic matter in the Utica Shale beneath the study areas is within the limits for the generation of gas but is too great for the existence of oil (Epstein and others, 1977).

The Middle Ordovician Trenton Limestone has produced gas locally to the northeast of the study areas south of Lake Ontario in central New York. A few deep tests in western Pennsylvania have penetrated the Trenton Limestone without finding gas (Wallace and deWitt, 1975). Consequently, there is no evidence of a potential for gas resources in the Trenton Limestone in the study areas.

A relatively small number of deep and ultra-deep oil and gas tests have penetrated into or through the dolomites and sandstones of the Cambrian sequence in western Pennsylvania and adjacent southwestern New York (Wallace and deWitt, 1975) (fig. 7). The upper part of the Cambrian sequence consists mainly of dolomite with some intercalated layers of porous sandstone. Locally in McKean Crawford Counties, Pa. (fig. 7), the upper unit of the sequence, the Gatesburg Formation or its lateral equivalents, yields gas from these porous sandstone beds (Harper, 1982). In Erie County, salt water has been commonly found in close proximity to the gas, and several tests found only salt water in the Gatesburg. The thickness and extent of the Gatesburg (Wagner, 1966) suggests that it underlies the study areas. However, the nearest test to penetrate the formation, the Biery and Johnson #1 Shaw, which was drilled to a depth of 9,410 ft at a site aobut 1.3 mi west of the Hickory Creek tract (fig. 5), found only salt water in the sandstone in the upper part of the Gatesburg, although two small noncommerical shows of gas were recorded in the dolomite above the sandstone (Wagner, 1966). These data indicate that the sandy dolomite of the Upper Cambrian sequence underlying the area contains some natural gas but the potential for gas resources in the study area is low.

In summary, the Allegheny Front-Hickory Creek Roadless Areas have a high potential for oil and a moderate potential for gas resource in the shallow Upper Devonian rocks; in more deeply buried Devonian and older rocks a moderate to high potential for gas in the upper half of the sequence; and a low potential in the Upper Cambrian rocks near the base of the sedimentary rock section.

Salt

The Salina Formation of Late Silurian age contains a bed of salt more than 50 ft thick beneath the southwestern part of the Hickory Creek tract (Fergusson and Prather, 1968). This bed of salt lies 3,400 ft below sea level. As long as shallow salt deposits remain to be mined in adjacent parts of the Appalachian basin, particularly those contiguous to the Great Lakes, the development of this deposit is unlikely.

Construction Materials

Shale, sandstone, conglomerate, and sand and gravel are potential construction materials that could be utilized in the study area. As recently as 1952, Warren County supported a small ceramics industry that produced brick ranging in quality from common red brick to face brick and tile. The brick and tile manufacturing plants were located between Warren and Youngsville and used shales of Late Devonian age and Quaternary glacial-outwash clay as a source of raw material. Shale samples collected at two sites along the western edge of the study areas were suitable for the manufacture of red brick (Leighton, 1941; fig. 2). However, because structural clay products are no longer manufactured in Warren County and shale or clay are no longer mined there, and because there are abundant resources of shale in northwestern Pennsylvania that are closer to markets, further production of shale from the study areas is unlikely.

Sandstone and conglomerate from the Pennsylvanian-age Olean and Connoquenessing Formations are abundant in the study area. Potential uses for this material are limited to rough dimension stone because of impurities and the textural and the bedding characteristics of rock.

Sand and gravel are present along the lower reaches of the streams that drain the study area, but sand and gravel deposits outside of the study areas are abundant.

Important constraints on the utilization of construction materials found in the study areas are the lack of haul-road access and the cost of hauling raw materials considerable distance to be cleaned and processed.

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