

INTEGRATED STUDY OF THE DEVONIAN-AGE BLACK SHALES
OF EASTERN OHIO

by

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ABSTRACT

As part of the effort of the U.S. Department of Energy's Eastern Gas Shales Project to evaluate the potential natural gas reserve of the Devonian shales in the Appalachian basin, the Division of Geological Survey, Ohio Department of Natural Resources, has undertaken an integrated study of these shales in Ohio.

The study includes (1) subsurface stratigraphic analysis using borehole geophysical logs, core, and drill cuttings from selected wells penetrating the shale section, (2) clay mineralogy and petrographic analysis of samples from core available from the project and other core on file at the Geological Survey, (3) geochemical analysis of sample splits from core at the same intervals used in the mineralogic and petrographic investigations, (4) fracture analysis of eastern Ohio using satellite and low-altitude remote-sensing imagery, and (5) gas-show monitoring in selected currently drilling oil and gas wells in Ohio. All elements of the integrated study are underway but most are in preliminary stages.

Upon completion of the study the combined data from the above investigations will provide a basis for assessing the most promising stratigraphic horizons within the shales for occurrences of natural gas and favorable areas of the state for exploration for natural gas from the Devonian shales. The integrated study also will provide data useful in the planning and design of production-stimulation techniques.

INTRODUCTION

The integrated energy-research proposal of the Ohio Division of Geological Survey is designed to enhance gas recovery from the Devonian black shales of Ohio and to provide the basic information needed to stimulate interest by oil and gas operators for exploration for natural gas from the Devonian shales in Ohio. The development of additional natural gas sources in Ohio would be a major benefit to the state in maintaining its industrial position and in providing jobs for its citizens. Work accomplished through this study will be published in map and report format for distribution of the data to the oil and gas industry in Ohio and to the general public.

Ohio is underlain by 25,000 square miles of an eastward-thickening alternating sequence of gray and black shales of Devonian age. These shales occur stratigraphically between the Onondaga Limestone below and the Berea Sandstone-Bedford Shale above. On the basis of production data from the Big Sandy field in eastern Kentucky, Janssens and de Witt (1975) estimated the Devonian black shale natural gas reserves for Ohio at 68 billion cubic feet of gas, if conditions in the shales in Ohio are similar to those in the Big Sandy field.

The Devonian shales have been drilled for natural gas since the 1880's. Initially gas was produced in noncommercial quantities at shallow depths along and adjacent to the outcrop in northeastern and central Ohio, but more recently commercial production has been found in several areas of the state. At present operators in Ohio are showing little interest in exploring for natural gas from the Devonian shales in Ohio, and very few data on the character of the shales are being generated or evaluated. To many operators the shales are just a formation which must be penetrated to get to the "Clinton" sandstone (Silurian), Ohio's primary reservoir for oil and gas.

Incentives are needed to make the Devonian shales in Ohio more attractive for exploration. These incentives must be in the form of higher prices for gas at the well head and new demonstrated exploration and production-stimulation techniques which will result in larger volumes of production and greater overall reserves per well.

The Ohio Division of Geological Survey believes the basis for development of new exploration and production-stimulation techniques for the Devonian black shales is a comprehensive knowledge of the shales. Before the initiation of the current study only one study (Schwietering, 1970) of the subsurface Devonian shales in Ohio had been undertaken; this study related chiefly to stratigraphic correlations between Ohio and New York and as yet has not been published.

PROPOSED INTEGRATED STUDY

The Division of Geological Survey's proposed integrated study consists of five individual but closely related comprehensive investigations which, when completed, will characterize the Devonian shales of Ohio with respect to stratigraphy, structure, distribution, petrology, mineralogy, geochemistry, and gas show-stratigraphic associations. The study includes (1) subsurface stratigraphic analysis using borehole geophysical logs, core, and drill cuttings from selected wells penetrating the shale section, (2) whole-rock and clay mineralogy and petrographic analysis of samples from core available from the project and core on file at the Geological Survey, (3) geochemical analysis of sample splits from core at the same intervals used in the mineralogic and petrographic investigations, (4) fracture analysis of eastern Ohio using satellite and low-altitude remote-sensing imagery, and (5) gas-show monitoring in selected currently drilling oil and gas wells in Ohio. All elements of the integrated study are underway but most are in the preliminary stages.

The combined data from the completed investigations will provide a basis for assessing the most promising stratigraphic horizons within the shales for occurrences of natural gas and the most favorable areas of the state for exploration of natural gas from the Devonian shales. The integrated study also will provide data useful in the planning and design of production-stimulation techniques.

REPORT OF PROGRESS

The Ohio Division of Geological Survey began work on the Devonian shale study after receipt of the initial funding on June 28, 1977. Prior to this date, the only work accomplished was the preparation and completion of maps showing the locations of Devonian shale producing wells and fields and wells from which gas shows had been reported from the Devonian shale sequence.

Following the June 28, 1977, funding date, the major emphasis was in ordering equipment and initiating a recruitment program to fill positions for professionals and technicians needed to meet the commitments of the proposal and contract. At present, all equipment has been received and is operational, and data are being generated on a daily basis. The majority of the proposed positions are now filled and an effort to fill the remaining vacancies is underway so that the program will be fully staffed by July 1978.

Reported results to date on most phases of the integrated study are preliminary to insure that the work of the Division correlates with the work of other state geological surveys and contracting analytical laboratories. The preliminary stratigraphic work has permitted resolution of most of the stratigraphic and correlation problems between the state geological surveys so that the detailed stratigraphic work can be accomplished without extensive later modifications and revisions.

Analytical work (mineralogy, petrology, and geochemistry) is also in preliminary phases. On the basis of the wide variance of results in the analytical analyses performed on the Round Robin sample (USGS SD01) by analytical laboratory contractors, much work still needs to be done in standardizing analytical procedures so that contractors can have confidence in the data produced and feel confident in making regional correlations and interpretations.

PROGRESS-STRATIGRAPHIC INVESTIGATIONS

Preliminary work on the stratigraphic investigations has been completed and the Division is now prepared to undertake the detailed stratigraphic investigations outlined in the Division's proposal and the Eastern Gas Shales Project contract. The following deliverable items under the Division's contract have been forwarded to the Eastern Gas Shales Project headquarters, Morgantown, West Virginia, or to the U.S. Geological Survey, Reston, Virginia.

- 1) Three regional cross sections showing the stratigraphy and distribution of the three major radioactive facies within the Ohio shale and one within the Olentangy shale.

- 2) A map showing the locations of Devonian shale producing wells and fields and a map showing the location of wells which have reported shows of oil or gas from the Devonian shale sequence.
- 3) Preliminary structure maps on the top of the Devonian shale, base of the Devonian shale, base of the Huron member of the Ohio shale, and base of a radioactive shale unit within the Olentangy shale (equivalent to the Rhinestreet Shale of the West Falls Group of New York State).
- 4) Preliminary isopach maps of the radioactive shale facies of the Olentangy shale (Rhinestreet equivalent) and the radioactive facies of the Huron member of the Ohio shale.

Majchszak (1977) discussed in detail the work involved in the development of the above-mentioned maps and cross sections and the results and conclusions derived from the preliminary work.

PROGRESS-CLAY MINERALOGY AND PETROLOGY INVESTIGATIONS

Whole-rock and clay-mineral analysis has been completed on samples from three cores taken in Ohio. Two of the cores were furnished by the Morgantown Energy Research Center and the third core was from the core repository of the Ohio Division of Geological Survey. The core locations are widely spaced and are shown on Figure 1. Analytical work on a fourth core is now underway. The results of the analytical work may have to be revised if standardization of analytical procedures becomes necessary.

Preliminary whole-rock and clay-mineral studies of the Chillicothe Test core (OGS-S-970) Ross County, Ohio, River Gas core (MERC-R-107) Washington County, Ohio, and the Glen Gery core (MERC-#5-745) Carroll County, Ohio, indicate significant variations in the percentages of dominant minerals both laterally and vertically. With further study these variations in mineralogy should help in delineating and characterizing stratigraphic units and interpreting postdepositional history.

In the Glen Gery core, the highly radioactive facies (cored interval 3080-3120) contained a much higher percentage of quartz and mica than the less radioactive facies. However, this relationship did not exist in the other two cores examined. At the present time, there are not enough data to explain this condition in the one core. The variation may be related to the degree of radioactivity, depositional environment, depositional history, or a number of other factors. Also, in the Glen Gery core kaolinite appears to have been altered or destroyed in carbonate-bearing shales (cored interval 3080-3200).

Other variations have been recognized in the Chillicothe Test core and in the River Gas core. In the Chillicothe Test core chlorite is absent in the clay fraction of the shales near the Ohio-Olentangy contact (cored interval 495-503). In the River Gas core carbonate minerals are found in all but one of the very dark-gray silty to nonsilty nonradioactive shales, but none are found in the black silty radioactive shales.

With further mineralogic study and the integration of the mineralogic data with geochemical and stratigraphic data the explanation for the lateral and vertical variations most likely will become evident. Studies to date indicate that more mineralogic data are necessary before significant geological conclusions can be drawn. To gain the maximum benefit from the mineralogic work, future coring sites should be strategically located where maximum facies development occurs within the shale sequence as defined by geophysical-log studies.

PROGRESS-PETROGRAPHIC INVESTIGATIONS

The petrographic phase of the shale-characterization investigation is now fully operational and thin sections of shale samples are being examined for mineral assemblages, rock textures, grain size, sedimentary structures, biogenic structures, paleontology, etc. Work on this phase of the project has not reached a point where data are sufficient for interpretive analysis.

PROGRESS-GEOCHEMICAL INVESTIGATIONS

The geochemical phase of the project is fully operational and sample splits from the mineralogy-petrology sampling intervals are now being analyzed for geochemical data. Analytical work on major, minor, and trace elements has been completed for sampled intervals of the Chillicothe Test core, and analytical work on major, minor, and trace elements is underway on the River Gas core. The analytical work on this phase of the shale characterization has not reached a point where data are sufficient for interpretive analysis.

PROGRESS-STRUCTURAL ANALYSIS

Fracture analysis has been started on two scenes of Landsat 1:1,000,000 imagery in southeastern Ohio. Over 400 linear features and several curvilinear features have been plotted on transparent overlays for each scene. The linear features were initially identified by direct visual inspection. Additional linear features have been added through enhancement of questionable linear features by viewing through 200-lines-per-inch Ronchi Rulings. The same scenes at scales of 1:500,000 and 1:250,000 will be examined in the immediate future so data may be transferred to 1:250,000 topographic maps and the linear features verified by interpretation of low-altitude air photos and subsequent field check.

Work to date indicates a preferred orientation, generally NW-SE and NE-SW, for two dominant sets of linear features and a preferred direction, generally E-W and N-S, for two subordinate sets. At this stage of the investigation no attempt has been made to correlate fracture intensity or fracture intersections with Devonian shale production or reported shows of oil and gas from the Devonian shales. This type of analysis will be done when the lineations are identified on low-altitude photographs and large-scale topographic maps and checked in the field.

The proposed detailed structure mapping on county base maps at a scale of one inch equals one mile has not been started at this time. Proposed mapping units for this study are the Knox Dolomite, "Clinton" sand (Packer Shell), Onondaga Limestone, and the Berea Sandstone. The delay in this phase of the structural interpretation is due to difficulty in recruiting a qualified geologist for this position.

PROGRESS-GAS-SHOW MONITORING

The gas-detection monitoring phase of the project is now in the field-investigation phase. The major emphasis to the present time has been in obtaining two gas-detector units, bench checking and modifying equipment, fabricating auxiliary equipment for connection to rotary units using either air or mud for drilling, fabricating auxiliary equipment for mounting gas-detector units in vans, and recruiting and training personnel to operate the units in the field.

The units are now operational and personnel have been hired and trained. Operators have been contacted and gas-show data are now being collected. As the Devonian sequence is penetrated detector operators are also collecting samples for sample-examination studies.

SUMMARY

The Division's integrated study of the Devonian-age black shales is now fully underway and data are being collected daily. The work accomplished to the present time has been preliminary, but future work will be detailed in nature to meet the task objectives of the Division's proposal and the Eastern Gas Shales Project contract.

Data collected in the past year under the resource-inventory and shale-characterization tasks of the contract are not sufficient for integrated correlations and interpretations.

Upon completion of the study the combined data from the individual investigations, when correlated and interpreted, will provide the basis for assessing the most promising stratigraphic horizons within the Devonian shale sequence for occurrences of natural gas and the most favorable locations in the state for exploration of natural gas from the Devonian shales. Data from the study will also be useful in planning future production-stimulation designs.

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Figure 1.—Location of core in Ohio from which samples were obtained for mineralogy, petrology, and geochemical analysis.