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DEVONIAN SHALE PROGRAM

Quarterly Progress Report, April—June 1979

MASTER

By

J. Negus-de Wys
Jeanette M. Dixon
Mark A. Evans
Kevin D. Lee
Brian R. Long

Henry W. Rauch
James E. Ruotsala
Richard T. Williams
Thomas H. Wilson
Robert C. Shumaker

Work Performed Under Contract No. EY-76-C-05-5194

Department of Geology and Geography
West Virginia University
Morgantown, West Virginia

U. S. DEPARTMENT OF ENERGY

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QUARTERLY PROGRESS REPORT

U. S. Department of Energy

Contract no. DE-AC21-76MC05194
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April - June 1979

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submitted by

Department of Geology and Geography
West Virginia University

Robert C. Shumaker, Project Director

co-authored by

J. Negus-de Wys, Jeanette M. Dixon, Mark A. Evans,
Kevin D. Lee, Brian R. Long, Henry W. Rauch,
James E. Ruotsala, Richard T. Williams, Thomas H. Wilson

Principal Investigators

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1.0 EXECUTIVE SUMMARY

QUARTERLY REPORT

U. S. DEPARTMENT OF ENERGY CONTRACT NO. DE-AC21-76MC05194
(formerly EY-76-C-05-5194)

APRIL - JUNE 1979

1.0 EXECUTIVE SUMMARY

1.0.1 General Introduction

The major accomplishments this past quarter have been the completion of manuscripts concerning: shale production at the Midway-Extra field of West Virginia (Figure 1) and surface fracture study in the Big Sandy field of eastern Kentucky (Figure 1). In our other areas of research we entered the summer field season where scientists working on the project are busy collecting data.

In last quarter's report delay was noted in the geophysical and subsurface fracture studies. We resolved the problems in both areas this quarter so that we are making good progress in both areas. The specifics of progress under each task are summarized below.

1.0.2 Regional Structure Studies

We have completed the tabulation of subsurface tops for several formations as noted on drillers' logs for the Midway-Extra - Cottageville area (Figure 1). We hope that detailed maps of this area will permit us to map basement fault trends that will be prospective for shale gas drilling to recover gas flows above the norm for that region.

We have expanded our structure study area to include part of Kanawha and Putnam Counties along the fracture domain boundary as shown by Kulander (1978 - manuscript in press).

By the end of next quarter the subsea elevations should be spotted preparatory to constructing a detailed structural map on a shallow formation.

1.0.3 Production Studies

As noted above, a major accomplishment this past quarter was the completion of a study on the Midway-Extra field of West Virginia by Mr. William W. Schaefer (Figures 1 and 2).

Figure 1

1.0 EXECUTIVE SUMMARY - continued

R. C. Shumaker

1.0.3 Production Studies - continued

He found a direct relationship between the subsurface structural trend in the area and productivity from the Lower Huron member of the Devonian shale (compare structure map Figure 3 and isopotential maps (Figures 4 and 6). Furthermore, he concluded that the structure was growing during the Devonian, and that this growth affected sedimentation of the reservoir (compare Figure 3 and Figure 5).

The relationships found at Midway-Extra are very similar to those found at Cottageville in that the production parallels subsurface structural trends. At Cottageville far more complete production data are available (de Wys and Shumaker, 1978) to establish this relationship, whereas, at Midway-Extra the production data available are only initial open flows. In both areas we have interpreted the shale structure to relate to basement faulting, and at Cottageville this interpretation was recently confirmed by seismic investigations (Sundheimer, 1978). The focal point of these observations is to explore for shale production off-structure above basement highs. Further, it suggests that the fracture porosity in this type field is not blanket-like, but is related either to compaction or a basement-linked stress field. We favor a basement-linked stress field based on the identical position of a mapped basement fault and highly productive wells at Cottageville.

1.0.4 Geophysical Studies

Last quarter we were experiencing electronic problems with the seismic equipment that caused serious delays to our geophysical program. These problems have been largely corrected, and we have successfully collected data on digital tape at Cottageville. We are presently in the process of arranging to process that data. The electronic problems were present in the equipment when we shot test site II; so we will reshoot the Wetzel County line A (Figure 1, site II) to verify the hand plotted results.

We have not received permission to shoot the Warfield fault site (Figure 1, site III) from the Norfolk and Western Railway; so we will delete that test site and return to Cottageville to shoot more reflection seismic and initiate refraction shooting thru that field.

STRUCTURE BASE OF BROWN SHALE (L. HURON)

W. Schaefer, 1979

Figure 3

BROWN SHALE ISOPOTENTIAL
OPEN FLOW AFTER STIMULATION

Figure 4

0 1 2
MILES
C.I. = 100
MCF/D
W. Schaefer, 1979

LOWER HURON ISOPACH MAP

Figure 5

0 1 2
MILES

W. Schaefer, 1979

Figure 6 STRUCTURE AND ISOPOTENTIAL CROSS SECTIONS

W. Schaefer, 1979

1.0 EXECUTIVE SUMMARY - continued -

R. C. Shumaker

1.0.5 Fracture Studies

A report on the surface fractures of eastern Kentucky was completed this past quarter. We found that fracture trends in each lithology were unique, and that none of the surface joint patterns in the Big Sandy gas field match the Devonian shale joint patterns exposed along the Cincinnati Arch (Figure 1). The ubiquity of pattern trends makes the use of surface joint data suspect for predicting subsurface fracture trends. The noted complexity in eastern Kentucky may be unique, and joint trends elsewhere throughout the basin and continental interior appear to be more regular. This noted complexity may account in part for the occurrence of widespread, highly productive shale gas wells found in eastern Kentucky.

Progress continues on fracture studies of oriented Devonian shale wells. We have completed study of 10 wells within the Appalachian basin, and we should complete all 13 wells of the study during the next quarter.

1.0.6 Structural Studies

Our effort here centered on completion of a manuscript concerning deformation of Devonian shales in a synclinal fold typical of the Appalachian Valley and Ridge Province. This report will be complete next quarter. Secondly, we are attempting to test the validity of extending the Parsons and Petersburg lineaments (Figure 1 cross-strike structural discontinuities) westward in the Appalachian Plateau by fracture intensity studies. Preliminary analysis suggests that the Parsons lineament affects joint intensity in the Plateau. Therefore, we have extended this CSD toward the shale portion of the basin. We are presently field sampling joint intensity in the Plateau portion of the Petersburg lineament.

We completed a "drilling depth to the base of the shale" map so that one can rapidly estimate the depth and cost to drill at any location within the northern West Virginia plateau area.

1.0.7 Hydrologic Studies

Preliminary analyses of data suggest a positive relationship among certain low-altitude photo linears, ground-water geochemistry, ground-water productivity, and shale gas well productivity in the Midway-Extra field area (Figure 1). The ground-water relationships are similar to those found at

1.0 EXECUTIVE SUMMARY - continued -

R. C. Shumaker

1.0.7 Hydrologic Studies - continued

Cottageville (Jones and Rauch, 1978), but the correlation is established with the north-northwest trending photo "fracture" trace trend in Midway-Extra field rather than the west-northwest trend as found at Cottageville. The cause for this difference is under investigation. Regardless of the underlying cause for this difference, the relationship among shallow ground-water geochemistry, photo fracture traces, and shale gas well productivity is sufficiently strong to permit empirical use for exploration in a limited area.

* * * * *

Abstracts submitted to Joint DOE/EGSP-ES/AAPG Symposium, to be held Oct. 1-4, 1979.

Paleozoic Disruptive Deformation in North American Continent and its Relationship to the Formation and Development of Interior Basins and Deformation Within the Orogenic Core by Robert C. Shumaker

Parameters of Geologic Structure Which Affect Devonian Gas Shale Production in West Virginia and Eastern Kentucky - A Progress Report 1978-1979 by R. C. Shumaker, J. Negus de Wys, J. M. Dixon, M. A. Evans, K. G. Kirk, K. D. Lee, B. R. Long, H. W. Rauch, J. E. Ruotsala, T. H. Wilson, W. W. Schaefer, R. T. Williams

Cross-strike Structural Discontinuities: Exploration Rationale for Eastern Plateau Province by Russell L. Wheeler

Tectonic Thinning by Extension Faulting and Shale Flowage, and Implications for Fractured Gas Reservoirs by Philip S. Berger and Russell L. Wheeler

Possible Plate Tectonic Effects on the Appalachian Upper Devonian Basin and the Eastern Kentucky Gas Field by Jane Negus-deWys

Lithology Studies of Upper Devonian Well Cuttings in the Eastern Kentucky Gas Field by Jane Negus-de Wys

Inorganic Geochemical Studies of Eastern Kentucky Gas Field(s) and Comparison with Gas Production by Jane Negus-de Wys and John J. Renton

Regional Survey of Surface Joints in Eastern Kentucky by Brian R. Long

Lineaments and Water Wells as Exploration Tools in the Midway-Extra Gas Field by Robert R. Beebe and Henry W. Rauch

The Parsons Cross Strike Structural Discontinuity as an Exploration Area for Fractured Gas Reservoirs by Thomas H. Wilson and Jeanette M. Dixon

APRIL THRU JUNE, 1979

PAPERS GIVEN

Jane Negus-de Wys: "Relations of Gas Occurrence to Geologic Parameters in Eastern Kentucky Gas Fields," Negus-de Wys, Jane and R. C. Shumaker, AAPG Annual Convention, Houston, Texas. April, 1979.

Mrs. Negus-de Wys chaired a session on Natural Gas Habitats at this AAPG Annual Meeting.

Jeanette M. Dixon: "A Method to Identify Zones of Intense Jointing with Application to the Parsons Lineament, West Virginia," Southeastern Section of Geological Society of America, Blacksburg, Virginia, April 25-28, 1979.

MEETINGS ATTENDED

Thomas H. Wilson: NATO Advanced Study Institute's Conference on Plate Tectonics and Continental Drift, School of Physics, University of Newcastle-upon Tyne, England, March 27 thru April 8, 1979.

Mr. Wilson attended the Thrust and Nappe Tectonics Symposium, April 9 thru April 11, 1979, Imperial College, London, England.

Jane Negus-de Wys: Met with Claude Dean, George Fingleton, R. C. Shumaker concerning geochemical studies, which are related to the lithology studies.

Henry W. Rauch: Met with Claude Dean and George Fingleton on May 7 to review the status of hydrogeology work in the Midway-Extra study area.

Jane Negus-de Wys and Robert C. Shumaker: Met with John M. Pezzetta, Grury Associates to review the Big Sandy gas field.

APRIL THRU JUNE, 1979

DELIVERABLES AND MILESTONES DELIVERED

Deliverable 3.3.15	"A Method to Identify Zones of Intense Jointing with
Milestone 3.4.30	Application to the Parsons Lineament, West Virginia,"
	- Jeanette M. Dixon (delivered April 9, 1979).
Deliverable 3.3.13	"Fractures from Devonian Shale Outcrops Along the
Milestone 3.4.23	Pine Mountain Thrust," - Kevin D. Lee (delivered
	May 21, 1979).
Deliverable 3.3.11	"Regional Survey of Surface Fractures in Eastern
Deliverable 3.3.17	Kentucky," - Brian R. Long (delivered June 22, 1979).
(in part)	
Deliverable 12	"Fracture Density and Orientation Study of the MERC #1
(in part)	Core from Monongalia County, West Virginia," - Mark
	A. Evans (delivered June 22, 1979).

2.0 CONTRACT OBJECTIVES

2.0 CONTRACT OBJECTIVES

Collect, compile and analyze geological data and prepare geological structure maps for eastern Kentucky and western West Virginia.

Determine if structural types and styles and surface lineations for productive areas of the Black Shales differ from those in non-productive areas.

Identify and define along with other contractors those geologic parameters that control gas production from the shales.

Determine the feasibility of using shallow penetration resistivity and seismic surveys to detect near surface faults and fractures and demonstrate their relationship to lineations observed on airborne imagery.

Determine if a relationship exists between ground water movement and shale gas productivity.

In conjunction with other contractors develop a method for selecting areas for drilling shale wells that have a potential for gas production.

3.0 TECHNICAL PROGRESS

3.1 Work Package 2100-2-1 STRUCTURE CONTOUR MAPS Robert C. Shumaker
Project Director

3.1.1 Current status of work and scheduled deliverables

We have completed abstracting structural data from drillers' logs preparatory to spotting Berea well tops in the Midway-Extra - Cottageville area.

3.1.2 Problem areas and suggested improvements

No problems.

3.1.3 Work plan for next quarter

Calculate subsea elevations of tops selected in 3.1.1 above and start plotting these data on maps of Cottageville - Midway-Extra area.

* * * * *

3.1 Work Package 2100-1-1 CROSS SECTIONS

J. Negus-de Wys

3.1.1 Current status of work and scheduled deliverables

Current status of work: 70% completed.

Scheduled deliverables: none.

- Paper presented at AAPG Meeting in Houston on Eastern Kentucky Gas Field.
- Chaired session on Natural Gas Habitat.
- Paper on Plate Tectonics Effects on the Devonian Basin accepted for the AAPG October Meeting.
- Paper on Geochemical Studies of Eastern Kentucky Gas Field accepted for EGSP October Meeting. Co-authored by J. J. Renton.
- Paper on Lithology and Log Studies of Eastern Kentucky Gas Field accepted for EGSP October Meeting.
- Paper on Geology of the Largest Gas Field in the Appalachian Basin submitted for the International Geological Congress, 1980, Paris.
- Paper on Geochemistry and Shale Gas Production in the Appalachian Basin submitted for the International Geological Congress, 1980, Paris.
- Microscope-camera calibration completed for transmitted light.
- Lithology studies in progress.
- Log correlation in progress.
- Meetings per monthly reports.

3.1.2 Problem areas and suggested improvements

None.

3.1.3 Work plan for next quarter

- Complete lithology studies.
- Prepare submitted and accepted abstracts and papers.
- Continue log correlation.

3.2 Work Package 2100-1-2 ISOPACH MAPSJ. Negus-de Wys

3.2.1 Current status of work and scheduled deliverables

Current status of work: 55% completed.

Scheduled deliverables: none.

3.2.2 Problem areas and suggested improvements

Schedule change: complete lithology studies and then
return to isopach maps.

3.2.3 Work plan for next quarter

- Continue log correlation, plotting, computer input.
- See under 3.1.1

* * * * *

3.3 Work Package 2100-2-1 STRUCTURE CONTOUR MAPSJ. Negus-de Wys

3.3.1 Current status of work and deliverables

Current status of work: 55% completed.

Scheduled deliverables: none.

3.3.2 Problem areas and suggested improvements

None.

3.3.3 Work plan for next quarter

Continue log correlation and plotting.

* * * * *

3.4 Work Package 3200-4-1 OIL AND GAS MAPSJ. Negus-de Wys

3.4.1 Current status of work and scheduled deliverables

Current status of work: 70% completed.

Scheduled deliverables: none.

3.4.2 Problem areas and suggested improvements

None.

3.4.3 Work plan for next quarter

- o Work on papers accepted and submitted to meetings (5).
See 3.1.1
- o Continue production comparisons.

* * * * *

3.1 Work Package 2100-1-1 SEISMIC

James E. Ruotsala

3.1.1 Current status of work and scheduled deliverables

1. We are now able to record seismic data on magnetic tape cassettes. Work on getting the data onto 9-track tape so it can be plotted is progressing along several fronts. To do the job through WUNET will require hardware now being purchased. Alternative plans of action involve other computer installations.
2. The line at Pricetown II has not yet been re-shot due to equipment problems.
3. Refraction seismic at Cottageville has not been shot.
4. No more seismic modeling in the Cottageville field has been done.

3.1.2 Problem areas and suggested improvements

Nothing new.

3.1.3 Work plan for next quarter

1. The Pricetown II line will be re-shot during the first part of July and should take one week.
2. The seismic reflection line begun by Keith Kirk will be completed immediately following Pricetown.
3. The seismic refraction line will be shot after the reflection work is completed.

Barring equipment problems, the above field work will be done by August 15.
4. We have given up on using the digital recorder bought from Bison Instruments, Inc. It will either be returned for a refund or salvaged for parts. The system for storage of field data on magnetic tape cassettes uses a microprocessor system on loan from VPI to Dr. Richard Williams. Dr. Williams has programmed the processor to read data from the Bison seismograph and write it on a magnetic tape cassette. We could store the data on a WUNET disk via a telephone line if something better than WYLBUR were available to do it. WYLBUR is both unreliable

3.1 Work Package 2100-1-1 SEISMIC - continuedJ. E. Ruotsala

3.1.3 Work plan for next quarter - continued

4. - continued - and slow and would probably take one week to reformat and transfer the small amount of data we now have. An alternative course being pursued by Rick is to write the data onto a floppy disk compatible with the IBM system 37 at Stewart Hall here on campus. This will require the purchase of hardware and will take one to two months. A telephone link to the computer at Gulf Research and Development is being looked into. The most promising short term solution is the system 34 compatible floppy disk.
5. As the field work is completed and the data is on tape or disk at WVNET, the plotting and processing will begin.

* * * * *

3.1 Work Package 2100-2-2 STRUCTURE STUDIESThomas H. Wilson

3.1.1 Current status of work and scheduled deliverables

- A. Attended the NATO Advanced Study Institute's Conference on Plate Tectonics and Continental Drift, and the Thrust and Nappe Tectonics Symposium. Although Ralph Horne was not in Ireland when I was there, we had a discussion by phone. I was able to discuss the project with many of the participants in both conferences and also talked with other Ireland Geological Survey personnel during the visit.
- B. Collection of fracture data is complete except for some remaining checks on fracture intensity in areas of interest. An additional week will be required to check contacts in the Middle Mountain and Elkhorn Mountain structures.
- C. The report on bedding orientation contours is being typed and will be complete within a week.

3.1.2 Problem areas and suggested improvements

None.

3.1.3 Work plan for next quarter

- A. Geologic map of Middle Mountain syncline will be completed.
- B. Analysis of fracture data will be completed.
- C. Manuscript on the geology of the Middle Mountain syncline will be completed.

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3.1 Work Package 2100-2-2 STRUCTURE STUDIESJeanette M. Dixon

3.1.1 Current status of work and scheduled deliverables

I gave a talk at the Southeast Section of the Geological Society of America meeting on method and application of measuring joint intensity.

Field work on the Petersburg and Parsons Lineaments has been initiated.

Field work on operator variability has been completed and analysis has begun.

Comprehensive exams have been successfully completed.

3.1.2 Problem areas and suggested improvements

None.

3.1.3 Work plan for next quarter

Finish all field work and complete statistical analysis of field data gathered in the Parsons and Petersburg Lineaments.

* * * * *

3.1 Work Package: 2200-1-2 FRACTURE DENSITY AND ORIENTATION Mark A. Evans

3.1.1 Current status of work and scheduled deliverables

Fracture data collection is complete on all cores being studied. Data analysis has begun on this data and is proceeding very well. The fracture report on the MERC #1 core has been completed.

3.1.2 Problem areas and suggested improvements

None.

3.1.3 Work plan for next quarter

Complete data analysis of fracture orientation data and photo-lineament data. Put together regional fracture maps and begin writing final report.

* * * * *

3.1 Work Package 2200-1-2 FRACTURE STUDIESKevin D. Lee

3.1.1 Current status of work and scheduled deliverables

- A. A report entitled "Fractures from Devonian Shale Outcrops Along the Pine Mountain Thrust" was completed and sent out.
- B. Work has begun in Prestonsburg, Kentucky, collecting depths of stratigraphic horizons in the Big Sandy gas field. Approximately 1,200 wells out of ~5,000 have been completed.

3.1.2 Problem areas and suggested improvements

None.

3.1.3 Work plan for next quarter

- A. Continue to collect data during July and August.
- B. Do all mathematics necessary on my data to construct maps, and begin the maps in September.

* * * * *

3.1 Work Package: 2200-1-2 FRACTURE STUDIESBrian R. Long

3.1.1 Current status of work and scheduled deliverables

All deliverables are completed. The final report has been submitted to DOE.

3.1.2 Problem areas and suggested improvements

None.

3.1.3 Work plan for next quarter

Project has been completed.

* * * * *

3.3 Work Package 3200-5-1 STRUCTURE/PRODUCTION CORRELATION Henry W. Rauch

Subtask - Correlate all data and attempt to establish a relationship between geologic features, lineaments, fractures, ground water, and oil and gas production.

3.3.1 Current status of work and scheduled deliverables

All basic data have been collected or measured, and all statistical analyses have been completed for the Midway-Extra study. All final figures have been prepared and progress is well underway on the preparation of a final report for this study. Significant associations were found between lineaments and gas well yield (both initial and final open flows), and especially between certain ground-water quality parameters and gas well yield (final open flow). There were no scheduled deliverables due for this quarter.

3.3.2. Problem areas and suggested improvements

No problems for this task.

3.3.3 Work plan for next quarter

The final report will be completed and delivered to M.E.T.C. and S.A.I. on the Midway-Extra study, as deliverable 3.3.18. We will also be preparing a paper for presentation and publication in Preprints for the Third Eastern Gas Shales Conference in October, 1979. Our DOE-sponsored project ends officially on October 1, 1979; we are currently seeking private support for continuing this research, so that it has a good chance of being brought to a successful conclusion as new applications for shale gas exploration.

* * * * *

3.4 Work Package 3200-5-3 LINEAMENT/STRUCTURE CORRELATION Henry W. Rauch

Correlate fractures and lineaments derived from photo analysis with results of ground water tests to determine if any relationship exists between ground water production and the occurrence of lineaments.

3.4.1 Current status of work and scheduled deliverables

All data have been measured, statistical tests have been made, and figures have been prepared for this part of the Midway-Extra study. Landsat lineaments are associated with low-producing shale gas areas for the Midway-Extra area, and should be avoided during gas exploration. A final report is now in preparation. There are no deliverables scheduled for this quarter.

3.4.2 Problem areas and suggested improvements

No problems for this task.

3.4.3 Work plan for next quarter

See task 3200-5-1 above.

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