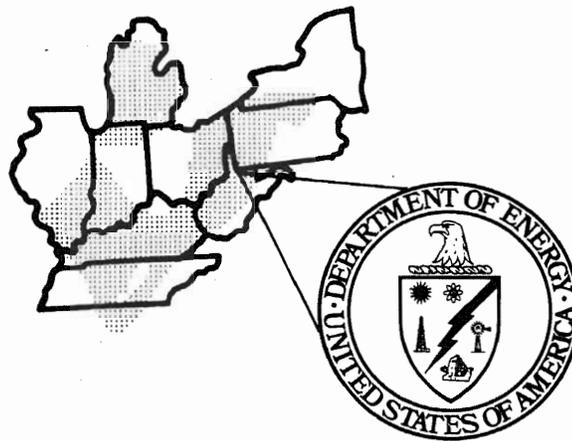


EASTERN GAS SHALES PROJECT

QUARTERLY REPORT
JULY 1 TO SEPT 30
1977



Prepared By

SCIENCE APPLICATIONS, INC.
MORGANTOWN, W. VA. 26505

Under Contract #EY-77-C-21-8078

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REPORT FORMAT DESCRIPTION

The following is a description of the format used to present the QUARTERLY REPORT for each RESOURCE and TECHNOLOGY contract.

Each contract report has the following major elements:

- TITLE PAGE
- 1.0 INTRODUCTION
- 2.0 TASK DESCRIPTIONS AND SCHEDULE
- 3.0 PROJECT HISTORY
- 4.0 TECHNICAL PROGRESS DURING PERIOD

The TITLE PAGE contains the title, contractor, contract funding, start and completion dates, Technical Project Officer (TPO), and Principal Investigator (PI).

Section 1, INTRODUCTION, includes a description of the purpose and objectives of the work to be performed under various Work Packages.

Section 2, TASK DESCRIPTIONS AND SCHEDULE, outlines the schedule of tasks to be done, subdivided according to appropriate Work Packages. Some schedules were estimated from milestone dates provided in the contracts.

Section 3, PROJECT HISTORY, provides a chronological list of the major technical and logistical events that have taken place during this and the previous reporting period. This information was obtained from file data consisting of contractor monthly and quarterly reports, correspondence, TPO reports, and minutes of meetings.

Section 4, TECHNICAL PROGRESS DURING PERIOD, presents details of work done. The technical progress is presented according to Work Package Tasks. The progress described was obtained from contractor monthly and quarterly reports and TPO reports.

RESOURCE CONTRACTS

CHARACTERIZATION OF DEVONIAN BLACK SHALE

FROM EASTERN UNITED STATES

INCOMPLETE REPORTS

Alfred University
Alfred, New York

Quarterly Report
July through September 1977

Contract No.: E(40-1)-5207

Contract Type: Cost

Contract Date: July 1, 1976

Completion Date: September 30, 1977

Contract TPO: C. W. Byrer

Contract PI: W. E. Brownell

Total Project Cost:

ERDA \$218,889

1.0 INTRODUCTION

This quarterly report reviews the achievements for Alfred University on Contract E(40-1)-5207 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project). This report covers only two months of the quarter as no monthly report for September or quarterly report was received from the contractor.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5207-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project.

<u>Events</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	9/17/76

EVENTS OF PREVIOUS QUARTER:

● Samples for physical testing received from MERC and testing initiated.	4/77
● Hydride generator operational.	5/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Determine hardness					
2200-2 Directional tensile strength testing					
2200-3 Point load testing					
2200-4 Directional sound velocity testing					
2200-5 Directional variations in elastic moduli					
2200-6 Pore-size distribution					
2200-7 Permeability testing					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Elemental analysis					
2300-2 Ultimate analysis					
2300-3 X-ray diffraction analysis (mineral concentrations > 2 percent)					
2300-4 Preferred orientation analysis					
2300-5 Petrographic analysis (mineral concentrations < 2 percent)					
2300-6 Size distribution analysis					
Final Report					

EVENTS OF THIS REPORTING PERIOD:

- Elemental analysis for 14 elements plus carbon and sulfur forms completed on 10 samples for the N.Y.G.S. 7/77
- Pore size distribution determination completed on 15 samples. 7/77
- Mineralogical procedures reported operational. 7/77
- Boron analysis procedure established. 8/77
- Elemental analysis of fifteen samples completed. 8/77
- Formulas developed for measuring permeability. 8/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in both Work Packages. The Physical Characterization Task (2200) work involved the measurement of pore size distribution, and density and permeability determinations. The Geochemical Characterization Task (2300) work involved a partial elemental analysis and some mineralogical determinations. All analytical procedures are reported to be operational at the end of the quarter with the exception of the sonic velocity apparatus.

4.2 Physical Characterization of Tasks (2200)

2200-1 Determine hardness

This test was reported operational at the end of the second quarter of FY77. No work was reported during the

past two quarters.

- 2200-2 Directional tensile strength
This task was initiated during the last quarter with the analysis of 132 samples. No progress was reported during this quarter.
- 2200-3 Point load testing
This task was initiated last quarter with the analysis of 44 samples and no further progress was reported this quarter.
- 2200-4 Directional sound velocity testing
New instrumentation has been installed but this procedure is still not completely operational.
- 2200-6 Pore size distribution
The first 15 samples were analyzed during this quarter. The curves are incomplete and ragged due to the inability of the mercury porosimeter method to analyze the smaller pore sizes.
- 2200-7 Permeability testing
This task was initiated this quarter and 4 samples were analyzed.

4.3 Geochemical Characterization Tasks (2300)

- 2300-1 Elemental analysis
Although initiated during the first reporting period in 1976, the first samples were not analyzed until this quarter. Those analyzed were not complete as they did not list nine of the elements from the "Statement of Work" in the contract. A total of fifteen samples were partially analyzed.
- 2300-2 Ultimate analysis
The first 15 samples were analyzed for carbon, sulfur, and nitrogen during this quarter.
- 2300-3 X-ray diffraction analysis
XRD has been performed on 15 samples during this quarter and all methods are reported to be operational.
- 2300-4 Preferred orientation analysis
All instrumentation and methods were reported to be operational last quarter but no samples have yet been analyzed.
- 2300-5 Petrographic analysis
This task was initiated during the second quarter of FY77 and no progress was reported this quarter.

2300-6 Size distribution analysis

This task was initiated during the second quarter of FY77 and no progress has been reported during the last two quarters.

CHEMICAL AND PHYSICAL
ANALYSIS OF EASTERN SHALE

Battelle Columbus Laboratories
Columbus, Ohio

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5205	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	March 1, 1978
Contract TPO:	A. E. Hunt	Contract PI:	M. J. Snyder
Total Project Cost:		ERDA:	\$499,800

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Battelle Columbus Laboratories on Contract E(40-1)-5205 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

No milestone chart is necessary as the tasks are repetitious over the duration of the contract.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization.	7/1/76
● Contract signed.	9/7/76

EVENTS OF PREVIOUS QUARTER:

● Wise County, VA, well cored and sampled.	4/22/77- 4/29/77
● Attended coring and sampling meeting, Morgantown, WV.	5/27/77
● Attended Fractographic Workshop, Morgantown, WV.	6/28/77- 6/29/77

EVENTS OF THIS REPORTING PERIOD:

- Henderson County, IL, well cored and sampled. 7/13/77-
7/17/77
- Tazewell County, IL, well cored and sampled. 8/16/77-
8/20/77
- Attended meeting on Enhanced Recovery of Oil and Gas
held by ERDA, Tulsa, OK. 8/30/77-
9/1/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for all contracted tasks in the Physical Characterization (2200), Geochemical Characterization (2300), and Information (1300) Work Packages.

4.2 Physical Characterization Tasks (2200)

2200-1 Porosity measurements

This task was initiated during the first reporting period in 1976 and work has continued through this quarter. During this quarter, 149 samples were analyzed, bringing the project total to 240 samples.

2200-2 Apparent volume measurements

This task is dependent on porosity and volume measurements from which the value is calculated. To date, 240 samples have been analyzed.

2200-3 Internal surface area measurements

This task was initiated during the first reporting period in 1976 and work has continued through this quarter.

During this quarter, 138 samples were analyzed, bringing the project total to 215 samples.

2200-4 Permeability measurements

This task was initiated last quarter with the analysis of 2 samples. An additional 12 samples were analyzed this quarter, for a project total of 14 samples.

2200-5 Pore size and distribution

This task was initiated last quarter with the analysis of one sample. This quarter, 41 samples were analyzed for a project total of 42 samples.

4.3 Geochemical Characterization Tasks (2300)

2300-1 Sample collection

This task was initiated during the first reporting period in 1976. To date, 379 samples from nine wells have been collected and canned.

2300-2 Off-gas analysis

This task was initiated during the first reporting period in 1976. To date, the pressure, volume, and composition have been determined for 379 samples.

2300-3 Sample preparation

This task is a preliminary step in the analytical procedure and is continuous over the life of the project.

2300-4 Ultimate analysis, OES

This task was initiated during the first reporting period in 1976. This quarter, 44 samples were analyzed, bringing the project total to 113 samples.

2300-5 X-ray diffraction analysis

This task was initiated during the first reporting period in 1976. This quarter, 34 samples were analyzed, bringing the total for the project to 37 samples.

2300-6 Heat treatment

This task was initiated last quarter with the analysis of six samples. Work continued this quarter with the analysis of four samples for a project total of 10 samples.

2300-7 SEM analysis

This task was initiated this quarter with the analysis of 22 samples.

2300-8 Gas release kinetics study

This task was initiated during the first reporting period in 1976 and work has continued to the present. This quarter, 14 analyses were completed, bringing the project total to 21 samples.

4.4 Information Tasks (1300)

1300-1 Compile and collect data

Data is being entered into the computer system as it is generated. This task is continuous throughout the project.

1300-2 Data correlation

This task is continuous as data is entered into the system. A number of data sets were analyzed during this quarter. C,H,N data was compared within a well and showed significant C scatter, high H/C ratios in some wells, and no correlation between C and depth. An inverse relationship between initial gas content and density, a relationship between gas content and total carbon, and no relationship between bulk density and porosity are indicated.

FRACTURING FLUID -- DEVONIAN SHALE
INTERACTION STUDY

Chenevert & Associates, Inc.
Houston, Texas

Summary Report
July through September 1977

Contract No.:	EY-77-X-21-1801	Contract Type:	Cost
Contract Date:	May 15, 1977	Completion Date:	September 30, 1977
Contract TPO:	C. A. Komar	Contract PI:	M. W. Chenevert
Total Project Cost		ERDA:	\$4,500

1.0 INTRODUCTION

This summary report reviews the work scope and achievements for Chenevert & Associates, Inc., on Contract EY-77-X-21-1801 from May through September 1977.

1.1 Purpose

The purpose of this project is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project) and to provide information on the behavior of Devonian Shale samples in contact with various fracturing fluids under the following Work Package:

2500 Fracture Surface Studies

1.2 Objective

The objective of the work is to investigate the physical changes in the Devonian Shales which occur when various fracturing fluids are placed in intimate contact with the shale. Studies in this area are designed to provide information as to which fluids will best minimize formation damage during fracturing and cleanup operations.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to describe in detail the scope and schedule of the project task. The only contracted task is:

2.1 Fracture Fluid Studies (2500)

2500-1 Determine the swelling tendencies of shale samples placed in intimate contact with various specified fracturing fluids in order to identify those fluids which will inhibit swelling.

2.2 Schedule and Milestones

The contracted work is of limited duration, scheduled to commence on May 15, 1977, and be completed by September 30, 1977. Three monthly progress reports and one final report are required. Due to the short time frame, detailed milestones are not required.

3.0 PROJECT HISTORY

The purpose of this section is to summarize the current status with respect to the overall project schedule and to present the history of significant events that have occurred to date.

3.1 Project Status

The contracted work was completed on September 9, 1977, with the submission and acceptance of the final report. No technical or logistical problems occurred and the work was completed on schedule.

3.2 Major Events

The following is a list of the major events that occurred on the project:

<u>Event</u>	<u>Date</u>
• Contract signed.	5/15/77
• All eight shale core samples tested with six fluids.	8/1/77
• XRD and water adsorption isotherm data completed.	9/77
• Final report of work submitted.	9/9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to summarize and outline in detail the technical accomplishments for the Work Package Task.

4.1 Summary

Eight shale core samples from Columbia Gas Well 20338, Wise County, Va, were analyzed for swelling tendencies when each was placed in intimate contact with the following fluids.

1. Fresh water
2. 30% methanol + 70% (water + 2% KCl)
3. 2% KCl water
4. Fresh water + 7 Gal HC-2/1000 Gal + 1/2 Gal Cla-Sta/1000 Gal
5. Fresh water + 2 Gal F-75/1000 Gal + 5 Gal L-42/1000 Gal
6. Kerosene

The first five fluids are prospective fracturing fluids, while kerosene is a cooling lubricant used while cutting shale samples for the testing procedures.

Overall, three of the ten samples experienced a high degree of swelling when exposed to fresh water, which caused the maximum swelling observed. The methanol-water and kerosene fluids minimized the swelling the greatest, while the other fracturing fluids produced variable results between the two extremes. XRD data and water adsorption isotherms showed that the ten samples contain only the slightly-swelling illitic and chloritic clays.

The swelling tendencies of the shales were quite variable, and due to the large sampling interval and limited number of analyses the data should not be considered quantitatively for the Devonian Shale sequence. More effort is required in this Work Package.

STRATIGRAPHIC SUMMARY OF DEVONIAN
MILLBORO AND HARRELL SHALES IN
PARTS OF PENNSYLVANIA, MARYLAND, WEST VIRGINIA AND VIRGINIA

Environmental & Regional Research Associates, Inc.
Johnson City, Tennessee

Summary Report
June through August 1977

Contract No:	EY-77-C-21-8153	Contract Type:	Cost
Contract Date:	May 27, 1977	Completion Date:	May 26, 1978
Contract TPO:	C. S. Dean	Contract PI:	K. Hasson
Total Project Cost:		ERDA:	\$14,500

1.0 INTRODUCTION

This summary report reviews the work scope and achievements for the Environmental & Regional Research Associates, Inc. (ERRA) on Contract EY-77-C-21-8153 since its implementation on May 27, 1977. Section 1 describes the purpose and objectives of the contract.

1.1 Purpose

The purpose of this contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project) and to provide information on the Devonian Millboro and Harrell Shales in parts of PA, MD, WV and VA, under the following Work Package:

2100 Geological Evaluation

1.2 Objectives

The main contract objective, as outlined in the "Statement of Work" is:

- To prepare and deliver for publication a narrative and illustrated stratigraphic summary of the Devonian Millboro and Harrell black shales in the states of PA, MD, WV and VA. The summary shall include an analysis of salient findings, a presentation of general conclusions, and a series of 16 north-south and east-west stratigraphic cross sections. The summary will also include approximately 10 maps.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to describe in detail the scope and schedule of contract tasks. All of the contracted tasks are in the Geological Evaluation (2100) Work Package:

2.1 Geological Evaluation Tasks (2100)

- 2100-1 Prepare a base map of the project area at a scale of 1:500,000. Compile and plot all pertinent data.
- 2100-2 Prepare a total of sixteen north-south and east-west stratigraphic cross sections to document the physical stratigraphy distribution over the project area and to verify the paleontologic control of time relationships.
- 2100-3 Prepare regional maps and a detailed narrative to describe type sections of the stratigraphic units and other key outcrops.

2.2 Schedule and Milestones

There are no milestones listed in the "Statement of Work" except the starting and completion dates of the contract. No timeline tasks schedule is assigned in the contract. Three quarterly reports and a final summary report are required.

3.0 PROJECT HISTORY

The purpose of this section is to summarize the current status with respect to the overall project schedule and to present the history of significant events that have occurred to date.

3.1 Project Status

Work on this contract is on schedule. There are no technical or logistical problems. This report is based on ERRA's first quarterly report, which covers June through August, 1977.

3.2 Major Events

The following is a list of the major events that have occurred on the project:

- Contract signed. 5/27/77
- Base map drafted. 8/77
- Eight regional maps of study area compiled. 8/77
- Cross section work initiated. 8/77
- Prepared paper for October, 1977 EGSP Symposium. 8/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to summarize and to outline in detail the technical accomplishments for the Geological Evaluation (2100) Work Package Tasks on which progress has been made.

4.1 Summary

The contracted work is an accelerated completion of studies carried out by the investigators over the last ten years. Therefore, a large volume of work has been generated:

- 2100-1 Prepare project area base map
The base map, at a scale of 1:500,000, has been drafted. Pertinent data has been compiled and plotted.
- 2100-2 Cross sections
Work was initiated this quarter on the cross sections, at a scale of one inch = 100 feet.
- 2100-3 Regional maps
Work was initiated this quarter on the following maps:
 1. Limits of the Harrell-Millboro Shales
 2. Type section location map
 3. Interpretive maps of the Tagharic onlap over Fulton Lake
 4. The areal extent of:
 - a. Clearville Siltstone
 - b. Chaneyville Siltstone
 - c. Harrell-Burkett Member
 - d. Tully Limestone
 - e. Pinchouts of several of the studied units

GEOLOGIC AND GEOCHEMICAL STUDIES
OF THE NEW ALBANY GROUP
IN ILLINOIS

INCOMPLETE REPORTS

Illinois State Geological Survey
Urbana, Illinois

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5203	Contract Type:	Cost-Sharing
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	J. J. Kovach	Contract PI:	R. E. Bergstrom N. F. Shimp

Total Project Cost:	ERDA	\$448,476
	ISGS	<u>76,241</u>
		\$524,717

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Illinois State Geological Survey on Contract E(40-1)-5203 from July through September 1977. The purpose of this contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project). This report is based on the July and August monthly reports as no reports were received for September.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5203-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date.	7/1/76
• Contract signed.	9/20/76

EVENTS OF PREVIOUS QUARTER:

- | | |
|---|------|
| • Two additional cross sections were finalized and the remaining sections are nearing completion. | 4/77 |
| • A data collection system that will permit data on stratigraphic horizons to be easily entered into the computer well information file has been devised. | 4/77 |
| • The Bausch and Lomb Zoom-Transfer Scope arrived and was installed. | 4/77 |
| • Analysis of the clay mineralogy of the shales of the upper part of the OlKY core was completed. | 4/77 |

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Advise ERDA on drill sites and coring					
2100-2 Literature review of New Albany Group					
2100-3 Geophysical log interpretations of shale content					
2100-4 New Albany Group well map and tabulation					
2100-5 Cross sections					
2100-6 Isopach maps					
2100-7 Lithofacies maps					
2100-8 Structure maps					
2100-9 Correlation of regional structure maps					
2100-10 Correlation of remote sensing and production data					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Core description, logging, and hardness					
2200-2 Index properties					
2200-3 Seismic velocity determinations					
2200-4 Indirect tensile testing					
2200-5 Point load testing					
2200-6 Radiographic core analysis					
2200-7 Thin section preparation and textural analysis					
2200-8 SEM and EDS analysis					
2200-9 Materials description and sample selection					

Figure 5203-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Selection of shale samples					
2300-2 X-ray diffraction analysis					
2300-3 Mineral and organic constituent distribution					
2300-4 Dispersed organic particle analysis					
2300-5 Elemental analysis					
2300-6 Determination of selected other elements					
2300-7 Ultimate analysis					
2300-8 Base exchange capacity and exchangeable cation determination					
2300-9 Separation technique investigation					
2300-10 Core elemental variation determination					
2300-11 Identification of best separation method					
2300-12 Hydrocarbon distribution analyses					
2300-13 Medium volatile hydrocarbon analyses					
2300-14 Low volatile hydrocarbon analysis					
2300-15 High molecular weight hydrocarbon analyses					
2300-16 Feasibility study of C13/C12 studies					
2300-17 Internal surface area measurement					
2300-18 Methane adsorption isotherms					
2300-19 Maps of BTU content					
<u>INFORMATION (1300)</u>					
1300-1 Data compilation and editing					
1300-2 Data encoding					

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
1300-3 Mineral resource evaluation system 1300-4 Design of grid routine classification					

Figure 5203-1 (Continued)

- Two of the low-temperature ashing machines broke down; repair parts are on order. 4/77
- The XRD work on the mineralogy of the coarse fraction from the O1IL core was completed. 4/77
- Orientation of the clay minerals in the O1KY core samples was completed. 4/77
- Work has begun on the classification grid. 4/77
- Analysis and calculation of results for gas contained in the O1KY core have been completed. 4/77
- Testing and calibration of the high pressure methane adsorption apparatus have begun. 4/77
- Three additional cross sections were completed, bringing the total to 17 and completing the primary network. 5/77
- The file of basic well data for wells reaching the Devonian in the southwest quadrant of Illinois has been completed. 5/77
- Reflectance analysis of vitrinite particles received from the O1KY core is nearing completion. 5/77
- All phases of sample preparation for the mineralogic and petrographic characterization of the O1KY and O1IL cores are completed. 5/77
- Design work is underway on the line files portion of MINERS. 5/77
- Analysis of the offgas from the O2IL core samples was begun. 5/77
- The first successful adsorption of methane on shale under high pressure has been completed for three samples from the O1KY core. 5/77
- Agreement reached between ERDA and Northern Illinois Gas Company to take a core of the New Albany Group in Henderson County, IL. 6/77
- A preliminary isopach map of the entire New Albany Group has been completed for the state of Illinois. 6/77
- Reflectance analysis of the O1KY and O1IL cores has been completed. 6/77

- Detailed petrographic analyses on all samples of the 01IL and 01KY cores have been completed except fluorescence analyses. 6/77
- Timing equipment from the directional seismic velocity apparatus returned to the factory for repair. 6/77
- Staff attended the coring and logging review and Fractography Workshop in Morgantown, WV. 6/27-29/77
- Base map drawing, data points plotting, and contouring and plotting of trend surfaces aspects of MINERS completed. 6/77
- Carbon isotope analysis performed on methane from four 01KY core samples and nine 02IL core samples. 6/77
- Internal surface area measurements were made on 37 samples from the 01KY and 01IL cores. 6/77

EVENTS OF THIS REPORTING PERIOD:

- Two hundred ninety feet of New Albany Shale core recovered from a Northern Illinois Gas Company well in Henderson County, IL (04IL). 7/77
- A computer-generated base map of wells penetrating the Devonian Shale in the SW quadrant of Illinois completed. 7/77
- Initiated development of an interactive retrieval system, utilizing a computer and a minicomputer to process physical testing data. 7/77
- Tinius Olsen compression machine for point load and indirect tensile testing installed and checked out. 7/77
- Four shale samples from Effingham County, IL core radiographed and eight additional samples prepared. 7/77
- Thin section analysis of Christian County, KY core (01KY) completed. 7/77
- Samples from 02IL and 03IL cores selected and processed for XRD and vitrinite reflectance studies. 7/77
- Thirty samples canned for out-gassing analyses from Henderson County, IL (04IL) core. 7/77
- Line files for the MINERS system have been designed and are about 50 percent complete. 7/77
- Attended USGS/PIC data encoding meeting at Pittsburgh, PA. 8/22/77

- Detailed petrographic analyses on all samples of the OILY and OIKY cores have been completed except fluorescence analyses. 6/7
- Timing equipment from the directional seismic velocity apparatus returned to the factory for repair. 6/77
- Staff attended the coring and logging review and Fractography Wrokshop in Morgantown, WV. 6/77
- Base map drawing, data points plotting, and contouring and plotting of trend surfaces aspects of MINERS completed. 6/77
- Carbon isotope analysis performed on methane from four OIKY core samples and nine O2IL core samples. 6/77
- Internal surface area measurements were made on 37 samples from the OIKY and OIIL cores. 6/77

EVENTS OF THIS REPORTING PERIOD

- 290' of New Albany Shale core recovered from a Northern Illinois Gas Company well in Henderson Co., IL. (O4IL) 7/77
- A computer-generated base map of wells penetrating the Devonian Shale in the SW quadrant of Illinois completed. 7/77
- Initiated development of an interactive retrieval system, utilizing a computer and a minicomputer to process physical testing data. 7/77
- Tinius Olsen compression machine for point load and indirect tensile testing installed and checked out. 7/77
- Four shale samples from Effingham County, IL core radiographed and eight additional samples prepared. 7/77
- Thin section analysis of Christian Co., KY core (OIKY) completed. 7/77
- Samples from O2IL and O3IL cores selected and processed for XRD and vitrinite reflectance studies. 7/77
- Thirty samples canned for out-gassing analyses from Henderson Co., IL (O4IL) core. 7/77
- Line files for the MINERS system have been designed and are about 50 percent complete. 7/77
- Attended USGS/PIC data encoding meeting at Pittsburgh, PA. 8/22/77

- Presented paper at ERDA Symposium on Enhanced Oil and Gas Recovery at Tulsa, OK., on adsorption/desorption studies of the Devonian Shale. 8/30/77
- Recovered complete New Albany section core from a Northern Illinois Gas Co. well in Tazewell Co., IL. 8/77
- Isopach maps of all main subunits of the New Albany Shale are in the data collection stage, SE quarter data collection completed. 8/77
- Several supplementary cross sections were completed to resolve complicated stratigraphic problems. 8/77
- Lithologic logging of core O4IL is in progress. 8/77
- Acid separation for vitrinite relectance studies of 20 samples from the O2IL and O3IL cores initiated. 8/77
- Completed a paper for the EGSP Symposium entitled "Petrology of the New Albany Group (Upper Devonian-Kinderhookian) in the Illinois Basin - A Preliminary Report." 8/77
- Accomplished complete elemental analysis for 37 samples. 8/77
- Initiated study of kerogen separation techniques. 8/77
- Initiated feasibility study to analyze collection procedures for obtaining representative samples for C¹³/C¹² isotope analysis; 13 analyses completed. 8/77
- Initiated gas release kinetics study (outside of contract). 8/77
- Internal surface area measured on cores from Christian Co., KY and Sangamon Co., IL. 8/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period. No report of activities for September, 1977 has been received.

4.1 Summary

Progress was reported during this quarter for some tasks in all of the Work Packages.

Work in the Geological Evaluation Task area included the recovery of two New Albany Group cores, generation of a computer map of Devonian tests in the SW quadrant of Illinois, cross-sectioning and the collection of isopach data.

Physical Characterization work consisted of lithologic core logging, radiography and installation and check-out of the Tinius Olsen compression machine.

The Geochemical Characterization work included canning of samples for outgas analysis, preparation of samples for XRD and vitrinite reflectance analyses, thin section, elemental, offgas and carbon isotope analyses, initiation of the separation technique investigation and internal surface area and methane adsorption isotherm studies.

Work is continuing in the Information Tasks.

4.2 Geological Evaluation Tasks (2100)

- 2100-1 Advise US ERDA on drill sites and coring During this reporting period, two cores were taken from Northern Illinois Gas Co. wells - 290' of New Albany Shale core in Henderson Co., IL and 259' of core in Tazewell Co., IL. The ISGS acted as liaison during the negotiations between US ERDA and the Northern Illinois Gas Co.
- 2100-3 Geophysical log interpretations of shale content This task was initiated last year. No progress has been reported for the last three quarters.
- 2100-4 New Albany Group well map and tabulation. A computer-generated base map of Devonian tests in the SW quadrant of Illinois was completed during this reporting period.
- 2100-5 Cross sections
The primary network of stratigraphic cross sections was completed last quarter. During this reporting period, several supplementary cross sections were completed to resolve complicated stratigraphic problems.

- 2100-6 Isopach maps
Isopach maps of all main subunits of the New Albany Group are in the data collection stage. Collection of the SE quarter data is complete.
- 2100-7 Lithofacies maps
This task was initiated during the second quarter of FY77. No progress has been reported in this area for the last two quarters.
- 2100-8 Structure maps
This task was initiated during the second quarter of FY77. No work was reported in this area for the last two quarters.
- 2100-10 Correlation of remote sensing and production data
This task was initiated during the first reporting period. No work was reported during this quarter.

4.3 Physical Characterization Tasks (2200)

- 2200-1 Core description, logging and hardness
Lithologic logging of core 011L (Henderson Co., IL) was begun during this reporting period.
- 2200-2 Index properties
This task was initiated during the first reporting period. No work has been reported for the last two quarters.
- 2200-3 Seismic velocity determinations
This task has been delayed due to equipment delivery and malfunction problems. Last quarter, the ISGS projected that routine analyses were to begin in August, 1977. No work was reported on this task during this reporting period.
- 2200-4 Indirect tensile testing
This and the following task (2200-5) are behind schedule due to equipment and delivery problems. During this quarter, the Tinius Olsen compression machine was installed and tested.
- 2200-5 Point load testing
The Tinius Olsen compression machine has been installed and tested. Routine testing of shale samples should begin during the first quarter of FY78.

- 2200-6 Radiographic core analysis
During this reporting period, four samples from core 02IL, Effingham Company, IL were radiographed. Eight additional samples have been embedded and slabbed for future analyses.
- 2200-7 Thin section preparation and textural analysis
As reported last quarter, routine horizontal sectioning of shale cores has been discontinued. Only those cores which show some promise of yielding significant data will be analyzed. No work in this task area was reported during this quarter.

4.4 Geochemical Characterization Tasks (2300)

- 2300-1 Selection of shale samples
During this reporting period, thirty samples of the 04IL core, Henderson Company, IL, were canned for outgassing analyses.
- 2300-2 X-ray diffraction analysis
Samples from the 02IL and 03IL cores were selected and processed for XRD analysis this quarter.
- 2300-3 Mineral and organic constituent distribution
All thin-section petrographic work on the 01KY core was completed during this reporting period.
- 2300-4 Dispersed organic particle analysis
Twenty samples from the 02IL and 03IL cores were selected and processed for vitrinite reflectance studies during this reporting period.
- 2300-5 Elemental analysis
A complete elemental analysis was run on 37 shale samples during this quarter. Nine more samples are undergoing analysis.
- 2300-9 Separation technique investigation
This study was initiated on schedule this quarter.
- 2300-12 Hydrocarbon distribution analysis
The offgas composition (C_1 - C_5) analysis of 52 canned shale samples was underway during this quarter.
- 2300-16 Feasibility study of C^{13}/C^{12} studies
Work continued in this area during this quarter. Thirteen analyses were completed.

- 2300-17 Internal surface area measurements
Analyses were performed on the OlKY and the ISGS Sangamon County, IL, cores during this quarter.
- 2300-18 Methane adsorption isotherms
Methane adsorption studies of the OlKY and the ISGS Sangamon County, IL, cores were undertaken during this quarter.

4.5 Information Tasks (1300)

- 1300-1 Data compiling and editing
This task is continuous throughout the study.
- 1300-2 Data encoding
A set of data forms for lithologic and thin section analysis using PIC formats as a basic guideline was proposed to allow computer encoding directly from the forms.
- 1300-3 Mineral Resource Evaluation System (MINERS)
The system has now been set up with two classes of line values.
- Class 1 - the digitized values refer to the line (contour lines, field outlines, etc.)
- Class 2 - the digitized values refer to the difference between two values (lines separating soil types, reserve estimates, etc.)
- 1300-4 Design of grid routine classification
This task, part of the MINERS data handling system, was initiated during the first reporting period. Although no major design obstacles have been encountered, no work was reported during this quarter.

STUDY OF THE NEW ALBANY SHALE
IN INDIANA

Indiana Department of Natural Resources
Geological Survey
Bloomington, Indiana

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5204	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	R. J. Watts	Contract PI:	M. E. Biggs
Total Project Cost:	ERDA \$233,360		

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Indiana Department of Natural Resources, Geological Survey, on Contract E(40-1)-5204 from July through September 1977. The purpose of the contract is to address the "Resource" and "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5204-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date.	7/1/76
• Contract signed.	9/21/76

EVENTS OF PREVIOUS QUARTER:

• Attended meeting of the API in Evansville.	4/7/77
• Visit by W. K. Overbey, MERC-EGSP Project Manager, with Survey staff.	4/13/77
• Survey Drillhole No. 275 cored and samples collected for degassing tests. The core contained a complete section of New Albany Shale.	4/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGIC EVALUATION (2100)</u>					
2100-1 Advise ERDA on drill sites and coring					
2100-2 Cross reference geophysics with shale content					
2100-3 Cross sections					
2100-4 Isopach maps					
2100-5 Lithofacies maps					
2100-6 New Albany Formation well map					
2100-7 Oil and gas production map					
2100-8 Regional structure maps					
2100-9 Specific horizon structure maps					
2100-10 Correlation of LANDSAT data					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Core description, logging, and hardness					
2200-2 Index properties					
2200-3 Seismic velocity analysis					
2200-4 Indirect tensile testing					
2200-5 Point load testing					
2200-6 Material description and selection					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Mineralogic and petrographic analysis					
2300-2 X-ray diffraction analysis					
2300-3 Thin section petrographic analysis					
2300-4 SEM textural and structural analysis					

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
2300-5 Maps of clay mineral distribution					
2300-6 TOC analysis					
2300-7 NMR and MS analysis					
2300-8 Ultimate analysis					
2300-9 Maps of BTU content					
<u>RESOURCE ASSESSMENT (2400)</u>					
2400-1 Gas reservoir analysis					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Lineament definition from remote sensing imagery					
<u>INFORMATION (1300)</u>					
1300-1 Compile, check, and edit data					
1300-2 Data encoding					

Figure 5204-1 (Continued)

- Attended SPES Symposium on Midwest Gas Production and Storage, in Indianapolis. 4/14/77
- Completed mapping of linear trends in Washington County from aerial photography. 4/77
- Completed description of the Phegley Core. 4/77
- Started analysis of New Albany Shale internal reference sample. 4/77
- Selected samples from the Phegley Core for physical testing. 4/77
- Constructed a device to grind shale cores to the cylindrical shape required for physical testing. 4/77
- Analyzed SDH No. 275 Core for moisture content, Shore hardness, and bulk specific gravity. 4/77
- Purchased a thermoconductivity detector-gas chromatograph. 4/77
- Initiated work on structure map contoured on top of the New Albany Shale. 5/77
- Completed preliminary version of structure map contoured on the base of the New Albany Shale. 5/77
- Compiled west to east cross sections of the New Albany Shale equivalents in the Michigan Basin. 5/77
- Submitted the following maps to ERDA:
 - Oil and gas shows in the New Albany Shale
 - Oil and gas shows in Middle Devonian Limestone
 - Oil and gas shows in the 100 feet of strata which overlies the New Albany Shale. 5/77
- Began mapping linear trends in Jackson County from aerial photographs. 5/77
- Prepared a computer program to enable a digitizer to plot the end point locations of each linear feature. 5/77
- Completed moisture loss and bulk density determinations of shale samples from two Marion County drillholes. 5/77
- Samples from the Phegley core sent to Twin Cities Labs for acoustical bench testing. 5/77
- Submitted an article entitled, "Indiana's Burning Hill-- Energy Source for the Future" to Outdoor Indiana. 6/14/77

- Attended the "Government-Industry Information Exchange on Devonian Gas Shales" in Lexington, KY. 6/20/77
- Attended coring and sampling meeting in Morgantown, WV 6/28/77-6/29/77
- Submitted abstracts of three papers to be presented at future ERDA-sponsored meetings. 6/77
- Completed a structure map contoured on top of the New Albany Shale in the Illinois and Michigan Basins. 6/77
- Completed mapping linear trends in Jackson County, KY. 6/77
- Prepared rose diagrams showing the distribution of linear trend orientations for Harrison, western Clark, Floyd and Washington Counties. 6/77
- Examined and described SDH No. 275 core. Determined XRD patterns of shale samples from the core. 6/77
- Outfitted a saw for sample preparation for Brazilian Split and point load tests. 6/77
- Analyzed New Albany Shale internal reference sample for CO₂, P₂O₅, and As. 6/77
- Ordered CHN analyzer. 6/77

EVENTS OF THIS REPORTING PERIOD:

- A paper entitled "The New Albany Shale and Equivalent Strata in Indiana" was submitted for publication in the Proceedings of the Third Annual ERDA Symposium on Enhanced Oil and Gas Recovery, and for presentation at the October, 1977 EGSP Symposium in Morgantown, WV. 7/77
- Staff attended the LERC "Confab 77" on Fossil Fuel Chemistry and Energy at Saratoga, NY. 7/77
- Completed the final version of structure contour maps drawn on the top and base of the New Albany Shale. 7/77
- Completed an isopach map of the New Albany Shale in Indiana. 7/77
- Completed a preliminary isopach map of the Antrim Shale in the Michigan Basin. 7/77
- Work initiated on picking the tops of the members of the New Albany Shale. 7/77

- The aerial photo study of Brown County, IN, was completed. Field study of the jointing pattern was completed near the type section. 7/77
- Porosity determined on 70 samples of the Phegley core. 7/77
- Bulk density determination procedure development initiated. 7/77
- Acoustical bench tests performed on 18 Phegley core samples. 7/77
- XRD clay analyses performed on three black shale samples. 7/77
- Major element determinations performed on six shale samples. 7/77
- The inductively coupled plasma optical emission spectrometer was received and installed. 7/77
- Two wells encoded to serve as sample data sets. 7/77
- Staff attended the PIC data encoding meeting in Pittsburgh, PA. 8/22/77
- Initiated work on a distribution and isopach map of the Hannibal Shale Member of the New Albany Shale. 8/77
- Prepared paper for the October, 1977 EGSP Symposium entitled "Gas Chromatographic Analysis of Fischer Retort Products of the New Albany Shale." 8/77
- Encoded geologic, production test and engineering data from a gas well, to test the WHCS system. 8/77
- Completed aerial map study of Lawrence County, IN lineament data. Initiated Monroe County, IN study. 8/77
- Began data compilation for Grassy Creek Shale Member isopach map. 9/77
- Completed preliminary isopach map of the Hannibal Shale Member. 9/77
- Prepared samples for point load and indirect tensile strength testing. 9/77
- Determined total water content on six samples of the internal reference shale. 9/77
- Low-temperature asher received, tested, found faulty and repaired. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in all Work Packages except Resource Assessment (2400).

The Geological Evaluation Task work consisted of isopach and structure mapping.

The Physical Characterization Task work included measurement of index properties and shale seismic velocities and sample preparation for shale strength testing.

The Geochemical Characterization work was XRD determination of clay content and analysis of major element composition of shale samples.

Exploration R&D Task work was a continuation of county-by-county mapping of lineament trends from aerial photos.

The Information Task work consisted of the initiation of data encoding of geologic, production test, and engineering information.

4.2 Geological Evaluation Tasks (2100)

2100-1 Advise ERDA on drill sites and coring

This task was initiated during the second quarter of FY77 and is continuous for the length of the project. No work has been reported for the last two quarters.

2100-4 Isopach maps

During this quarter an isopach map of the New Albany Shale in Indiana was completed, a preliminary isopach of the Antrim Shale in the Michigan Basin and the Hannibal Shale Member in Indiana were completed. Data compilation

was initiated for an isopach map of the Grassy Creek Shale Member in Indiana.

- 2100-5 Lithofacies maps
Work on this task was initiated during the first quarter of FY77. No progress has been reported in this area for the last two quarters.
- 2100-8 Regional structure maps
Final versions of structure maps contoured on the top and base of the New Albany Shale in Indiana were completed during this quarter and sent to ERDA/MERC.
- 2100-9 Specific horizon structure maps
During this quarter, work was initiated on this task by picking geophysical log tops of individual members of the New Albany Shale.

4.3 Physical Characterization Tasks (2200)

- 2200-1 Core description, logging, and hardness
This task was initiated during the first reporting period. No work was reported during this quarter.
- 2200-2 Index properties
During this quarter, porosity measurements, which averaged less than 1%, were performed on 70 samples of the Phegley core. Bulk density analytical procedures were established. The moisture content of six samples of the internal reference shale was determined.
- 2200-3 Seismic velocity analysis
During this quarter, eighteen Phegley core samples were tested on the acoustical bench in order to determine seismic velocities.
- 2200-4 Indirect tensile strength testing
During this reporting period, 58 shale samples were prepared for testing.
- 2200-5 Point load testing
During this reporting period, 130 shale samples were prepared for point load tests.

4.4 Geochemical Characterization Tasks (2300)

- 2300-1 Mineralogic and petrographic analysis
This task was initiated last quarter. No additional work was reported during this quarter.

- 2300-2 X-ray diffraction analysis
During this quarter, three New Albany shale samples were analyzed for clay content. Six samples of the internal reference shale standard were analyzed for thirteen major elements, with little variation seen in the analytical results.
- 2300-3 Thin section petrographic analysis
This task was initiated during the second quarter of FY 77. No progress has been reported on this task for the last two quarters.
- 2300-4 SEM textural and structural analyses
This task was initiated during the first reporting period. No work has been reported since that time.
- 2300-7 NMR and MS analysis
The inductively coupled plasma-optical emission spectrometer was received and installed during this reporting period.
- 2300-8 Ultimate analysis
According to reports received last quarter, a CHN analyzer is still on order. Delivery was to have been made during September, 1977.

4.5 Exploration R&D Tasks (3200)

- 3200-1 Lineament definition from remote sensing imagery
During this reporting period, the aerial photo study of Brown County, IN was completed. Linear trends were plotted on an overlay map. A joint pattern field study near the type section was also completed. The lineament map of Lawrence County, IN was completed and work was begun on the lineament map of Monroe County, IN. Additionally, existing lineament data has been transferred from county maps to a 1:250,000 base map.

4.6 Information Tasks (1300)

- 1300-1 Compile, check and edit data
This task is continuous for the duration of the contract.
- 1300-2 Data encoding
This task was initiated this quarter when geologic, production test, and engineering data from the Bramble gas well were encoded as a test of the WHCS system. The data encoding required 30 cards.

INTERACTION BETWEEN GASES AND SHALE
OF THE EASTERN UNITED STATES

Juniata College
Juniata, Pennsylvania

Quarterly Report
July through September 1977

Contract No.:	DY-76-S-05-5197	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	A. E. Hunt	Contract PI:	P. D. Schettler
Total Project Cost:		ERDA:	\$45,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for Juniata College on Contract DY-76-S-05-5197 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

There are no milestones listed in the "Statement of Work", except the starting and completion dates of the contract, and no time-line tasks.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	9/1/76

EVENTS OF PREVIOUS QUARTER:

● Vacuum system rebuilt and design changed.	5/77
● Training session held for student personnel.	5/77
● Attended outgassing workshop, Morgantown, WV.	5/5/77
● Obtained new Barocell pressure transducer.	6/77
● Attended coring and sampling meeting, Morgantown, WV.	6/27/77

- Attended Fractographic Workshop, Morgantown, WV. 6/28/77-
6/29/77

EVENTS OF THIS REPORTING PERIOD:

- Initiated analyses of the effects of foreign gases on offgassing. 7/77
- Completed study of effects of temperature on offgassing. 8/77
- Completed study on effects of water on shale. 9/77
- Concept of specific degasibility developed. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in both Work Packages. The Physical Characterization Task (2200) work involved the determination of helium and methane isotherms, diffusion constants, and total absorptive capacity measurements (TAC). The Geochemical Characterization Task (2300) work involved the determination of volume and composition of outgas and the effects of temperature and foreign gases on outgassing.

4.2 Physical Characterization Tasks (2200)

- 2200-1 Total adsorptive capacity (TAC) measurement
This task was initiated during the first reporting period in 1976. During the quarter, determinations were performed on 50 samples.
- 2200-2 Permeability measurement
This task was initiated during the first reporting period with the analysis of 24 samples. No progress was reported this quarter.

2200-3 Gas diffusion constant analysis

This task was initiated during the second quarter of FY77 and a total of 25 samples was analyzed with varying numbers of adsorption isotherms per sample. Diffusion constants had been determined for a total of 20 samples. During this quarter, diffusion constants were measured on 153 samples and adsorption isotherms on 50 samples.

4.3 Geochemical Characterization Tasks (2300)

2300-1 Shale degassing analysis

This task was initiated during the first reporting period in 1976 and prior to this quarter, 263 samples had been analyzed for volume and composition. During the quarter, an additional 20 samples were analyzed for volume and composition, 29 samples were analyzed to determine the effects of foreign gases, and a study of the effect of temperature on outgassing was completed.

SURFACE CHEMISTRY AND SPECTROSCOPIC
TECHNIQUES FOR CHARACTERIZATION OF
ORGANIC CONSTITUENTS OF DEVONIAN
SHALE

Morgantown Energy Research Center
Morgantown, West Virginia

Quarterly Report
July through September 1977

Contract No.:	EGSP-MERC No.1	Contract Type:	Internal
Contract Date:	October 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	J. J. Kovach	Contract PI:	J. J. Kovach
Total Project Cost:		ERDA	\$312,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Morgantown Energy Research Center (MERC) project titled, "Surface Chemistry and Spectroscopic Techniques for Characterization of Organic Constituents of Devonian Shales." The purpose of this study is to address the "Resource" aspects of the EGSP.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure MERC 1-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● "ERDA Fossil Energy Project Planning Form" date.	4/15/76
● Project initiated.	10/1/76

EVENTS OF PREVIOUS QUARTER:

● NMR analysis initiated.	4/77
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EVENTS OF THIS REPORTING PERIOD

● Comparative NMR data between gray and brown shale completed	7/77
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TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p>GEOCHEMICAL CHARACTERIZATION (2300)</p> <p>2300-1 Organic material analysis</p> <p>2300-2 Characterize chemical structures</p> <p>2300-3 Characterize pore structures</p> <p>2300-4 Organic material relationships</p>					

Figure MERC 1-1

- Water absorption measurements indicate that this does not create a problem with the shale samples. 7/77
- Limits of proton (¹H) NMR relaxation rates determined. 8/77
- Installation of a hard-wired pulse programmer completed. 9/77
- Cross-polarization accessory installed and tested 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

All tasks scheduled for initiation at this time are operational and no major technical or logistics problems are expected to develop to delay completion of the project. Work during this quarter involved the development of nuclear magnetic resonance (NMR) techniques of analysis applicable to samples of the Devonian Shale.

4.2 Geochemical Characterization Tasks (2300)

2300-1 Organic Material Analysis

This task was initiated during the first reporting period in 1976 and NMR analysis was initiated last quarter. NMR analysis was continued during this quarter with comparisons of black and gray shales and treated and untreated samples. Cross polarization accessory equipment has been installed as has a hard wired variable pulse programmer.

2300-2 Characterize chemical structure

This task was initiated during the first reporting period in 1976 and no progress has been reported during the last two quarters.

2300-3 Characterize pore structure
This task was initiated during the first reporting period in 1976 and no progress has been reported during the last two quarters.

GEOCHEMISTRY OF THE DEVONIAN SHALE

Morgantown Energy Research Center
Morgantown, West Virginia

Quarterly Report
July through September 1977

Contract No.:	EGSP-MERC No. 2	Contract Type:	Internal
Contract Date:	October 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	J. J. Kovach	Contract PI:	J. J. Kovach
Total Project Cost:		ERDA	\$150,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Morgantown Energy Research Center (MERC) project titled, "Geochemistry of the Devonian Shale" from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure MERC 2-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976." The project is to be completed by September 30, 1979.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● A technology exchange meeting on geochemistry and thermal maturation was held at MERC.	8/25/76- 8/26/76
● Project Planning Form submitted.	9/10/76
● Project initiated.	10/1/76

EVENTS OF PREVIOUS QUARTER:

● A manuscript on the organic content of the Hazard County, KY, core has been submitted for publication.	5/77
● A manuscript has been initiated describing the method of removing pyrite from the shale.	5/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>GEOCHEMICAL CHARACTERIZATION (2300)</u></p> <p>2300-1 Kerogen and bitumen characterization</p> <p>2300-2 Retorting parameter determination</p> <p>2300-3 Organic-mineral kinetic study</p>					

Figure MERC 2-1

- Statistical analyses received and interpretation initiated. 5/77
- Results of the statistical correlations are being compiled for a paper at the First EGSP Symposium. 6/77

EVENTS OF THIS REPORTING PERIOD:

- EGSP Symposium paper on organic content of Hazard, KY core completed. 8/77
- EGSP Symposium paper on Cottageville core completed. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported in the first two tasks of the Geochemical Characterization Work Packages. The third task is not scheduled to begin until FY78.

4.2 Geochemical Characterization Tasks (2300)

2300-1 Kerogen and bitumen characterization

This task was initiated during the second quarter of FY77 and work has continued to the present. Infrared analysis was used to determine the alkane/alkene ratio of benzene extracts from the shale using 5 regions of the infrared spectrum.

The University of Southern California is working on this task under a grant from MERC. During this quarter, they developed a calibrated IR method for directly determining the concentration of pyrite in kerogen and investigated methods for removal of pyrite from kerogen. Bitumen extracts were characterized by fractionization and

the aromaticity of asphaltic material in the shales determined. The aromaticity of pyrite-free kerogen concentrates was determined by XRD. Studies of the thermal and chemical degradation of kerogen were initiated.

Vanderbilt University, also under a MERC grant, performed XRD on four separate kerogens and recorded no distinct peaks other than pyrite.

2300-2 Retorting parameters

This task was initiated last quarter and has continued through this quarter with benzene extractions of the shale. Benzene extracts have been correlated with organic solvent extractable material as an indicator of depositional environment or thermal history.

PHYSICAL AND CHEMICAL CHARACTERISTICS
OF DEVONIAN SHALE SAMPLES

Mound Laboratory
Miamisburg, Ohio

Quarterly Report
July through September 1977

Contract No.:	EY-76-C-04-0053	Contract Type:	Cost
Contract Date:	October 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	L. C. Headley	Contract PI:	R. E. Zielinski
Total Project Cost:		ERDA:	\$369,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for Mound Laboratory on Contract EY-76-C-04-0053 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 0053-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	10/1/76

EVENTS OF PREVIOUS QUARTER:

● Mechanical testing equipment received.	4/28/77
● Detailed hydrocarbon analysis completed for Martin and Christian Counties, KY, and Effingham County, IL.	4/77
● Vitrinite reflectance study completed for Martin and Christian Counties, KY, and Effingham County, IL.	5/77
● Data management system established.	5/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>PHYSICAL CHARACTERIZATION (2200)</u></p> <p>2200-1 Rupture characteristics</p> <p><u>GEOCHEMICAL CHARACTERIZATION (2300)</u></p> <p>2300-1a Organic carbon analysis</p> <p>2300-1b Fischer Assay</p> <p>2300-1c GC analysis</p> <p>2300-1d Oil analysis</p> <p>2300-1e Hydrocarbon analysis</p> <p>2300-2 Kerogen analysis</p> <p>2300-3 Hydrocarbon release during mechanical loading</p> <p>2300-4 Physicochemical NMR, SEM and EDS analysis</p>					

- Special study initiated to determine effects of moisture in shale. 5/77
- Special dilatometer study initiated to determine effects of fracture fluids on shale. 5/77
- Special clay mineralogy studies initiated. 5/77
- Attended meeting at MERC to discuss program progress. 5/4/77
- Attended outgassing meeting at MERC. 5/4/77
- Presented data management system at MERC. 5/5/77
- Demonstrated data management system at MERC. 6/3/77
- Attended coring and sampling meeting, Morgantown, WV. 6/27/77
- Attended Fractography Workshop, Morgantown, WV. 6/28/77-6/29/77

EVENTS OF THIS REPORTING PERIOD:

- All samples from the KY-2 core have been prepared for physical testing and Shore hardness tests. 7/77
- The dilatometer study of sample KY-2-33 has been completed with four test fluids. 7/77
- Gas volume and composition completed on KY-2 core. 7/77
- C₁-C₇ hydrocarbons, organic carbon, C₄-C₇ hydrocarbons, C₁₅+ Soxhlet extractions, P-N hydrocarbons, visual kerogen assessment, and vitrinite reflectance completed on Va-1 and P-1 samples. 7/77
- Kerogen samples prepared and shipped to MERC. 7/77
- Diametral compression tests completed on KY-2. 8/77
- Gas volume and composition completed on O-1, I-1, and Va-1 cores. 8/77
- Gas volume and composition completed on all samples. 9/77
- Clay mineralogy studies completed for I-1, P-1, KY-2, and Va-1 cores. 9/77
- Stable carbon isotope studies completed on KY-2, Va-1, P-1, O-1, and I-1 cores. 9/77
- Pyrolysis GC completed on I-1 and P-1 cores. 9/77

- Glove box prepared for mechanical testing. 9/77
- Permeation study initiated. 9/77
- Biostratigraphy study completed on O-1, P-1, Va-1,
and KY-2 cores. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

The Physical Characterization Work Package (2200) tasks involved sample preparation, Shore hardness, diametral compression, and mechanical testing to determine effects of relative humidity on fractures. The Geochemical Characterization Work Package (2300) tasks involved analysis of gas volume and composition, clay mineralogy, stable carbon isotopes, pyrolysis gas chromatography, C₁-C₇, C₁₅+, kerogen characterization, vitrinite reflectance, fuel yield/pulsed NMR, and detailed C₄-C₇ hydrocarbons.

4.2 Physical Characterization Tasks (2200)

2200-1 Rupture Characteristics

Shore hardness and diametral compression testing was completed on the KY-2 core and work initiated on O-1 and I-1 core samples. The mechanical testing equipment is operational and the sample preparation procedure has been changed to allow the sample to be prepared in a helium atmosphere.

4.3 Geochemical Characterization Tasks (2300)

- 2300-1a Organic carbon content
Organic carbon analysis has been completed for all samples received.
- 2300-1b Fischer Assay
All samples from wells O-1, P-1, I-1, and KY-2 have been analyzed. All other samples are in progress.
- 2300-1c GC analysis
Pyrolysis GC has been completed on wells I-1 and P-1.
- 2300-2 Kerogen analysis
Kerogen characterization is complete on 90 percent of the samples received. Vitrinite reflectance and C₁₅₊ hydrocarbon studies are also complete on 90 percent of the samples.
- 2300-3 Hydrocarbon release during mechanical loading
This task is associated with Task 2200-1 and is in progress at this time. Permeation studies have been initiated.
- 2300-4 Physicochemical, NMR, SEM, and EDS analysis
Pulsed NMR experiments to determine the relationships between the total hydrogen content, oil yield, organic carbon content, and total gas content of the Martin County, KY, well have been completed and indicate a high degree of correlation between the variables. SEM studies of the Martin County and Christian County, KY, wells have been completed.

4.4 Special Studies Requested by ERDA-MERC

Moisture effects

This task was initiated last quarter with NMR studies and continues this quarter with studies on the effects of relative humidity on fractures.

Dilatometry study

This task was initiated last quarter and work has continued to the present. During this quarter, samples from well KY-2 were exposed to water, water and 2 percent KCl, 30 percent methanol-70 percent water, and KCl and kerosene.

Clay mineralogy

This task was initiated last quarter and four wells (I-1, P-1, KY-2, Va-1) were completed during this quarter.

Statistical analysis of the Clinton Sand

This task was initiated this quarter and the first phase has been completed and the second phase initiated.

Biostratigraphy studies

Biostratigraphy studies were initiated and completed on wells I-1, O-1, Va-1, and KY-2.

Archeological survey

An archeological survey was initiated and completed on potential well sites in Lawrence and Scioto Counties, OH. The Preservation Officer for the State of Ohio has agreed with the recommendations of the survey and artifacts collected are presently at Mound.

CHARACTERIZATION AND HYDROCARBON RESOURCE
APPRAISAL OF MIDDLE AND UPPER
DEVONIAN BLACK SHALES IN NEW YORK STATE

University of the State of New York
Regents Research Fund, Inc.
(New York Geological Survey)
Albany, New York

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5206	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	M. West	Contract PI:	A. van Tyne L. Rickard
Total Project Cost:		ERDA:	\$59,475

1.0 INTRODUCTION

This quarterly report reviews the achievements for the University of the State of New York Regents Research Fund (Geological Survey) on Contract E(40-1)-5206 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5206-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	9/30/76
● Contract approved by N.Y.S. Board of Regents.	10/27/76

EVENTS OF PREVIOUS QUARTER:

● Attended EGSP stratigraphers' meeting at Reston, VA.	4/14/77
● Completed inventory and compilation of well data.	4/77
● Attended symposium on improved oil and gas recovery, Bradford, PA.	5/12/77
● Submitted to MERC abstract of proposed paper for EGSP Symposium.	6/23/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Cross sections					
2100-2 Regional stratigraphic correlations					
2100-3 Isopach and structure maps					
2100-4 Specific horizon structural maps					
2100-5 Lineament maps					
2100-6 Black shale well map					
2100-7 Current oil and gas production maps					
2100-8 Past oil and gas production maps					
2100-9 Clay mineral distribution maps					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Core lithologic description					
<u>RESOURCE ASSESSMENT (2400)</u>					
2400-1 Estimation of recoverable reserves					
<u>INFORMATION (1300)</u>					
1300-1 Data encoding					

Figure 5206-1

- Attended EGSP meeting, Pittsburgh, PA. 6/24/77
- Submitted eight base maps to USGS, Reston, VA. 6/77

EVENTS OF THIS REPORTING PERIOD:

- Visited Albany office to discuss regional correlations. 7/11/77-7/15/77
- Attended stratigraphy meeting with USGS, Pennsylvania GS, and Ohio GS in Pittsburgh, PA. 7/19/77
- Completed assembling of basic data for the project. 7/77
- Samples from five new wells received and processed. 7/77
- First annotated WHCS formats for New York wells received from PIC. 8/10/77
- Attended meeting with USGS and PIC in Pittsburgh, PA. 8/22/77
- Submitted paper to MERC for EGSP Symposium. 9/9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in the Geological Evaluation Work Package (2100) and Information Work Package (1300).

The Geological Evaluation Task (2100) work involved the completion of the study of the Dunkirk and Rhinestreet black shales and the preparation of a paper on these units for the EGSP Symposium. Information Task (1300) work was centered around resolving problems with the encoding format.

4.2 Geological Evaluation Tasks (2100)

- 2100-1 Cross sections
This task was initiated during the first reporting period in 1976 and work continued through the last quarter. No work was reported during this quarter.
- 2100-2 Regional stratigraphic correlations
This task is continuous for the duration of the project. Previous work extended correlations over the boundaries of adjacent states. Much of the current work on the Dunkirk and Rhinestreet shales would contribute to this task.
- 2100-3 Isopach and structure maps
This task was initiated last quarter with the completion of the base maps (8) and isopach and structure contour maps of the Dunkirk and Rhinestreet black shales. This quarter, the maps were finalized and prepared for presentation.
- 2100-4 Specific horizon structure maps
This task was initiated last quarter with the completion of the structure contour maps of the Dunkirk and Rhinestreet shales. During this quarter, text and illustrations were prepared for a paper to be presented at the EGSP Symposium.
- 2100-5 Lineament maps
Data continues to be collected but there is no indication that it is being plotted.
- 2100-6 Black shale well maps
This task was initiated in the second quarter of FY77. Work had been temporarily suspended to concentrate on the Dunkirk and Rhinestreet black shale studies but now has been started up again.
- 2100-7 Current oil and gas production maps
This task was initiated in the second quarter of FY77 and data collection and construction of the base map were completed last quarter.
- 2100-8 Past oil and gas production maps
This task was initiated during the second quarter of FY77 and the data collection and base map were completed last quarter.

4.3 Physical Characterization Tasks (2200)

- 2200-1 Core lithologic descriptions
This task is continuous over the length of the project and is implemented as core is made available.

4.4 Resource Assessment Tasks (2400)

2400-1 Estimation of recoverable reserves

This task has been initiated by starting data collection.

4.5 Information Tasks (1300)

1300-1 Data encoding

This task was initiated during the first reporting period in 1976. The data inventory has been completed. Work this quarter involved the resolution of formatting problems with PIC.

EASTERN GAS SHALES PROJECT STUDY
OF THE
UPPER DEVONIAN SHALE IN OHIO

Ohio Department of Natural Resources
Geological Survey
Columbus, Ohio

Quarterly Report
July through September 1977

Contract No.:	EY-76-C-05-5200	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	R. J. Watts	Contract PI:	R. A. Struble
Total Project Cost:		ERDA:	\$170,894

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Ohio Department of Natural Resources, Geological Survey, on Contract EY-76-C-05-5200 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5200-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	9/27/77

 EVENTS OF PREVIOUS QUARTER:

● Attended meeting with ERDA-MERC in Morgantown, WV.	4/19/77
● Participated in Columbus, OH EGSP meeting.	6/22/77
● Signed SRSA contract.	6/23/77
● Attended coring and sampling meeting in Morgantown, WV.	6/27/77
● Attended Fractographic Workshop in Morgantown, WV.	6/28/77- 6/29/77
● Received fully executed SRSA contract.	6/30/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Advise ERDA on drill sites and coring					
2100-2 Cross sections					
2100-3 Isopach maps					
2100-4 Lithofacies maps					
2100-5 Devonian Shale well map					
2100-6 Oil and gas production map					
2100-7 Regional structure maps					
2100-8 Specific horizon structure maps					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Density analysis					
2200-2 Size analysis					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Mineralogic and petrographic analysis					
2300-2 Lithologic description					
2300-3 X-ray diffraction analysis					
2300-4 Thin section petrographic analysis					
2300-5 Organic fraction analysis					
2300-6 SEM analysis					
2300-7 Elemental analysis					
2300-8 Proximate analysis					
2300-9 Ultimate analysis					
2300-10 Geochemical cross sections and maps					

Figure 5200-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>RESOURCE ASSESSMENT (2400)</u>					
2400-1 Monitoring of gas shows					
2400-2 Correlation of gas shows					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Lineament definition from remote sensing imagery					
<u>INFORMATION (1300)</u>					
1300-1 Plot unrecorded wells					
1300-2 Compile, check, and edit data					
1300-3 Data encoding					

Figure 5200-1 (Continued)

EVENTS OF THIS REPORTING PERIOD:

- Attended meeting in Pittsburgh, PA, with USGS and Pennsylvania Geological Survey. 7/19/77
- Work initiated on well selection for isopach maps of Devonian Shale units in eastern Ohio. 7/77
- Work initiated on structure maps on the top of the shale and units within the shale. 7/77
- Attended meeting with USGS, PIC, and ERDA/MERC in Pittsburgh, PA. 8/22/77
- Completed preliminary isopach map of the radioactive facies of the Lower Huron Member and the Rhinestreet equivalent in Ohio. 8/77
- Completed preliminary structure map on the base of the Huron Member. 8/77
- Lineament interpretation from LANDSAT initiated. 9/77
- Mineralogy, petrology, and geochemistry work initiated. 9/77
- Contract modification received. 9/15/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during the reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in the Geological Evaluation, Geochemical Characterization, and Exploration R&D Work Packages. Geological Evaluation work involved the construction of preliminary isopach and structure maps. The first samples for the Geochemical Characterization were taken near the end of the quarter. The Exploration R&D Work

Package was initiated this quarter with lineament definition from LANDSAT photographs.

4.2 Geological Evaluation Tasks (2100)

- 2100-1 Advise ERDA on drill sites and coring
This task is continuous for the duration of the project and information is supplied as requested.
- 2100-3 Isopach maps
This task was initiated during this quarter and preliminary isopach maps of major lithologic units in eastern Ohio were completed. The maps included the radioactive facies of the Lower Huron Member, the radioactive facies of the Upper Huron Member, and the radioactive facies of the Rhinestreet equivalent.
- 2100-5 Devonian Shale well map
This task was completed during the last quarter.
- 2100-6 Ohio and gas production map
This task was completed during the last quarter.
- 2100-8 Specific horizon structure maps
This task was initiated this quarter and a preliminary structure map on the base of the Lower Huron Member was completed for incorporation into the regional structure map to be constructed by the USGS.

4.3 Geochemical Characterization Tasks (2300)

Samples were collected, representative splits taken, and preparation initiated for the following tasks:

- 2300-1 Mineralogic and petrographic analysis
- 2300-2 Lithologic description
- 2300-3 X-ray diffraction analysis
- 2300-4 Thin section petrographic analysis
- 2300-5 Organic fraction analysis
- 2300-6 SEM analysis
- 2300-7 Elemental analysis
- 2300-8 Proximate analysis

2300-9 Ultimate analysis

2300-10 Geochemical cross sections and maps

4.4 Exploration R&D Tasks (3200)

3200-1 Lineament definition from remote sensing data

Twenty-five (25) scenes of multiseasonal LANDSAT transparencies were obtained and lineament identification and interpretation initiated during this quarter.

STRATIGRAPHIC FRAMEWORK FOR THE MIDDLE
AND UPPER DEVONIAN BLACK SHALES AND
RELATED ROCKS OF WESTERN AND CENTRAL
PENNSYLVANIA

Pennsylvania Topographic and Geologic Survey
Harrisburg, Pennsylvania

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5198	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	J. B. Roen	Contract PI:	W. S. Lytle
Total Project Cost:		ERDA	\$81,073

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Pennsylvania Topographic and Geologic Survey on Contract E(40-1)-5198 from July through September 1977. The purpose of the contract is to address the "Resource" aspect of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5198-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	9/20/76

EVENTS OF PREVIOUS QUARTER:

● Stratigraphic cross section completed and turned in to USGS at Reston, VA.	4/14/77
● Show and production map completed and turned in to USGS at Reston, VA.	4/14/77
● Attended meeting with USGS at Reston, VA.	4/14/77
● Schematic diagram of nine cross sections turned in to USGS.	5/1/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>GEOLOGICAL EVALUATION (2100)</u></p> <p>2100-1 Devonian Shale well map</p> <p>2100-2 Onondaga drilling depth map</p> <p>2100-3 Cross sections</p> <p>2100-4 Lithofacies maps</p> <p>2100-5 Structure maps</p> <p>2100-6 Isopach maps</p> <p><u>INFORMATION (1300)</u></p> <p>1300-1 Encode data</p> <p>1300-2 Core storage</p>	<p>✓</p>	<p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p>	<p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p>	<p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p>	<p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p> <p>✓</p>

Figure 5198-1

- Contour maps, including isopach of the radioactive zone, thickness of interbedded radioactive shale, and structure maps on the base of the Dunkirk and Rhinestreet Shales sent to USGS at Reston, VA. 6/13/77
- Corrected show and production map resubmitted to USGS at Reston, VA. 6/13/77

EVENTS OF THIS REPORTING PERIOD:

- Attended stratigraphy meeting with USGS, Ohio G.S., and N.Y.G.S. in Pittsburgh, PA. 7/19/77
- Show and production map submitted to ERDA/MERC. 7/21/77
- Attended meeting with USGS and PIC in Pittsburgh, PA. 8/22/77
- Attended meeting with Moody and Associates, Inc. in Meadville, PA. 9/29/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in both Work Packages. The Geological Evaluation Task (2100) work involved making corrections on the finished cross sections and the show and production map, gathering data and constructing structure maps, maps of the radioactive zones, and the drilling depth map. All tasks have been initiated and are generally on schedule.

The Information Tasks (1300) have been initiated. Data is being compiled and the quantity, quality, and distribution of the data is being closely checked.

All work is generally proceeding on schedule and no technical or logistics problems which could cause delays are anticipated at this time.

4.2 Geological Evaluation Tasks (2100)

2100-1 Devonian Shale well map

This task was initiated during the first reporting period in 1976 and was completed during the following quarter. Corrections were made and the map resubmitted last quarter. The MOD was sent to ERDA/MERC for final review this quarter.

2100-2 Onondaga drilling depth map

This task was initiated during the 1976 reporting period and work continues to the present. It was scheduled for completion on February 1, 1977, and is behind schedule at this time. All data collection and plotting is completed and the drafting is 95 percent completed at this time.

2100-3 Cross sections

This task was initiated during the 1976 reporting period and work has continued to the present. The local and basinwide sectioning programs were reported as complete. Changes suggested by the USGS have been made to all sections and drafting is ready to begin.

2100-4 Lithofacies maps

Work was initiated during the second quarter of FY 77 with the collection of detailed data. This work has continued through this quarter.

2100-5 Structure maps

This task was initiated during the second quarter of FY 77 and work continued through the last quarter with the submission of the maps of the Dunkirk and Rhinestreet Shales. No progress was reported during this quarter.

2100-6 Isopach maps

Data continues to be compiled for Pennsylvania on the cumulative thickness of radioactive Dunkirk, Rhinestreet, and Huron Black Shales having 20 API units or greater.

4.3 Information Tasks (1300)

1300-1 Encode data

Data collection was initiated during the second quarter of FY77 and has continued to the present. Encoding is not scheduled to begin until October 1, 1977.

1300-2 Core storage

To date, no core has been reported as received.

EVALUATION OF THE CHATTANOOGA SHALE
IN THE TENNESSEE VALLEY AND RIDGE
FOR NATURAL GAS AND URANIUM

NO REPORTS

Tennessee Department of Conservation
Division of Geology
Nashville, Tennessee

Quarterly Report
July through September 1977

Contract No.:	EY-76-C-05-5196	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion date:	September 30, 1977
Contract TPO:	C. I. Pierce	Contract PI:	A. T. Statler
Total Project Cost:		ERDA:	\$209,971

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Regional stratigraphic cross sections					
2100-2 Correlation of stratigraphic units					
2100-3 Local and regional stratigraphic framework					
2100-4 Isopach and isolith maps					
2100-5 Structure maps of well-identified units					
2100-6 Structure maps of black shale members					
2100-7 Areal structural patterns					
2100-8 High fracture porosity area maps					
2100-9 Oil and gas production maps					
2100-10 Correlation of production areas and fracture and structure patterns					
2100-11 Geologic mapping and outcrop studies					
2100-12 Potential natural gas pool maps					
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Drilling and partial coring of Chattanooga Shale					
3100-2 Wireline geophysical logging					
3100-3 Drilling and partially coring at two additional sites (if recommended)					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Shallow seismic profiles					
3200-2 Test hole and seismic location map					

Figure 5196-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>PRODUCTION AND STIMULATION R&D (3300)</u></p> <p>3300-1 Testing and treating of potential gas-bearing zones (if recommended)</p> <p><u>INFORMATION (1300)</u></p> <p>1300-1 Data compilation and encoding</p> <p>1300-2 Preparation of open-file data</p>					

Figure 5196-1 (Continued)

GEOLOGICAL, GEOCHEMICAL, AND GEOPHYSICAL
APPRAISAL OF ENERGY RESOURCES OF THE
DEVONIAN BLACK SHALE IN THE APPALACHIAN BASIN

United States Geological Survey
Reston, Virginia

Quarterly Report
July through September 1977

*Contract No.: EX-76-C-01-2287

Contract Date: January 1, 1976

Completion Date: September 30, 1977

Contract TPO: A. E. Hunt

Contract PI: W. deWitt, Jr.

Total Project Cost:

ERDA \$1,859,480

* The USGS is performing work under an Interagency Agreement rather than a contract.

1.0 INTRODUCTION

The Quarterly Report reviews the achievements for the United States Geological Survey on Interagency Agreement EX-76-C-01-2287 from July through September 1977. The purpose of the Interagency Agreement is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of tasks. The individual tasks and their schedule by Work Package are shown in Figure 2287-1. Additional details of task requirements are given in the "Six-Month Summary Report, July 1 to December 31, 1976".

Most work being done by the USGS involves coordination and evaluation of data from EGSP contractors. As such, most Work Package Tasks, as shown in Figure 2287-1, will continue over the duration of the other EGSP contracts. Some specific tasks in each of the Work Packages have earlier completion dates.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Interagency Agreement E(49-18)-2287 signed establishing the USGS Shale Characterization (SC) and Resource Appraisal (RA) Program as a part of the EGSP	2/4/76

EVENTS OF PREVIOUS QUARTER:

- Initiated a search for participants in cutting a core in the Devonian Shale in Chautauqua County, NY. Search

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Monitoring of stratigraphic work					
2100-2 Regional correlation of basic units					
2100-3 Publication of contractor maps					
2100-4 Unit delineation and correlation with production					
2100-5 Regional lineament analysis					
2100-6 Lineament analysis and correlation with gravimetric data					
2100-7 Structural studies of stratigraphy					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Sample analysis					
2300-2 Revision of sampling program					
2300-3 Reconnaissance survey of maturation					
2300-4 Vitrinite reflectance/CCI comparison					
2300-5 Publication of maturation analysis					
2300-6 Conodont studies					
2300-7 Core uranium and trace element analysis					
2300-8 Clay extraction procedure development					
2300-9 X-ray machine automation					
<u>RESOURCE ASSESSMENT (2400)</u>					
2400-1 Determination of reserves					

Figure 2287-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>EXPLORATION R&D (3200)</u> 3200-1 Orbit Gas Well analysis 3200-2 Borehole gravimeter logging					
<u>INFORMATION (1300)</u> 1300-1 EGSP ADP system 1300-2 Data checklist and forms 1300-3 Well location maps					

Figure 2287-1 (Continued)

- coordinated with N.Y.G.S. 4/6/77
- Held meeting for EGSP stratigraphers at the USGS facility in Reston, VA 4/14/77
- Conference with A. Hunt and J. Smith on revised scheduling of stratigraphic work and possibilities of an enlarged core-drilling program 4/18/77
- Submitted a report by J. Schmoker entitled "A Borehole Gravity Survey to Determine Density Variations in the Devonian Shale Sequence of Lincoln County, West Virginia" to ERDA/MERC 4/22/77
- Half-year budget revision completed 4/25/77
- First regional cross section (Tennessee to west central New York) approved by Branch Chief 4/29/77
- Attended quarterly review at ERDA/MERC 5/10/77
- Submitted map of areas of greatest potential for accelerated core drilling program in the Appalachian Basin to ERDA/MERC 5/19/77
- Participated in ERDA's MOPPS at the USGS facility at Reston, VA 5/24-26/77
- Stratigraphy data input formats for the EGSP data system drafted and printed by PI 5/25-27/77
- Conference with Pennsylvania Geological Survey about "six-months" deliverables maps 6/13/77
- Work schedules and budget for FY78 completed 6/15/77
- Attended EGSP technology transfer meeting in Lexington, KY 6/20/77
- Attended EGSP technology transfer meeting in Columbus, Ohio 6/22/77
- Attended EGSP technology transfer meeting in Pittsburgh, PA 6/24/77
- 6 abstracts prepared for 1st Annual Devonian Shale Symposium 6/77
- Attended coring and sampling meeting in Morgantown, WV 6/27/77
- Arranged to run borehole gravity surveys of several old Oriskany wells in cooperation with Columbia Gas Transmission Corp. 6/27/77

- Measured sections and collected samples from Big Stone Gap and Duffield, VA and Little War Gap, Tenn. in cooperation with the University of Cincinnati 6/27-28/77
- Analysis of gas data from cores in Wise County, VA and Martin County, KY completed 6/30/77
- Examined outcrop near Clay City, KY that has no recognizable Berea Sandstone or Bedford Shale 6/30/77
- Stratigraphic and structural data for the accelerated "one hot zone" study received from Pennsylvania Geological Survey and the New York Geological Survey 6/30/77

EVENTS OF THIS REPORTING PERIOD:

- 940 stratigraphic annotations were sent to the University of Kentucky 7/6/77
- Outcrop of Devonian Shale along the Cincinnati Arch was examined 7/11-13/77
- Samples for geochemical analysis obtained from Tennessee Division of Geology 7/11-13/77
- Held meeting on stratigraphic correlations for New York, Pennsylvania, and Ohio Geological Surveys in Pittsburgh, PA 7/19/77
- Late Devonian conodonts found in lower stratigraphic horizon than encountered previously 7/77
- Joint lineation data collected from the Valley and Ridge Province of Virginia and West Virginia 7/77
- Revision of staff assignments for FY78 completed 7/77
- Agreement between ERDA and USGS to publish large maps and charts determined to be illegal 7/77
- Tentative date for a meeting between contractor and PIC set for August 22 7/77
- Reviewed Case-Western Reserve proposal 8/3/77
- Stratigraphic Services, Inc. presentation in Reston, VA 8/9/77
- Held workshop with PIC and EGSP contractors to clarify and update encoding formats 8/22/77
- Attended review of Lewin & Assoc. analysis of the EGSP at the ERDA 3rd Symposium on Enhanced Oil and Gas Recovery 8/29/77

- 10/20/77 date set for workshop for EGSP contractors on data encoding at MERC 8/77
- Reviewed proposal to make a preliminary survey of surface outcrop of Devonian Shales in the Appalachian Region 9/1/77
- Attended meetings with MERC, SAI, and Intercomp D & E in Morgantown, WV 9/8/77
- Attended meeting with Lewin & Assoc. in Washington, DC 9/20-21/77
- First regional stratigraphic cross section has been prepared for printing 9/77
- Stratigraphic and structural data collected from Ohio, Pennsylvania and southwestern New York. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Work reported for this quarter included field work to collect structural, stratigraphic, and lineation data and attending workshops and conferences with MERC and EGSP contractors. Samples were collected for geochemical analysis and work initiated.

The project is behind schedule in several specific tasks. Information Work Package Tasks have not been effectively implemented and are over nine months behind schedule. A new schedule of task-specific completion dates is necessary.

4.2 Geological Evaluation Tasks (2100)

2100-1 Monitoring of stratigraphic work

A meeting was held in Pittsburgh, PA with the New York, Pennsylvania, and Ohio Geological Surveys to discuss the possible early completion of some phases of this program.

- 2100-2 Regional correlation of basic units
This task was initiated in the first reporting period in 1976 and work has continued to the present. This quarter, the first regional cross section is reported to be ready for printing.
- 2100-3 Publication of contractor maps
This task has been set back for an indeterminate period by the decision that the agreement between ERDA and the USGS to publish large maps and charts is illegal. In order to obtain printing for these items, ERDA will have to go through GPO.
- 2100-4 Unit delineation and correlation with production
This task was initiated during the second quarter of FY77 with the construction of a map illustrating the eight areas in the Appalachians considered to have a high gas production and potential. The finalized map was submitted to ERDA/MERC last quarter and no further progress was reported this quarter.
- 2100-5 Regional lineament analysis
This task was initiated during the first reporting period in 1976 and no progress was reported last quarter. During this quarter, field data was collected from the Valley and Ridge Province of Virginia and West Virginia.
- 2100-6 Lineament analysis and correlation with gravimetric data
This task was initiated last quarter and no progress was reported during this quarter.
- 2100-7 Structural studies of stratigraphy
This task was initiated this quarter with the collection of field data from Ohio, Pennsylvania, and New York.
- 4.3 Geochemical Characterization Tasks (2300)
- 2300-1 Sample analysis
This task was initiated during the second quarter of FY77. During this quarter, samples were collected from the Tennessee Division of Geology and are currently undergoing analysis.
- 2300-2 Revision of sampling program
This task was initiated last quarter. No progress was reported this quarter.
- 2300-3 Reconnaissance survey of maturation
This task was initiated during the first reporting period in 1976. No progress has been reported during the last two quarters.

2300-6 Conodont studies

This task was initiated this quarter with the study of conodonts from outcrops in Tennessee and Virginia. These studies have identified the black shale at Little War Gap, Clinch Mountain, TN, as Rhinestreet or younger and the metabentonite as Upper Devonian eliminating a correlation with the Tioga Metabentonite. The Rhinestreet was also identified at the Greendale Syncline, Scott County, VA.

2300-7 Core uranium and trace element analysis

This task was initiated during the first reporting period in 1976. During this quarter, samples were collected and are currently being analyzed.

4.4 Exploration R&D Tasks (3200)

3200-2 Borehole Gravimeter logging

This task was initiated during the first reporting period in 1976. Some work was done last quarter. No progress was reported this quarter.

4.5 Information Tasks (1300)

2300-1 EGSPADP System

This task has been in the implementation stage for more than eleven months. Problems areas are not yet resolved and several more meetings were held this quarter. A final meeting has been set for October 20 at MERC with the final formats to be delivered to the contractor by November 1.

2300-2 Data checklists and forms

Very little progress was reported during this quarter. The task is to be completed next quarter along with development of the ADP System.

ENERGY RESOURCES OF THE DEVONIAN
SHALES IN THE APPALACHIAN BASIN

University of Cincinnati
Cincinnati, Ohio

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5201	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	R. C. Kepferle (USGS)	Contract PI:	P. E. Potter
Total Project Cost:		ERDA	\$183,513

1.0 INTRODUCTION

This quarterly report reviews the achievements for the University of Cincinnati on Contract E(40-1)-5201 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5201-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date.	7/1/76
• Contract signed.	8/17/76

EVENTS OF PREVIOUS QUARTER:

• Collected samples from cores at Morgantown, WV.	4/77
• Collected samples from core at Lexington, KY.	4/77
• Field trip to western Virginia to locate shale outcrops.	4/77
• Training field trip to Virginia and Tennessee.	5/77
• Collected samples from core at Morgantown, WV.	6/27/77- 6/28/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Appalachian Basin Analysis					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Particle orientation studies					
2200-2 Pore space studies					
2200-3 Porosity and permeability analysis					
2200-4 Particle surface area analysis					
2200-5 Grain size analysis					
2200-6 Aggregate particle morphology studies					
2200-7 Grain orientation studies					
2200-8 Bedding features description					
2200-9 Paleontological description					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Organic material determination					
2300-2 Exchangeable cation determination					

Figure 5201-1

- Field trip to West Virginia. 6/77

EVENTS OF THIS REPORTING PERIOD:

- Analyses completed for organic carbon, mineral carbon, carbon isotopes, and uranium on 45 outcrop samples. 7/77
- 25 samples sent to USGS (Denver) for uranium analysis. 7/77
- Characterization study of banding in the Devonian Shale initiated to determine what effects different shale members may have on stimulation efficiency. 7/77
- Determined that carbon isotope values are affected by extraction techniques. 8/77
- Attended encoding meeting with USGS and PIC in Pittsburgh, Pa. 8/22/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during the reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in the Geological Evaluation (2100) and Geochemical Characterization (2300) Work Packages. The Geological Evaluation task work involved the measurement of stratigraphic sections and paleocurrent indicators and the construction of isopach and structure contour maps. The Geochemical Characterization task work involved the analysis of outcrop samples for organic and mineral carbon, carbon isotopes, and uranium analysis.

4.2 Geological Evaluation Tasks (2100)

2100-1 Appalachian Basin analysis

This task was initiated during the first reporting period in 1976 and work has continued to the present. During this quarter, work was centered around the measurement of stratigraphic sections and the mapping of paleocurrent indicators. During this quarter, 710 measurements of paleocurrent indicators were mapped, bringing the total to 1216 measurements. Isopach maps of the upper and lower parts of the Huron Member of the Ohio Shale in Kentucky were completed as was a structure contour map on the base of the Ohio Shale in eastern Kentucky.

4.3 Physical Characterization Tasks (2200)

This work package was initiated during the second quarter of FY77 with the installation of the SEM.

2200-8 Bedding features description

A study was initiated this quarter to study banding in the shale to determine what effects different shale members have on stimulation efficiency. Preliminary results obtained indicate that the soft member of the banding is higher in moisture, lower in Shore hardness, and less organic than the hard member.

4.4 Geochemical Characterization Tasks (2300)

2300-1 Organic material determination

This task was initiated in the second quarter of FY77 with the analysis of 60 samples for C^{13}/C^{12} and continued through last quarter with the analysis of 50 samples for total carbon. During this quarter, 45 samples from outcrops were analyzed for organic and mineral carbon, C^{13}/C^{12} , and uranium and an additional 25 samples sent out for uranium analysis.

2300-2 Exchangeable cation determination

A paper on this work was completed and was being expanded. No progress was reported during this quarter.

BLACK SHALE STUDY

IN

KENTUCKY

University of Kentucky Research Foundation
Lexington, Kentucky

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5202	Contract Type:	Cost-Sharing
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	R. C. Kepferle (USGS)	Contract PI:	E. N. Wilson

Total Project Cost:	ERDA	\$270,626
	U. Kentucky	<u>20,009</u>
		\$290,635

1.0 INTRODUCTION

This quarterly report reviews the achievements for the University of Kentucky Research Foundation on Contract E(40-1)-5202 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5202-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date.	7/1/76
• Contract signed.	9/29/76

EVENTS OF PREVIOUS QUARTER:

• Staff attended workshop in Reston, VA, held to coordinate interstate stratigraphic progress.	4/77
• The outcrop extent of the Sunbury-Ohio-New Albany-Chattanooga Shales has been delineated.	4/77
• Well spotting completed for Lewis County, KY.	4/77
• Staff attended symposium on "Economics of Natural Gas."	4/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Examination of outcrop and well cuttings samples and logs					
2100-2 Advise ERDA on drill sites and coring					
2100-3 Regional stratigraphic description and correlation					
2100-4 Lithofacies maps and cross sections					
2100-5 Black shale depositional model					
2100-6 Correlation of lithologic and time-stratigraphic units					
2100-7 Regional structure maps and cross sections					
2100-8 Detailed Structure contour maps					
2100-9 Isopach maps					
2100-10 Oil and gas production maps					
2100-11 Lineament maps					
2100-12 Correlation of remote sensing and production data					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Core and outcrop description and logging					
2200-2 Floral and faunal description					
2200-3 Description of sedimentary structures					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 X-ray diffraction analysis					
2300-2 Kerogen elemental chemistry analysis					
2300-3 Petrographic analysis					

Figure 5202-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
2300-4 Kerogen/radioactivity/gas production investigations 2300-5 Statistical evaluation of geochemical data <u>INFORMATION (1300)</u> 1300-1 Compile and encode data					

Figure 5202-1 (Continued)

- Perry County, KY core arrived from ERDA. 4/77
- Procedures established for sampling core in storage at the Kentucky Geological Survey. 4/77
- Staff met with MERC/EGSP Project Manager in Morgantown, WV. 5/77
- Four stratigraphic sections along the outcrop belt measured, sampled, and described. 5/77
- Samples from the Letcher County, KY Pine Mountain core were sent to University of Illinois for thin-sectioning. Samples from the Perry County core are being prepared. 5/77
- Well log inventory for Lawrence County completed and the inventory for Morgan County begun. 5/77
- The outcrop at Clay City, KY re-measured. 5/77
- Scintillometer acquired as an additional tool for stratigraphic analysis. 5/77
- Formatting for interface with the PIC data bank is underway. 5/77

EVENTS OF THIS REPORTING PERIOD:

- Seven complete stratigraphic sections measured. 7/77
- Preliminary study of 50 thin sections completed. 7/77
- Georef bibliography compiled with 500 references. 7/77
- Attended meeting with water quality group of KY DNR. 7/15/77
- Catalogue of published sample descriptions completed. 7/77
- Professional paper on wireline logs and sample studies accepted for presentation at EGSP Symposium. 7/77
- An expanded catalogue of stratigraphic names initiated. 7/77
- Isopach maps of the Upper and Lower Huron Member of the Ohio Shale completed. 7/77
- Attended meeting with PIC and USGS at Pittsburgh, PA. 8/22/77
- Work initiated on Morgan County, KY well log inventory. 8/77
- Initiated Perry County thin section work. 8/77

- Initiated study of carbonized Foerstia in coalified wood samples separated from the shale. 8/77
- Morgan and Montgomery County, KY well log inventories completed. 9/77
- Martin County, KY well core described and sampled. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in all Work Packages. The Geological Evaluation work involved examination of well cuttings to augment stratigraphic data, measurement of stratigraphic sections, construction of isopach maps, and completion of a bibliography. The Physical Characterization work involved the description of well cores and palentological studies of the core. The Geochemical Characterization work consisted of thin section sampling, preparation, and analysis. Information Task work involved the development of a Calcomp plotting program to plot data from Carter coordinates and work on formatting for future interfacing with PIC.

4.2 Geological Evaluation Tasks (2100)

- 2100-1 Examination of outcrop and well cuttings samples and logs
This task was initiated during the first reporting period in 1976 and work has continued to the present. During this quarter, sample descriptions from three wells were prepared and supplied to other EGSP contractors.

- 2100-2 Advise ERDA on drill sites and coring
This task is ongoing and continues for the duration of the project on a site specific basis.
- 2100-3 Regional stratigraphic description and correlation
This task was initiated during the first reporting period in 1976 and work has continued to the present. Prior to this quarter, four regional cross sections and a tie section were completed. During this quarter, comments from the USGS and Va. Div. of Min. Res. were incorporated into the southern tie sections and sample studies initiated.

The preparation of a base map with well locations and other pertinent information is still in progress. A map of the black shale is also in progress and the well log inventories have been completed for twelve counties. These maps and the inventory can be applied to all of the following tasks:

- 2100-4 Lithofacies maps and cross sections
- 2100-5 Black shale depositional model
- 2100-6 Correlation of lithologic and time stratigraphic units
- 2100-7 Regional structure maps and cross sections
- 2100-8 Detailed structure contour maps
- 2100-9 Isopach maps
Isopach maps of the Upper and Lower Huron Shale were completed during the quarter.
- 2100-10 Oil and gas production maps

4.3 Physical Characterization Tasks (2200)

- 2200-1 Core and outcrop description and logging
This task was initiated during the first reporting period in 1976 and work has continued to the present. During this quarter, an additional seven stratigraphic sections were measured and described as well as the core from the Martin County, KY well. Three Virginia wells were also described.

2200-2 Floral and faunal description

This task was initiated during the second quarter of FY77 and work has continued to the present. During this quarter, work was initiated on the examination of carbonized film of Foerstia and coalified wood.

2200-3 Description of sedimentary structure

This task was initiated during the second quarter of FY77. During this quarter, work consisted of a description of laminae in the Martin County, KY core.

4.4 Geochemical Characterization Tasks (2300)

2300-1 X-ray diffraction analysis

This task was initiated during the first reporting period in 1976 and work has continued to the present. Prior to this quarter, most work consisted of instrument installation and modification and the development of methodology. During this quarter, a ceramic plate pulverizer was installed and the preparation of a backlog of samples was initiated.

2300-2 Kerogen elemental chemical analysis

This task was initiated during the first reporting period in 1976. During this quarter, analyses were initiated on kerogen which had been separated from the black shale as well as analyses of coalified wood and carbon film.

2300-3 Petrographic analysis

This task was initiated during the first reporting period in 1976 and work has continued to the present. During this quarter, 50 thin sections were analyzed and an additional 50 were prepared.

2300-4 Kerogen/radioactivity/gas production investigation

This task was initiated during the first reporting period in 1976 and work has continued to the present. During this quarter, a radioactivity profile was performed on the Martin County, KY well.

2300-5 Statistical evaluation of geochemical data

Although not scheduled for initiation until FY79, the task was initiated in the second quarter of FY77. Preliminary analytical data has continued to be evaluated since that time.

4.5 Information Tasks (1300)

1300-1 Compile and encode data

This task was initiated during the first reporting period in 1976 and work has continued to the present. Data is being compiled as it is generated and formatting for interfacing with the PIC storage system is in progress.

STRATIGRAPHY AND PETROGRAPHY

OF THE

TIOGA BENTONITE

University of North Carolina
Chapel Hill, North Carolina

Quarterly Report
July through September 1977

Contract No.:	EY-76-S-05-5195	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	January 1, 1978
Contract TPO:	C. S. Dean	Contract PI:	J. M. Dennison
Total Project Cost:		DOE	\$12,495

1.0 INTRODUCTION

This quarterly report reviews the achievements for the University of North Carolina on Contract EY-76-S-05-5195 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5195-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	8/17/76

EVENTS OF PREVIOUS QUARTER:

● Outcrop locations and descriptions have been verified for all the states studied in the Appalachian Basin.	4/77
● Rough drafts of the cross sections, columnar sections, and maps specified in contract milestone No. 3 set for April 1 are either complete or nearly complete.	4/77
● The contract PI visited the Kentucky Geological Survey to obtain new well data on the Tioga Bentonite, visited exposures of the Devonian Shale near Lexington, KY, and collected samples of granite from the Berea Pluton near	4/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>GEOLOGIC EVALUATION (2100)</u></p> <p>2100-1 Measure stratigraphic sections</p> <p>2100-2 Cross Sections</p> <p>2100-3 Columnar sections</p> <p>2100-4 Tioga control point map</p> <p>2100-5 Isopach maps</p> <p>2100-6 Lithofacies maps</p> <p>2100-7 Tuff bed maps</p> <p>2100-8 Grain size distribution maps</p> <p><u>PHYSICAL CHARACTERIZATION (2200)</u></p> <p>2200-1 Mineral grain size analysis</p> <p><u>GEOCHEMICAL CHARACTERIZATION (2300)</u></p> <p>2300-1 Thin section petrographic examination</p> <p><u>INFORMATION (1300)</u></p> <p>1300-1 Tabulate and encode data</p>					

Fredericksburg, VA, which is believed to be the source of the Tioga eruptions.

EVENTS OF THIS REPORTING PERIOD

- Completed all maps based on the petrographic study of the Tioga Bentonite. 7/77-8/77
- Submitted an abstract of a paper to be presented at the October, 1977 EGSP Symposium entitled "Tioga Bentonite Time Marker Associated with Devonian Shales in Appalachian Basin." 8/77
- Contract supplemental agreement signed. 9/22/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period. Progress reported in this section is based on data provided for July and August, 1977 by the Technical Project Officer (TPO).

4.1 Summary

Technical progress was reported for the Geological Evaluation (2100) and Physical Characterization (2200) Work Packages. The 2100 work consisted of the completion of all contracted maps, while the 2200 Work Package involved the completion of the mineral grain size analysis work.

A supplemental contract agreement was signed between ERDA and UNC on September 22, 1977.

4.2 Geological Evaluation Tasks (2100)

All maps based on the petrographic study of the Tioga Bentonite have been completed. This work applies to the following tasks:

2100-4 Tioga control point map

2100-5 Isopach maps

2100-6 Lithofacies maps

2100-7 Tuff bed maps

It was reported last quarter that all cross sections and columnar sections were complete or nearly complete. This work applies to the following tasks:

2100-2 Cross sections

2100-3 Columnar sections

No further information concerning this work was received during this reporting period.

4.3 Physical Characterization Tasks (2200)

2200-1 Mineral grain size analysis

This task has been completed. The results were incorporated into the paper to be presented at the October, 1977 EGSP Symposium.

4.4 Information Tasks (1300)

1300-1 Tabulate and encode data

No progress has been reported in this task since initiation of the contracted work.

NOTE: Funding authorization by UNC administration and formal progress on this contract were suspended on June 30, 1977. Informal progress has continued, but is hindered by a lack of funds.

CHARACTERIZATION AND EVALUATION OF
THE DEVONIAN SHALES IN WEST VIRGINIA

West Virginia Geological Survey
Morgantown, West Virginia

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5199	Contract Type:	Cost-Sharing
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	C. S. Dean	Contract PI:	L. Woodfork

Total Project Cost:	ERDA	\$660,364
	WVGS	<u>123,390</u>
		\$783,754

1.0 INTRODUCTION

This quarterly report reviews the achievements for the West Virginia Geological Survey on Contract E(40-1)-5199 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5199-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date.	7/1/76
• Contract signed.	10/29/76
• Funding operational.	12/6/76

EVENTS OF PREVIOUS QUARTER:

• Pilot study on utility of subsurface data completed.	4/77
• Correlation charts sent to USGS, Reston, VA.	4/77
• Attended meeting of EGSP stratigraphers at Reston, VA.	4/14/77
• Samples of core from Well 20402 selected.	4/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Advise ERDA on drill sites and coring					
2100-2 Cross sections					
2100-3 Isopach maps					
2100-4 Lithofacies maps					
2100-5 Black shale depositional model					
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Density determinations					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u>					
2300-1 Mineralogic and petrographic analysis					
2300-2 Core fabric analysis					
2300-3 Mineral and organic constituent distribution					
2300-4 Mineralogic analysis					
2300-5 X-ray diffraction analysis					
2300-6 Mineralogical and petrographic data illustration					
2300-7 Correlation of mineralogy parameters with hydrocarbon analysis					
2300-8 Elemental analysis					
2300-9 Iso-compositional cross sections					
2300-10 Investigation report					

(1981)

(1981)

(1981)

Figure 5199-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>RESOURCE ASSESSMENT (2400)</u></p> <p>2400-1 Define potential gas source beds and reserves</p> <p><u>INFORMATION (1300)</u></p> <p>1300-1 Data compilation and editing</p> <p>1300-2 Data encoding</p>					<p>(1981)</p>

Figure 5199-1 (Continued)

- Contract for installation of mini-computer finalized and signed. 4/77
- Biostratigraphic study of conodonts initiated. 4/77
- Manuscript on the use of uncorrected XRD data submitted to ERDA. 4/77
- Manuscript on nomenclature of the Upper and Middle Devonian clastics completed for publication in the Survey Newsletter. 4/77
- Reconnaissance field work on outcrops in Ohio, Pennsylvania, and New York completed. 5/77
- Three hundred core samples from Well 20403 were sent out for palynological analysis. 5/77
- One hundred core samples were collected from Wells 11940 and 12041. 5/77
- Manuscript on preliminary petrologic description of the Devonian Shale by Larese and Heald was submitted to ERDA. 5/77
- Field sampling of outcrops in central Ohio and the eastern panhandle of West Virginia completed. 5/77
- Isopach map of the Huron Shale submitted to USGS at Reston, VA. 6/77
- Structure contour map on the base of the Huron Shale submitted to USGS at Reston, VA. 6/77
- Completed 185 bulk density measurements. 6/77
- Completed XRD analyses of 35 samples. 6/77
- A Mossbauer spectroscopic study of pyrite in the shale was initiated. 6/77
- PIC stratigraphic data formats received. 6/77
- Programming for the Jackson County, WV, mapping project completed. 6/77
- Examination of core from Well 20338 initiated. 6/77
- Publication by ERDA of the report on the preliminary petrologic description of the Devonian Shale by Larese and Heald. 6/77
- Manuscript on the occurrence of Foerstia in the Lincoln County, WV, cores has been completed. 6/77

- Attended national AAPG meeting in Washington, DC. 6/12/77-6/16/77
- Attended EGSP meeting in Pittsburgh, PA. 6/24/77
- Attended coring and sampling meeting in Morgantown, WV. 6/27/77
- Attended Fractographic Workshop in Morgantown, WV. 6/28/77-6/29/77

EVENTS OF THIS REPORTING PERIOD:

- Attended IOCC meeting in Nashville, TN 7/14/77-7/16/77
- Attended coordination meeting with USGS in Reston, VA. 7/15/77
- Cross sections in Cabell County were prepared to test the stratigraphic framework. 7/77
- USGS furnished with data on previously submitted cross sections. 7/77
- Paper on Foerstia occurrence in Lincoln County core completed and sent out for review. 7/77
- 301 feet of core obtained in Henderson County, IL. 7/77
- 116 samples were collected for petrology analysis from the Lincoln County core (CFTC 20402). 7/77
- Slabbing completed on Jackson County core (CFTC 11940) 7/77
- Work initiated on CGSC core 12041. 7/77
- Vacuum apparatus constructed to aid in determination of grain density. 7/77
- Initiated a study on the use of photomicrographs for grain size determinations of silt size particles. 7/77
- Initiated work to determine presence of amorphous iron. 7/77
- Initiated feasibility study of using X-radiographs to determine sedimentary structures. 7/77
- Paper on use of uncorrected X-ray data sent out for publication. 7/77
- Paper on use of radiography completed. 7/77
- Coding form designed for stratigraphic data from drillers logs. 7/77

- Stratigraphic data from driller's logs in Cabell and Wayne Counties coded. 7/77
- Preliminary adaption of PIC stratigraphic formats completed. 7/77
- Preliminary structure contour maps drawn on the tops of the Berea Sandstone and Onondaga Limestone were completed. 7/77
- Devonian Shale well penetration map completed for Jackson County. 7/77
- File of producing shale wells completed and put on tape. 7/77
- Attended SEM short course in Chicago. 8/14/77-8/20/77
- Attended PI/USGS Coding Workshop, Pittsburgh 8/22/77
- Attended ERDA Symposium, Tulsa 8/30/77-9/1/77
- Manuscripts completed on Devonian Shale in Ohio and a model of the Catskill Delta. 8/77
- Completed compilation of subsurface stratigraphic data for Jackson County, WV. 8/77
- Field check of Devonian outcrops in New York completed. 8/77
- Constructed EGSP displays. 8/77
- Slabbing of core #11940 for petrographic analysis completed. 8/77
- Radiograph positives of #20338 were printed. 8/77
- 40 samples taken from #20338 for analysis. 8/77
- 32 thin section analyses of #20403 were completed. 8/77
- Matrix density determination initiated by vacuum apparatus. 8/77
- 25 samples analyzed by XRD. 8/77
- Use of an internal standard procedure for clay XRD initiated. 8/77
- Several manuscripts on iron sulfides in shale were completed. 8/77
- Final draft of manuscript on the use of uncorrected

- X-ray data was completed. 8/77
- Description, orientation, photography, and fracture logging of core #20338 were completed. 8/77
- 221 feet of core collected from Tazewell County, IL. 8/77
- Completed statistical analysis of petrographic data. 8/77
- Mini-computer sent out for bids. 8/77
- A file of wells penetrating the Devonian Shale has been initiated. 8/77
- Attended West Virginia Oil and Gas Festival at Sistersville, WV. 9/14/77-9/17/77
- Four stratigraphic cross sections prepared. 9/77
- Isopach maps of the Upper and Lower Huron shales completed. 9/77
- Structure map of Burning Springs, WV area prepared. 9/77
- SEM installed and tested. 9/77
- Technique for measuring grain densities developed. 9/77
- Initiation of experiments to test the effect of ultrasonic vibration on shale porosity. 9/77
- Encoding of stratigraphic data initiated. 9/77
- Processing of data from cores #109 and #20336 completed. 9/77
- Background research on Pine Mountain thrust completed. 9/77
- Paper on Catskill Delta model was sent to ERDA for publication. 9/77
- Paper on petrology of Lower Huron Shale sent to ERDA for publication. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in the Geological Evaluation (2100), Physical Characterization (2200), Geochemical Characterization (2300), and Information (1300) Work Packages. The Geological Evaluation Task work involved completion of isopach, structure contour maps and cross sections, field checks of shale outcrops, and paleontological and palynological studies. All Geological Evaluation Tasks have been initiated and no milestones are scheduled prior to FY 1980.

Physical Characterization Tasks are on schedule.

Most Geochemical Evaluation Tasks (2300) scheduled for initiation this year are operational. The Elemental Analysis Task (2300-8) has not begun due to delays in equipment delivery and space preparation. No tasks are scheduled for completion prior to FY 1980 and no major technical or logistics problems are expected in the future.

The Information Tasks (1300) are all operational.

4.2 Geological Evaluation Tasks (2100)

2100-1 Advise ERDA on drill sites and coring

This task was initiated after contract signing and will be ongoing over the duration of the project.

2100-2 Cross sections

This work was initiated in the first reporting period. During this quarter, cross sections in Cabell County were prepared to test the stratigraphic framework and illustrations for four stratigraphic cross sections were prepared. A cross section summarizing the palynological study was completed.

2100-3 Isopach maps

This task was initiated during the second quarter of FY77. During this quarter, illustrations of the maps of the Upper and Lower Huron shales were prepared.

2100-4 Lithofacies maps

This task was initiated during the second quarter of FY77. During this quarter, collection of surface and

subsurface data has continued. A map of key wells showing available data was completed during the previous quarter.

2100-5 Black shale depositional model

This task was initiated last quarter and the data compilation, field examinations, and paleontological studies have continued. Also, during this quarter, a paper was prepared on the Catskill Delta model in the Appalachians.

4.3 Physical Characterization Tasks (2200)

2200-1 Density determinations

This task was initiated during the second quarter of FY77. Work has continued as samples become available and is on schedule at this time.

With the modification of the contract to include the sample collection, core storage, and initial physical testing, several tasks are added to this section. These tasks would include:

2200-2 Directional sonic velocity measurements

2200-3 Hardness determination

2200-4 Point load measurements

2200-5 Tensile strength measurement

These tasks are ongoing as core is collected from the various wells and the work appears to be on schedule at this time.

4.4 Geochemical Characterization Tasks (2300)

2300-1 Mineralogical and petrographic analysis

This task was initiated during the first reporting period in 1976 and work has continued to the present. During this quarter, 156 samples were collected for petrographic analysis, radiograph positives for core #20338 were printed, 150 photomicrographs were taken and a study to use photomicrographs for grain size determinations of silt-sized particles was initiated. A total of 32 thin sections were analyzed and samples were prepared for thin section and radiography. Manuscripts on the use of radiography in shale analysis and the petrology of the Lower Huron shale are being prepared.

2300-5 X-ray diffraction analysis

This task was initiated during the second quarter of FY77 and work has continued to the present. During this quarter, 92 samples were analyzed, bringing the total to

209. A professional paper on the use of uncorrected X-ray data was completed and sent out for publication.

2300-7 Correlation of mineralogy parameters with hydrocarbon analysis

This task was initiated in the second quarter of FY77, 3 years in advance of the schedule, with some preliminary correlations. During the last two quarters, no further work has been reported.

2300-8 Elemental analysis

This task was initiated in the second quarter of FY77 with the beginning of the modification of laboratory space for the new equipment. Renovation has been unavoidably delayed by the necessity to rewire the laboratory.

4.5 Information Tasks (1300)

1300-1 Data compilation and editing

The task was initiated during 1976 and work has continued to the present. The structure and design of the data base were completed during the second quarter of FY77 and data is added to the system as it is generated.

1300-2 Data encoding

This task was initiated during the second quarter of FY77 and work has continued to the present. During this quarter, encoding of stratigraphic data using the PIC data format was initiated.

ANALYSIS OF STRUCTURAL GEOLOGICAL PARAMETERS
THAT INFLUENCE GAS PRODUCTION
FROM THE DEVONIAN SHALE
OF THE APPALACHIAN BASIN

INCOMPLETE REPORTS

West Virginia University
Morgantown, West Virginia

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5194	Contract Type:	Cost
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	C. I. Pierce	Contract PI:	R. C. Shumaker
Total Project Cost:		ERDA	\$164,232

1.0 INTRODUCTION

This quarterly report reviews the achievements for West Virginia University on Contract E(40-1)-5194 from July through September 1977. The purpose of the contract is to address the "Resource" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5194-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976." Some task schedules were estimated from milestone dates given in the contract "Statement of Work."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	9/30/77

EVENTS OF PREVIOUS QUARTER:

● Sample map legend prepared.	4/77
● Seismic and resistivity apparatus received.	4/77
● Onondaga structure map completed.	5/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>GEOLOGICAL EVALUATION (2100)</u>					
2100-1 Structure maps of eastern Kentucky and West Virginia					
2100-2 Specific horizon structure contour maps					
2100-3 Shale facies structure maps					
2100-4 Maps of oil and gas pools					
2100-5 Fracture and structural analysis of selected oil and gas pools					
2100-6 Fracture and structural analysis of selected nonhydrocarbon-producing areas					
2100-7 Lineament and fracture studies of Task 2100-5, 2100-6, areas					
2100-8 Correlation of geologic and production data					
2100-9 Subcrop studies					
2100-10 Assess joint lineament and stress data for eastern Kentucky and West Virginia					
2100-11 Kinematic analysis of exposed geologic structures					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Select areas of major faults for seismic and resistivity studies					
3200-2 Seismic survey of Task 3200-1 areas					
3200-3 Resistivity survey of Task 3200-1 areas					
3200-4 Seismic and resistivity surveys over selected areas near high productivity Devonian wells					

Figure 5194-1

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
3200-5 Selected three areas for ground-water studies					
3200-6 Seismic surveys over Task 3200-5 areas					
3200-7 Resistivity surveys over Task 3200-5 areas					
3200-8 Ground-water testing					
3200-9 Correlation of ground water and lineament data					
3200-10 Map shallow structures for Task 3200-1, 3200-4, and 3200-5, areas					
3200-11 Evaluate the use of shallow geophysical methods to identify lineations					

Figure 5194-1 (Continued)

- Basement structure maps completed for eastern Kentucky and West Virginia. 6/77
- Preliminary structure map of top of Big Lime in West Virginia completed. 6/77
- Maps of the Devonian Shale gas fields in eastern Kentucky and West Virginia completed. 6/77
- Requests for bids for an aerial camera mount were submitted to prospective bidders. 6/77

EVENTS OF THIS REPORTING PERIOD:

- Initiated work on adding PIC control-well formation tops on the regional structure maps of eastern KY. 7/77
- 75% of the regional fracture pattern study area in eastern KY has been sampled on a one station per quadrangle grid. 7/77
- A detailed field map of the Cottageville Field, Jackson County, WV has been constructed by hand due to problems in creating computer-generated maps. 225 wells have been spotted on the base map and production histories for 80% of the producing wells have been compiled. 7/77
- Geophysical field vehicle delivered. 7/77
- Field tested noise-reducing seismic filter. 7/77
- Field tested hydraulic thumper. 7/77
- Hired two structural geologists and a production geologist. 8/77
- Prepared final draft of Cottageville Field, Jackson County, WV base map for the October, 1977 EGSP Symposium. 8/77
- Completed isopressure map of Devonian Shale wells in Cottageville Field, Jackson County, WV. 8/77
- Compiled information on 65 water wells in Jackson County, WV. 8/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period. No technical reports were received for the month of September, 1977.

4.1 Summary

Technical progress was reported for some of the tasks in both work packages. The Geological Evaluation work consisted of structure contour mapping, field mapping of fracture patterns in eastern KY, completion of an isopressure map and initiation of isoproduction and final open-flow maps of the Cottageville Field study area.

The Exploration R&D work included the initiation of two tasks, Ground Water Testing (3200-8) and Correlation of Ground Water and Lineament Data (3200-9).

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.2 Geological Evaluation Tasks (2100)

2100-2 Specific horizon structure contour maps

Work was initiated this quarter on adding control-well formation tops, obtained from PIC data, to the regional structure mapping of eastern Kentucky.

- 2100-5 Fracture and structure analysis of selected oil and gas pools
Field work in eastern KY continued during the quarter, in an effort to establish the regional fracture patterns found in shale, coal, and limestone lithologies. Data has been collected from approximately 150 stations throughout the project area. The data is being prepared for computer analysis.
- 2100-8 Correlation of geologic and production data
A detailed field map of the Mount Alto (Cottageville) Field was constructed by hand this quarter. Program and plotting problems have delayed generation of computer drawn maps. Some 225 wells have been spotted on the base map and production histories have been compiled for nearly 80% of the producing wells. An isopressure map of the Devonian Shale wells was completed during this reporting period and work was begun on isoproduction and final open-flow maps.

4.3 Exploration R&D Tasks (3200)

After a substantial procurement delay, the contractor has been able to obtain the field vehicle required to accomplish the following tasks:

- 3200-2 Seismic survey of Task 3200-1 areas.
- 3200-3 Resistivity survey of Task 3200-1 areas.
- 3200-4 Seismic and resistivity surveys over selected areas near high productivity Devonian wells.
- 3200-6 Seismic surveys over Task 3200-5 areas.
- 3200-7 Resistivity surveys over Task 3200-5 areas.

The vehicle is being outfitted with the required equipment for the seismic and resistivity surveys. Field testing of the vehicle will begin as soon as all equipment installation and modification is accomplished.

- 3200-8 Ground water testing
This task was initiated this quarter when information on approximately 65 water wells in the Jackson County WV study area was compiled. The well information includes well diameter, depth, elevation, yield, location, depth to water and water temperature and conductivity. Well water samples were analyzed for Ca^{+2} , Mg^{+2} , HCO_3^- , SO_4^{-2} , NO_3^- , Cl^- and pH.

3200-9 Correlation of ground water and lineament data

This task was initiated during the current reporting period. Fractures are being mapped in the Task 3200-8 project area, using USGS 1:20,000 scale aerial photographs.

PREDICTION OF IN SITU STRESSES
FROM DIRECTIONAL PROPERTIES
OF ROCK CORES
FOR FIELD DEVELOPMENT OF DEVONIAN SHALE

West Virginia University
Morgantown, West Virginia

Summary Report
June through September 1977

Contract No.: EY-77-C-21-8087
Task 5

Contract Type: Cost

Contract Date: June 1, 1977

Completion Date: May 31, 1977

Contract TPO: C. I. Pierce

Contract PI: S. Peng

Total Project Cost:

ERDA \$28,000

1.0 INTRODUCTION

This summary report reviews the scope of work and achievements for West Virginia University on Contract EY-77-C-21-8087, Task 5, for the period June 1 through September 30, 1977. This contract is a continuation of Contract E(46-1)8028 which was completed on May 31, 1977. Section 1 describes the purpose and objectives of the contract.

1.1 Purpose

The purpose of the contract is to address the "Resource" aspects of EGSP (Eastern Gas Shales Project) and to provide information on the Devonian Shales under the following Work Packages:

2200 Physical Characterization

3200 Exploration R&D

1.2 Objectives

The objectives of this research are to measure the directional properties of Devonian Shale core samples from Columbia Gas Co. Well #20403, Lincoln County, West Virginia, determine their relationship to preferred direction of fracturing, and establish the feasibility of developing a wire-line tool for in situ stress measurement and orientation of fractures.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to describe in detail, the scope and schedule of contract tasks. The individual tasks, by Work Package, are as follows:

2.1 Physical Characterization Tasks (2200)

2200-1 Determine ultrasonic longitudinal velocity measurements in diametral directions, at 30-degree intervals on the periphery of the core sample using three repetitions per direction. One sample will be measured every 10 feet over the following interval in the following sequence.

- a. 3470 to 3700 feet
- b. 3000 to 3400 feet
- c. 2836 to 3000 feet

2200-2 Determine ultrasonic shear velocity on the samples described in 2200-1 using the same procedures.

2200-3 Determine point load at one-foot intervals over the sequence listed in 2200-1.

2200-4 Determine indirect tensile strength using the Brazilian Split method on a set of six (6) samples taken at each ten-foot interval over the same intervals and sequences as 2200-1.

2200-5 Determine directional elastic constants and Poisson's Ratio using the same samples used in 2200-2.

2.2 Exploration R&D (3200)

3200-1 Determine the feasibility of developing a directional wireline tool for in situ stress and preferred orientation determination by comparing preferred azimuth orientation from the directional properties tests with the measured induced fracture orientation from the borehole televiewer.

2.3 Schedule and Milestones

The proposed schedule for the tasks is given in Figure 8087A-1.

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>PHYSICAL CHARACTERIZATION (2200)</u> 2200-1 Ultrasonic longitudinal velocity measurements 2200-2 Ultrasonic shear velocity measurements 2200-3 Point load measurements 2200-4 Indirect tensile strength measurements 2200-5 Directional elastic constants measurement and Poisson's Ratio		A B A B A B A B A B	C C A B C C C C C C		
<u>EXPLORATION R&D (3200)</u> 3200-1 Determine feasibility of developing a directional wireline tool					

Figure 8087A-1

The Physical Characterization Tasks are divided into three phases based on the sequence of core used as samples. Phase A will consist of testing of the core over the interval from 3470 feet to 3700 feet, Phase B from 3000 feet to 3400 feet, and Phase C from 2836 feet to 3000 feet. The Exploration R&D Task will not begin until the data from the Physical Characterization tasks is compiled.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date	6/1/77
• Preparation of samples initiated	6/77
• Draft of final report of previous contract (8028) revised and submitted to ERDA/MERC for review	8/77
• Final report of contract 8028 recommended for acceptance	9/77
• Contract signed	9/28/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks in which progress has been made during this reporting period.

4.1 Summary

Sample preparation and testing for the Physical Characterization Tasks are underway and appear to be on schedule. Work has not been reported

on individual tasks at this time. Delay in initiation of many tasks can be attributed to the four-month delay in the signing of the contract.

TECHNOLOGY CONTRACTS

GAS WELL FRACTURING
IN THE
DEVONIAN SHALE OF OHIO

American Exploration Company/Vescorp Industries, Inc.
Worthington, Ohio

Quarterly Report
July through September 1977

Contract No.:	E(40-1)-5253	Contract Type:	Cost-Sharing
Contract Date:	December 10, 1976	Completion Date:	January 10, 1979
Contract TPO:	K.-H. Frohne	Contract PI:	F. D. Ryan J. M. Cochrane

Total Project Cost:	ERDA:	\$487,593
	Contractor:	<u>1,035,683</u>
		\$1,523,276

1.0 INTRODUCTION

This quarterly report reviews the achievements for American Exploration Company/Vescorp Industries, Inc., (Amex/Vescorp) on Contract E(40-1)-5253 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and schedules by Work Package are shown in Figure 5253-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract signed and authorized.	12/10/76
<hr/> EVENTS OF PREVIOUS REPORTING PERIOD:	
● A meeting was held to discuss preliminary fracture design.	5/77
● The Phase I Report was submitted to MERC.	6/77
<hr/> EVENTS OF THIS REPORTING PERIOD:	
● The archeological field work was completed.	9/77
● The Phase I (Task 3100-1) wells have been selected and approved for the project.	9/77
● A draft of a paper planned for presentation at the EGSP Symposium in October was submitted to MERC for approval.	9/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>FIELD OPERATIONS (3100)</u></p> <p>3100-1 Drill, core, log, and case three wells</p> <p>3100-2 Drill, log, and case three additional wells</p> <p>3100-3 Drill, core, log, and case three additional wells</p> <p><u>EXPLORATION R&D (3200)</u></p> <p>3200-1 Optimize well locations</p> <p>3200-2 Lineament definition from remote sensing imagery</p> <p>3200-3 Select well locations</p> <p><u>PRODUCTION AND STIMULATION R&D (3300)</u></p> <p>3300-1 Foam fracture two wells and cryogenic fracture one well</p> <p>3300-2 Foam fracture one well and cryogenic fracture two wells</p> <p>3300-3 Optimize scaled-up fracture on three wells</p>					

Figure 5253-1

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

The Exploration R&D Task, which was completed in June 1977, resulted in the selection of nine sites plus twenty-two alternate sites. Recent EIA studies may result in the loss of some original and alternate locations. Land leasing problems have also resulted in the loss of well locations. Plans have been made to initiate the first task in the Field Operations Work Package next quarter. Some preliminary design has been done for the Production and Stimulation R&D Tasks.

4.2 Field Operations Tasks (3100)

Plans have been made to start drilling wells in the first part of November 1977. The first core is planned for the middle of November 1977.

4.3 Exploration R&D Tasks (3200)

The Exploration R&D Task was completed May 1977. The completion of this task was followed by the submittal of a Phase I Report which summarizes all work done for this Work Package. This report included several maps and figures as noted in the EGSP Quarterly Report, April 1 to June 30, 1977, submitted by Science Applications, Inc.

Also included in the Phase I Report were nine well site recommendations and twenty-two alternate well site locations. The locations were based on remote sensing imagery studies and lineament trace maps. The site locations

were made in areas of high lineament concentration.

EIA results and land leasing problems may cause the loss of some of these locations. The failure to acquire 25,000 acres of land previously thought to be tied up in the process of lease acquisition resulted in the loss of five well locations. The archeology study associated with Environmental Impact Assessment may cause the loss of two or more additional locations.

4.4 Production and Stimulation R&D Tasks (3300)

Preliminary fracture design meetings were held to discuss foam fracturing and methanol/CO₂ (cryogenic) fracturing. Additional meetings are scheduled to finalize decisions on a subcontractor to fracture the wells and the type of stimulation technique to be used.

PROJECT GASDEVEL-GAS PRODUCTION
STIMULATED BY MASSIVE HYDRAULIC FRACTURING

Columbia Gas System Service Corporation
Columbus, Ohio

Quarterly Report
July through September 1977

Contract No.:	EF-76-C-05-5303	Contract Type:	Cost-sharing
Contract Date:	July 1, 1976	Completion Date:	December 1978
Contract TPO:	C. A. Komar	Contract PI:	W. F. Morse

Total Project Cost:	ERDA:	\$2,500,000
	Contractor:	<u>2,303,715</u>
		\$4,803,715

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Columbia Gas System Service Corporation Contract EF-76-C-05-5303 from July through September 1977. The purpose of this contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 5303-1. A new proposed schedule is shown in Figure 5303-2. All references to departure from schedules will still refer to the original schedule shown in Figure 5303-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976".

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date.

<u>Event</u>	<u>Date</u>
• Contract authorization.	7/1/76
• Contract signed.	7/29/76
• Modification of operations pertaining to Columbia Gas Contract EF-76-C-05-5303.	12/28/76

EVENTS OF PREVIOUS QUARTER:

• Intercomp submitted post-fracture reservoir test analysis report on Well 20237.	4/77
• Well 20245 (Clinton) located in Trumbull County, OH, was plugged and abandoned.	5/24/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79
<u>GEOLOGIC EVALUATION (2100)</u>				
2100-1 High fracture density maps				
<u>PHYSICAL CHARACTERIZATION (2200)</u>				
2200-1 Microfracture and elastic constant analysis				
<u>FIELD OPERATIONS (3100)</u>				
3100-1 Clean out, log and pretest two existing Clinton Sand wells (OH)				
3100-2 Complete and pretest two new Clinton Sand wells (OH)				
3100-3 Drilling through pretesting of two Berea Sand wells (VA)				
3100-4 Drilling through pretesting of two Benson Sand wells (WV)				
3100-5 Drilling through pretesting of two Oriskany Sand wells (WV)				
3100-6 Drilling through pretesting of three Devonian Shale wells (KY, VA)				
<u>EXPLORATION R&D (3200)</u>				
3200-1 Lineament definition from remote sensing imagery				
<u>PRODUCTION AND STIMULATION R&D (3300)</u>				
3300-1 MHF and cryogenic fracture stimulation of Task (3100-1) wells				

Figure 5303-1 (Original Schedule)

TASK DESCRIPTION	FY 73	FY 77	FY 78	FY 79	FY 80
3300-2 MHF and dendritic fracture stimulation of Task (3100-2) wells		-----	-----		
3300-3 MHF and dendritic fracture stimulation of Task (3100-3) wells		-----	-----	-----	
3300-4 MHF and dendritic fracture stimulation of Task (3100-4) wells		-----	-----	-----	
3300-5 MHF and dendritic fracture stimulation of Task (3100-5) wells		-----	-----	-----	
3300-6 Cryogenic fracture stimulation of Task (3100-6) wells		-----	-----	-----	
3300-7 Subcontractor analysis of MHF, in situ stress and core		-----			

Figure 5303-1 (Original Schedule) - (continued)

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
3300-2 MHF and dendritic fracture stimulation of Task (3100-2) wells					
3300-3 MHF and dendritic fracture stimulation of Task (3100-3) wells					
3300-4 MHF and dendritic fracture stimulation of Task (3100-4) wells					
3300-5 MHF and dendritic fracture stimulation of Task (3100-5) wells					
3300-6 Cryogenic fracture stimulation of Task (3100-6) wells					
3300-7 Subcontractor analysis of MHF, in situ stress and core					

Figure 5303-2 (Original Schedule) - (continued)

- Well 20338-T (Devonian) located in Wise County, VA was drilled, cored, and logged. 5/77
- Well 11354 has been selected to replace Well 11344 in the program. 5/77
- Two Benson Sand well locations in Upshur County, WV have been submitted to ERDA for approval. 6/77

EVENTS OF THIS REPORTING PERIOD:

- A proposed revised schedule on the Columbia-ERDA 13-well fracturing program was submitted to ERDA/MERC. 7/29/77
- Two substitute Medina sandstone well sites in Chautauqua County, NY, have been proposed by Columbia to replace two Oriskany sand well sites in West Virginia.
- Two Benson Sand well sites in Upshur County, WV, were approved by ERDA/MERC. 7/77
- Test data from 90 producing Clinton Sand wells surrounding the MHF and dendritic fracture research wells in Trumbull and Mahoning Counties, OH, were analyzed. The results of the analysis will be used for comparison with the research wells for performance evaluation. 8/77
- Well 11354 (Clinton) located in Coshocton County, OH, was re-treated with an MHF. 9/12/77
- Well 20338-T (Devonian Shale) located in Wise County, VA, was treated with a cryogenic fracture in Zone 1 (Middle Brown Shale). 9/14/77
- Verbal contract modifications were agreed upon by ERDA and Columbia. 9/77
- A "Post MHF - Well Test Analysis, Well 20211 (Pittston)" report was submitted by Intercomp. 9/21/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

There has been no progress reported on the Physical Characterization Tasks (2200) for this contract. Work should be initiated soon to complete these tasks by March 1978, as scheduled.

Most Field Operations Tasks have been initiated. One of six tasks has been completed, three tasks are in progress, one task is waiting for a drilling rig to become available, and one task is awaiting contract modification approval from ERDA. All tasks are to be completed by February 1978.

The Exploration R&D Task (3200) has been initiated. Lineament definition from remote sensing imagery was used to select eleven well locations. Two sites have been changed because of well and ownership problems. Work was initiated in the selection of two remaining sites. This task is scheduled for completion by October 1977.

Some of the Production and Stimulation R&D Tasks (3300) have been initiated, but none have been completed. Four wells have been stimulated and are being cleaned up and evaluated. Technical difficulties encountered in designing cryogenic treatments has delayed treatment of some wells. These tasks are scheduled for completion by December 1978.

The entire project has been scheduled for completion by December 1978. Current delays may cause an overall two-month slippage.

4.2 Field Operations Tasks (3100)

3100-1 Clean out, log, and pretest two previously treated Clinton Sand Wells (OH)

This task was initiated during the first reporting period in 1976 and work has continued to the present.

Well No. 11236, located in Trumbull County, OH, was cleaned out, logged, and pretested prior to an MHF in the Clinton Sand (Zone 1) on September 22, 1976.

Well No. 11236 was also logged with temperature and density surveys in an effort to define productive Devonian Shale Intervals (Zone 2). Two intervals of interest were found. The casing was cemented through the zones of interest. The well is now ready for clean out, perforating and pretesting in Zone 2. These operations will be performed as soon as a rig is available. This well is scheduled for dual completion in both the Devonian Shale and Clinton Sand.

Well No. 11354 (Clinton) located in Coshocton County, OH has been selected to replace Well No. 11344, which was deleted from the program because of minority ownership problems. This well was previously drilled, logged, cased and stimulated in the Clinton Sand. During this reporting period, Well No. 11354 was cleaned out, pretested and prepared for a stimulation treatment.

- 3100-2 Complete and pretest two new Clinton Sand Wells (OH)
This task was initiated and completed during the first reporting period in 1976.

Well No. 20237, located in Mahoning County, OH, was perforated, acidized, and pretested in the Clinton Sand Formation during August 1976. The well produced only 3 MCFD with a three-day shut-in surface pressure of 1250 psig before fracture, which is below the production rate required for reservoir testing.

Well No. 20245, located in Trumbull County, OH, was perforated, acidized twice, and pretested in October and November 1976. The pretest was brief since there was no measurable gas production and only 106 psig five-day tubing shut-in pressure.

- 3100-3 Drill through pretesting of two Berea Sand wells (VA)
This task was initiated during the first reporting period in 1976 and work has continued through this quarter.

Well No. 20211, located in Dickenson County, VA, was drilled to total depth May 1975. In November and December 1976, the well was perforated, acidized, and pretested in the Berea Sand Formation. It flowed at 84 MCFD after 6 hours open flow and recorded a 72-hour rock pressure of 810 psi. Detailed reservoir tests were not performed on this well since it had a low open flow.

Well No. 20342, in Buchanan County, VA, logged through the Berea Sand Formation in October 1976. Core samples were sent to MERC for orientation. After orientation, 24 feet (26 samples) of the 74-foot total core were sent to Terra Tek, Inc., for in situ core analysis.

In February after acid washing perforations, an attempt was made at performing pretests on Well No. 20342. The well, producing at a rate of 430 MCFD, was shut in for a buildup test. Two pressure bombs were lost in the well and during attempts to pull the tubing and bombs, the tubing and casing parted. An attempt was made to recover the tubing and bombs and repair the casing, but was unsuccessful. Therefore, the well was abandoned on April 13, 1977.

A site offsetting Well No. 20342 has been selected to replace the aforementioned well. Drilling will be scheduled as soon as a modification to the contract and site selection have been approved.

3100-6 Drilling through pretesting of three Devonian Shale wells (KY, VA)

This task was initiated during the first reporting period in 1976 and work has continued through this quarter.

Well No. 20336, located in Martin County, KY, was drilled, cored, and logged through the Devonian Shale in October-November, 1976. A total of 982 feet of oriented core was obtained. One sample out of every five feet was canned, a few selective samples were taken by Battelle, and the rest of the core was sent to MERC for orientation and distribution.

Plans were made to perforate, acidize, and pretest this well the next quarter.

Well No. 20337, located in Martin County, KY, was drilled and logged through the Devonian Shale to a total depth of 3602 feet in November 1976. During the reporting period, plans were made to perforate, acidize, and pretest this well next quarter.

Well No. 20338-T, located in Wise County, VA, was drilled, cored 350 feet (oriented), logged, and cored through the Devonian Shale in April-May, 1976. The first black shale interval (4870 feet to 5020 feet) was cored in its entirety. The second shale interval (5230 feet to 5455 feet) was cored as planned, but while drilling to total depth an unexpected additional 100 feet of shale was encountered.

4.3 Exploration R&D Tasks (3200)

3200-1 Lineament definition from remote sensing imagery

This task was initiated during the first reporting period in 1976 and work has continued to the present. Satellite and U-2 imagery were used to define lineaments in study areas in Upshur County, WV. Site selections there have been made based on lineament and seismic studies along

with field measurements of fractures.

3200-2 Select locations for project wells

This task was initiated during the first reporting period and will be ongoing for the duration of the contract.

Previous work consisted of well site selection for Well No. 20342 in Virginia, No. 20337 in Kentucky, No. 20342 in Virginia, No. 20337 in Kentucky, No. 20338 in Virginia, Well No. 11354 in Ohio, and Well No. 20538 and 20539 in West Virginia.

Two locations have been selected in New York to replace locations in West Virginia. A contract modification is required for final approval of these sites.

4.4 Production and Stimulation R&D Tasks (3300)

3300-1 MHF and cyrogenic fracture stimulation of Task 3100-1 Wells

An MHF was performed in the Clinton Sand Formation of Well No. 11236 located in Trumbull County, OH, on September 22, 1976. Post-fracture work consisted of well cleanup. The well had produced 85 percent of the fracture fluid and was making 50 MCFPD into the pipeline system as of December 31, 1976. The well was producing 50 MCFPD as of March 31, 1977 and 45 MCFPD as of May 1977. The previously planned post-fracture test is postponed until dual completion and stimulation operations are completed.

Currently plans are being made to fracture the Devonian Shale in this well (dual completion) with a cryogenic treatment. This is scheduled for the middle of next quarter.

Well No. 11354 (Clinton) was previously treated (prior to this program) with 69,300 gallons of gelled water emplacing 39,000 pounds of sand. The open flow recorded after this treatment was 252 MCFPD.

Well No. 11354 (Coshocton County, Ohio--Clinton) was retreated on September 12, 1977 with an MHF. The MHF consisted of 344,000 gallons of Versagel and water used to implace 600,000 pounds of sand. The average injection rate was 30 BPM and the average injection pressure was 2500 psig. Cleanup operations are now underway prior to scheduling a post fracture reservoir test.

3300-2 MHF and dendritic fracture stimulation of Task 3100-2 wells

A dendritic fracture was performed in the Clinton Sand of

Well No. 20237 located in Mahoning County, OH, on August 31, 1976. The well was post-fracture tested from November 10 to 15, 1976, by Intercomp. On December 31, 1976, it was producing from 200 to 400 MCFPD into the pipeline system.

During this reporting period, the well produced at a rate of 86 MCFPD and had produced a total of 34.6 MMCF of gas.

The post-fracture test analysis has been submitted by Intercomp (Reservoir Engineering Consultants). The test results suggest that significant results were achieved by dendritic fracturing this well. The results indicate that a larger effective fracture area was created in this well than in conventionally fractured wells. It will not be known if this results in greater production until a sufficient production history is obtained to compare to production from offset conventionally fractured wells.

An MHF was performed in the Clinton Sand of Well No. 20245 located in Trumbull County, OH, on November 10, 1976. The well was shut in for a buildup test December 31, 1977. Little gas was produced after fracturing.

After cleanup operations were completed, the well produced salt water. Efforts were made to reduce water production and increase gas production, but were unsuccessful. Therefore, on May 24, 1977, this well was plugged and abandoned. It would be termed a failure since it did not respond to the MHF.

3300-3 MHF and dendritic fracture stimulation of Task 3100-3 wells

An MHF was performed in the Berea Sand of Well 20211 located in Dickenson County, VA, on January 1, 1977. The post-fracture test was completed in April, 1977 and the data has been compiled and sent to Intercomp for analysis. The open flow before MHF was 84 MCFPD and the initial open flow after treatment was 2.054 MMCFPD.

The current average daily gas production since stimulation is 694 MCFPD. The cumulative gas produced after being on line 106 days is 73.3 MMCF.

Well 20342 located in Buchanan County, VA, was scheduled for a dendritic fracture treatment in the Berea Sand Formation in March 1977. Parted tubing and casing strings have caused this well to be abandoned on April 13, 1977.

Columbia has selected a site to drill an offset well to this well since the natural open-flow was 430 MCFPD. The alternate site selected will be fractured using a dendritic technique and the results will be compared to Well No. 20211 which was treated with an MHF.

The "Post MHF Well Test Analysis" Report was submitted to Columbia by Intercomp in August, 1977. Based on this analysis it was determined that Well No. 20211 appears to have more potential for production than the conventionally fractured wells in the same field. The improvement can be attributed to two reasons:

- 1) The MHF improved the potential above potential from a conventional fracture treatment.
- 2) There was more net pay thickness in this well.

Additional studies have been undertaken to evaluate the MHF treatment based on comparison of production data from Well No. 20211 and other surrounding conventionally fractured Clinton Sand wells.

3300-6 Well No. 20338-T (Devonian) located in Wise County, VA was cryogenic fractured on September 14, 1977. The treatment consisted of 97,500 gallons of fluid (62,500 gallons gelled water + 35,000 gallons of CO₂) and 2700 sacks of sand. The fluid injection rate established was 30.2 BPM at 1910 psi. Presently, operations consist of cleanup activities.

MASSIVE HYDRAULIC FRACTURING
IN THE DEVONIAN SHALE

Columbia Gas System Service Corporation
Columbus, Ohio

Quarterly Report
July through September 1977

Contract No.:	E(46-1)-8014	Contract Type:	Cost-Sharing
Contract Date:	June 18, 1975	Completion Date:	December 1977
Contract TPO:	C. A. Komar	Contract PI:	W. F. Morse

Total Project Cost:	ERDA	\$2,154,155
	Contractor	<u>2,240,870</u>
		\$4,395,025

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Columbia Gas System Service Corporation Contract E(46-1)-8014 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 8014-1. A new proposed schedule is shown in Figure 8014-2. All references to departure from schedules will still refer to the original schedule shown in Figure 8014-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project.

<u>Event</u>	<u>Date</u>
• Contract signed.	6/18/75
• Contract initiation date.	6/18/75

EVENTS OF PREVIOUS QUARTER:

- Finished post fracture buildup test on Zone 2, Well 20401. 4/4/77
- Halliburton discussed their proposals to stimulate Well 20403 (Zone 3) and 20401 (Zone 2) in a meeting with Columbia and MERC. 4/11/77

TASK DESCRIPTION	FY 75	FY 76	FY 77	FY 78	FY 79
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Drilling through pretesting of one Devonian Shale well	-				
3100-2 Drilling through pretesting of one additional Devonian Shale well	-				
3100-3 Drilling through pretesting of one additional Devonian Shale well	-				
<u>EXPLORATION R&D (3200)</u>					
3200-1 Lineament definition from remote sensing imagery	-				
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 MHF stimulation of Task 3100-1 well					
3300-2 MHF stimulation of Task 3100-2 well					
3300-3 Optimize and MHF stimulation of Task 3100-3 well					
<u>ECONOMIC ANALYSIS (3500)</u>					
3500-1 Economic analysis of production from Task 3100-1 well					
3500-2 Economic analysis of production from Task 3100-2 well					
3500-3 Economic analysis of production from Task 3100-3 well					

Figure 8014-1 (Original Schedule)

TASK DESCRIPTION	FY 75	FY 76	FY 77	FY 78	FY 79
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Drilling through pretesting of one Devonian Shale well	-				
3100-2 Drilling through pretesting of one additional Devonian Shale well	-				
3100-3 Drilling through pretesting of one additional Devonian Shale well	-				
<u>EXPLORATION R&D (3200)</u>					
3200-1 Lineament definition from remote sensing imagery	-				
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 MHF stimulation of Task 3100-1 well					
3300-2 MHF stimulation of Task 3100-2 well					
3300-3 Optimize and MHF stimulation of Task 3100-3 well					
<u>ECONOMIC ANALYSIS (3500)</u>					
3500-1 Economic analysis of production from Task 2100-1 well					
3500-2 Economic analysis of production from Task 3100-2 well					
3500-3 Economic analysis of production from Task 3100-3 well					

Figure 8014-2 (Revised Schedule)

- Dowell discussed their proposals to stimulate Well 20401 (Zone 2) in a meeting with Columbia and MERC. 4/12/77
- Perforated Zone 2 (Middle Gray Shale--Middle Brown Shale), Well 20401. 4/15/77
- Perforated Zone 3 (Upper Brown Shale--Middle Gray Shale), Well 20403.
- A final core analysis report titled, "Rock Mechanics Studies Related to Massive Hydraulic Fracturing of Eastern United States Devonian Shales, Final Core Analysis Report," has been submitted by Terra Tek, Inc. 4/77
- MHF was performed on Well 20401 (Zone 2). 5/17/77
- MHF with foam performed on Well 20403 (Zone 3). 5/23/77
- "Massive Hydraulic Fracturing Stimulation of Eastern Devonian Shale Gas Reservoirs"--an executive summary report (preliminary draft) was submitted by Terra Tek, Inc. 5/77
- H.K. Van Poolen and Associates, Inc., submitted a post fracture report titled, "Analysis of Columbia Gas Transmission Corporation's Well No. 20403, Lincoln County, West Virginia." 5/77
- Started post fracture tests on Well 20401 (Zone 2). 6/23/77
- Columbia personnel attended the Coring and Logging Review and the Fractographic Workshop held by MERC in Morgantown, WV. 6/27/77-6/29/77
- Started post fracture tests on Well 20403 (Zone 3). 6/30/77

EVENTS OF THIS REPORTING PERIOD:

- A post fracture test was completed on Well 20401 (Zone 2). The data was compiled and sent to H.K. Van Poolen and Associates, Inc., for analysis. 7/25/77
- Well 20401 (Zone 3--Middle Gray Shale) was treated with a modified water type MHF (foam and water components). 8/15/77
- Well 20403 (Zone 4--Upper Gray Shale) was treated with a foam type MHF. 8/29/77
- A verbal contract modification was agreed upon, with written modification and approval to follow. 9/15/77
- Started post fracture test on Well 20401 (Zone 3). 9/21/77

- A pressure interference test on Well 20403 (Zone 4 versus Zones 1, 2, and 3) indicated communication between zones. 9/24/77-9/30/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported for some of the tasks in all Work Packages except Economic Analysis (3500). The Field Operations Tasks were completed March 30, 1976. Well 20401 (3100-2) was not cored, to enable Well 20403 (3100-1) to be cored through the entire Devonian Shale Formation. Well 20402 (3100-3) was drilled as planned. This task was completed four months behind schedule due to problems in gaining site access.

The Exploration R&D Task was completed August 8, 1975. This task consisted of using remote sensing imagery to select well sites in areas of high fracture density. The task was completed on schedule.

Production and Stimulation R&D work has been initiated on Wells 20403 and 20401. Well 20403 has been stimulated in four zones with massive hydraulic foam fracture (MHFF) treatments. Well 20401 has been stimulated in three zones with a massive hydraulic fracture (MHF) treatment. The tasks are about six months behind schedule because of a two-month delay attributed to production problems and site access delay.

The Economic Analysis Work Package (3500), scheduled to begin by February 1, 1977, has not yet been initiated. A six-month delay should be expected because of other project delays.

4.2 Production and Stimulation R&D Tasks (3300)

3300-1 MHF stimulation of Task 3100-1 well

Previous work on Well 20403 consisted of two MHFF treatments. The first was in the Marcellus Zone and produced 90 MCFPD after fracturing. The second stimulation was in the Middle Brown Shale Zone and produced an average of 375 MCFPD after fracturing. The gray shale section was treated with an MHF during the reporting period (zone 3) and is being cleaned up. During the reporting period, Well 20403 was perforated, tested and stimulated in the Upper Gray Shale, Zone 4. August 24, 1977 the well was perforated with 24 holes in a 70 foot interval in the Upper Gray Shale, Zone 4. The zone was broken down with 4000 gallons of 15% NE acid on August 26, 1977. The gas flow gauged at 381 MCF after 24 hours on August 27, 1977. A temperature log was run on the well to determine the zone of production and it was determined that the gas was entering the wellbore through zone 4.

The well was massively hydraulic fractured with foam and sand on August 29, 1977. The quality of the 347,000 gallons of foam was approximately 83 percent and was pumped at an average rate of 35 BPM. The 405,000 pounds of sand emplaced consisted of 60,000 pounds of 80/100 mesh sand and 345,000 pounds of 20/40 mesh sand. A pre-pad consisting mostly of 80/100 mesh sand and Dowell's TLC-80 Diverter were used to attempt to inhibit any communications that may have existed or may have been induced with Zones 1, 2, and 3.

Twenty percent of the fracture fluid has been recovered. The well was making 162 MCFPD when it was shut-in for an interference test.

The interference test proved communications exist between Zone 4 and Zones 1, 2, and 3. The well was shut-in after the interference test was completed for further post fracture testing.

All four zones have been stimulated and the production testing is all that remains to be done in this Work Package for this particular well. Plans are made to place the well in line for testing pending construction of a gathering system.

3300-2 MHF Stimulation of Task 3100-2 well

Prior work on Well 20401 consisted of two MHF treatments. The first MHF was performed using gelled water in the Marcellus Zone (Zone 1), the largest gelled water treatment east of the Mississippi River. The initial open flow after cleanup was 110 MCFPD.

The second MHF was performed using mainly gelled water with some foam in the Middle Gray--Middle Brown Shale, Zone 2. The initial open flow after treatment was 111 MCFPD.

During the reporting period Zone 3 (Middle Gray Shale) was treated with a modified water type MHF (foam and water components). August 3, 1977, the well was perforated with 24 holes in a 104-foot interval of the Middle Gray Shale section, Zone 3. The zone was broken down with 1000 gallons of HCl acid in August 1977. On August 12, 1977, the well was making no gas after two days of cleanup.

The well was treated with MHF (foam, gelled water, and sand combination) on August 15, 1977. The maximum pumping rate of 50 BPM was achieved while pumping gelled water and sand. The 89,000 gallons of water and 11,400 gallons of foam were used to emplace 352,000 pounds of sand in the fracture.

After cleanup the well was shut in for post fracture testing on September 22. Open flow prior to shut-in was 84 MCFPD.

4.3 Physical Characterization Tasks (2200)

Although this Work Package was not defined as part of the contract, work has been done in this area and the following technical progress was reported prior to this reporting period. Terra Tek, Inc., a subcontractor, submitted the following reports:

- "Determination of the Strain Relaxation and Their Relation to Surface Stresses in the Devonian Shale."
- "Comparison of Log and Laboratory Measured P-Wave and S-Wave Velocities."
- "Massive Hydraulic Fracturing Stimulation of Eastern Devonian Shale Gas Reservoirs."

The following conclusions may be drawn from Terra Tek's reports:

- Fracture containment analysis indicates that Gray Shales on either side of the Middle Brown Shale would act as barriers to vertical fracture growth in the Brown Shale.
- The Gray Shale can be fractured, but fractures will propagate out of zone and reduce lateral growth.
- The Lower Brown Shale (Marcellus) is a candidate for hydraulic fracturing.
- Tentative results suggest that the Middle and Lower Brown Shales are the only candidates for MHF technology.

DIRECTIONALLY DRILLED WELL

IN THE

DEVONIAN SHALE

Consolidated Gas Supply Corporation
Clarksburg, West Virginia

Quarterly Report
July through September 1977

Contract No.:	E(46-1)-8047	Contract Type:	Cost-Sharing
Contract Date:	September 30, 1976	Completion Date:	December 31, 1977
Contract TPO:	C. A. Komar	Contract PI:	T. A. Kuhn

Total Project Cost:	ERDA	\$582,356
	Contractor	<u>168,935</u>
		\$751,291

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Consolidated Gas Supply Corporation on Contract E(46-1)-8047 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 8047-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976".

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on this project:

<u>Event</u>	<u>Date</u>
● Contract signed and authorized.	9/30/77
● Contract supplemental agreement signed and effective.	9/30/77
● Contract modification No. M002.	5/12/77

EVENTS OF THE PREVIOUS QUARTER:

- Tour of Cottageville, WV, area by Cathy Tonnesson and Chuck Hall of Lawrence Livermore Laboratory, responsible for environmental impact statements. 4/19/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Drill a deviated well					
3100-2 Log with wireline tools					
3100-3 Run and cement production casing					
3100-4 Evaluate logging program and design multiple-stage fracture					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Seismic survey					
3200-2 Study and analyze remote sensing imagery					
3200-3 Study and analyze near-surface measurements of the earth's stress field					
3200-4 Study and analyze the orientations of surface joints in rocks					
3200-5 Study and analyze the fracture density and fracture orientation data from oriented cores					
3200-6 Determine area in Devonian Shale with highest fracture density from data in Task 3200-5					
3200-7 Locate and design a directionally-controlled deviated well					
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 Hydraulically fracture the Devonian Shale in several intervals					
3300-2 Conduct well tests					
3300-3 Place in production. Monitor and report production for 5 years					

Figure 8047-1

- Modification No. M002 to contract No. EY-76-C-21-8047 updating the time schedule for the project. 5/12/77
- Approval to use the revised standard API drilling contract received from Mr. A. H. Frost, Jr., Oak Ridge, TN. 5/4/77
- Geophysical Services, Inc., subcontractor to Consolidated Gas Supply Corporation, began seismic work in the Cottageville, WV area. Final report is expected by September 15. 6/15/77

EVENTS OF THIS REPORTING PERIOD:

- Geophysical investigations in the field have been completed. 7/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress was reported in the Exploration R&D Work Package. Seismic work was started in June 15, 1977. The geophysical investigation report is due in October.

No additional work packages have been initiated since all are dependent on the completion of Exploration R&D Tasks.

4.2 Exploration R&D Tasks (3200)

3200-1 Seismic survey

Processing of the data collected by Geophysical Services Inc. on primary lines I, II & III is continuing in the southern part of the area and the 3D processing on the remainder of this grid is underway. The investigation report is due in October.

- 3200-2 Study and analyze remote sensing imagery
This work has been completed and reported in the last quarter.
- 3200-3 Study and analyze near-surface measurements of the earth's stress field
This work has been completed and reported in the last quarter.
- 3200-5 Study and analyze the fracture density and fracture orientation data from oriented cores
This work has been completed and reported in the last quarter.

4.3 Field Operations Tasks (3100)

Work not initiated.

4.4 Production and Stimulation R&D Tasks (3300)

Work not initiated.

MASSIVE HYDRAULIC FRACTURING PROGRAM
FOR GAS STIMULATION

Lawrence Livermore Laboratory
Livermore, California

Quarterly Report
July through September 1977

Contract No.:	W-7405-ENG-48	Contract Type:	Cost
Contract Date:	February 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	G. Schott	Contract PI:	M. Hanson
Total Project Cost:		ERDA	\$650,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Lawrence Livermore Laboratory on Contract W-7405-ENG-48 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 7405-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1977."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
<ul style="list-style-type: none"> ● LLL contracted Southwest Research Institute to construct a dry-hole acoustic logging system. 	4/76- 6/76
<hr/>	
EVENTS OF THE PREVIOUS QUARTER:	
<ul style="list-style-type: none"> ● LLL attended the technical meeting for Rio Blanco ERDA-industry MHF experiments. 	4/77
<ul style="list-style-type: none"> ● Paper discussing permeability enhancement with explosives was presented at the ANS Topical meeting in Golden, Colorado. 	4/77
<ul style="list-style-type: none"> ● Two-dimensional numerical model to simulate the hydraulic fracturing phenomenon was completed. 	4/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>PHYSICAL CHARACTERIZATION (2200)</u>					
2200-1 Indirect tensile strength testing					
2200-2 Uniaxial stress testing in extension					
2200-3 Uniaxial stress testing in compression					
2200-4 Triaxial strain testing					
2200-5 Uniaxial stress testing (confinement)					
2200-6 Sonic travel time testing					
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Sonic logging					
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 Modeling MHF					(1981)

Figure 7405-1

- LLL staff toured the sites of Consolidated Gas Corp. at Cottageville, WV and AMEX/VESCORP sites in southern Ohio to prepare EIA statement. 4/77
- Two unsolicited proposals were reviewed for ERDA and submitted. 5/77
- Completed the PTC/KY-WV environmental assessments and first draft of PTC/Union Oil environmental assessment. 5/77
- The Annual Environmental Assessment Report (AEAR) was reviewed and comments submitted. 5/77
- Attended the Enhanced Gas Recovery Working Group meeting in Washington, D.C. 5/77

EVENTS OF THIS REPORTING PERIOD

- Hosted the third ERDA in-house gas working group meeting. 7/77
- Presented paper discussing the enhancement of permeability by explosives detonated in boreholes presented at 6th AIRAPT International high pressure conference at the University of Colorado. 7/77
- Analyzed the layering effects near pressurized hydro-fracture on surface slopes and displacements and computer plot have been completed. 7/77
- Preliminary draft of the EIA for AMEX/VESCORP projects in southern Ohio has been completed and submitted to MERC. 7/77
- A paper discussing the status and the past year's progress of the LLL gas stimulation program was presented at the third annual ERDA National Symposium on Enhanced Oil and Gas Recovery and Improved Drilling Methods at Tulsa, OK 8/77
- The Incomplete Cholesky Conjugate Gradient [ICLG(0)] relaxation method has been programmed into the two dimensional hydraulic fracturing model. 8/77
- Preliminary draft report of the EIA on the proposed Consolidated Gas, Inc. deviated well in West Virginia was completed. 8/77
- Environmental assessment report for P.T.C. has been updated. 8/77

4.0 TECHNICAL PROGRESS DURING PERIOD

4.1 Summary

The Physical Characterization Work Package (2200) involved the continuing study of various stresses. No progress was reported for this quarter in the Field Operations Work Package (3100). Progress in the production and stimulation R&D Work Package (3300) involved both experimental and model development to simulate hydraulic fracturing. Work also included reservoir analysis and environmental impact assessments.

4.2 Physical Characterization Tasks (2200)

A series of experiments in 4-inch cubes of PMMA to determine the effects of initial cracks near the borehole on the subsequent hydraulic fracture propagation were conducted. These cubes were subjected to uniaxial stress fields at varying orientations. When the pre-crack was perpendicular to the applied uniaxial compressive stress, it was found that under hydraulic pressure new cracks initiated at the borehole wall were parallel to the applied stress. When applied stress was at 45° to the pre-cracks, cracks propagate and curve in the direction of the applied stress.

The Incomplete Cholesky Conjugate Gradient relaxation method has been programmed into the two-dimensional hydraulic fracturing model. Calculations on the effects of layering on surface deformation and stress changes in the field are being performed.

4.3 Field Operations Tasks (3100)

3100-1 Sonic logging
No work reported.

4.4 Production and Stimulation R&D Tasks (3300)

3300-1 Modeling MHF

The two-dimensional hydraulic fracturing model has been applied to calculate the effects of parameter changes. Calculations to analyze the effects of pore pressure on stress concentration factors have been performed. Calculations to analyze layering effects near a pressurized hydrofracture on surface slopes and displacements have been completed, including computer plots. Calculations were performed to analyze the effects of fracture orientations in elongated gas sand lenses. Parametric calculations to analyze the effect of permeability changes in reservoir material have been started. Calculations indicate that changes in pore pressure around a pressurized fracture occur slower in low permeability reservoirs. Studies on pulse testing in conventional and vertically fractured wells are being carried out.

The preliminary draft of the Environmental Impact Assessment for the Amex/Vescorp project in Lawrence and Scioto Counties, Ohio, has been completed and submitted to Morgantown Energy Research Center (MERC).

The environmental assessment report for PTC has been updated and is being published.

The Consolidated Gas Environmental Assessment is complete. Final details for reports will be based on siting and stimulation techniques. An outline of necessary data elements is being compiled for information dissemination to industry, and an outline of format and context of Environmental Assessment Reports is being compiled.

EXPLOSIVE STIMULATIONS AND LASER
CHARACTERIZATION METHODS FOR
DEVONIAN SHALES

INCOMPLETE REPORTS

Los Alamos Scientific Laboratory
Los Alamos, New Mexico

Quarterly Report
July through September 1977

Contract No.: W-7405-ENG-36

Contract Type: Ongoing

Contract Date: March 8, 1977

Completion Date: September 1977

Contract TPO: G. Schott

Contract PI: W. J. Carter
N. Vanderborgh

Total Project Cost:

\$500,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Los Alamos Scientific Laboratory on Contract W-7405-ENG-36 from July through August 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 36-1. Additional details of task requirements are described in the previous quarterly report, January through March 1977.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● ERDA "Fossil Energy Project Planning Form" submitted by Los Alamos	4/8/76

EVENTS OF THE PREVIOUS QUARTER:

● Ultrasonic transverse and longitudinal velocities at ambient pressures have been measured	4/77
● Hugoniot of the available shales have been obtained (as function of density and orientation) down to pressures of about 40km	4/77
● Stress and relief wave profile using plane-impact gun experiments have been measured	4/77
● Dynamic spall measurements have been performed	4/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>PHYSICAL CHARACTERIZATION (2200)</u> 2200-1 Measure dynamic mechanical properties					
<u>GEOCHEMICAL CHARACTERIZATION (2300)</u> 2300-1 Pulse laser for gas analysis and geochemical characterization					
<u>PRODUCTION AND STIMULATION R&D (3300)</u> 3300-1 Stimulation with explosive jet devices					

Figure 36-1

- Acquired large samples of limestone with properties similar to shale. 5/77
- Hardware modification to the Function Input-Output Processor to allow direct usage of 64 additional digital-to-analog conversions has been completed. 5/77
- Dynamic properties of core from Columbia Well 20402 have been determined and documented. 6/77
- Pulse laser, Apollo Model 5, was acquired. 6/77

EVENTS OF THIS REPORTING PERIOD:

- Post-shot probing of the holes made by the three shaped charges fired into the limestone was completed. 7/77
- Uranium-lined shaped charges were fired into magnetic grout. 7/77
- Laser instrument was assembled and calibrated. 7/77
- Logic for two-dimensional gas diffusion model for the analog computer has been completed. 7/77
- Completed economic study of single versus dual hydraulic fracture at normal distance from well bore. 7/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress has been reported in various Work Packages. The Physical Characterization Task Work (2200) was reported to have been completed in the last quarter. In the Geochemical Characterization Task (2300) it has been reported that the laser instrument has been assembled and calibrated. In the Production and Stimulation R&D Task (3300) the holes

shot by three shaped charges at the Nevada test site have been studied. Uranium-lined shaped charges were fired into magnetic grout to determine optimum liner thickness for jet penetration.

The logic for a two-dimensional gas diffusion model for the analog computer has been completed. An economic study of a single versus dual hydraulic fracture was completed.

4.2 Physical Characterization Task (2200)

2200-1 Measure dynamic mechanical properties
The work was completed and reported in the last quarter. No new work has been reported during this period.

4.3 Geochemical Characterization Task (2300)

2300-1 Pulse laser for gas analysis and geochemical characterization
The activity centered upon instrument assembly and initial calibration experiments which have been completed. Various gas chromatographic parameters have been determined.

4.4 Production and Stimulation R&D Tasks (3300)

3300-1 Stimulation with explosive jet devices.
Post shot probing of the holes made by the three shaped charges fired into the limestone at the Nevada Test site indicate the presence of substantial limestone rubble at the bottom of the holes. A pre-existing rubble pile with particles at random orientations would have serious deleterious effect on penetration. Rubble age will be studied. Uranium-lined shaped charges were fired into magnetic grout to determine optimum liner thickness for jet penetration. Ten grout targets 0.3m thick and 0.9m on a side were stacked face to face and blasted. The 0.75mm liner jet destroyed three slabs and the fourth showed no evidence of jet attack. The 1.5mm liner penetrated the first eight slabs and went 100mm into the ninth. Hole diameter was 50mm at 0.3m penetration tapering to 20mm at 1.8m then bulging to 45mm before termination.

Conclusions of an economic study of a single versus dual hydraulic fracture placed parallel to and 7.8m from wellbore are, that for permeabilities of 10μ darcy

and higher, the single fracture yields a higher present value of net revenues and for permeabilities of 1μ darcy and less the dual fracture yields a higher present value.

The wiring of the analog computer and its logic has been completed for the two-dimensional gas diffusion model.

CHEMICAL EXPLOSIVE FRACTURING
OF THE DEVONIAN SHALE
IN KENTUCKY

INCOMPLETE REPORTS

Petroleum Technology Corporation
Redmond, Washington

Quarterly Report
July through September 1977

Contract No.:	EY-76-C-08-685	Contract Type:	Cost-Sharing
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	C. A. Komar	Contract PI:	S. J. LaRocca
Total Project Cost:		ERDA:	\$897,837
		Contractor:	<u>436,963</u>
			\$1,334,800

1.0 INTRODUCTION

This quarterly report reviews the achievements for Petroleum Technology Corporation on Contract E-76-C-08-685 from July through September 1977. The purpose of this contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 685-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976".

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Contract authorization date.	7/1/76
● Contract signed.	2/15/76

EVENTS OF PREVIOUS QUARTER:

● Continued attempts at well cleanout failed and decision was made to cement squeeze old casing.	4/77
● Continued failure to stop water flow and caving by cementing.	5/77
● Liner cemented inside well.	5/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Re-work, log and test Well No. 685-1					
3100-2 Drill, log and test Well No. 685-2					
3100-3 Drill, log and test Well No. 685-3					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Site selection from lineament correlations					
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 Explosive fracturing (Well No. 685-1)					
3300-2 Explosive fracturing (Well No. 685-2)					
3300-3 Explosive fracturing (Well No. 685-3)					
<u>ECONOMIC ANALYSIS (3500)</u>					
3500-1 Economic assessment of production from Well No. 685-1					
3500-2 Economic assessment of production from Well No. 685-2					
3500-3 Economic assessment of production from Well No. 685-3					

Figure PTC 685-1

- Well cleaned out to a total depth of 3244 feet. 6/23/77
- GR, caliper and temperature logs run in the hole. 6/77
- Production test equipment run in the well. 6/77
- Contract review held with PTC, ERDA-Las Vegas, and contract TPO. 6/77

EVENTS OF THIS REPORTING PERIOD:

- Contract status review held at MERC. 9/14/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

No work was done on this contract during the reporting period. All work has been suspended until after completion and preliminary evaluation of the CEF stimulations on the two PTC/Columbia Gas wells scheduled for December 1977. The contract work is now an additional three months behind schedule.

CHEMICAL EXPLOSIVE FRACTURING
OF THE DEVONIAN SHALE
IN WEST VIRGINIA

INCOMPLETE REPORTS

Petroleum Technology Corporation
Redmond, Washington

Quarterly Report
July through September 1977

Contract No.:	E(25-1)-686	Contract Type:	Cost-Sharing
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	C. A. Komar	Contract PI:	S. J. LaRocca

Total Project Cost:	ERDA	\$705,131
	Contractor	<u>249,001</u>
		\$954,132

1.0 INTRODUCTION

This quarterly report reviews the achievements for Petroleum Technology Corporation on Contract E(25-1)-686 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 686-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976".

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
• Contract authorization date	7/1/76
• Contract signed	9/15/76

EVENTS OF PREVIOUS QUARTER:

• Production averaging about 30 to 35 MCFPD over period through June 1977.	6/77
• Post-stimulation production tests indicate casing damage is causing partial blockage of flow from well	6/77
• Contract modified to permit simultaneous drilling and stimulation of two remaining contract wells, both to be stimulated with single rather than dual-stage completions	6/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Drill, log and test Well No. 686-1 (open hole)					
3100-2 Drill, log and test Well No. 686-2 (open hole)					
3100-3 Drill, log and test Well No. 686-3 (cased)					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Site selection from lineament correlations					
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 Explosive fracturing (Well No. 686-1)					
3300-2 Explosive fracturing (Well No. 686-2)					
3300-3 Explosive fracturing (Well No. 686-3)					
<u>ECONOMIC ANALYSIS (3500)</u>					
3500-1 Economic assessment of production from Well No. 686-1					
3500-2 Economic assessment of production from Well No. 686-2					
3500-3 Economic assessment of production from Well No. 686-3					

Figure 686-1

EVENTS OF THIS REPORTING PERIOD:

- Contract status review held at MERC 9/14/77
- Well 686-1 flowing about 25 MCFPD into pipeline 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

Technical progress achieved on the Production and Stimulation Work Package consisted of post-fracturing production testing. This was the only activity ongoing on this contract. The two other wells to be stimulated using the CEF technique on this contract are currently scheduled for next quarter.

CANYON SAND EXPLOSIVE FRACTURING

INCOMPLETE REPORTS

Petroleum Technology Corporation
Redmond, Washington

Quarterly Report
July through September 1977

Contract No.:	E(26-1)-687	Contract Type:	Cost-Sharing
Contract Date:	July 1, 1976	Completion Date:	September 30, 1977
Contract TPO:	C. A. Komar	Contract PI:	S. J. LaRocca

Total Project Cost:	ERDA	\$ 751,806
	Contractor	<u>431,700</u>
		\$1,183,506

NOTE:

ALL CONTRACT WORK SUSPENDED UNTIL AT LEAST MARCH 1978 DUE TO EQUIPMENT SCHEDULING ON OTHER PROJECTS AND UNTIL CONTRACTOR EQUIPMENT ADAPTED TO SUIT THE HIGH TEMPERATURE ENVIRONMENT AT THE LOCATION.

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>FIELD OPERATIONS (3100)</u>					
3100-1 Drill, log and test Well No. 687-1					
3100-2 Drill, log and test Well No. 687-2					
<u>EXPLORATION R&D (3200)</u>					
3200-1 Site selection from lineament correlations					
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 Explosive fracturing Well No. 687-1					
3300-2 Explosive fracturing Well No. 687-2					
<u>ECONOMIC ANALYSIS (3500)</u>					
3500-1 Economic assessment of production from Well No. 687-1					
3500-2 Economic assessment of production from Well No. 687-2					

Figure 687-1

NATURAL GAS MASSIVE HYDRAULIC
FRACTURE RESEARCH AND ADVANCED
TECHNOLOGY PROJECT

Sandia Laboratories
Albuquerque, New Mexico

Quarterly Report
July through September 1977

Contract No.:	AP(29-1)-79	Contract Type:	Cost
Contract Date:	August 1, 1975	Completion Date:	September 30, 1977
Contract TPO:	G. Schott	Contract PI:	C. Schuster
Total Project Cost:		ERDA:	\$1,100,000

1.0 INTRODUCTION

This quarterly report reviews the achievements for the Sandia Laboratories on Contract AP(29-1)-79 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 79-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
● Authorization date.	7/1/76

EVENTS OF PREVIOUS QUARTER:

● Initiated mining to and mapping fracture geometry for proppant distribution experiment.	3/77
● Initiated reduction of mineback data for plotting and visual projections.	3/77
● MHF conducted by Gas Producing Enterprises, Inc., in a multilayered tight gas sand formation in Utah.	3/77
● Identified distinct time zones for formation and lineal extension of fractures.	3/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<u>EXPLORATION R&D (3200)</u>					
3200-1 Geophysical and remote sensing data analysis					
<u>PRODUCTION AND STIMULATION R&D (3300)</u>					
3300-1 Proppant penetration evaluation-hydraulic fracturing					
3300-2 Hydraulic fracturing adjacent to formation interface					
3300-3 Chemical explosive fracturing on a former fracture					
3300-4 Chemical explosive fracturing on a new fracture					
3300-5 Advance development for MHF					

Figure 79-1

- Initiated development of seismic sensor package for downhole use. 3/77

EVENTS OF THIS REPORTING PERIOD:

- Sandia representatives attended the Enhanced Recovery Conference in Tulsa, OK. 8/30/77-9/1/77
- Sandia representatives attended a meeting at MERC to discuss the past, present, and future aspects of Sandia's fossil energy projects. 9/29/77
- Initiated mineback operation to the hydraulic fracturing adjacent to a formation interface. 9/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during the reporting period.

4.1 Summary

Technical progress was reported for some tasks in the Production and Stimulation R&D Work Package. Progress was reported for the Exploration R&D Tasks, but the work was related to the Western Tight Gas Sands Program and not to the EGSP. Work is continuing in proppant distribution, hydraulic fracture geometry, and liquid explosive techniques.

The chemical explosive fracturing tasks were initiated slightly ahead of schedule. All other tasks are on schedule except the field instrumentation experiment. All tasks should be completed on schedule.

4.2 Exploration R&D Tasks (3200)

3200-1 Geophysical and remote sensing data analysis

Prior work consisted of monitoring Columbia Gas Well 20401 with electrical potential instruments before, during, and after MHF. Difficulties were encountered while monitoring the job. Data analysis was inconclusive.

Development of an electronic potential package for down-hole use was completed. EGSP staff and contractors decided that installation of a probe in the well, use of KCl to reduce the potential of fracturing fluid, and installation of additional monitoring equipment cannot be justified due to high costs, high risk of well difficulties due to fracturing down the casing instead of the tubing, and poor results from the previous test.

Additional tests will be considered if alterations are made in the program to reduce the risk and cost of monitoring the fracture treatment.

Recent information obtained from the Western Tight Gas Sand Project indicates that Sandia can predict the azimuth of a hydraulic fracture. There is also some evidence to indicate that these fractures have been asymmetric. Presently, Sandia is developing a method to calculate the ratio of asymmetry and trying to determine fracture length using a tank model now being developed.

4.3 Production and Stimulation R&D Tasks (3300)

3300-1 Proppant penetration evaluation--hydraulic fracturing

Previously, a fracture system created hydraulically in November 1976 was excavated to view proppant distribution and fracture geometry. The well was initially fractured with 1600 gallons of gelled fluid carrying three successive colors of sand proppant injected in a six-foot open-hole section at a 1400-foot depth in ash-fall tuff. Upward and lateral propagation of the main fracture were found to be terminated by interception of a parting plane zone and a fault present in the original rock. A secondary fracture surface not attached to the main fracture by a propped path was observed. The observed proppant distribution was found to be random.

Tests to identify possible distortion of the local stress field by previous underground nuclear explosions in the vicinity are still being carried out. Reduction of the mineback fracture data to Cartesian sectional plots and projections for visualization are underway.

- 3300-2 Hydraulic fracturing adjacent to formation interface
No work has been performed on this task. Plans are to perform a grouted hydraulic fracture adjacent to a boundary between ash-fall and welded tuff. This work is scheduled for October 12, 1977. Mineback operations were initiated in September 1977 toward the area to be fractured. The mineback should reach the fracture area in January or February 1978 and analysis of the fracture is scheduled for completion by April 1, 1978.
- 3300-3 Chemical explosive fracturing on a former interface
Prior work consisted of preparation for a planned test of fragmentation of the Antrim Shale (Michigan Basin, Devonian) for in situ retorting to produce oil and gas. SLA is currently conducting laboratory tests of four commercial liquid explosives. Flow of the liquids through the sand packs has been possible only with coarser sand than is optimum for the propping of hydraulic fractures, and propagation of detonation of the liquids through the sand packs has still not been achieved.

The conditions being created in these tests to simulate sanding off in a horizontal, propped, hydraulic fracture are considerably different than would be expected in hydrocarbon well applications where proppant is emplaced simultaneously with fluid in nearly vertical fractures. Nevertheless, these stringent tests renew concern for greater precision in determining the performance of explosives displaced from a borehole than is afforded by current and past field demonstration tests. These tests had a primary objective to measure the overall influence of explosive treatment on well production.

SLA previously performed tests using 5-pound cylindrical charges in boreholes, followed by grout injection tests and mineback to observe stress cage effects. Results of these tests are as follows:

Explosions produced a sealed-off pocket within a shell of compacted rock, which remained pressurized for weeks after the shot.

The hydraulic fracturing in the zone (tuff), in a vertical ring aligned with the greater principal horizontal stress, occurred at unexpectedly low fluid pressures when grout was injected.

Mineback to the area of chemical explosive verified the above pressure-induced data. The chemical explosive created a cavern, a thin zone of compression that was impermeable and an area of relieved stress that was subject to much lower hydraulic breakdown pressures than normally expected. The work implies that chemical explosive fracturing can cause a damaged area followed by a relieved or possibly fractured area.

3300-4 Chemical explosive fracturing on a new fracture
Some progress was noted and incorporated in Task 3300-3.
To date, little positive information has been obtained
indicating fracturing with an explosive fluid and sub-
sequent detonation of the explosive fluid will work in
attempting to stimulate tight gas wells.

ROCK FRACTURE IN WELL STIMULATION
BY TAILORED-PULSE LOADING

Stanford Research Institute
Menlo Park, California

Summary Report
July through September 1977

Contract No.:	EY-76-C-03-0115	Contract Type:	Cost
Contract Date:	August 15, 1977	Completion Date:	August 14, 1978
Contract TPO:	James Mercer	Contract PI:	Stuart McHugh
Total Project Cost:		ERDA:	\$92,864

1.0 INTRODUCTION

This summary report reviews the work scope and achievements for Stanford Research Institute (SRI) on Contract EY-76-C-03-0115 since its implementation on August 15, 1977. Section 1 describes the purpose and objectives of the contract.

1.1 Purpose

The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project) under the following Work Package:

Modeling (3600)

1.2 Objectives

There were no contract objectives outlined in the "Statement of Work." The implied contract objectives from the SRI Proposal for Research, SRI No. PYU 76-287, are as follows:

- To determine the relative and absolute importance of various rock properties (such as porosity, degree of saturation, strength vs. confining pressure, and inherent fracture flaw distribution) in controlling rock fracture by the dynamic pressure loading of well bores.
- To determine the ranges of the important properties that will permit successful well fracturing by tailored-pulse loading, and the correlation of these ranges with actual values found in rocks of interest.
- To critically evaluate the prospects for successfully implementing a well stimulation technique based on pressure-pulse tailoring using propellants.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to describe in detail the scope of

work associated with this contract. The individual tasks, by Work Package, are as follows:

2.1 Modeling (3600)

3600-1 Develop a model to evaluate the effects of pulse loading over varying time periods (explosive properties) for Devonian Shale intervals of known physical characteristics.

3600-2 Perform physical model tests (minimum of four) to verify model and determine the rubblization, compaction, plastic flow and fracture production for various loading and overburden conditions.

2.2 Schedule and Milestones

The contract does not contain a schedule of milestones. The only contract requirement is that all tasks must be completed by August 14, 1978. A request for more information has been sent to the contractor.

3.0 PROJECT HISTORY

The purpose of this section is to summarize the current status with respect to the overall project schedule and to present the history of significant events that have occurred to date.

3.1 Project Status

Work was initiated on the contract on August 15, 1977. The Modeling Tasks have been initiated. All work is progressing as expected.

3.2 Major Events

The following is a list of the major events that have occurred on the project:

Event	Date
● Contract Initiated	8/15/77

- Contract Signed 9/26/77
- SRI received six core samples from the Illinois State Geologic Survey 10/5/77
- The parameter sensitivity study was initiated. 10/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to summarize and outline in detail the technical accomplishments for Work Package Tasks on which progress has been made.

4.1 Summary

Work has been initiated on both modeling tasks. Devonian Shale cores from the Illinois State Geological Survey have been received and preliminary parameter sensitivity studies were initiated. A computer code is being developed as required.

4.2 Modeling (3600)

3600-1 Model development

A preliminary parameter sensitivity study is currently being conducted. Data on Devonian Shale reported by Carter et al. are being used in SRI's 1D PUFF (stress wave propagation) code with the fracture subroutine (FRAG). The objective of this work is to qualitatively determine the sensitivity of the stresses and the fracture distribution to the fracture parameters used in FRAG. Additional work on the computer codes and development of new codes is being conducted as required. The results of this work will aid in designing the experiments on the shale cores.

3600-2 Model verification, results, and implications

On October 5, 1977 SRI received six cores (each 4 in. in diameter by 18 in. long) of Devonian Shale from Mr. Paul Dumontelle at the Illinois State Geological Survey.

EARTH FRACTURE SYSTEMS

INCOMPLETE REPORTS

West Virginia University
Morgantown, West Virginia

Quarterly Report
July through September 1977

Contract No.:	E(46-1)-8040	Contract Type:	Cost
Contract Date:	October 1, 1975	Completion Date:	September 30, 1977
Contract TPO:	C. I. Pierce	Contract PI:	R. C. Shumaker
Total Project Cost:	ERDA \$19,210		

1.0 INTRODUCTION

This quarterly report reviews the achievements for West Virginia University on Contract E(46-1)-8040 from July through September 1977. The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project).

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to outline the scope and schedule of contract tasks. The individual tasks and their schedule by Work Package are shown in Figure 8040-1. Additional details of task requirements are given in the "Six-Month Summary Report, Period Ended December 31, 1976."

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project:

<u>Event</u>	<u>Date</u>
<u>EVENTS OF PREVIOUS QUARTER:</u>	
● Black and white high altitude multispectral photography was obtained for use in preparing detailed photolineament maps of selected areas in West Virginia.	4/77
<u>EVENTS OF THIS REPORTING PERIOD:</u>	
● Computer plots of data were examined. Those found to be in error or incomplete were rerun.	8/77
● The first draft of the final report of the contract work was initiated.	8/77

TASK DESCRIPTION	FY 76	FY 77	FY 78	FY 79	FY 80
<p><u>GEOLOGICAL EVALUATION (2100)</u></p> <p>2100-1 Collection and correlation of geologic literature</p> <p>2100-2 Correlation of production data with fracture and lineament patterns</p> <p><u>EXPLORATION R&D (3200)</u></p> <p>3200-1 Analysis of regional fracture patterns from remote sensing imagery</p> <p><u>INFORMATION (1300)</u></p> <p>3100-1 Computer and statistical analysis</p>					

Figure 8040-1

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period. This report is based only on the August 1977 Technical Project Officer (TPO) report.

4.1 Summary

Work on this contract is nearing completion. The first draft of the final report covering the contracted work has been initiated. The only other progress reported during the quarter was in the Information Task area (1300). Computer data plots were analyzed. Those found to be in error or incomplete were rerun.

FRACTURE MECHANICS INVESTIGATIONS

ASSOCIATED WITH CORING AND

HYDRAULIC INDUCED FRACTURES

West Virginia University
Morgantown, West Virginia

Summary Report
July through September 1977

Contract No.:	EY-77-C-21-8087 Task 10	Contract Type:	Cost
Contract Date:	August 15, 1977	Completion Date:	August 14, 1978
Contract TPO:	C. S. Dean	Contract PI:	S. H. Advani
Total Project Cost:		ERDA:	\$54,388

1.0 INTRODUCTION

This report reviews the scope of work and achievements for West Virginia University on Contract EY-77-C-21-8087, Task 10, from July through September 1977. Section 1 describes the purpose and objectives of the contract.

1.1 Purpose

The purpose of the contract is to address the "Technology" aspects of the EGSP (Eastern Gas Shales Project) and to provide information on the Devonian Shale under the following Work Packages:

3200 Exploration R&D

1.2 Objectives

The objectives as outlined in the proposal are:

- The employment of sophisticated fracture mechanics concepts for layered rock media to the state-of-the-art research and development techniques developed by previous contractors.
- The application of developed predictive and design criteria to specific MERC hydraulic fracture experiments.
- The determination of magnitude of in situ stresses in Devonian Shale from fracture patterns observed in extracted cores.

2.0 TASK DESCRIPTIONS AND SCHEDULE

The purpose of this section is to describe in detail, the scope and schedule of contract tasks. The individual tasks, by Work Package, are as follows:

2.1 Exploration R&D Tasks (3200)

- 3200-1 Characterize field and experimental data variables such as stratigraphy, material properties, pore pressure, formation permeability and porosity, and in situ stresses from MERC data. Selected data from hydraulic fracturing experiments will include fracturing fluid properties, surface pumping pressure versus time plots, flow rate versus time plots, and shut-in pressure values.
- 3200-2 Develop structural model simulations using elasticity theory and finite elements concepts with fracture mechanics considerations. Apply fracture initiation and extension criteria on a local stress intensity factor basis. Construct a fluid flow model using Bernolli's equations (with friction losses) in the fracture and Darcy's equation for the formation.
- 3200-3 Predict fracture width and length from the coupled structural and fluid flow model. Obtain pressure profiles in the fracture and leak-off flow rates.
- 3200-4 Determine the optimum sets of values and design charts for fracturing fluid viscosity, density, flow rate, and bottom hole treatment pressure for maximizing fracture length in relation to specific hydraulic fracturing jobs.
- 3200-5 Identify repetitive fracture patterns in Devonian Shale cores with respect to relative time sequence or correlation with the location of the drilling core bit. Outline relevant mechanisms for fracture initiation and extension.
- 3200-6 Select dominant fracture mechanisms for fracture initiation and extension for the core boundary value problem analysis.
- 3200-7 Formulate a model employing classical isotropic elasticity theory to study the effects of tectonic stresses, overburden load, and load induced from the coring operation. The results of this model will be used to examine the bounds of tectonic stress difference ($\sigma_1 - \sigma_2$) and axial bit load for inducing the observed fractures.
- 3200-8 Conduct detailed stress computations incorporating the core geometry, material anisotropy, and core bit load with arbitrary tectonic stresses.
- 3200-9 Compute in situ stresses from the results of 3200-8 and make correlations to values from hydraulic fracturing experiments or other available in situ stress data.

2.2 Schedule and Milestones

The only time constraint applied to this contract is the completion of all work by August 14, 1978. Although many of these tasks would follow a sequence there are no milestones prior to the final report due at the end of the contract period.

3.0 PROJECT HISTORY

The purpose of this section is to present the history of significant events that have occurred to date on the project.

<u>Event</u>	<u>Date</u>
● Contract signed.	8/5/77
● Contract authorization date.	8/15/77
● Attended ERDA meeting on Enhanced Oil and Gas Recovery, Tulsa, OK.	8/30/77- 8/31/77
● Submitted paper for EGSP Shale Symposium.	8/77
● Attended organizational meeting at MERC.	9/6/77

4.0 TECHNICAL PROGRESS DURING PERIOD

The purpose of this section is to present the technical accomplishments for Work Package Tasks on which progress has been made during this reporting period.

4.1 Summary

West Virginia University has been working on this contract for only six weeks and work is still in the preliminary stages, although

several tasks have been initiated.

4.2 Exploration R&D Tasks (3200)

- 3200-1 Characterization of field and experimental data
Work was initiated on this task by the use of the stratigraphy of the Columbia MHF wells in Lincoln County, WV, to provide predictive and design criteria for fracture confinement in the pay zone.
- 3200-2 Structured and fluid flow response simulations
This task was initiated with fluid flow simulations on the Consolidated Gas foam fracture experiments.
- 3200-3 Classical elasticity theory model evaluations
This task was initiated with the study of solutions for a ring load on a semi-infinite medium.