Statement of Project Objectives

Creating a Geologic Play Book for Appalachian Basin Trenton-Black River Exploration

A. OBJECTIVES

The prime objective of this proposed basin-wide research effort is to develop an integrated, multi-faceted, resource-assessment model of Trenton-Black River reservoirs in New York, Ohio and West Virginia. A second objective is to define possible fairways within which to conduct more detailed studies, leading to further development of the gas resources in Ordovician fractured carbonates of the Appalachian basin. A third objective is to develop an integrated structural-diagenetic-stratigraphic model for the origin of Trenton-Black River hydrothermal dolomite reservoirs. These objectives will be achieved by creating an industry-government research consortium to conduct geologic, petrographc and geochemical studies in eight task areas. The research will be conducted by the Appalachian Oil and Natural Gas Research Consortium and administered through the West Virginia University Research Corporation.

B. SCOPE OF WORK

To facilitate increased exploration and higher success rates in this emerging play, our approach will be to create a detailed and multi-disciplinary play book. This scientific data package will be designed for explorationists; both those currently involved in the play, and those from other basins who need to come up to speed as quickly as possible to get involved in the play. The tasks of this proposed study include:

- Structural and seismic analysis and mapping
- Analysis of stratigraphic relationships and thickness mapping of key units

- Analysis of petrographic data and synthesis of depositional environments
- Analysis of isotope geochemistry and fluid inclusion data
- Analysis and summary of petroleum geochemical data
- Analysis of production data/histories and horizontal well technology
- Data, GIS, and website management
- Project management

Staff from each of the five state agencies on the research team will be responsible for gathering data and interpreting formation tops and geology from within their state, and assisting wherever feasible on all tasks. However, each agency will take lead responsibility on tasks as outlined below.

C. TASKS TO BE PERFORMED

Task 1.0 - Structural and Seismic Investigations - Kentucky Geological Survey

The Trenton-Black River fractured carbonate play appears to be heavily dependent upon basement structure for both fracture generation and the migration of hydrothermal fluids needed for dolomitization. Evidence suggests that in both the dolomitized reservoirs in New York (e.g. Gloades Corners field) and Ohio (e.g. York field), and the fractured limestone reservoir in West Virginia (e.g. Cottontree field), the host fractures were created from minor movements along basement-rooted faults. In addition, where increased porosity from dolomitization is a factor, the hydrothermal fluids needed for alteration likely migrated through basal sandstones until they reached the affected fracture/fault conduits. In fact, some researchers have hypothesized that these basal sandstone units altered the geochemistry of fluids migrating through them such that dolomitization could occur upon exiting these sandstones.

Because the play appears to be basement-dependent, a first approach will be to produce an up-to-date structure contour map on the Precambrian surface, including fault locations and major structural axes, which may be prime indicators of potential Trenton-Black River fairways or target areas. All structures will be included on one map, but those faults that are interpreted to have had an influence on Trenton-Black River reservoirs will be displayed on a separate map. There are numerous sets of fractures and faults throughout the basin, but not all of these have produced Trenton-Black River dolomite or fractured reservoirs. Discriminating structures that are related to the play from those that formed earlier or later in the various areas and under varying tectonic conditions will be critical. Additional horizons will be selected for structure contour mapping and may include, but will not be restricted to: the Knox Unconformity, top of Trenton Limestone and top of Ordovician. These maps will be created using available 2D reflection seismic data, geophysical well log interpretation and public domain gravity and magnetic data. Initially, the structural effort will take advantage of in-house seismic data at the participating agencies. However, efforts will be made to acquire other data at low or no cost.

Finally, the fracture linkages between the dispersal medium and the potential host carbonates of the Trenton, Black River and Beekmantown intervals will be evaluated for zones of likely hydrothermal dolomite development, taking into consideration the age and style of the fracturing and the timing of hydrothermal fluid movement.

Task 2.0 - Stratigraphic Analysis and Thickness Mapping of Key Units - Ohio Geological Survey

Type well logs from each producing area will be analyzed and available samples, cores and FMI (formation micro-imaging) logs tied to geophysical logs for correlation purposes. A regional, interconnected network of cross sections will be constructed to define stratigraphic

relationships, facies changes and sequence boundaries. This stratigraphic analysis may indicate units or surfaces that require additional mapping and analysis. This cross section network also will establish the formation/interval boundaries to be used in structural and isopachous mapping, and will provide insight into the structural relationships between basement, Cambrian sandstones and Trenton-Black River fault systems. Using past literature and this cross section network, a regional correlation chart will be prepared.

There is some indication that the presence and thickness of the basal Cambrian sandstone may be critical in the development of hydrothermal dolomites. A thick, continuous unit of sandstone would provide a medium for the dispersal of basement fluids thought critical in charging the fractures involved in the development of Trenton-Black River hydrothermal dolomites. Maps of the distribution and thickness of the basal sandstones will be included.

Input will be sought from participating companies on which other units should be mapped. Likely candidates would include: the Knox Group, the Trenton-Black River interval and Upper Ordovician shales and limestones. These maps will be created using geophysical well logs, driller's records and available 2D reflection seismic data where appropriate.

Task 3.0 - Petrographic Analysis – Pennsylvania Geological Survey

Petrographic analysis of the Trenton-Black River carbonates will provide descriptions of depositional facies, a reconstruction of the diagenetic history of the rocks and documentation of the porosity systems in the reservoirs. The distribution of porosity in the Trenton-Black River carbonates defines the locations of existing and potential petroleum reservoirs. Documentation of porosity systems in the Trenton-Black River rocks will provide a clear conception of the origin and three-dimensional distribution of pores. This information will reveal the pathways hydrocarbons followed from their source to the reservoir and then to the wellbore. This

information is vital to efficient well placement and well-stimulation design. Petrographic data also help geologists and petroleum engineers to improve their interpretation of wireline log responses and to better map porosity, fluid saturations and permeability.

All of the known Trenton-Black River reservoirs, except the West Virginia fields, which produce from fractured, non-dolomitized limestone, are reportedly developed in hydrothermal dolomites. Hydrothermal dolomites are well-documented in Kentucky outcrops, and preliminary work on cores in Pennsylvania reveals hydrothermal dolomites in the Trenton-Black River interval in the subsurface of northwestern, and possibly northeastern, Pennsylvania. Because the play appears contingent upon specific petrologic characteristics, we plan to obtain and provide comprehensive petrographic data on the depositional facies, diagenetic history and porosity systems in the Trenton-Black River for the entire basin.

Our first task will be to identify all available subsurface samples from cores and high-quality cuttings. We also will target appropriate outcrops within the study area for field descriptions and sampling. All samples will be processed through a first-run description of lithology and analyzed by x-ray diffraction for a precise determination of mineralogy.

We also propose to address the petrography of the interbedded shales in the Trenton-Black River sequence to support our interpretations of depositional environments and source rock geochemistry.

Once we have completed a comprehensive petrographic study of the Trenton-Black River in the basin, we will summarize our most pertinent observations about the nature of porosity in these unique units and present case histories that reveal variations in reservoir development in different areas. Finally, petrologic observations summarized in these case histories will be integrated with the regional geologic framework constructed by other members of the research

team to help predict the location of new Trenton-Black River reservoirs in the basin.

We also will analyze the mineralogy of fracture surfaces in core samples to unravel the history of fluid migrations through the Trenton-Black River carbonates. Specific analytical techniques will be selected as needed and deemed appropriate after we assess all samples.

Task 4.0 - Isotope Geochemistry and Fluid Inclusion Analysis – New York State Museum

Sampling for and analysis of fluid inclusions, stable isotopes, trace elements and strontium isotopes will be carried out using representative wells from across the basin. Samples from matrix dolomites, fracture- and vug-filling dolomites, and unaltered limestone will be chosen from fields in each state where available. These new data will be integrated with existing data and used in the development of an overall model for dolomitization. Further, these data and interpretations will be integrated with other analyses from this investigation in the development of an integrated structural-diagenetic-stratigraphic model for the origin of the Trenton-Black River hydrothermal dolomite reservoirs.

Task 5.0 - Petroleum Geochemistry - Pennsylvania Geological Survey

Organic geochemistry is a critical component of sedimentary basin analysis. Organic geochemistry provides analytical data used to identify and map petroleum source rocks. Specific maps include organic richness, type of organic matter and thermal maturity of a source rock. Such maps are essential elements of any effort to determine the stratigraphic and geographic distribution of effective source rocks in a petroleum system.

There is some controversy concerning the petroleum source rocks for the Trenton-Black River reservoirs of eastern North America. Obermajer and others (1999) and Colquhoun and Trevail (2000) suggest that the Trenton strata of Ontario are a mainly self-sourcing petroleum system with short-range migration, and they propose that this may be the case for Trenton-Black

River reservoirs elsewhere. Ryder and others (1998) advocate a Utica Shale-Antes Shale source for the Ordovician carbonate reservoirs in the Appalachian basin. There appears to be merit to both arguments. Effective source rocks are documented in both the Trenton limestones and the Utica and Antes shales of the Appalachian basin (Cole and others, 1987; Wallace and Roen, 1989; unpublished data at the Pennsylvania Geological Survey).

We plan to approach the petroleum geochemistry of the Trenton-Black River in two ways. First, we will summarize all existing data from unpublished and published sources. Second, we plan to obtain new organic geochemical analyses for cores and samples from throughout the basin. Analyses will include total organic carbon (TOC), Rock-Eval Pyrolysis, extract analyses (bitumen and hydrocarbons), organic petrography, thermal alteration index and conodont alteration indices. Products of these analyses will include geochemical well logs and source rock maps showing thickness, organic richness and thermal maturity of effective source rocks for the play.

We also propose budgeting for selected stable isotopic analyses of gases from producing Trenton-Black River reservoirs in the basin. $\delta^{13}C$ of hydrocarbon gases and δD of methane will provide specific information on the source, maturity and migration history of these gases.

Task 6.0 - Analysis of Production Data/Histories and Horizontal Well Technology – West Virginia Geological Survey and the New York State Museum

Available production data on this developing play are very limited. Those production histories that are available will be gathered, documented and summarized. If sufficient data exist, production maps will be constructed and decline curve analysis attempted. Also, if data warrant, production amounts will be compared to productive interval thickness, completion practices, etc. to investigate if statements can be made concerning preferred methods.

. Several tens of horizontal wells have been drilled on Trenton-Black River structures in Ontario, Canada on the northern edge of the Appalachian basin. Horizontal drilling is a technology that may help to make Trenton-Black River fields more economically viable and cut down on dry holes. Our research will include successful horizontal well plans and analysis of dry holes vs. productive wells for both vertical and horizontal wells. Furthermore, we will attempt to learn the average production rates and ultimate recovery for horizontal vs. vertical holes.

Task 7.0 - Data, GIS, and Website Management – West Virginia Geological Survey

The Kentucky Geological Survey (KGS) has the rights to the GEOFILE Appalachian seismic data, consisting of 3,400 miles of 100 percent digital data in Kentucky, West Virginia, Pennsylvania and New York. These rights allow KGS to use the data for interpretation purposes, and with permission of the owner, SEISCO, Inc., to publish selected parts of the data. The Ohio Geological Survey has approximately 450 miles of public-domain 2D reflection seismic data available. Additional seismic data will be sought from industry and other government sources. Often, for research purposes, data may be obtained at little or no cost.

Each consortium partner has public-domain gravity and aeromagnetic data, drilling and completion records for oil and gas wells, production data, geophysical logs (many in digital format), samples, cores, miscellaneous analytical data and reports for use in the project. After inventorying available data, samples and cores, additions will be sought from industry to fill sparse and no-data areas. Much of the basic well data already has been compiled in digital form. Digital basemaps are available to each agency for use in map production. The consortium agencies are uniquely suited to provide data and analysis for the proposed investigation.

All data, reports, images and maps, either collected or created for this project, will be integrated in a central computer repository. A secure web site will be created for the project with

user accounts and passwords for researchers and funding participants. As data are collected and interpretations made they will be available to account holders on the website. Regardless of what software is used to create individual maps, they will be converted to ESRI file format for use in an ArcGIS environment. The website will use ESRI's ArcIMS system to integrate and distribute the GIS via the Internet. We expect that, by collecting data and maps centrally and distributing them live, final report preparation at the conclusion of the project will be more efficient.

After the agreed upon proprietary period, and perhaps the removal of some company proprietary data, the website and results will be made available to the public.

Task 8.0 – Project Management – West Virginia Geological Survey

The final project task is to keep the research on schedule, meet all milestones and deliverable dates, file all required reports on time and stay within the budget. Overall project management will be provided by the Director of the Appalachian Oil and Natural Gas Research Consortium, with management of each individual subcontract to be provided by the heads of the oil and gas sections at the State Geological Surveys and the New York State Museum.

D. DELIVERABLES

Using the information and interpretations outlined above, the research team will develop an integrated structural-diagenetic-stratigraphic model for the origin of the Trenton-Black River hydrothermal dolomite reservoirs. This model will be employed with structural and tectonic analyses to identify possible fairways and target areas that are favorable for the creation of productive pools. Companies may then concentrate their future geophysical and geochemical programs in these preferred areas, thus increasing their chances of economic success.

A listing of products to be delivered from this project will include:

- Structure map of the basement, including all faults and axes
- Separate maps of faults of different relative ages and styles
- Structure maps on the Mt. Simon, Trenton-Black River and other formations
- Isopach maps of the Mt. Simon, Trenton-Black River and other formations
- Regional cross section network illustrating relationships of basement structure to Mt. Simon and host carbonate units
- Isotope geochemistry and fluid inclusion report, data and interpretations
- Petrographic report, data and interpretations
- Petroleum geochemical well logs and source rock maps showing thickness, organic richness and thermal maturity of effective source rocks for the play.
- Production histories and interpretations
- Evaluation of effectiveness of horizontal drilling in the play
- Ordovician dolomite and hydrocarbon fairway and target area maps
- Play book and final digital products: database, GIS files and images

E. BRIEFINGS/TECHNICAL PRESENTATIONS

It is understood that we will prepare and present a detailed briefing for presentation to the COR in Pittsburgh, Morgantown or Tulsa, as directed, at least twice during the proposed two-year study. In addition, it is understood that we will present a technical paper at the DOE/NETL Annual Contractor's Review Meeting in either Pittsburgh or Morgantown.

After the end of the contract period, additional technology transfer will be accomplished via the website, publications, workshops conducted in a cooperative effort with the Petroleum

Technology Transfer Council and presentations at other regional and national conferences.

Technical Discussion

Forecasters continue to predict that the United States may need to increase gas production to 30 trillion cubic feet per year within the next 20 years, an increase of approximately 40 percent above current production. Faced with this immediate need to begin converting our gas resources to producible gas reserves, operators are looking for potentially giant plays in older basins that will require new approaches or technology to be successful. Such a play is the current Trenton-Black River gas play of the Appalachian basin, a seismic-dependent, high-technology, deep play that has attracted national and international attention. This play currently has producing wells in New York, Ohio, West Virginia and Ontario, and indications suggest productive trends may be found between and beyond the current areas of proven reservoirs. Many companies from other parts of the U.S. and Canada are anxious to enter this deep play, but are not familiar with the basin geology, tectonics, data sources or regulatory contacts. Further, because this is a multi-state play, many Appalachian-based operators who would like to venture into the play are not familiar with these same factors on a basin-wide basis.

The Trenton and Black River formations currently produce from fractured, dolomitized zones in New York, Ohio and Ontario, and from fractured zones in West Virginia. There is a large potential for further development along east-west trends within the eastern and central Appalachian basin and along northwest-southeast trends farther to the west. In West Virginia, drilling continues along northeast-trending, basement-controlled faults associated with the Rome Trough. Recently in that state, however, there have been fewer discoveries and new approaches are needed to develop exploration scenarios. More basic research into the controls operating in

Pennsylvania, Ohio and Kentucky are needed to understand the potential in these states. Expanded exploration and development of Cambro-Ordovician gas plays, which will convert gas resources to gas reserves in the near term, is extremely important to the future of the basin.

Trenton-Black River hydrothermal dolomites have been prolific oil and gas producers for more than a century**.** Drilling began in 1884 and more than 100,000 wells were drilled in the Lima-Indiana trend, producing about 500 million barrels of oil. The giant Albion-Scipio field in Michigan has produced in excess of 125 million barrels of oil, and the adjacent Stoney Point field another 8 million barrels of oil and 9 billion cubic feet of gas. A group of smaller fields in southwest Ontario has produced more than 2 million barrels of oil. These successes reflect the potential for near term success in expanding our gas reserves in deep, high-pressured, fractured carbonate reservoirs in the Appalachian basin. However, this is an expensive, high-technology play, and new approaches and detection methods are necessary to accurately locate new fields and increase gas production in the near term from throughout the play area.

The surface occurrence of discreet dolostone bodies in Upper and Middle Ordovician limestones of the Appalachian basin has been well documented (Black and Haney, 1975) and provides an excellent laboratory for a better understanding of these important hydrothermal dolomites. These isolated dolostone bodies are spatially related to mapped faults, and have been interpreted as products of hydrothermal fluids, which moved along fault conduits, replacing adjacent limestone in the host formations. Oil and gas production from these formations is attributed to increased porosity and permeability within hydrothermal dolomites and fractured limestones, both localized along faults. Often, these faults and fracture zones derive from relatively small reactivations of much older faults within the Precambrian basement. Oil and gas reservoirs in the Trenton-Black River play are narrow, linear, fractured limestone and dolostone

bodies, often with vuggy to cavernous porosity. This well-developed porosity and fault-related fracturing often results in high oil/natural gas production rates from these fields. Because of their narrow, linear nature, however, they often are very difficult to locate and produce. Only by understanding the basinal context and framework can clues to their location be found.

Scientific and Technical Merit

(1) How the proposed work relates to the "Research Objectives for This Solicitation"

One of our goals is to create a play book for the Trenton-Black River play that will enable industry to more accurately assess the gas resource in the play, and greatly increase gas production from the Appalachian basin. This goal, which is consistent with the stated goal of this solicitation, can be achieved with the expansion of this play from New York, through Pennsylvania and West Virginia into Kentucky and adjacent parts of Ohio. Already, just a few dozen Trenton-Black River wells in New York produce a significant percentage, now in excess of 20 percent, of the gas in a state with more than 20,000 gas wells. These numbers illustrate the potential that this play has to increase Appalachian basin production from a deep, over pressured, complex reservoir, or set of reservoirs that may have a wide extent throughout the basin. This potential, however, cannot be realized unless new methods can be developed to more fully understand the resource and new technologies can be developed to detect areas of natural fracturing and replacement of host limestone by hydrothermal dolomite along these fractures. Again, these technical needs are consistent with the solicitation for Area of Interest 9.

(2) How the proposed work will result in improvements over existing technologies

Currently, operators locate all exploratory wells in the play based on their interpretation

of 2D seismic lines. Initially, when they did this they were looking for a sag on the top of the Trenton, which is a reflection of the decrease in volume as the host limestone was converted to more porous dolomite. However, this approach does not seem to be as valid in West Virginia, where no dolomite has been reported. Therefore, a better understanding of how different styles of reservoirs have formed will lead to better seismic models and methods of detection. In addition, data, information and interpretations that are not available to all operators will become available to everyone after the conclusion of this project. Furthermore, the availability of acreage is a problem in this play, so operators tend to concentrate their research and exploration efforts in areas where they hold an acreage position. Therefore, even companies who are currently involved in the play may feel comfortable with what they have learned in one or two geographic areas, but are no better off than an outsider in terms of their knowledge in other areas of the basin. This project would help everyone, the small companies without a research staff, and the larger independents already involved in the play. In fact, a number of companies already drilling Trenton-Black River wells have endorsed this project and have committed to join our proposed Trenton-Black River Research Consortium.

(3) The degree to which the proposed work identifies and/or makes progress on new concepts; the likelihood of developing a new successful technology

We are confident that our integrated, multi-disciplinary approach will lead to a resource assessment model that can be used by industry to their advantage to more fully develop this play. Our confidence was bolstered by a meeting we hosted for industry on September 25, 2002 during which we presented the approach contained within this proposal, and received their enthusiastic endorsement and commitment to join us. Additional comments and suggestions

offered by industry during that meeting were considered and incorporated into this proposal. Companies have offered us data and information, for research purposes only, that have been held confidential to date, that will allow us to do more than can be done with publicly available information. Among these will be production data on horizontal as well as vertical wells, which will enable us to evaluate the success of this technology where it has been applied and determine other areas where it will have the greatest potential. Another potential partner is considering a 3D seismic project, the results of which could be made available to us for evaluation.

(4) The scientific and technical basis and merit of the proposed work

Our approach will include a number of different scientific disciplines, including: seismic analyses for structural mapping and detection of reservoirs; stratigraphic analyses, including thickness mapping of key units; analyses of petrographic data, leading to a synthesis of depositional environments that may control later dolomitization; isotope geochemistry and fluid inclusion analyses, to help develop an integrated structural-stratigraphic-diagenetic model of the origin of hydrothermal dolomite reservoirs; organic geochemistry analysis to determine and map petroleum source rocks; and development of an integrated database and secure website in a GIS environment, to make information and results readily available to our company partners. No one, to our knowledge, has attempted such a multi-disciplinary approach, certainly not at the basin-wide scale that we are proposing.

(5) Anticipated benefits

The results of this project will provide information that should save companies some exploration money and reduce the cost of finding gas. Thus, industry should be stimulated to

explore a wider area than is the current case. Furthermore, a better understanding of the geology and reservoir characteristics of these deeper reservoirs should help to meet natural gas demand in the years to come. It has been estimated that within twenty years the U.S. demand for natural gas will exceed 30 Tcf per year, up from approximately 21 Tcf currently. It is imperative that new targets be identified and drilled to meet this demand, and the Trenton-Black River Play is considered to have the greatest potential to be the next giant play in the Appalachian basin.

(6) Feasibility of the proposed concept

Based on our 12-year experience as a research consortium, and on our interaction with industry involved in the play and supportive of our approach, we consider our concept to be quite feasible, one that will lead to success. The commitment of industry to supply additional information, and to provide suggestions on what their needs are to develop this play, have further strengthened our approach and our confidence that we will be successful.

Technical Approach and Understanding

The main objectives of this proposed project are: to develop a multi-faceted, resource-assessment model of the Trenton-Black River Play, enabling operators to make informed decisions regarding the economics of getting involved in the play; to define fairways or target areas in which to concentrate detailed studies and seismic programs, leading to further development of the play; and to develop an integrated structural-diagenetic-stratigraphic model of the origin of hydrothermal dolomite, which will lead to better interpretations of seismic data, locations of fracture zones and selections of drill sites.

These objectives will be achieved through a multi-disciplinary approach involving seven

research tasks. All tasks will be conducted concurrently by an industry-government research consortium that could involve as many as 20 companies, four state geological surveys, the New York State Museum and West Virginia University. Industry partners in the consortium will provide direct cost share as well as data and information not otherwise available to the public.

(1) Project schedule and major milestones

This is envisioned as a relatively short, two-year study for a project of this magnitude, so all tasks will be worked on concurrently, with each task lasting for the duration of the contract period. Our anticipated start date is April 1, 2003, with a completion date of March 31, 2005.

The milestone schedule for major deliverables listed in this proposal is shown in Table 1.

Table 1. Milestone Schedule — **month due**

Task 1: Structure contour map of basement surface	21
Task 1: Structure map of basement faults	21
Task 1: Structure maps of the Mt. Simon, Trenton-Black River, etc	
Task 2: Isopach maps of the Mt. Simon, Trenton-Black River, etc	
Task 2: Regional cross sections	
Task 3: Petrographic report	21
Task 4: Isotope geochemistry and fluid inclusion report	
Task 5: Petroleum geochemistry well logs and source rock maps	15
Task 6: Production histories and interpretations	21
Task 6: Evaluation of effectiveness of horizontal drilling	15
Task 7: Fairways and target areas	24

Task 7: Play book, digital products, database and GIS 24

(2) Staffing plan

A fairly large management and research team will be assembled from among consortium partners, including a Project Manager; five Team Managers, one for each subcontract; and 11 research geologists or specialists, plus the necessary support staff at each survey.

Douglas G. Patchen (WVURC prime contract) will be responsible for project management, all technical and financial reports and coordination of technology transfer. K. Lee Avary, James Drahovzal, John Harper, Taury Smith and Larry Wickstrom will be responsible for the West Virginia, Kentucky, Pennsylvania, New York and Ohio subcontracts, respectively.

.Research team members will include the following: Dave Harris and John Hickman, geologists with the Kentucky Geological Survey; Mark Baranoski and Ron Riley, geologists with the Ohio Geological Survey; Chris Laughrey and Jaime Kostelnik, geologists with the Pennsylvania Geological Survey; Michael Hohn, Dave Matchen and Ron McDowell, geologists with the West Virginia Geological Survey; and a geologist/GIS specialist and geology technician with the New York State Museum. Hours required for each task by labor category per project year are listed in Table 2.

Table 2. Labor Categories and Hours	**Year 1**	**Year 2**	**Total**
Task 1: structural geologists	3165	3251	6416
Task 2: stratigraphers	1213	1126	2339
Task 3: petrographers	878	195	1073
Task 4: geochemists			
Task 5: geochemists	975	98	1073
Task 6: geologists	400	400	800

Task 7: geologists	400	400	800
GIS specialist	1975	1975	3950
Task 8: managers	390	390	780
	293	293	586

(3) Travel required to perform the proposed work

Three trips have been budgeted to allow us to present two briefings to our COR at DOE facilities in Pittsburgh, Morgantown, or Tulsa, and a technical paper at the DOE/NETL Annual Contractor's Review Meeting at NETL facilities in either Morgantown or Pittsburgh. Additional travel will be required to visit up to 20 company partners to seek data and input. These visits have been assigned to survey partners based on the company's location to reduce travel costs. Finally, we plan to hold quarterly meetings in a central location like Pittsburgh to review the technical progress and status of our research, and to present briefings to our company partners.

The only air travel that will be involved is a possible trip by the Project Manager to Tulsa, and flights from Albany to Pittsburgh by our NY State Museum partner for quarterly meetings.

(4) Applicant's understanding of the "Research Objectives for this Solicitation"

The stated objectives for Area of Interest 9, Subtopic 4 – Resource assessments, are to conduct gas resource assessments of major plays to better characterize the nation's resource base; to assess on-shore marginal resources, like fractured carbonates in the Trenton-Black River; and to focus on specified basins, one of which is the Appalachian basin. Larger goals are to help insure an adequate supply of natural gas as demand increases; and to meet the need to develop the technology that is necessary to produce gas from deeper, tighter, more complex, less

understood reservoirs, including better fracture detection methods. This proposal directly addresses these stated goals and objectives. We propose to collect and analyze all the information that is necessary to characterize and assess the resource base in a deep, poorly understood, complex set of reservoirs in a fractured, often dolomitized carbonate that has a great potential to dramatically increase gas production in the Appalachian basin.

(5) Prior research and application to proposed work

Our research of the Trenton Play as it existed in 1995, before the current play began, gave us a basic understanding of basin-wide Trenton stratigraphy, reservoir types, gas fields and shows at that time. Individual well and gas field data were entered in databases in the various state surveys, and in the overall field-scale database for the Gas Atlas project. These databases and other information gathered for the atlas are available for this project. After the current Trenton-Black River Play began in New York in 1995, we became involved through our contract with the Petroleum Technology Transfer Council to host technology workshops. Our objective was to bring everyone up to speed on the play using publicly available information and speakers with at least a limited knowledge of various aspects of the play. Four PTTC workshops were hosted that collectively drew more than 600 registrants, considerable more than the regional and national average of 40-50 per workshop. In addition, one consortium partner, the Kentucky Geological Survey, was awarded a contract from the New York State Energy Development Authority for a field and core study of outcrop analogs of the suspected reservoir in New York. Results from that study will be integrated with results from the proposed effort. Our New York State Museum partner is conducting its own Trenton-Black River research, including detailed studies of existing cores and well logs to interpret Trenton facies that are preferentially

dolomitized by hydrothermal fluids coming up from the basement. The Pennsylvania Geological Survey has in its possession thin sections from a Trenton well drilled near the Henderson Dome as part of a DOE-funded Secondary Gas Recovery contract awarded to our consortium. Again, these data will become part of the petrographic study. The Pennsylvania Survey also has conducted studies of source rocks and petroleum geochemistry. Our survey partners in Ohio and West Virginia have actively followed this play, and have presented numerous papers at regional and national meetings to increase the awareness of industry at the national level.

Technical and Management Capabilities

The proposed research effort will be conducted by members of a newly-created Trenton-Black River Research Consortium. This project-specific consortium may include up to 20 independent gas producers and the full membership of the Appalachian Oil and Natural Gas Research Consortium, which recently was expanded to include the New York State Museum. Other members include the state geological surveys in Ohio, Pennsylvania, Kentucky and West Virginia, and the National Research Center for Coal and Energy at West Virginia University. Available personnel within these organizations bring a wealth of technical knowledge and experience to this project.

(1) Credentials, capabilities and experience of key personnel

Project management will be provided by the Director of the Appalachian Oil and Natural Gas

Research Consortium, who will be responsible for keeping the project on schedule while meeting all reporting requirements. The supervisors of the oil and gas programs of the Kentucky, Ohio,

Pennsylvania and West Virginia Geological Surveys and the New York State Museum will supervise

and coordinate the research teams in their respective agencies. These five key management-level professionals will work closely with the Project Manager to keep the effort on schedule.

Collectively, the personnel who will be assigned to this project have several hundred years of relevant experience in conducting and managing oil and gas related research projects in the Appalachian basin. These individuals were part of the research teams that produced the Atlas of Major Appalachian Gas plays, enhanced the TORIS database, measured and predicted reservoir heterogeneity in oil fields in Ohio and West Virginia, characterized oil reservoirs in West Virginia, were involved in coal-mine methane research in West Virginia and Pennsylvania, and conducted secondary gas recovery research in Pennsylvania, all through consortium contracts with DOE.

(2) Relevant corporate experience in managing projects of a comparable size

The Appalachian Oil and Natural Gas Research Consortium was formed in 1988 as a partnership among the state geological surveys in four states and the departments of Geology & Geography and Petroleum & Natural Gas Engineering at West Virginia University. During the past 14 years, the Consortium has created teams from the vast talent pool afforded them through this partnership arrangement to conduct eight, multi-year, DOE-funded research projects. The most visible product resulting from this work is the "Atlas of Major Appalachian Gas Plays." Nearly all of the team members for the proposed effort worked on the basin-wide gas atlas and TORIS projects.

Overall project management for all AONGRC contracts rests with the Consortium Director (Patchen), who will serve in the same capacity on this project. In addition, the heads of the oil and

gas programs at the four state surveys (Avary, Drahovzal, Harper, Wickstrom) who managed their individual subcontracts on all Consortium projects to date, will serve in similar roles.

Other projects successfully completed by the AONGRC include studies of reservoir heterogeneity in West Virginia, Ohio and Pennsylvania; enhancing the Total Oil Recovery Information System (TORIS) for the Appalachian basin; secondary gas recovery efforts focused on the Medina sandstone in Pennsylvania; coal mine methane utilization in Pennsylvania and West Virginia; reservoir characterization of oil fields in West Virginia; on-going documentation of preferred upstream management practices in Ohio, Pennsylvania, Kentucky and West Virginia oil fields; and a second current project to implement a technology transfer program throughout the Appalachian basin for the Petroleum Technology Transfer Council. To date, these projects have involved more than $10,000,000 in DOE funds and more than $5,000,000 in cost share from industry and state government.

(3) Overall project organization, roles and responsibilities

The prime contractor for this effort will be the West Virginia University Research Corporation. The Research Corporation will assign the responsibility to complete this contract to the Appalachian Oil and Natural Gas Research Consortium, which is a university program under the National Research Center for Coal and Energy. The Research Corporation will enter into subcontract agreements with each of the Consortium partners - the Kentucky, Ohio, Pennsylvania and West Virginia Geological Surveys, and the New York State Museum. Ultimately, the Directors of each of these state agencies will be responsible for their subcontracts, but effectively, the responsibility will rest with the heads of the oil and gas groups in each agency.

The West Virginia Geological Survey will be responsible for providing the project manager (Patchen), subcontract manager (Avary), a GIS specialist and three research geologists, and will be responsible for tasks 6, 7 and 8. The Kentucky Geological Survey will provide a subcontract manager (Drahovzal) and two research geologists, and will be responsible for task 1. The Ohio Geological Survey will provide a subcontract manager (Wickstrom) and two research geologists, and will be responsible for task 2. The Pennsylvania Geological Survey will provide a subcontract manager (Harper) and two research geologists, and will assume the lead role in tasks 3 and 5. The New York State Museum will provide a subcontract manager (Smith) and two additional team members, and will be responsible for task 4.

Although each survey/museum has been assigned the responsibility of a lead role on a task-by-task basis, research geologists in each survey will have a role in collecting and interpreting data in their respective states and supplying the data to the lead survey for each task.

(4) Description of facilities and equipment

In their letters of commitment, the directors of all consortium partners have committed whatever is necessary to successfully complete this project, not only specific research and management personnel, but the full use of their facilities and equipment, including laboratories, vehicles, hardware and software, as well. Collectively, the consortium has adequate facilities and equipment to complete the project, and each partner has what is necessary to successfully conduct and complete their assigned roles. Only a few pieces of new equipment will be required.

Each survey has a digital database of wells drilled in their respective states, including all Trenton and deeper wells. Each survey has personnel, hardware and software capable of

generating and printing the maps and cross sections for this project; conducting the petrographic and geochemical studies; and migrating key data into a GIS environment and creating interactive websites, although the responsibility for this task will lie with the West Virginia Geological Survey.

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