

Penn State Petroleum GeoSystems Annual Report 1998-1999

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1. Executive Summary

In the fall of 1999, 4 students began their graduate education within the GeoSystems Initiative at the Pennsylvania State University. This new educational effort links the Geosciences and the Energy and GeoEnvironmental Engineering Departments within the School of Earth and Minerals Sciences. The 4 students bring individual strengths in geology, geophysics, petrophysics, and petroleum engineering. Members of the GeoSystems team will take common, cross-training, and disciplinary depth courses, share common office and lab space, and will intern with Shell Offshore Incorporated in the summer of 2000. The team will pursue both individual, and team-based research on Shell's Bullwinkle (GC 65) field. A state-of-the-art computing facility has been developed to house the initiative. The Initiative is supported by the Shell Foundation, Shell Offshore Inc., Texaco, Chevron, and the Landmark Graphics Corporation.

2. Overview

In the fall of 1997, Shell scientists visited the Department of Geosciences and the Department of GeoEnvironmental Engineering to learn of ongoing educational and research efforts and to look for possible mechanisms by which these departments could strengthen their linkage with industry. The departments endeavored to communicate the breadth and depth of education and research activities. The interdisciplinary nature of the teaching and research activities was emphasized. During the winter of 1998, representatives from these departments visited Shell Offshore Inc. in New Orleans. Shell communicated to Penn State representatives the nature of the modern exploration/exploitation process.

Over the course of these visits, discussions emphasized the changing nature of employment within the oil industry. A common approach used by companies today is to form teams of specialists to explore and/or produce hydrocarbons. A typical team might include a geologist, geophysicist, petrophysicist, and a petroleum engineer. These teams must work synergistically together to find and produce hydrocarbons amidst an extremely competitive environment driven by low oil prices.

With this new model, new challenges have arisen. Teams need to form quickly and function well. There is limited time and money for in-house training. Finally, the very nature of the exploration/exploitation process is changing. Geologists, geophysicists, and engineers need to start thinking of the basin system in a holistic sense. The team must rapidly assimilate and interpret a vast amount of digital data on the workstation and work fluently, technologically, and in many dimensions.

Out of these discussions arose the vision that there was common ground between the interdisciplinary research and educational goals at Penn State and the need for geoscientists and engineers to be more prepared for the team-based, interdisciplinary, and applied approach used in the petroleum industry. A radical experiment was proposed. Penn State and Shell Oil would work together to devise a two-year masters program entitled the GeoSystems Initiative.

It was envisioned that the first GeoSystems Team would be composed of a petroleum engineer, a geologist, and a geophysicist. The team would matriculate in August 1999

and graduate in 2001. The team would take common, cross-training, and disciplinary depth courses, share common office and lab space, and intern with Shell Offshore Incorporated in the summer of 2000. Finally the team would use state of the art resources to pursue individual research theses on an offshore Gulf of Mexico oil field. The ensuing report describes our progress toward these goals.

3. The GeoSystems Team

We have recruited 4 outstanding students for the first GeoSystems Team: 1) Kevin Best, (petroleum engineer); 2) Joe Comisky (petrophysicist); 3 Mike Moreland (geologist); and 4) Alastair Swanston (geophysicist). Brief bios of each student are included as Appendix A. Kevin, Mike, and Alastair are supported by Shell and they will intern with Shell Offshore Inc. as a team during the summer of 2000. Joe Comisky is supported by a Chevron Fellowship. He is a full member of the GeoSystems Team, but he will intern independently.

4. Curriculum

Graduate students in the Petroleum GeoSystems Initiative will receive either a Geoscience Masters Degree or a Petroleum and Natural Gas Engineering Masters Degree, depending on their training and interest at the time of application. All students will take common core curriculum including seismic processing and interpretation, fluid flow, evaluation of oil and gas-producing properties, and reservoir geosystems. In addition, petroleum engineers will take depth courses in their field and breadth courses in geosciences. Geoscientists will take depth courses in their field and breadth courses in petroleum engineering. Appendix B lists the curriculum that was envisioned for GeoSystems engineers and geoscientists. Appendix C illustrates the actual and projected courses for these students.

A capstone experience of the team's educational experience links engineering, geology, and geophysics in examining a petroleum reservoir and an outcrop analog in order to construct a geologic and production model for that reservoir.

5. Facilities

20 Hosler Building, which is located at the boundary between our engineering and geoscience departments, was renovated to be a computer lab/workroom for the GeoSystems Team. The room is equipped with 4 UNIX, and one NT workstation. All the computers are linked to the geosciences and petroleum and natural gas engineering computing networks.

The GeoSystems Team has access to a full suite of industry software and a sophisticated array of workstations, plotters, and other hardware through the Applied Geophysical Instructional Facility (AGIF) (Attachment 1). Landmark Graphics Corporation has provided a 4.5 million dollar software grant to support this facility. Software includes seismic processing programs (Promax), seismic interpretation software (Seisworks), reservoir simulation software (VIP), and production analysis software (DSS).

6. Project Selection: Bullwinkle (Green Canyon 65)

Bullwinkle (Green Canyon 65) is the Gulf of Mexico oilfield that will form the foundation for teaching and research in the GeoSystems Initiative. Bullwinkle has an extraordinary database and it is a well characterized example of a modern deepwater turbidite reservoir. These reservoir systems are of major importance worldwide.

Tom Wilson (S.O.I.), after discussion with colleagues at Shell, summarized the following potential research directions :

With a total of 13 productive sands/horizons and 22 productive reservoirs at Bullwinkle, a comprehensive study of the field is beyond the scope of what the Petroleum GeoSystems project team could reasonably accomplish in the time frame of the M.S. program.

We suggest a study focused on the "J1" and "J2" sands in the Reservoir "B" area (Western portion of field). The rationale is:

The "J1" and "J2" RB reservoirs have the greatest volume significance in the field, containing the bulk of Bullwinkle's expected ultimate recovery.

The "J1" and "J2" are hydraulically connected in the hydrocarbon column apparently across an erosional surface at the base of a "J1" channel member in an up-dip position. Any study of reservoir performance requires working with seismic/well/production data from both horizons.

The amalgamated channel and the ponded fan reservoir facies represented by the "J1" and "J2" sands are important reservoir types in many deepwater GOM and international deepwater developments.

Significant Shell study efforts have been focused on the "J1" and "J2" reservoirs during pre-development planning (1987-1991), and during early production (1991-1994). Little formal study has been conducted subsequently, however. An excellent opportunity currently exists to provide a comprehensive review of Bullwinkle "J1"/"J2" reservoir geology and production performance now that the reservoir is far along in it's producing life. An integrated review of all subsurface data could provide a very useful analog to assist decision-making in future deepwater exploration and development decisions in similar reservoir styles.

Additional potential development well locations exist in the far updip edge of the "J1" reservoir (GC 110) which may be drilled during the next 2-4 years. Review of "J1"/"J2" production performance could provide a stronger basis for these future well recommendations.

7. Data Status

A list of data received from Shell Oil for the Bullwinkle field is attached (Appendix D). Data include 3 3-D seismic surveys (post-stack), 2D seismic data (pre-and post-processed), digital log data, core data, production data, etc. The seismic and wireline data have been loaded into our Landmark system. We are loading various marker information.

8. Personnel

We have put together a support team of professional and administrative personnel to support the GeoSystems Team.

Peter Flemings, Associate Professor of Geosciences: Peter Flemings is the Director of the Petroleum GeoSystems Initiative. Dr. Flemings emphasizes the multi-disciplinary study of stratigraphy, subsurface fluid flow, sediment transport and stratigraphy. A strong component of his effort is the use of seismic (2 and 3-D) and well data. He also emphasizes the integration of observation with theory in both research and teaching, and relies heavily upon realistic, problem-based projects to teach students.

Turgay Ertekin is the Associate Head of the Department of Energy and Geo-Environmental Engineering. Dr. Ertekin has over twenty years of petroleum engineering experience. His research interests are in the areas of numerical and analytical modeling, well test analysis, enhanced oil recovery, coal seam degasification and unconventional gas reservoirs. He teaches undergraduate and graduate courses in fluid flow dynamics in porous media.

Rudy Slingerland is the head of the Department of Geosciences. Dr. Slingerland specializes in clastic sedimentology, especially mechanics of sediment transport, placer genesis, mathematical modeling of streams, numerical simulation of circulation in epicontinental seas, genesis and interpretation of cross-strata, and barrier island dynamics.

Avrami Grader, Associate Professor of Petroleum and Natural Gas Engineering: Dr. Grader's main research goals are to further our scientific understanding of multiphase flow of fluids in porous media, and to investigate how the simultaneous flow of fluids affects our ability to predict the behavior of underground strata. The specific areas of research are two- and three-phase flow in porous media, transient pressure analysis with its effects on well testing and on reservoir engineering water influx problems, and multiphase flow dynamics in the near wellbore domain including wellbore mechanics.

Jim Ashbaugh, Senior Research Assistant: Jim Ashbaugh is a reservoir engineer with 5 years of industry experience. Jim has an extensive background in production data analysis and reservoir simulation using Eclipse and VIP. His research interests include reservoir characterization, time-lapse seismic analysis, and reservoir modeling.

Heather Johnson, Project Assistant: As a project assistant Heather is responsible for management of all data received from industry. This includes logging of incoming data, loading of digital data on the geosciences system, database maintenance, and access/security of all data.

Nancy Levitsky, Administrative Assistant: Nancy handles all administrative duties for the Petroleum GeoSystems Initiative including: managing program finances, organizing travel for GeoSystems Members, acting as first line of support for GeoSystems Initiative, maintaining all GeoSystems files, and handling promotional efforts including print advertising, brochures & posters.

9. Budget

The itemized budget for fiscal year 1999 (7/1/98-6/30/99) is illustrated in Appendix E. The Department of Geosciences expended \$28,393.54 for salary support and room renovations. A total of \$37,039.02 was spent from the Shell GeoSystems Grant. The majority of these moneys were spent recruiting the GeoSystems team and preparing facilities for team members. It was expected that the GeoSystems Initiative would not spend all of its '98-'99 moneys. Costs for the upcoming two years (while students are in residence) will exceed income from Shell and the carry over from this year will cover these higher expenditures.

Appendix A - GeoSystems Student Biographies



Kevin D. Best

Petroleum GeoSystems

20 Hosler Building

University Park, PA 16802

814-863-8123

bestkd1@geosc.psu.edu

- ♦ **Education:** Bachelor of Science, Mechanical Engineering, May 1997, The Pennsylvania State University, University Park, PA
Jr/Sr GPA: 3.52
- ♦ **Work Experience:** 6/97 – 7/99, Texaco Group Inc., Houston TX
Engineer – Offshore Engineering Department
- ♦ **Co-Op Experience:** 4/95-5/96, Toyota Motor Manufacturing, USA, Inc., Georgetown, KY. Manufacturing/Production/Stamping/Tool and Tie Department



Joseph T. Comisky

Petroleum GeoSystems

20 Hosler Building

University Park, PA 16802

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comisky@geosc.psu.edu

- ♦ **Education:** Bachelor of Science, Geosciences, August 1999, The Pennsylvania State University, University Park, PA
Jr/Sr GPA: 3.71

- ♦ **Thesis:** "Prediction and Characterization of Overpressure Using Reflection Seismic Interval Velocities Compared with Wireline Results, South Timbalier block 295 offshore Louisiana".

- ♦ **Work Experience:** 6/98 – 8/98, Intern, Schlumberger Geco-Prakla, Houston, TX. Interned in the Data Processing/Tape Services Department.

- ♦ **Honors:** John and Betty Teas Scholarship, 1997 & 1998; Chevron Undergraduate Scholar, 1998; Drake Memorial Scholarship, 1999; Dean's List: Fall 1997 & 1998, Spring 1998 & 1999



Michael Moreland
Petroleum GeoSystems
20 Hosler Building
University Park, PA 16802
814-863-8123
moreland@geosc.psu.edu

- ◆ **Education:** Bachelor of Science, Geosciences, Hydrology Option, The Pennsylvania State University, University Park, PA, Anticipated Graduate, Fall 1999, Jr/Sr GPA: 3.91
- ◆ **Thesis:** “The Importance of Aridity and pCO₂ on Quaternary Vegetation Shifts”
- ◆ **Honors:** Freshman’s President Award, Penn State, Spring 1995; Baccalaureate Student of the Year, Penn State-Mont Alto, Spring 1996; The Ron Landon Foundation Hydrology Scholarship, Department of Geoscience, Penn State, Fall 1998



Alastair Swanston
Petroleum GeoSystems

20 Hosler Building
University Park, PA 16802
814-863-8123
swanston@geosc.psu.edu

- ◆ **Education:** Bachelor of Science, Geophysics, May 1999,
The University of Edinburgh, Edinburgh, Scotland
Jr/Sr GPA:
- ◆ **Work Experience:** 7/98 – 8/98, CGG London Processing Centre,
Summer Student Processing Geoscientist.
- ◆ **Awards:** University Merit Certificates: Geology 3, Geophysics 2,
Geology 2, Geology 1; Certificates: Physics 1A, University Colours:
Outstanding service to E. U. Hillwalking Club

Appendix B - Proposed GeoSystems Curriculum

Appendix A is a general outline of the curriculum envisioned for members of the GeoSystems Initiative.

Common Courses (13 Credits)	
GEOSC 558	Multichannel Seismic Processing (4)
PNGE 501	Steady State Flow in Porous Media (3)
PNGE 550	Advanced Engineering Evaluation of Oil- and Gas-Producing Properties (3)
GEOSC 597B	Reservoir GeoSystems (3)

Cross-Training Courses	
<i>Geosciences for Engineers (6-9 credits)</i>	
GEOSC 439	Principles of Stratigraphy (3)
GEOSC 465	Structural Geology (3)
GEOSC 454	Petroleum Geology (3)
<i>Engineering for Geoscientists (10 credits)</i>	
PNGE 450	Drilling Design and Production Engineering (3)
PNGE 451	Oil Well Drilling Laboratory (1)
PNGE 410	Applied Reservoir Engineering (3)
PNGE 405/6	Rock and Fluid Properties (with lab) (3)
Disciplinary Depth Courses	
<i>For Engineers (12 credits)</i>	
PNGE 511/12/13	Flow in Porous Media Series (select one) (3)
PNGE 520	Phase Relations in Reservoir Engineering
PNGE 555/75/76	Drilling and Production Series (select one) (3)
<i>For Geologists (7-10 credits)</i>	
GEOSC 479	Advanced Stratigraphy (3)
GEOSC 555	Advanced Structural Geology (3)
GEOSC 454	Petroleum Geology (3)
<i>For Geophysicists (7-10 credits)</i>	
GEOSC 507	Seismology (4)
GEOSC 597D	Signal Processing (3)
GEOSC 454	Petroleum Geology (3)

Appendix C - Current and Future Individual Course Schedules

During the fall of 1999, faculty members from the both the Energy and GeoEnvironmental Engineering Department and the Geosciences Department met with each member of the GeoSystems Team. The courses that each student is taking for fall '99 are listed below. In addition, a preliminary schedule for future course work is also attached.

Schedule for Kevin Best

Fall 1999

Course Number	Course Description	Credits
GEOSC 558	Multi-channel seismic	4
	GeoSystems Seminar	1
PNG 501	Steady flow in porous media	3
PNG 520	Phase behavior	3
PNG 511	Numerical solutions of flow equations	3
PNG 590	Colloquium	1
		15

Spring 2000

Course Number	Course Description	Credits
GEOSC 454	Petroleum geology	3
GEOSC 597B	Petroleum GeoSystems	3
	Field Stratigraphy	2
PNG 576	Production operations	3
PNG 450	Drilling	3
PNG 451	Drilling lab	1
		15

Fall 2000

Course Number	Course Description	Credits
PNG 550	Engineering evaluation of oil and gas fields	3
PNG 575	Gas-lift design and optimization	3
	GeoSystems Seminar	1
		7

Spring 2001

Course Number	Course Description	Credits
GEOSC 439	Stratigraphy or	3
GEOSC 465	Structural geology	
PNG 600	Research	6
		9

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Schedule for Joe Comisky

Fall 1999

Course Number	Course Description	Credits
PNG 511	Numerical solutions of flow equations	3
PNG 440	Formation Evaluation	3
GEOSC 507	Seismology	3
		<hr/>
		9

Spring 2000

Course Number	Course Description	Credits
GEOSC 597B	Petroleum GeoSystems	3
GEOSC 559	Seismology	3
PNG 450	Drilling	3
PNG 451	Drilling lab	1
		<hr/>
		10

Fall 2000

Course Number	Course Description	Credits
PNG 550	Engineering evaluation of oil and gas fields	3
GEOSC 590	Colloquium	1
EMECH 524A	Mathematical methods in engineering	3
		<hr/>
		7

Spring 2001

Course Number	Course Description	Credits
PNG 410	Reservoir engineering	3
Geosci 600	Research	6
		<hr/>
		9

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Schedule for Mike Moreland

Fall 1999

Course Number	Course Description	Credits
GEOSC 558	Multi-channel seismic	4
	GeoSystems Seminar	1
		<hr/> 5

Spring 2000

Course Number	Course Description	Credits
GEOSC 585	Sedimentary geology	3
GEOSC 597B	Petroleum GeoSystems	3
PNG 410	Reservoir Engineering	3
	Field Stratigraphy	2
		<hr/> 11

Fall 2000

Course Number	Course Description	Credits
GEOSC 479	Advanced Stratigraphy	3
PNG 550	Engineering evaluation of oil and gas fields	3
PNG 501	Steady flow in porous media	3
GEOSC 590	Colloquium	1
		<hr/> 10

Spring 2001

Course Number	Course Description	Credits
PNG 450	Drilling	3
PNG 451	Drilling lab	1
GEOSC 600	Research	6
		<hr/> 10

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Schedule for Alastair Swanston

Fall 1999

Course Number	Course Description	Credits
GEOSC 558	Multi-channel seismic	4
ACS 513	Signal Processing	3
PNG 405	Rock and fluid properties	3
PNG 406	Rock and fluid properties - Lab	1
	GeoSystems Seminar	1
		<hr/>
		12

Spring 2000

Course Number	Course Description	Credits
GEOSC 454	Petroleum geology	3
GEOSC 597B	Petroleum GeoSystems	3
PNG 450	Drilling	3
PNG 451	Drilling lab	1
	Field Stratigraphy	2
		<hr/>
		12

Fall 2000

Course Number	Course Description	Credits
PNG 550	Engineering evaluation of oil and gas fields	3
	GeoSystems Seminar	1
GEOSC 590	Colloquium	1
PNG 501	Steady flow in porous media	3
		<hr/>
		8

Spring 2001

Course Number	Course Description	Credits
GEOSC 600	Research	6
		<hr/>
		6

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Appendix D - Status and Progress in Working with Data Received

On July 29, 1999 the GeoSystems Program at Penn State received information on three 3D seismic surveys of the Green Canyon 65 (Bullwinkle) field and the surrounding areas from Shell Offshore Inc. The digital data included eleven 8mm tapes and two 3.5" disks. The digital data on the 8mm tapes contained Shell's Bob Brown Database, Log Data and navigation and survey information for the three 3D surveys. The two disks contained Bottom Hole Pressure Data and GC65 checkshot data. The paper data included three maps (one each) of the 3D surveys and 42 scout tickets for the wells. We also received binders that included paper copies of the Conventional Core Data, the PVT Data, and the Mechanical Well Sketches.

On August 30, 1999 we received additional digital data from Shell which included 5 more 8mm tapes containing two 2-D lines that intersect the Green Canyon 65 (Bullwinkle) field. The data included pre-stacked, stacked, and migrated SEG-Y for the two lines, stacked and migrated velocities for the two lines, a navigation tape, and also included in the digital data was the coordinates of the blocks for the area surrounding GC65.

Data loading began on August 2, 1999 by importing the Bob Brown database into our Landmark Graphics software. Well headers, which included the unique well identifiers, the common well names, the x and y coordinates, the Kelly-Bushing elevations and the total depth of the wells were then loaded. Seventy-four log curves were then loaded into their respective well files. The directional survey and the checkshot data was imported, and the position logs calculated through the software program. After checking the data for errors and inconsistency, loading the three 3D surveys was initiated.

The Bull 3D survey was loaded first; using two programs in the Landmark software called SEG-Y Analyzer and PostStack Data Loader. Loading of the first survey was completed on August 18, 1999. The Bull34 and Bull35 surveys were loaded in the same manner, they were completely loaded by August 19 and August 22, 1999, respectively.

The 2-D seismic data has been loaded into ProMAX. The block coordinate data was used to make an overlay of block boundaries and numbers for use in Landmark packages.

Data Format	Contents	Date Received
8mm Tape – tar	Bob Brown Databases	7/29/99
8mm Tape – tar	Digital Log Data	7/29/99
8mm Tape – tar	Navigation Data for 3D Surveys	7/29/99
8mm Tape – SEGY	Bull 3D Survey	7/29/99
8mm Tape – tar	Bull Navigation Data	7/29/99
8mm Tape – SEGY	Bull34 3D Survey	7/29/99
8mm Tape – SEGY	Bull34 3D Survey	7/29/99
8mm Tape – tar	Bull34 Navigation Data	7/29/99
8mm Tape – SEGY	Bull35 3D Survey	7/29/99
8mm Tape – SEGY	Bull35 3D Survey	7/29/99
8mm Tape – tar	Bull35 Navigation Data	7/29/99
8mm Tape – tar	2D Navigation Data	8/30/99
8mm Tape – SEGY	2D Pre-Stack Data	8/30/99
8mm Tape – SEGY	2D Stacked and Migrated Data	8/30/99
8mm Tape – SEGY	2D Stacked and Migrated Velocities	8/30/99
8mm Tape – tar	Coordinates for Blocklines	8/30/99
3.5" Disk	Checkshot Data	7/29/99
3.5" Disk	Bottom Hole Pressure Data	7/29/99
Paper	Bull 3D Survey Map	7/29/99
Paper	Bull34 3D Survey Map	7/29/99
Paper	Bull35 3D Survey Map	7/29/99
Paper	2D Survey Map	9/7/99
Paper	Scout Tickets	7/29/99
Paper	Conventional Core Data	7/29/99
Paper	P-V-T Data	7/29/99
Paper	Mechanical Well Sketches	7/29/99
Paper	Well Logs	9/23/99

Appendix E - Fiscal Year 1999 Expenditures

Petroleum GeoSystems Expenditures

Fiscal Year 1999

Geoscience Funds

Salaries	\$10,000.00
Renovation of 20 Hosler	\$18,393.54
Total	\$28,393.54

Texaco Fellowship

Julie Napotnik	\$2,575.00
Balance	\$22,425.00

Chevron Fellowship

Expenses	\$0.00
Balance	\$14,000.00

Shell

Computer	\$19,276.15
Meals for Recruits	\$89.36
Mail Services	\$638.85
Promotion	\$8,578.64
Reception	\$593.63
Salaries	\$7,500.75
Supplies	\$1,056.46
Travel	\$14,807.15
Website	\$419.99
Balance	\$37,039.02