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TITLE: GEO-ENGINEERING MODELING THROUGH INTERNET INFORMATICS (GEMINI)

Cooperative Agreement No.: DE-FC26-00BC15310
Contractor Name and Address: The University of Kansas Center for Research Inc.
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DOE Cost of Project: $ 877,271 (Budget Period 10/01/00 -- 09/30/03)
Principal Investigators: John H. Doveton (Program Manager)
W. Lynn Watney
Project Manager: Daniel J. Ferguson, NPTO Tulsa, Oklahoma
Reporting Period: January 1, 2002 -- March 31, 2002

OBJECTIVES

The objectives of GEMINI (Geo-Engineering Modeling through Internet Informatics) are to apply an interdisciplinary effort to develop an interactive, integrated Internet Website that will build real-time geo-engineering reservoir models for the Internet using the latest technology in Web applications. The client will be able to retrieve databases, upload information, and run software interactively using the intelligent interfaces that will efficiently assemble a project based on the definition of a three-dimensional data volume. Analytical software operating on the assembled data and results will be delivered to the client through the web pages. System informatics, consisting of the network, software, data, and tutorial components, will permit the client to develop any number of projects. Analytical components of GEMINI include assembling fluid and rock parameters, basic
and enhanced wireline log interpretation, data mining, spatial analysis and visualization, volumetrics, material balance, and specific parameterization and formatting of these results suited for input into reservoir simulation software. A tutorial module will instruct clients on theory, application of analytical tools, and operation of GEMINI. Participating major and independent companies will provide information and expertise to provide feedback during the development process.

The development of GEMINI will proceed through the following tasks, each performed in collaboration with different team members and under the supervision of the project manager:

- **Design of the project interface:**
  Evaluation of the needs of users and the definition of software options. Coding of interface and application software to build projects including real-time assembly of information and access to analytical tools. Implementation of a phased development strategy and schedule for GEMINI to take full advantage of the changing hardware and software environment and unanticipated opportunities recognized as the application modules are developed.

- **Reservoir characterization:**
  Definition of reservoir parameters and the construction of linked software and databases. Translation and coding of new software for analytical programs for petrophysical modeling to run as web applications. Integration of analytical software with assembled information. Coding software for geomodel development to assist client in making decisions on key procedures such as definition of pay and correlative modeling.

- **Geo-engineering modeling:**
  Development of new software to access the geologic model and obtain volumetric calculations for comparison with results computed from software coded to conduct material balance. Parameterize model as input for reservoir simulation.

- **Technology transfer:**
  The testing of project design and analytical software, using data obtained from participating companies. This process will involve the solicitation of continuous company feedback as well as the conduct of an annual meeting to review progress. A tutorial interface will also be developed, with the integration of tutorial material with the GEMINI software.

The project deliverables to USDOE will be:

- **An internet web-site capable of building petroleum projects designed by the Internet client in a user-friendly environment including an interface to help the client assemble the database, run analytical tools, and build the well model, geomodel, and geo-engineering model optimized for performance and access, coupled with an ability to upload data, download results, and import information into other applications. The procedures will be optimized for performance and access, while the software will be tested during development using company data and feedback to ensure that it meets the needs of industry. The system informatics (network, software, data, and tutorial components) will be made**
sufficiently flexible to allow the user to operate on equivalent data from any location and not restricted to material that is part of the web-site.

- Rock and fluid catalogs.
- Analytical software tools to include web-based applications to assemble fluid and rock parameters, conduct basic and enhanced wireline log interpretation, spatial analysis and visualization, correlative modeling, volumetrics, material balance, and specific parameterization and formatting of results suited for input into reservoir simulation.
- A tutorial module including theory, application of analytical tools, and operation of GEMINI.
- Reports of data distribution, seminars, conferences, and workshops will be provided to USDOE as records of technology transfer activities.

SUMMARY OF TECHNICAL PROGRESS BUDGET PERIOD 2

Progress is reported for the period from January 1, 2002 to March 31, 2002. In this sixth quarter,

Task 1: Design of the Project Interface
Task 2: Reservoir Characterization
   Petrophysical modeling
Task 3: Geoengineering modeling
Task 4: Technology transfer
   Project application
   Tutorial interface
Task 1: Design of the project interface:

The performance of petroleum reservoirs is determined by the extent and nature of the energy available for the movement of the oil and gas and by the flow properties of the systems comprised of oil, gas, water and the porous media. A thorough understanding of the volumetric and phase behavior of petroleum fluids is indispensable in predicting the performance of petroleum reservoirs and in guiding the selection of techniques to be used to produce them.

The PVT Module (Figure 1) was designed to assist the Gemini User in calculating the physical properties of petroleum fluids. The physical properties of petroleum fluids are required for most petroleum engineering calculations. The PVT Module utilized common empirical relationships to estimate PVT properties for oil, gas, and water.

![Figure 1: PVT Module Applet.](image)

The PVT Module was designed to provide simple dialogs that will assist the Gemini User in performing the necessary calculations (Figure 2). The User enters the necessary input parameters and selects the calculate button and a results dialog will appear (Figure 3). The results dialog allows the Gemini User to save the output to their computer or print the results (Figure 4).
Figure 2: PVT - Oil Formation Volume Factor.

Figure 3: PVT - Oil Formation Volume Factor – Results

RESULTS

| Solution gas-oil ratio (Rs - scf/STB) | 20 |
| Gravity of stock-tank oil (API - degree API) | 2 |
| Reservoir temperature (T - degree F) | 200 |
| Gas gravity (Air=1) | 2 |
| Formation Volume Factor of Saturated Black Oil (Bob - res bbl/stb) | 1.078476 |

Save and print the results using 'Save As' & 'Print' options in your browser

Figure 4: Output of the Oil Formation Volume Factor Results.
The PVT Module will compute the following calculations.

- **Oil Calculations:**
  - Oil Formation Volume Factor,
  - Coefficient Of Isothermal Compressibility,
  - Dead and Saturated Oil Viscosities calculations.

- **Water Calculations:**
  - Compressibility of Brine,
  - Viscosity of Water.

- **Gas Calculations:**
  - Gas Formation Volume Factor,
  - Gas Compressibility,
  - Gas Viscosity calculations.

The PVT Module can be viewed from the Gemini Application Web Site and selecting the PVT Module Icon Button or selecting the following web address,

http://www.kgs.ukans.edu/Gemini/Version_2.3/pvtApplet.html

**Task 2: Reservoir Characterization**

The drill stem test (DST) module is being developed to be able to access and process digital drill stem test data to compute permeability knowing the thickness of the zone being tested, obtain the reservoir pressure through a Horner Plot, and display fluid recoveries for use as an indication of initial production rates. Over 1000 digital DST files currently reside in the Kansas Geological Survey’s Oracle database, information that was donated by Triolobite Testing. The user will eventually be able to upload their own DST data to compliment this publicly available information. In addition to providing vital analyses for DST, the availability of the software should encourage more use, access, and integration of this information. GEMINI will permit comparison of these results with those derived from well logs and cores to substantiate quantitative characterization of the reservoir. The results will also help to delimit flow units for use in geomodeling and volumetric analysis. The formation volume factor needed in this analysis can be derived from GEMINI’s PVT module.

A dialog box from the prototype DST module has tabs for well header that in turn has separate sheets for well data, parameters, details. The later dialog box in the well header is shown below including summary information about the well temperature, pressures, and recoveries.
Example of dialog box from well header-detail in the DST module.
An example of another dialog box from the DST module is shown below for the worksheet of pressure data vs. incremental time used to construct the Horner Plot.
Construct of a dialog box from the GEMINI DST prototype module showing the general layout of the worksheet displaying the data that is read from the electronic DST file and used to create the Horner Plot.

**Task 3: Geoengineering modeling**

PVT data play an indispensable role in reservoir engineering calculations. GEMINI hosts different reservoir engineering tools to analyze DST data, calculate volumetric reserves in place and initiate some material balance calculations. PVT data is integral to each of these calculations. PVT data can be generated from laboratory measurements on representative fluid samples from the reservoir. However, it is not uncommon for the user to lack access to fluid samples from the reservoir of interest or laboratory measured PVT data sets.

Extensive research has resulted in a huge body of published literature on the physical properties of reservoir fluids. The recent past has seen a move towards the standardization of laboratory procedures for analyzing fluid properties and significant advances in leveraging the equations of state to calculate gas-liquid equilibria. Also, understanding about the chemical nature of petroleum fluids has matured. As a result of these advances, numerous correlations have also been developed to estimate, often with reasonable accuracies, different PVT properties of reservoir fluids. Available equations
express these tabular and graphical correlations in forms that can be easily programmed into simple input-output modules.

In the absence of measured PVT data, it is common practice in the industry to resort to standard published correlations to estimate the PVT properties of reservoir fluids based on a minimal set of known data. The PVT module of GEMINI helps the user to calculate some of the basic PVT properties of oil and gas, that are required as inputs to DST analysis, volumetric and material balance calculations, given a limited set input data.

**Task 4: Technology transfer**

**GEMINI Industry Review Meeting, March 14, 2002, BP facilities, Houston, TX**

The March 14 review meeting was held at the Westlake Park Office Building Complex of BP. Those companies attending the GEMINI session included three members of BP, four members of Pioneer Resources, and one member of Phillips Petroleum. The agenda included a review of GEMINI, on-line demonstration of working modules, and wrap-up/summary. We had a lively discussion throughout the presentation with useful comments and feedback.

A manual, prepared for the meeting, was utilized to guide the presentation. The manual contains two parts, Part 1: Step-by-Step Approach to Using GEMINI and Part 2: Background and Application. Both parts of the manual are available as downloadable PDF files on the GEMINI website [http://www.kgs.ukans.edu/Gemini/index.html](http://www.kgs.ukans.edu/Gemini/index.html).

Activities described in the workshop include:

1) Create a password protected project;
2) Incorporate well data from the Survey’s website into the new project;
3) Upload LAS wireline log files from a user’s computer;
4) Display digital LAS logs, tailoring display of logs with standard log tracks, core data display, and interactive selection and display of formation tops from database or added by user, and interactive selection of intervals for petrophysical log analysis;
5) Conduct search for core analyses, cross plot of core data, and display of core images using Rock catalog prototype;
6) Log analysis computations including Pay Cutoffs, Water Saturation, Depth Constrained Cluster Analysis, Compositional Analysis, and construction of Pickett Plot using modules currently available in the PfEFFER module;
7) PVT calculations to derive parameters used in Volumetrics and Material Balance modules; and
8) Calculation, gridding, and mapping of original oil or gas in place using prototype of Volumetric module.

The modules “Well Profile”, “Fluid Catalog”, and “PVT Calculator” had been completed and being beta tested. The PfEFFER petrophysical module,
Volumetric/Production module, and Rock Catalog module had been prototyped and the working demo could be accessed through the latest release of GEMINI following the Step-by-Step Manual.

The real-time web access to GEMINI was accomplished satisfactorily using a 28.8 kb phone line. A participant also accessed GEMINI using a Compaq Pocket PC with a wireless connection to the Internet. This demonstrated to us the utility and feasibility of remote access, and indicated a certain degree of ease of use and functionality, even through a stylus and small screen were used.

Items discussed with participants include:

1. Type and format of company data needed for GEMINI testing;
2. Ability to upload a production file;
3. Ability to upload all major data for reservoir characterization;
4. Output all depth related data derived from GEMINI as pseudo LAS format;
5. Compare GEMINI to Canadian web tools;
6. Remove dashes in API number;
7. Add color shading for shale fraction and porosity cutoffs in Well Profile;
8. Compute and show oil or gas recovery efficiency in addition to OOIP in Volumetrics Module;
9. When reading LAS files accommodate for slight variations in format; and
10. Comment that commercial software tools already available to larger companies; Response is that GEMINI is
   a. freely accessible,
   b. shared via the Web with colleagues and team members wherever they are,
   c. provides iterative means to model petrophysical data,
   d. define and correlate flow units,
   e. conduct volumetrics and material balance on simple gridded models before moving to more complex characterizations, and finally,
   f. data and results can be exported to other software for additional analysis, e.g., using geostatistics to distribution reservoir properties between wells, run additional engineering analyses including reservoir simulation.

As a comparison and for added perspective, the following were comments from participants in the October 2nd GEMINI meeting with DOE and industry partners:

1. Interest in extending software to run offsite such as an intranet;
2. Ability to save activities and parameters of project and refresh displays as new data are added to project;
3. Use mouse listener to enhance interactivity of graphics such as well profile;
4. Add elevation (sea-level datum) track and seismic time alongside depth column in well profile;
5. Use color cube concept to display additional data in Pickett cross plot;
6. Interest in incorporating autocorrelation methods in cross section module;
7. Export of results to outside systems, download parameters and project profile, output “pseudo” LAS, plot files, and organized set of parameters and grids for simulation;
8. Generate additional parameters including density of hydrocarbon at reservoir conditions, velocity of fluid, and derivation of mechanical properties from logs such as Young’s Modulus and Poison’s Ratio;
9. Generate net pay and mobile OOIP;
10. Interest in a robust tutorial module;
11. Provide upload of LAS files as soon as possible so user can test GEMINI;
12. Use color fill rather than color lines on Log Profile and show pay cutoffs in similar way;
13. Incorporate colored dendrogram for use in depth-constrained cluster analysis to help distinguish zonation;
14. Include variable time steps in DST module to be able to use FIT results;
15. Address security issues in use of Java and legacy issues of uploaded company data;
16. Address issues and procedures regarding defining and preserving formation tops and nomenclature;
17. Incorporate risk analysis such as use of high, medium and low cases and running sensitivity analyses; forecasting;
18. Emphasize that GEMINI minimizes complexity and facilities integration, saving time and resources to accomplish reservoir characterization tasks, and
19. Add free-form data area to GEMINI resembling spreadsheet.

We are considering these suggestions in the context of our deliverables to meet the contract and interest in maximizing use of GEMINI.

**Subtask 4.2: Tutorial interface:**

The Gemini project now includes a tutorial web page component. As each module is completed, a tutorial sequence of html pages are created to familiarize users both with the underlying concepts of the module and the operational actions that would take in operating the module. The initial tutorial was written to service he PVT Calculator and can be reviewed at [http://www.kgs.ukans.edu/Gemini/Version_2.3/pvtApplet.html](http://www.kgs.ukans.edu/Gemini/Version_2.3/pvtApplet.html). The tutorial reviews the use of oil, water, and gas calculations with regard to viscosity, compressibility, and other factors.